Research Findings

The Effect of Potassium on the Yield and Quality of Turmeric *(Curcuma longa)*

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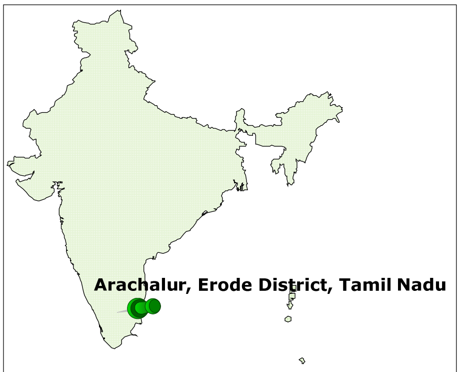
The experiment signboard, Arachalur, Tamil Nadu. Photo by P.K. Karthikeyan.

Introduction

Turmeric (*Curcuma longa)* is a tropical rhizomatous crop cultivated most extensively in India, followed by Bangladesh, China, Thailand, Cambodia, Malaysia, Indonesia, and the Philippines. In India, the main turmeric-growing states are Tamil Nadu, Andhra Pradesh, Maharashtra, Orissa, Karnataka and Kerala. In Tamil Nadu, as much as 25,000 hectares of turmeric are cultivated, with a production of more than 125,000 mt of cured rhizome yield. Turmeric is prized for its ability to impart a brilliant yellow-gold color to food and is an essential ingredient in curry and curry powders, giving culinary dish a characteristic peppery taste (Ravindran *et al*., 2007). The active components in turmeric possess a broad spectrum of biological activities with various beneficial properties e.g. anti-bacterial, anti-fungal, anti-parasitic, anti-mutagen, anti-inflammatory, hypolipidemic, hepatoprotective; lipoxygenase, cyclooxygenase, and protease-inhibitory effects, besides being effective in reactive oxygen species scavengers and lipid peroxidase inhibitors (Khanna, 1999).

As a crop, turmeric has a high demand for plant mineral nutrients and yield production generally responds to increased soil fertility; the quantity of fertilizers (inorganic or organic) required by the crop depend on the variety selected, as well as soil and prevailing weather conditions during crop growth. The average cured rhizome yield of turmeric ranges from 3-5 mt ha^{-1} in the Erode district, of Tamil Nadu (Selvarajan and Chezhiyan, 2001). However, inadequate nutrient management and nutrient mining has led to low productivity of fresh rhizome yield in the major turmeric growing regions in South India. In order to study the effect of potassium and magnesium on turmeric production, and on its quality attributes of the crop under conditions of adequate supply of nitrogen and phosphorus, a field experiment was carried out on the Irugur soil series (Inceptisols) in the western zone of Tamil Nadu.



Map of India showing the experimental site.

Materials and Methods

The field experiment was carried out on an Inceptisol (a soil with little horizon development) in farmers' holdings at Arachalur, in the Erode District of Tamil Nadu, under the supervision of the Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University. Soil samples taken from the field experiment prior to treatment application, were analyzed for all important soil parameters adopting standard procedures (Table 1).

Table 1. Soil properties.

Physical Properties	unit	
Clay	g kg^{-1}	155
Silt	g kg^{-1}	230
Fine sand	g kg^{-1}	240
Coarse sand	g kg^{-1}	350
Texture		Sandy loam
Chemical Properties		
Soil pH (1:2)		6.5
EC	dSm^{-1}	0.05
CEC	cmole kg^{-1}	12.1
Organic carbon	g kg^{-1}	4.8
$KMnO_4$–N	mg kg^{-1}	105
Olsen –P	mg kg^{-1}	8.2
NH_4OAC–K	mg kg^{-1}	60
Exchangeable Ca	cmole kg^{-1}	7.0
Exchangeable Mg	cmole kg^{-1}	1.8

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The experimental design was a randomized block design with seven treatments replicated threefold. The details of the treatments are given in Table 2.

Table 2. Experimental treatments.

Treatment	Potassium application (kg ha^{-1})
K1	Control (no potash)
K2	40
K3	120
K4	200
K5	260
K6	260+60*
K7	320

*60 kg $MgSO_4$ ha^{-1}

120 kg of N ha^{-1} (urea), 50 kg P_2O_5 ha^{-1} (superphosphate), 5 kg $ZnSO_4$ ha^{-1}, and 5 kg Fe SO_4 ha^{-1} were applied to all treatments.

A plot size of 10 x 6 m was used, with the experimental site being previously prepared in broad ridge and furrow for the cultivation of the rhizomes. Farmyard manure - at a rate of 25 mt ha^{-1}, as well as 50 kg of P_2O_5 ha^{-1} and 5 kg of $ZnSO_4$ ha^{-1} and 5 kg of $FeSO_4$ ha^{-1} - were applied as a basal treatment on all plots. The fertilizers, potassium (as muriate of potash KCl), nitrogen (as urea) and magnesium (as $MgSO_4$) were applied in four equal splits. The first split was applied basally and the rest at 30, 60, and 90 days after planting. Various cultivation procedures, including irrigation and plant protection measures, were carried out as per the recommended practice for the region. During crop growth, growth parameters viz., tiller count per plant and secondary rhizomes per plant were recorded. The crop was harvested 290 days after planting and the yield of fresh rhizomes was documented. Rhizome samples were collected, dried and analyzed for the content of nitrogen (Alkaline permanganate method, (Subbiah and Asija, 1956), phosphorus (0.5 M $NaHCO_3$ (pH 8.5), (Olsen *et. al.*, 1954)) and potassium (Neutral normal ammonium acetate method–flame photometry, (Stanford and English, 1949)). The curcumin (yellow pigment of tumeric) content of rhizome samples was estimated by the method suggested by ASTA (1968). Uptake of nutrients by rhizomes was calculated at harvest by making use of the data on nutrient contents and yields of the cured rhizomes.

Potash fertilized turmeric crop (Curcurma longa) cv. Erode local. Photo by P.K. Karthikeyan.

Results and Discussion

Yield and quality

The positive response of turmeric to increased potassium fertilization expressed itself by way of enhanced tillering coupled with increased yields (Table 3).

The treatment (K6) which received 260 kg of K_2O ha^{-1} and 60 kg $MgSO_4$ ha^{-1} recorded the highest tiller count (14.7 $plant^{-1}$) but the difference between that and treatment K5 (260 kg of K_2O ha^{-1}), which recorded 14.3 tillers $plant^{-1}$ was not statistically significant. A similar trend, with slightly higher but non significant values between treatment K6 (with addition of Mg) and treatment K5, was recorded for both secondary rhizome and fresh rhizome yield. Singh *et al.*, (1998) also showed that increasing rates of potassium application had a positive and significant effect on fresh rhizome yield. Yield declined significantly at the highest rate of potassium application

Table 3. Influence of potassium on the yield and quality of turmeric cv. Erode local.

Treatments	Potash application	No. of tillers	No. of secondary rhizomes	Fresh turmeric yield	Curcumin content
	kg ha^{-1}	*No./plant*	*No./plant*	*mt ha^{-1}*	*%*
K1	0 (control)	3.70	8.70	18.0	2.90
K2	40	5.70	13.3	24.3	3.30
K3	120	8.00	17.7	28.3	3.63
K4	200	10.7	20.3	31.4	3.93
K5	260	14.3	23.3	34.4	4.47
K6	260 + 60*	14.7	24.0	34.9	4.53
K7	320	11.0	20.7	32.4	4.07
CD (P=0.05)		0.80	2.09	1.68	0.15

*60 kg $MgSO_4$ ha^{-1}

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(treatment K7) in accordance with the other growth and yield parameters.

Rhizome quality is judged on how much curcumin it contains. This important quality parameter of the rhizome has been shown to increase significantly in response to K application (Singh *et al.*, 1992). Our results confirmed this finding with significantly increased concentrations as a consequence of K application.

The control recorded a value of 2.9 per cent which was significantly lower than the other treatments (3.30-4.53 per cent). The highest curcumin content of 4.53 per cent was recorded in treatment K6 (K and Mg), followed by treatment K5 which recorded 4.47 per cent, but again the difference between these two treatments was not statistically significant.

Large rhizomes due to potash application (K6, 260 kg of K_2O ha^{-1};left) and no K applied (K1, right). Photo by P.K. Karthikeyan.

Nutrient content and uptake

Nutrient content of N, P and K of the rhizome at harvest (Table 4) - particularly those of K - show an increasing trend similar to yield and yield attributes, with significantly increased values recorded after application of K. The highest K contents of 2.2 per cent K (in treatments K5 and K6 with 260 kg K_2O ha^{-1}) contrasted markedly against the control of 1.6 per cent (treatment K1). This beneficial effect of K application on rhizome K content is in agreement with the findings of Subramanian *et al.*, (2001). With the exception of treatment K4, both N and P contents were also somewhat increased by K application.

Since both dry weight yields of the rhizomes and their respective nutrient contents were considerably increased by K application, the effect of K fertilization in increasing uptake of N, P and K as the products of dry matter and nutrient content was even greater. Highest dry matter yields were recorded in treatment K6 with uptakes of nitrogen, phosphorus and potassium of 86, 14, and 151 kg ha^{-1}, respectively. This beneficial effect of K fertilization in increasing the uptake and utilization of other nutrients is an important aspect of K fertilization. In this experiment (as calculated from the data shown in Tables 3 & 4) K application at 260 kg ha^{-1} resulted in a more than 2.5 fold increase in yield of cured rhizomes with markedly raised quality, increasing curcumin production fourfold from 75 to 305 kg ha^{-1}.

The application of magnesium had no significant effect on any of the parameters recorded in this experiment. In all cases, however, the benefits of applying 260 kg K_2O ha^{-1} appeared to be slightly improved by the magnesium treatment. In view of possible competitive effects between K and Mg in uptake and utilization (see Mengel and Kirkby, 2001), this observation needs to be borne in mind in future work with this crop, particularly on soils where magnesium supply might be limiting.

Conclusions

The influence of potassium on growth, yield, nutrient uptake and quality

Table 4. Influence of potassium on nutrient uptake of cured rhizome for turmeric cv. Erode local.

Treatments	Potash application	Cured rhizome yield	Nutrient content			Nutrient uptake		
			N	P	K	N	P	K
	kg ha⁻¹	*mt ha⁻¹*	---------%---------			-------*kg ha⁻¹*--------		
K1	0 (control)	2.57	1.20	0.16	1.60	31	4	41
K2	40	3.75	1.23	0.16	1.80	46	6	68
K3	120	4.71	1.24	0.16	1.93	59	8	91
K4	200	5.77	1.20	0.15	2.10	69	9	121
K5	260	6.83	1.25	0.20	2.20	86	14	150
K6	260 + 60[(1)]	6.87	1.25	0.20	2.20	86	14	151
K7	320	5.82	1.24	0.16	2.10	72	10	122
CD (P=0.05)		0.35	0.02	0.01	0.03	4.60	0.807	7.97

*60 kg $MgSO_4$ ha^{-1}

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parameters of turmeric *cv. Erode local* was assessed from a field experiment on an Inceptisol low in available K in Tamil Nadu, the major turmeric growing region of south India. Increasing the application rate of potassium in the form of KCl enhanced growth, nutrient uptake and utilization, increasing yield and quality of turmeric. From our findings, the application of 260 kg K_2O ha^{-1} should be recommended. This more than doubled cured rhizome yield and increased curcumin content by over 50 per cent. These results suggest that the turmeric crop requires large amounts of potassium for both yield and quality. No statistical evidence of a beneficial effect on yield or quality parameters was found by supplying magnesium at the highest rate of K application. In view of the competitive effects of these two nutrients in uptake and utilization, however, the possible beneficial effect of magnesium application does need to be borne in mind in cultivating turmeric on soils low in magnesium.

Turmeric (Curcurma longa) cv. Erode local. Photo by P.K. Karthikeyan.

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References

ASTA. 1968. Colour power of turmeric. Method 18. *In*: Official Analytical Methods. American Spice trade Association, New York. p.38.

Khanna, N.M. 1999. Turmeric - nature's precious gift. Current Sci., 76(10):1351-1356.

Mengel, K., and E.A. Kirkby. (2001) Principles of Plant Nutrition Kluwer p. 849.

Olsen, S.R., C.V. Cole, F.S. Watanbe, and A.L. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular No. 939. USDA.

Ravindran P.N., K. Ravindran, Nirmal Babu, and K. Sivaraman. 2007. Turmeric: the genus Curcuma; Medicinal and aromatic plants--industrial profiles. CRC Press, Taylor & Francis Group Boca Raton, FL. p. 236.

Selvarajan, M., and N. Chezhiyan. 2001. Studies on the influence of Azospirillum and different levels of nitrogen on growth and yield of turmeric (*Curcuma longa L.*). South Indian Hort., 49:140-141.

Singh, V.B., B. Swer, and P.P. Singh. 1992. Influence of nitrogen and potassium on yield and quality of turmeric cv. Lakadong. Indian Cocoa, Arecanut and Spices J., 15(4):106-108.

Singh, V.B., N.P. Singh, and B. Swer. 1998. Effect of potassium and nitrogen on yield and quality of turmeric *(Curcuma longa)*. J. Potassium Res., 14(1/4):88-92.

Stanford, S., and L. English, 1949. A use of flame photometer in rapid soil tests of potassium and calcium. Agron. J., 41:446-447.

Subbiah, B.V., and G.L. Asija. 1956. A rapid procedure for estimation of available nitrogen in soils. Current. Sci., 25:259-260.

Subramanian, K.S., N. Sivasamy, and T. Thangaraj. 2001. Integrated nutrient management for turmeric. Spice India, 14 (12):25-26. ■

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