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Effect of different levels of N, P and K alone or in combination with farmyard manure on soil properties, yield and economics of turmeric in acid Alfisol of Himachal Pradesh

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ABSTRACT

The study was primarily devoted to assess the effect of different levels of NPK fertilizers with or without farmyard manure on soil properties, rhizome yield and economics of turmeric.A field experiment was laid for eight treatments comprised of different levels of NPK alone or in combination with FYM in a completely randomized block design with three replications. The results showed that application of NPK fertilizers as per STCR with FYM@ 5t ha^{-1} for targeted yield 40 t ha^{-1} resulted maximum soil organic carbon (9.03 g kg^{-1}), soil available NPKS (392, 42.1, 194 and 23.3 kg ha^{-1}, respectively). Maximum nutrient concentration and uptake in rhizome and straw were also higher in STCR based treatments over traditional methods. Rhizome yield (231 q ha^{-1}) and straw yield (16.1 q ha^{-1}) were also found to be maximum in the same treatment, whereas, the maximum benefit-cost ratio of 3.15 was recorded in the treatment of STCR based target yield of 20 t ha^{-1} followed by soil test based (3.04) treatment and least (1.97) in absolute control.

1. Introduction

Turmeric (*Curcuma longa L.*) is regarded as one of the religious spice crop of India. Being herbaceous perennial medicinal plant it belongs to family *Zingiberaceae and sub-family Zinigeradeae.* Cultivation of turmeric requires temperature between 20 and 30°C and soil pH range of 4.5 to 7.5. Its rhizome contain appreciable amounts of 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). Apart from its religious value it is also used in pharmaceuticals products to cure various diseases such as stomach disorders, fever, dropsy, ulcer and blood purifier (Kanwar, 2000). India is the largest producer of this spice crop around the globe and accounts 80 per cent of total production and 60 per cent of world's exports. Occupying an area of about 193.40 thousand hectares, Indian farmers produce 1052.10 thousand tonnes turmeric per annum (Anonymous, 2017).

In the era of increasing population and industrialization, rapid expansion of industries created conditions for modernizing agriculture. Therefore precision based farming is the key to maintain both the yields level and soil health. In early 20's, the levels of N, P and K removal in India were about 28 million tonnes against addition of only 18 million tonnes and resulted a negative balance of 10 million tonnes (Rao and Srivastava, 2000) which ultimately causing multiple nutritional deficiencies in plants. In recent years, prescription based fertilizer recommendation approach flagged its superiority over soil test based and general recommended dose methods as its application is based on equations which promise maximum yields levels with increasing fertilizer rates. Moreover, this approach harmonizes the concept of fertilize the soil versus fertilize

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the crop and ensure the real balance between the applied fertilizer nutrients among themselves and with the soil available nutrients. It helps to realize higher response ratio as the nutrients are applied in proportion to the magnitude of deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization (Rao and Srivastava, 2000). Moreover, application of organic manure with fertilizer N is known to stimulate the mineralizable N fractions and increase the efficiency of inorganic N fertilizer in the soil (Singh *et al.* 2002).

Prescription based fertilizer approach has already proved its superiority over the conventional fertilizer application methods in many crops by improving the nutrient pool in soils and by towering productivity of crop and socio-economic status of the farmers in the country. Very less work has been done among the comparison of soil test crop response with traditional methods of fertilization.

2. Material and methods

A field experiment was laid down with eight treatments replicated thrice in completely randomized block design during *kharif* season at the experimental farm of the Department of Soil Science, CSKHPKV, Palampur, Himachal Pradesh, India. The site was located at an elevation of about 1290 m amsl. The finger rhizomes were planted with the spacing of 30 cm x 15 cm in plots size of 10 m^2 (5m×2m). The nutrient sources were applied through urea, SSP and MOP containing 46, 16 and 60 per cent N, P_2O_5 and K_2O, respectively. Farmyard manure was applied on dry weight basis containing 0.5% N, 0.2% P_2O_5 and 0.5% K_2O per cent. The following treatments were incorporated in the study to compel on turmeric.

T_1: Farmer's practice (7.5 N: 15 P_2O_5: 15 K_2O kg ha^{-1} + FYM@ 5 t ha^{-1})
T_2: General recommended dose (30 N: 60 P_2O_5: 60 K_2O kg ha^{-1}+ FYM@ 5 t ha^{-1})
T_3: Soil test based ((30 N: 45 P_2O_5: 75 K_2O kg ha^{-1})
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

***** In targeted yield treatments FYM was applied @ 5 t ha^{-1} and the doses of fertilizers were calculated by the following equation based on STCR concept.

$$F\ N = 1.30\ T - 0.58\ SN - 0.08\ ON,$$

$$F\ P_2O_5 = 0.45T - 1.00\ SP - 0.10\ OP,$$

$$F\ K_2O = 1.78T - 1.21SK - 0.10\ OK$$

In above equations, FN, F P_2O_5, F K_2O were the 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 the N, P and K supplied by FYM, respectively in kg ha^{-1}.

3. Results

Soil properties

Results revealed that the application of NPK with or without FYM had no sigificant effect on soil pH which was in confirmation with studies of Srinivasan *et al.* (2000) in ginger and turmeric. Application of NPK with FYM improved the soil organic carbon over the NPK alone treatment of T_3. STCR based T_7 treatment brought maximum of 9.03 g kg^{-1} organic carbon content. Incorporation of NPK with FYM under STCR based treatments showed positive response on available N, P, K and S content. Maximum N (392 kg ha^{-1}), P (42.1 kg ha^{-1}), K (194 kg ha^{-1}), S (23.3 kg ha^{-1}) was recorded in STCR based T_7 treatment.

Nutrients concentrations in rhizome and straw (%)

Incorporation of NPK with FYM under STCR based treatments increased the nutrient concentrations over traditional methods of fertilization. In rhizome, maximum N (0.85 %), P (0.25%), K (1.12%) and S (0.18%) were recorded in STCR based T_7 treatment (Table 3). While, in straw similar treatment excelled over all the other treatment with maximum N (0.36%), P (0.09%), K (0.23%) and S (0.18%). Among the traditional methods application of NPK (30:60:60) with FYM@ 5 t ha^{-1} under T_2 increased the rhizome N concentration by 26.08 and 11.53 per cent, P concentration by 6.17 and 3.61 per cent, K concentration by 3.80 and 2.75 per cent and S concentration by 50 and 25 per cent over the T_1 and T_3, respectively.

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

Soil property	Value
Physical analysis	
Water holding capacity (per cent)	52.4
Particle Size analysis	
Sand (%)	22.7
Silt(%)	43.6
Clay(%)	31.7
Textural class	Silty clay loam
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

Table 2: Effect of different fertilization methods on soil pH, organic carbon and macronutrients (N, P, K and S) in turmeric in an acid Alfisol.

Treatments	Soil pH (0-15 cm)	Organic carbon (g kg^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available S (kg ha^{-1})
T_1	5.5	8.32	323	32.4	134	19.9
T_2	5.4	8.41	340	36.1	150	22.6
T_3	5.3	7.60	329	34.8	142	20.1
T_4	5.4	8.66	350	36.7	154	20.9
T_5	5.4	8.76	363	37.6	169	21.7
T_6	5.4	8.92	375	39.4	183	23.1
T_7	5.4	9.03	392	42.1	194	23.3
T_8	5.3	7.53	290	24.3	101	16.3
SE m ±	0.073	0.18	1.87	0.03	0.63	0.11
CD(P= 0.05)	NS	0.44	4.46	0.08	1.55	0.24

Table 3. Effect of prescription based fertilizer application on nutrients concentration (%) in rhizome and straw of turmeric crop

Treatments	N(%)		P(%)		K (%)		S (%)	
	Rhizome (%)	Straw (%)	Rhizome (%)	Straw (%)	Rhizome (%)	Straw (%)	Rhizome (%)	Straw (%)
T_1	0.71	0.23	0.19	0.081	1.05	0.14	0.10	0.041
T_2	0.75	0.29	0.22	0.086	1.09	0.16	0.15	0.045
T_3	0.73	0.26	0.21	0.083	1.06	0.15	0.12	0.043
T_4	0.79	0.27	0.21	0.084	1.07	0.15	0.13	0.040
T_5	0.81	0.31	0.22	0.087	1.09	0.19	0.15	0.046
T_6	0.84	0.35	0.24	0.089	1.11	0.22	0.17	0.049
T_7	0.85	0.36	0.25	0.090	1.12	0.23	0.18	0.050
T_8	0.69	0.16	0.17	0.078	1.02	0.11	0.07	0.035
SE m ±	0.003	0.003	0.004	0.003	0.004	0.003	0.003	0.0008
CD(P=0.05)	0.01	0.01	0.01	0.001	0.01	0.01	0.01	0.002

NPKS uptake by rhizome and straw (kg ha^{-1})

Supplementation of NPK fertilizers along with FYM enhanced the nutrient uptake in turmeric STCR treatment T_7 attained maximum nutrient uptake N (66.6 kg ha^{-1}), P (19.63 kg ha^{-1}), K (87.5 kg ha^{-1}) and S (13.88 kg ha^{-1}) but on the contrary were at par with STCR based treatment of T_6 which might be due to the fact that further increased doses of fertilizers beyond plant requirement did not increase the yield in same succession. Among the traditional methods T_2 treatment improved the N uptake by 26.1, P by 27.1, K by 24.7, S by 59.3 per cent over the soil test based (T3) treatment (Table 4).

Table 4. Effect of different fertilization methods on N, P, K and S uptake (kg ha^{-1}) by turmeric crop.

Treatment	N uptake		P uptake		K uptake		S uptake	
	Rhizome	Straw	Rhizome	Straw	Rhizome	Straw	Rhizome	Straw
T_1	19.6	1.45	5.22	0.52	28.9	0.90	2.65	0.26
T_2	26.6	2.37	7.87	0.70	38.3	1.34	5.40	0.37
T_3	21.1	1.70	6.19	0.54	30.7	0.97	3.39	0.28
T_4	22	1.71	5.97	0.52	30.1	0.91	3.55	0.25
T_5	46.6	3.70	12.80	1.03	62.3	2.19	8.40	0.54
T_6	65	5.52	18.38	1.42	86.0	3.57	12.94	0.78
T_7	66.6	5.76	19.63	1.45	87.5	3.66	13.88	0.80
T_8	13.5	0.72	3.28	0.36	20.1	0.52	1.44	0.16
SE m ±	1.35	0.09	0.65	0.01	1.64	0.09	0.46	0.01
CD(P=0.05)	3.26	0.23	1.54	0.04	3.91	0.23	1.10	0.03

Similar trend have been observed on the nutrient uptake in straw, where, highest values of N uptake (5.76 kg ha^{-1}), P (1.45 kg ha^{-1}), K (3.66 kg ha^{-1}) and S (0.80 kg ha^{-1}) were associated with STCR based T_7 treatment while the minimum was recorded in absolute control (Table 4). Among the traditional practices, T_2 treatment improved the NPKS uptake over the soil test based (T_3) and famer's practice (T_1). Higher uptake rates in STCR based treatments could be attributed to higher rates of fertilizers which ultimately increased the yield and nutrients concentration in plant.

Effect of different fertilization methods on yield of turmeric (q ha^{-1})

Balanced and judicious application of fertilizers as per STCR basis along with FYM increased the growth and yield attributes of turmeric. STCR based T_7 treatment recorded highest yield (228.5 q ha-1) followed by another STCR T_6 treatment but were at par with each other (Table 5). Among the traditional methods, combined NPK and FYM application under T_2 treatment excelled over NPK alone soil test based (T_3) treatment for returning higher yield (117.5 q ha^{-1}).

Table 5. Effect of different fertilization methods on rhizome and straw yield (q ha^{-1}) of turmeric crop

Treatment	Rhizome(q ha^{-1})	Straw (q ha^{-1})
T_1	91.6	6.4
T_2	117.5	8.2
T_3	96.8	6.4
T_4	93.3	6.2
T_5	168.5	11.8
T_6	228.5	16
T_7	231	16.1
T_8	50.6	4.6
CD (P= 0.05)	3.48	0.52

Effect of different fertilization methods on economics of turmeric cultivation

STCR based treatment showed promising results for higher returns as compared to all the other treatments (Table 6). Highest value of produce ₹ 4,15,800 ha^{-1} was recorded under T_7 followed by T_6 with the value of ₹ 4,11,300 ha^{-1}. The highest net returns (₹ 3,08,278 ha^{-1}) was observed in T_6 followed by T_7 (₹ 2,82,875 ha^{-1}) where the least net returns were in absolute control (T_8) (₹ 60, 510 ha^{-1}). Regarding the benefit: cost ratio, STCR based T_5 treatment gave 3.15 followed by soil test based (3.04). Instead of higher net returns in T_7 resulted in lower B: C ratio of 2.21 and the reason behind such lower benefit cost ratio was higher cost of cultivation and inputs.

Table 6. Effect of different fertilization methods on the economics of turmeric crop

Treatment	Rhizome yield (q ha^{-1})	Straw yield (q ha^{-1})	Value of produce (₹ ha^{-1})	Cost of inputs (₹ha^{-1})	Net returns (₹ha^{-1})	B:C
T_1	91.6	6.4	1,64,880	42,454	1,22,426	2.88
T_2	117.5	8.2	2,11,500	53,310	1,58,190	2.96
T_3	96.8	6.4	1,74,240	43,084	1,31,156	3.04
T_4	93.3	6.2	1,67,940	44,724	1,23,216	2.75
T_5	168.5	11.8	3,03,300	73,120	2,30,180	3.15
T_6	228.5	16	4,11,300	1,03,022	3,08,278	2.99
T_7	231	16.1	4,15,800	1,39,925	2,82,875	2.21
T_8	50.6	4.6	91080	30,570	60,510	1.97

4. Discussion

The study indicated that in acid Alfisols of Himachal Pradesh, soil organic carbon and macronutrients accumulation were markedly influenced with different fertilization treatments combined with farm yard manure as compared to sole application of NPK. The conclusion has been in conformity with many previous studies (Reddy and Rao, 1978; Govind *et al.*, 1990; Holeplass *et al.*, 2004; Rudrappa *et al.*, 2006; Su *et al.*, 2006). The study also revealed that alone chemical fertilizer did not create the better soil environment for yield maximization. Therefore, combined application of chemical and organic fertilizer found effective for higher yield of turmeric. In addition to this application of farmyard manure improved the physical, chemical and biological properties of soil, which resulted in better growth of plants and development of quality rhizomes (Chamroy *et al.*, 2015; Hossain & Ishimine, 2007; Velmurugan *et al.*, 2007; Mohapatra & Das 2009; Roy *et al.*, 2010; Dinesh *et al.*, 2010). Moreover, Manhas & Gill (2010) found that application of FYM increased the growth, dry matter accumulation, yield and quality of turmeric. The farmyard manure provided nutrients to the turmeric and hence improved edaphic factors, which ultimately brought higher vegetative growth. The results are in agreement with the findings of (Roy et al., 2010; Dinesh et al., 2010; Mohapatra & Das, 2009; Manikerri, 2006; Majumdar *et al.*, 2002) which reported that combined application of NPK with manure improved the vegetative growth and biomass production effectively. Application of nutrient sources with FYM through STCR based were reported to improve soil P status than conventional soil testing methods as reported by Barma (1986) and Singh *et al.,* (2010). Lower content of available nutrients in control treatment could be attributed to mining of soil nitrogen as no external fertilizers were applied in this treatment. Similar findings were earlier reported by Saha (1998).

5. Summary

Soil test crop response brought maximum values of organic carbon (9.03 g kg^{-1}), soil available NPKS (392, 42.1, 194 and 23.3 kg ha^{-1}) as compared to other conventional methods of fertilization. Apart from STCR, soil test based showed promising results on the economic analysis as it also results higher benefit cost ratio of 3.04 as compared to farmer's practice and general recommended dosage of fertilizers. Overall, STCR approach excelled over all the different treatments and positively safeguarded nutrient status and soil health.

6. Conclusion

Based on the results of the experiment, it may be concluded that treatment T_7 and T_6 were found most suitable in relation to soil properties, yield and economics of turmeric (Curcuma longa L.) cultivation under the agro-climatic conditions of Himachal Pradesh. However, these findings are based on one year experiment, therefore further experiments on the same needed to substantiate the results.

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