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Effect of nitrogen, phosphorus and potassium application on yield and quality of turmeric (*Curcuma longa* L.) in an acid soil

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Abstract

Field experiments were conducted during rainy (Kharif) seasons of 2001 and 2002 to study the effect of nitrogen, phosphorus and potassium application on yield and quality of turmeric (*Curcuma longa* L.) in an acid silty clay loam soil classified as Typic Hapludalf. A significant increase in rhizomes and stover yield was received under 100,125 and 150 per cent levels of nutrient application. The highest yields of rhizomes (153.6 q/ha) and stover (27.1 q/ha) were obtained under treatment comprising 150 per cent NPK (45 kg N+ 45 kg P_2O_5+90 kg K_2O /ha) nutrient levels. The uptake of N, P and K as affected by different treatments followed the trend, similar to rhizomes yield. Application of phosphorus and potassium gave beneficial effect in increasing the curcumin and starch contents of turmeric rhizomes. Whereas, application of N and NP significantly increased the protein content and further addition of K did not significantly increase the protein content of rhizomes.

Key words: Nitrogen, phosphorus, potassium, turmeric, rhizome yield, uptake, quality.

Introduction

India exports about 20 different kinds of spices and among them, turmeric ranks fourth in foreign exchange earnings. Turmeric or *Haldi* constitutes boiled, dried, cleaned and polished rhizomes of *Curcuma longa* L. and this crop in Indian subcontinent accounts for 90 per cent of total world turmeric production which is considered to be the best in the world market because of high curcumin content. In India, turmeric is cultivated in 140 thousand hectares with a production of 600 thousand tones, out of which, 27,204 tones of value at Rs. 801.5 lakh rupees is exported every year (Peter *et al.*,2000). In Himachal Pradesh, turmeric occupied an area of about 150 hectors with a production of 110 tonnes with an average yield of 0.73 t/ha (Anonymous,2005). Considering the importance of this crop in our national economy, attention need to given to the production of quality produce as per exportable standards. Consequently, the productivity and quality of this crop needs to be upgraded (Medhi and Bora, 1993). For higher productivity balanced and optimum nutrition is essential, however, in state of Himachal Pradesh the use of N, P and K fertilizers in turmeric is infinitesimally small. It was therefore, found imperative to study the effect of different levels of N, P and K on rhizomes yield, nutrient uptake and quality of turmeric in an acid soil.

Material and Methods

Field experiments were conducted on silty clay loam soil classified as Typic Hapludalf at the experimental farm of the Department of Soil Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during Kharif season of 2001and 2002.The experimental soil had pH 5.7, CEC 9.2 C mol (p^+) /kg, organic carbon 9.0 g/ kg, available N, P and K were 238.0, 14.1 and 198.0 kg/ha, respectively. The treatments consisted of three levels (100,125 and150 per cent) each of N, NP and NPK. These treatments were tri replicated in RBD. Turmeric (cultivar T-12) was sown @ of 20 q rhizome/ ha in 10 m^2 plot size. The recommended dose (R D) of N, P_2O_5 and K_2O (30, 30 and 60 kg/ ha) were applied through urea, diammonium phosphate and muriate of potash, respectively. One-third dose of N and full dose of phosphorus and potash were applied as basal dose at the time of sowing and one-third of nitrogen was applied two months after planting and the remaining four months after planting.

At maturity yield of cleaned fresh rhizomes was recorded. The rhizomes samples were taken for determination of N, P and K contents. The oven dried rhizomes samples were

finely ground in a Wiley mill and in the ground samples N was determined by Kjeldahl's method (Jackson, 1967). Finely ground samples were digested in triacidic mixture of concentration H_2SO_4, HNO_3 and $HClO_4$ (10:4:1) and in the extract phosphorus was determined by vanadomolybedate Phosphoric acid yellow colour method and potassium by flame photometric method. Protein content in rhizome was obtained by multiplying the total N content with a factor of 6.25. Curcumin content in finely ground turmeric powder was determined calorimetrically (Manjunath *et al.*, 1991) and starch content was determined following the method suggested by Sadasivam and Manickam (1996).

Results and Discussion

Rhizomes and Stover yields

There was a significant increase in rhizome and stover yields under all levels of nutrient application (Table 1). The highest rhizome (128.5 q/ha) and Stover (24.7 q/ha) yield of turmeric was recorded with the application of 150 per cent level which was 17.9 and 17.1 per cent higher compared to 100 per cent level, respectively. Likewise, a significant increase in yields of turmeric rhizomes and stover were observed with the addition of each nutrient. Maximum rhizomes (144.1 q/ha) and stover (25.9 q/ha) yields were noted in plots supplied with NPK nutrient, which were 48.0 and 30.2 per cent higher than N alone, respectively. The interaction effects of different nutrient and their levels were found to be significant in increasing the rhizomes and stover yields of turmeric. The interaction effects revealed highest yields of rhizomes (153.6 q/ha) and stover (27.1q/ha) under treatment comprising 150 per cent NPK nutrient levels which were 81.3 and 52.3 per cent higher in comparison to 100 per cent N alone, respectively. Increase in rhizomes and stover yields with the application of N, P and K might be due to higher NPK requirement of turmeric crop, as the experimental soil tested only medium in available NPK contents. The beneficial effect of combined use of NPK at 150 per cent level could be attributed to an increased rate of photosynthetic activity due to nitrogen, coupled with accelerated transport and efficiency in utilizing photosynthetic products in the presence of phosphorus and potassium. This may have stimulated vegetative and reproductive growth, thus leading to increase rhizomes and stover yields. Similar findings were also reported by Govind *et al.* (1990) and Medhi and Bora (1993) in turmeric crop.

Table 1. Effect of different levels of nutrients on rhizomes and stover yield (q/ha) of turmeric (Mean of two years)

Levels	Rhizomes				Stover			
	Nutrients			Mean	Nutrient			Mean
	N	NP	NPK		N	NP	NPK	
100%	84.7	108.6	133.8	109.0	17.8	21.6	24.0	21.1
125%	102.8	124.8	144.9	124.2	20.0	23.2	26.8	23.3
150%	104.8	127.1	153.6	128.5	21.8	25.3	27.1	24.7
Mean	97.4	120.2	144.1		19.9	23.4	25.9	
CD	Level	Nutrients	Interaction		Level	Nutrients	Interaction	
(P=0.05)	3.5	4.6	7.8		0.41	0.53	0.93	

Nutrient uptake

Total uptake of N, P and K at maturity increased significantly under all the tried levels of nutrients (Table 2). Highest N, P and K uptake to the tune of 40.1, 18.7 and 46.2 kg/ha was recorded under treatment comprising 150 per cent level of RD which were 22.6, 24.7 and 12.1 per cent higher in comparisons to 100 per cent level of nutrient, respectively. Similarly application of NP and NPK nutrient over N alone significantly influenced the uptake of major elements in rhizomes of turmeric. Maximum N, P and K uptake 43.1, 21.0 and 55.2 kg/ha were noted with the application of

NPK nutrient, which were 40.8, 61.5 and 62.8 per cent higher than N alone, respectively. The interaction effects between different nutrient and their levels were found to be significant in increasing the total N, P and K uptake. Highest N, P and K uptake of 47.9, 22.7 and 56.7 kg/ha was recorded with 150 per cent NPK application (45 kg N + 45 kg P_2O_5 + 90 kg K_2O / ha). This may be explained due to the fact that each plant nutrient has specific metabolic functions in the plant system. So the combined use of NPK improved the crop growth and increased rhizomes yield that resulted in higher uptake of N, P and K. The results are in corroboration with the findings of Singh *et al.* (1998), and Srinivasan *et al.* (2000).

Table 2. Effect of different levels of nutrients on nutrient uptake (kg/ha) of turmeric (Mean of two years)

Levels	Nutrients			Mean
	N	NP	NPK	
		Nitrogen		
100%	26.3	33.4	38.3	32.7
125%	31.7	37.6	43.1	37.2
150%	33.7	38.8	47.9	40.1
Mean	30.6	36.4	43.1	
CD (P=0.05)	Levels:1.3	Nutrients: 1.6	Interaction:2.4	
		Phosphorus		
100%	11.2	14.9	19.0	15.0
125%	13.4	17.4	21.2	17.3
150%	14.4	18.9	22.7	18.7
Mean	13.0	17.1	21.0	
CD (P=0.05)	Levels:0.4	Nutrients: 0.5	Interaction :0.9	
		Potassium		
100%	30.1	40.3	53.1	41.2
125%	34.3	42.2	55.8	44.1
150%	37.3	44.5	56.7	46.2
Mean	33.9	42.4	55.2	
CD (P=0.05)	Levels:0.9	Nutrients: 1.2	Interaction : 2.1	

Quality Characteristics

Curcumin

The quality of turmeric is valued mainly on the presence of curcumin in rhizomes. Data presented in (Table 3) indicate a favorable impact of NP and NPK nutrient on the quality of turmeric. There was, however, no significant effect of different levels of nutrient on curcumin content. Maximum curcumin content (3.08 %) was observed with NPK application which was 5.1 and 11.2 per cent higher than NP and N, respectively. Among the interactions effects only different nutrient were found to increase the curcumin content. Highest content of curcumin (3.12 %) was recorded with 150 per cent R D of NPK which was significantly superior over other interaction. The data (Table 3) further revealed beneficial effect of phosphorus and potassium fertilizer in increasing the curcumin content of turmeric. Application of 150 per cent R D of NPK was observed to be significantly better then 150 per cent sole application of N (45 kg N/ha alone) and 150 per cent NP (45 kg N+ 45 kg P_2O_5 /ha) in increasing the curcumin content. This increase in curcumin in rhizome is due to the role of potassium and phosphorus in promoting synthesis of photosynthates, their transport to rhizome and to enhance their conversion into carbohydrate, protein and vitamins. Such a favorable effect of K and P on curcumin content of turmeric has been reported by Gupta *et al.* (1990) and Singh *et al.* (1998).

Protein

There was a significant increase in protein content of rhizomes up to 125 per cent level and further increase with the increasing nutrient level failed to reach the level of

significant (Table 3). Similarly application of N and NP significantly increased the protein content and further addition of K gave a non-significant increase in protein content. Among the interactions effect the highest content of protein (8.58 %) was obtained under 150 per cent NP (45 kg N + 45 kg P_2O_5 /ha) which was at par with 150 per cent NPK. Such a favorable effect of N and P fertilizer on protein content of rhizomes has also been reported by Chiu et *al.* (1993). The positive effect of N on protein content can be explained in light of the observations documented by Tisdale *et al.* (1995) which states that the amount of protein produced may be affected by the amount of N supplied to the crop.

Table 3. Effect of different levels of nutrients on quality parameters (%) of turmeric (Mean of two years)

Levels	Nutrients			Mean
	N	NP	NPK	
		Curcumin		
100%	2.80	2.90	3.05	2.92
125%	2.75	2.93	3.08	2.92
150%	2.77	2.96	3.12	2.95
Mean	2.77	2.93	3.08	
CD (P=0.05)	Levels: NS	Nutrients: 0.09	Interaction : 0.12	
		Protein		
100%	7.61	8.14	8.33	8.03
125%	8.14	8.38	8.46	8.33
150%	8.23	8.58	8.58	8.46
Mean	7.99	8.36	8.46	
CD (P=0.05)	Levels:0.15	Nutrients: 0.25	Interaction :0.44	
		Starch		
100%	5.64	6.26	6.97	6.29
125%	5.61	6.46	7.19	6.42
150%	5.61	6.51	7.46	6.53
Mean	5.62	6.41	7.21	
CD (P=0.05)	Levels:0.10	Nutrients: 0.14	Interaction : 0.25	

Starch

The starch content of rhizomes increased with increasing levels of nutrients as well as with the addition of each nutrient (Table 3). The maximum starch content 7.46 per cent was found in 150 per cent NPK which was 3.8 and 7.0 per cent higher than 125 and 100 per cent NPK, respectively. The increase in starch content of rhizomes with the application of phosphorous and potassium may be due to the fact that in root crops, synthesis of starch required considerable quantities of P and K. Since potassium is required for carbohydrate metabolism in the formation and translocation of starch and phosphorus favours the synthesis of organic compounds such as phospholipids, nucleic acids and enzymes which are essential for the synthesis of carbohydrates and starch. Similar results were reported by Uppal *et al.* (1993).

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