Mysore J. Agric. Sci., 52 (2) : 409-415, 2018

Influence of Specific Nutrient Management Practices on Yield, Quality and Nutrient Use Efficiency in Turmeric

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Abstract

The present investigation was conducted at farmer's field of Byadamudlu village in Chamarajanagara district of southern dry zone of Karnataka to evaluate the influence of various nutrient management practices recommended by different institutions on growth, quality and nutrient use efficiency in turmeric. The experiment consisted of fourteen treatments and was laid out in a randomized complete block design, with three replications. Significantly higher length of rhizome, weight, girth, length of mother rhizome and fresh rhizome yield were recorded (15.74 cm, 66.77 g, 7.18 cm, 4.59 cm and 34.07 t ha^{-1}, respectively) with recommended dose of fertilizers by University of Agricultural Sciences, Bangalore (UAS-B) along with microbial consortia (MC) and arka actino plus. Similarly higher curcumin (5.257%), essential oil (5.424%), maximum nitrogen (63.72%), phosphorus (37.17%) and potassium (79.26%) use efficiencies were registered with the tried nutrient management practices.

Keywords : Nutrient management, rhizome yield, curcumin, nutrient use efficiency

Turmeric (*Curcuma longa* L.) is a commercial crop grown for its aromatic rhizomes which is used for cosmetic and culinary purposes since antiquity. The secondary metabolites of turmeric such as essential oils and curcumin have many important uses. The rhizome of turmeric is extensively used in cooking, medicine, cosmetics and fabric dying. Curcumin is the principal secondary metabolite of turmeric and has many medicinal uses.Currently India is the largest producer, exporter and consumer of turmeric in the world and is rated high in the world market for its curcumin content. Turmeric is a tropical rhizomatous crop, which has a high demand for mineral nutrients from the soil and responds to increased soil fertility in terms of yield.

Skewed nutrient management specifically focused on nitrogen has resulted in declining soil fertility. Least emphasis has been given to P and K and other secondary and micronutrients. Turmeric being a nutrient exhaustive crop responded with a linear increase in fresh rhizome yield with increased levels of NPK and organic manures. Incorporation of organic manures and bio-fertilizers either alone or in combination with inorganic fertilizers promoted soil quality (Dinesh *et al.*, 2010). There is an urgent need to adopt appropriate soil and plant nutrient management practices that ensure soil quality.

In Karnataka, Chamarajanagara belonging to Southern Dry Zone is one of the major turmeric growing district. The nutrient practices adopted by farmers of Chamarajanagara district is entirely different compared to that recommended by UAS-B. Since, Chamarajanagara is located near Tamilnadu and Kerala, the agricultural practices especially the application of inorganic fertilizers which are costly inputs are mixed resulting in reduced yields.

The present study was undertaken to evaluate the influence of several nutrient management practices on quality, yield and nutrient use efficiencies in turmeric.

Material and Methods

The experiment was conducted in farmer's field at Byadamudlu village of Chamarajanagar (taluk and district) which is located in the Southern Dry Zone (Agro-climatic zone VI) of Karnataka at 11°53'5" N latitude and 76° 59'33" E longitude at an altitude of 704 m above mean sea level (MSL).

Soil samples were drawn near the rhizosphere of crop and analysed for various parameters by employing standard analytical procedures. The soil of experimental site was sandy clay loam in texture with the bulk density of 1.38 Mg m^{-3} and porosity of 47.1 per cent. The soil was neutral in reaction (pH 7.78) and non-saline(EC 0.40 dS m^{-1}). The surface soil was low in organic carbon content (0.25 %) with cation exchange capacity of 20.6c mol (p^+) kg^{-1} soil. The soil was low in available N (148 kg ha^{-1}), high in available P_2O_5 (58.8 kg ha^{-1}) and available K_2O (388.8 kg ha^{-1}) and sufficient concentration in micronutrients. Similarly plant samples were analysed for various parameters by using standard procedures.

The field experiment was laid out in a randomized complete block design consisting of 14 treatments comprising of fertilizer recommendations (rec.) of various institutions, microbial consortia (MC) containing N-fixers and P-solubilizers and Arka Actino Plus (AAP) a biopesticide. The Plot Size of each block was 7.3 m x 3 m (21.9 m^2). The treatments were T_1 (Absolute control), T_2 (Farmer's practice - 180:150:120 kg N, P_2O_5, K_2O ha^{-1}), T_3 (UAS-Brec. - 150:125:250 kg N, P_2O_5, K_2O ha^{-1}), T_4 (ICAR-IISR rec. -60:50:120 kg N, P_2O_5, K_2O ha^{-1}), T_5 (TNAU rec.- 125:60:108 kg N, P_2O_5, K_2O ha^{-1}), T_6 (Soil test based rec. -175:100:213 kg N, P_2O_5, K_2O ha^{-1}), T_7 (50% UAS-Brec. - 75:63:125 kg N, P_2O_5, K_2O ha^{-1}), T_8(75% UAS-Brec. (113:94:187 kg N, P_2O_5, K_2O ha^{-1}), T_9 (50% UAS-B rec. - 75:63:125 kg N, P_2O_5, K_2O ha^{-1} + MC), T_{10} (75% UAS-Brec. (113:94:187 kg N, P_2O_5, K_2O ha^{-1} + MC), T_{11}(100% UAS-Brec.- 150:125:250 kg N, P_2O_5, K_2O ha^{-1}+ MC), T_{12}(50% UAS-Brec.- 75:63:125 kg N, P_2O_5, K_2O ha^{-1} + MC+ AAP), T_{13}(75% UAS-B rec. -113:94:187 kg N, P_2O_5, K_2O ha^{-1} + MC+ AAP) and T_{14} (100% UAS-B rec. - 150:125:250 kg N, P_2O_5, K_2O ha^{-1}+ MC+ AAP). Farm yard manure (N-0.46, P- 0.20 and K- 0.44%) was applied at 25 t ha^{-1} for each plot except absolute control. As per the treatments, phosphorus was applied in two splits as single super phosphate (16% P_2O_5) at the time of sowing and as DAP after one month of sowing. Nitrogen and potassium were applied in five equal splits. Urea (46% N) and muriate of potash (60% K_2O) were used as N and K fertilizers for subsequent applications.

Yield parameters like the length of rhizome (cm), weight of the mother rhizome (g), the girth of mother rhizome (cm) and length of mother rhizomes (cm) were recorded. Rhizome and shoot biomass were recorded plot wise and converted to t ha^{-1}, Agronomic efficiency (kg kg^{-1}) and Nutrient useefficiency (NUE) was calculated using as indicated below :

The agronomic efficiency is the additional yield per unit of input as indicated by kg of rhizome per kg of applied N and was computed using the following formula.

$$AE = \frac{\text{Rhizome yield (kg ha}^{-1}\text{) - Rhizome yield in absolute control (kg ha}^{-1}\text{)}}{\text{Quantity of fertilizer N applied (kg ha}^{-1}\text{)}}$$

$$NUE = \frac{\text{Nutrient uptake}_{\text{(treated)}} - \text{Nutrient uptake}_{\text{(control)}}}{\text{Total nutrient added (kg ha}^{-1}\text{)}} \times 100$$

Dry matter recovery was computed as per cent dry weight of rhizome to the fresh rhizome weight. The nutrient requirement was calculated as uptake of nutrient per unit production of rhizomes. Yield response is the yield difference between treated plots and control plot. Response yard stick for each treatment was calculated as yield response to total fertilizer applied (N, P_2O_5 and K_2O kg ha^{-1}).The curcumin content of turmeric was determined by following the method of Manjunath *et al.* (1991) and total essential oil was determined by ASTA method (Anon,1968). The data was statistically analysed as per the procedure of Gomez and Gomez (1984).

Results and discussion

The results of the study indicating the influence of various treatments on yield and yield parameters are presented in Table I. The yield attributing factors have appropriate relevance on plant productivity and in increasing the yield. The yield parameters like the length of rhizome, weight, girth and length of mother rhizome were significantly higher (15.74 cm, 66.77 g, 7.18 cm and 4.59 cm, respectively) due to nutrient management practice as recommended by UAS-B along with MC and AAP (T_{14}). However, the treatments with only MC along with UAS-B package

TABLE I

Effect of different nutrient management practices on yield and yield parameters of turmeric

Treatments	Length of rhizone (cm)	Length of Mother rhizones (cm)	Weight of Mother rhizones (g)	Girth of Mother rhizones (cm)	Yield (t ha $^{-1}$)	
					Shoot	Rhizome
T_1	8.43	3.02	35.41	3.54	2.17	7.86
T_2	14.08	3.62	60.39	5.84	5.82	21.82
T_3	15.06	4.31	64.20	6.42	5.09	29.79
T_4	11.87	3.06	49.85	4.99	2.83	18.09
T_5	12.59	3.24	57.41	5.74	4.64	17.91
T_6	12.45	3.63	49.92	4.99	5.81	23.76
T_7	10.59	3.08	44.48	4.45	2.86	18.96
T_8	12.48	3.64	56.87	5.69	3.60	23.88
T_9	10.84	3.16	43.47	4.35	2.86	19.82
T_{10}	12.18	3.55	51.16	5.12	3.85	25.09
T_{11}	15.27	4.45	65.63	6.96	5.13	31.79
T_{12}	11.64	3.39	46.68	4.67	2.90	20.06
T_{13}	13.54	3.95	56.91	5.69	3.95	26.51
T_{14}	15.74	4.59	66.77	7.18	5.15	34.07
S.Em±	0.599	0.114	3.006	0.499	0.262	1.579
CD (p=0.05)	1.72	0.31	8.97	1.42	0.74	4.50

and without MC were on par. The maximum fresh rhizome yield of turmeric (34.07 t ha^{-1}) was recorded with the UAS-B rec. along with MC and AAP (T_{14}), the other treatments receiving only MC along with UAS-B rec. and without MC were on par. However, rhizome yields of 18.09, 17.91 and 23.76 t ha^{-1} were recorded in treatments T_4 ($N_{60}P_{50}K_{120}$ – ICAR-IISR rec.), T_5 ($N_{125}P_{60}K_{108}$ – TNAU rec.) and T_6 ($N_{175}P_{100}K_{213}$ – soil test based rec.), respectively. The treatment with UAS-B recommendation along with MC and AAP was superior over other treatments with an increase of 14.37 per cent rhizome yield compared to UAS-B rec.and 56.11 per cent compared to farmer's practice. Application of nutrient as per farmer's practice produced higher shoot dry matter followed by soil test based recommendation. Balanced nutrition with 1.2:1:2 ratio of N, P and K, respectively, resulted in the significant effect on yield and yield contributing characters of turmeric.Similar results were obtained by Roy and Hore (2012).

Dry matter of rhizome was recovered at maximum 25.9 per cent due to UAS-B rec. along with MC and AAP (T_{14}) and minimum of 19.8 per cent in absolute control, whereas the UAS-B rec.without MC and AAP (T_3) recorded 25.0 per cent (Table II). These findings are similar to that of Kamlesh *et al.* (2015) who reported that application of N at 150 kg ha^{-1} was optimum for good dry rhizome weight. Application of increased levels of P and K had significantly increased the total dry matter of turmeric. Further, harvest index of turmeric was non-significant.

Harvest index of turmeric observed under different nutrient management practices is presented in Table II. Harvest index of turmeric ranged from 78.36 to 87.39 per cent. Perusal of data indicated that harvest index of turmeric was not significantly influenced by different nutrient management practices, may be due to a proportionate increase in both rhizome and straw yields among varied practices.

TABLE II

Effect of different nutrient management practices on dry matter recovery, harvest index, Curcumin and Essential oils of turmeric

Treatments	Dry Matter recovery (%)	Harvest index (%)	Curcumin (%)	Essential oils (%)
T_1	19.8	78.36	2.650	2.726
T_2	25.3	78.94	4.763	4.913
T_3	25.0	85.40	5.247	5.413
T_4	20.8	86.49	3.433	3.524
T_5	24.5	79.42	4.760	4.910
T_6	24.6	80.34	5.243	5.406
T_7	21.4	86.90	3.843	3.951
T_8	24.5	86.89	4.400	4.521
T_9	21.5	87.39	3.993	4.108
T_{10}	24.6	86.69	4.403	4.528
T_{11}	25.6	86.09	5.253	5.417
T_{12}	21.6	87.35	4.393	4.521
T_{13}	24.8	87.04	4.410	4.531
T_{14}	25.9	86.86	5.257	5.424
S.Em±	2.022	3.152	0.047	0.183
CD (p=0.05)	5.75	NS	0.141	0.522

The quality of turmeric is often identified on the basis of colour intensity of rhizomes, which depends upon the curcumin content of the rhizomes. Curcumin, the secondary metabolite was an important quality attribute of turmeric. Higher curcumin content was recorded in treatment T_{14} ($N_{150}P_{125}K_{250}$ -100% UAS-B rec. +MC+AAP) *i.e.*, 5.257 per cent and was on par with the treatments T_{11} (5.253 %), T_3 (5.247%) and T_6 (5.243%) which treated with $N_{150}P_{125}K_{250}$ -100 per cent UAS-B rec.+MC, $N_{150}P_{125}K_{250}$ – UAS-B rec. and $N_{175}P_{100}K_{213}$ - soil test based rec., respectively. Minimum curcumin content was registered in absolute control (T_1) with 2.650 per cent (Table 1I). Higher curcumin content due to balanced nutrition and imposed bio-fertilizers. Similar results were also recorded by Asghari *et al.* (2009) and Karthikeyan *et al.* (2009).

Essential oils are produced by active cells of most of the plants. In the present study, essential oils were determined in rhizomes immediately after harvest. Higher essential oils was recorded (Table II) in treatment T_{14} ($N_{150}P_{125}K_{250}$ -100% UAS-B rec. +MC+AAP) recorded 5.424 per cent and was on par with the treatments T_{11} (5.417 %), T_3 (5.413 %), T_6 (5.406 %), T_2 (4.913 %) and T_5 (4.910 %) which treated to $N_{150}P_{125}K_{250}$ -100% UASB rec.+MC, $N_{150}P_{125}K_{250}$ – UASB rec., $N_{175}P_{100}K_{213}$ – soil test based rec., $N_{180}P_{150}K_{120}$ – farmers' practice and $N_{125}P_{60}K_{108}$ – TNAU rec., respectively. Minimum essential oils was recorded in control (2.726 per cent).

The number of oil bearing cells increased under superior nutrient management. Increased essential oil of turmeric is due to nitrogen and other nutrient supply. Singh *et al.* (2017) also opined that fertilizers had positive influence on essential oil synthesis.

Among the use efficiencies of major nutrients, the use efficiency of potassium was maximum compared to nitrogen and phosphorus (Table III).

TABLE III

Effect of different nutrient management practices on nutrient use efficiency, agronomic efficiency, yield response and response yard stick of turmeric

Treatments	Nutrient use efficiency (%)			Nutrient requirement (Kg t $^{-1}$)			Agronomic efficiency (kg Kg $^{-1}$)	Yield response (t ha $^{-1}$)	Response yard stick (kg Kg $^{-1}$)
	N	P_2O_5	K_2O	N	P_2O_5	K_2O			
T_1	-	-	-	0.435	0.316	0.404	-	-	-
T_2	37.07	18.21	66.60	1.316	0.961	1.655	77.6	13.96	31.02
T_3	47.65	29.26	69.29	1.325	0.900	2.246	146.2	21.93	41.78
T_4	52.95	26.67	56.35	1.102	0.582	1.454	170.5	10.23	44.47
T_5	41.98	26.78	61.53	1.323	0.686	1.508	80.4	10.05	34.30
T_6	44.36	34.77	63.98	1.427	0.787	2.304	90.9	15.90	32.58
T_7	50.62	23.46	52.79	1.241	0.620	1.496	148.0	11.10	42.19
T_8	50.17	26.61	56.05	1.446	0.760	2.012	141.8	16.02	40.67
T_9	54.45	24.45	59.35	1.291	0.624	1.522	159.5	11.96	45.48
T_{10}	55.18	29.33	62.93	1.476	0.787	2.040	152.5	17.23	43.72
T_{11}	58.76	34.93	74.71	1.536	0.947	2.451	159.5	23.93	45.58
T_{12}	56.65	27.08	61.11	1.296	0.648	1.543	162.7	12.20	46.38
T_{13}	60.62	31.26	66.32	1.538	0.794	2.073	165.0	18.65	47.32
T_{14}	63.72	37.17	79.26	1.606	0.958	2.497	174.7	26.21	49.91

Nutrient availability in the soil-plant system is dictated by complex interactions among plants, microbes and other living organisms. Nutrient transformations in soil are induced by activities of the physical, chemical and microbial entity. Intensively grown commercial crops demand more nutrients resulting inhigh nutrient use efficiency. Further, it is evident from the data that the maximum use efficiency of N, P and K were 63.72, 37.17 and 79.26 per cent, respectively in the treatment UAS-B rec. along with MC and AAP (T_{14}). Among all other treatments, minimum nutrient use efficiency was observed due to farmer's practice (37.07, 18.21 and 66.60 per cent for N,P and K, respectively). Application of microbial consortia resulted in increased activity of beneficial microbes, which play an important role in the mobilization of nutrients and thereby facilitating the better availability of nutrients resulting in high nutrient use efficiency (Krishnamoorthy *et al.,* 2015).

Among the treatments, the nutrient requirement for producing one tonne of fresh rhizome ranged from 1.102-1.606, 0.582-0.958 and 1.454-2.497 kg N, P_2O_5 and K_2O, respectively except in case of absolute control. Higher NPK requirement might be due to higher utilization of nutrients by the turmeric for higher yield.

Agronomic efficiency refers to additional yield per unit of input indicated by kg of rhizome per kg of applied N. An increase in agronomic efficiency from 146.2 to 174.7 kg kg^{-1} was recorded with MC+AAP along with $N_{150}P_{125}K_{250}$ -100 per cent UAS-B rec. However the farmers' practice achieved only 77.6 kg kg^{-1}. High agronomic efficiency could be obtained if the yield increment per unit N applied is high because of reduced losses and increased uptake of N.

Yield response is the difference in rhizome yield between treated and control plots. Yield response as influenced by different nutrient management practices is presented in Table III. Perusal of data on yield response indicating that treatment T_{14} ($N_{150}P_{125}K_{250}$ - 100 per cent UASB rec.+MC+AAP) recorded best response of 26.21 t ha^{-1}, followed by T_{11} ($N_{150}P_{125}K_{250}$ -100% UASB rec. +MC) and T_3 ($N_{150}P_{125}K_{250}$ -100% UASB rec.) of 23.93 and 21.93 t ha^{-1}, respectively. Similarly the yield response to per unit fertilizer applied *i.e.*, response yard stick is given in Table III. It is clear from the table that, maximum response per unit fertilizer applied was obtained in T_{14} ($N_{150}P_{125}K_{250}$ -100% UASB rec.+MC+AAP) of 49.91 kg kg^{-1}, whereas, farmers' practice resulted in 31.02 kg kg^{-1} only. This might be due to balanced application of nutrients as inorganic fertilizers along with different inoculants which have increased the solubility of nutrients, thus increasing the uptake of nutrients under those treatments. Higher response may be due to effective utilization of NPK nutrients by the crop in respective treatment and balanced uptake of NPK nutrients. Similar were the results of Chandrakant and Basavaraja (2018).

The relationship between rhizome yield and nutrient requirement of turmeric

The nutrients required to realize optimum yield depends on an ideal nutrient management. Equations relating to N, P_2O_5 & K_2O requirement (kg t^{-1}) and rhizome yield configure the nutrient requirement of turmeric. The gradient obtained were 0.056, 0.0319 and 0.0789 with R^2 values of 0.5197, 0.7232 and 0.9191 for N, P_2O_5 & K_2O, respectively being the requirement for rhizome yield (Fig. 1). The study proved that potassium, the quality nutrient element, largely influenced the yield of rhizome followed by nitrogen and phosphorus. The positive response of turmeric to increased potassium fertilization was expressed by enhanced tillering coupled with increased yields.

The nutrient management practice including UAS-B rec. along with MC and AAP (T_{14}) is best suited for Southern Dry Zone of Karnataka producing a higher turmeric yield and higher nutrient use efficiency. It also resulted in higher curcumin and essential oils.

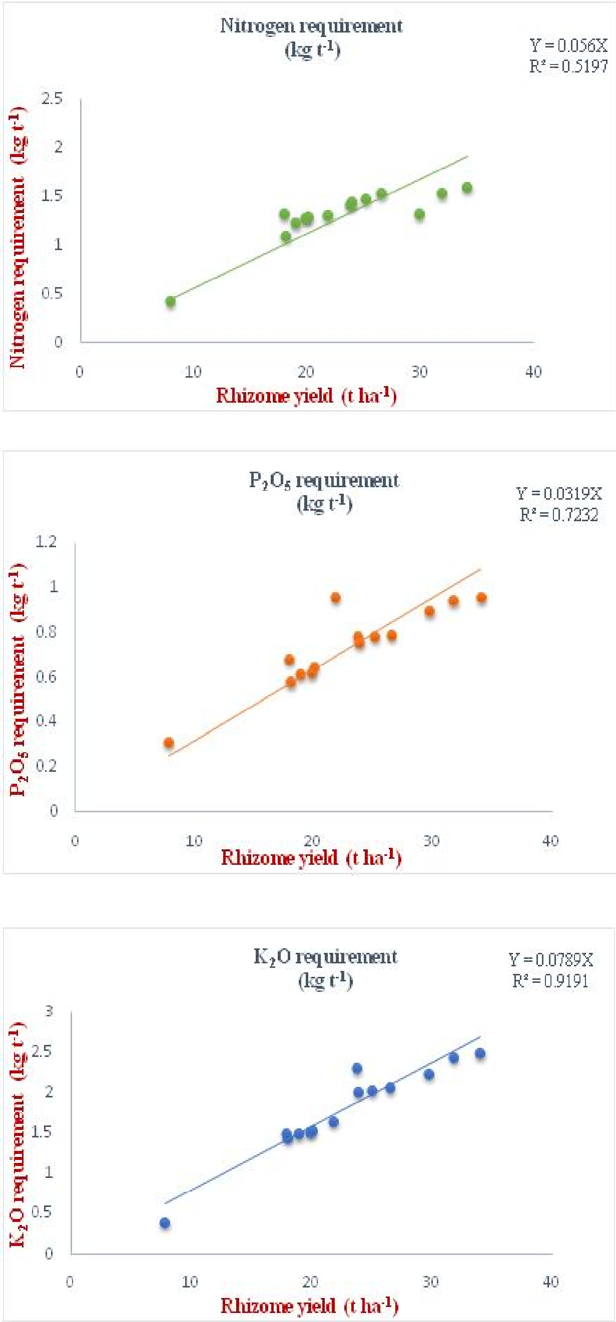

Fig. 1 : Relationship between the rhizome yield and nutrient requirement of turmeric

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(*Received :* May, 2018 *Accepted :* June, 2018**)**