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Effect of straw mulch and integrated nitrogen management on yield and quality of turmeric under North Indian plains

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ABSTRACT

The continuous application of nitrogen (N) through chemical source has shown deleterious effect on productivity of turmeric, whereas availability of organic source is very limited to meet the nitrogen requirement. Therefore it was considered worth to study the impact of integration of chemical and organic source of N on productivity of turmeric. A three-year field experiment was conducted at Punjab Agricultural University, Ludhiana, during 2011-12 to 2013-14 to study the response of turmeric to straw mulching and N applied through different combinations of organic manure (FYM) and N-fertilizer (urea). Application of paddy straw as mulch @ 6.25 t ha^{-1} significantly increased the plant height, number of tillers, mother, primary and secondary rhizomes, rhizome weight and yield of turmeric. The fresh rhizome yield increased by 85.0 and 34.9% during 2011-12 and 2012-13, respectively, due to mulch application over no-mulch. A slight improvement was noticed in curcumin content, however, the difference between mulch and no-mulch treatments was non-significant. Application of 125 kg N/ ha through FYM alone, produced the highest rhizome yield during all study years (20.6, 22.36 and 23.17 t/ha during 2011-12, 2012-13 and 2013-14, respectively), which was, however, statistically at par with the application of two-third and half of organic manure along with one-third and half of N through urea, respectively. Nitrogen substitution through urea beyond 50% resulted into reduced growth and fresh rhizome yield. Hence, integration of 50% of N (62.5 kg/ha) through organic manure (FYM) and 50% of N through fertilizer urea enhanced the turmeric yield as compared to 100% N fertilizer alone. Quality parameter in terms of curcumin content did not show any significant differences with the different combinations of integrated nitrogen source.

Key words: Curcumin, farm yard manure, nitrogen, rhizome yield, straw mulch, turmeric.

INTRODUCTION

Turmeric (*Curcuma longa* L.) is an important spice crop, grown for its aromatic underground rhizome. India is the largest producer and the major part of its production is consumed within the country. The nutritional requirement of turmeric varies with varieties, locations in relation to quality and productivity of crop (Babu and Muthuswami, 1). The use of optimum dose of N is of vital importance, being an essential constituent of nucleic acid, it increases the number of leaves and tillers, which affect growth, yield and quality of turmeric. The response of turmeric to N varies widely according to soil and climatic conditions. It's nutrient requirement is high due to shallow rooting and capacity to produce large amount of dry matter per unit area, hence sufficient quantity of nutrient has to be applied to meet its nutritional requirement (Nagarajan and Pillai, 14). The application of farmyard manure (FYM) and mulch have favourable effect on turmeric rhizome yield. The application of mulch, conserves soil moisture by decreasing evaporation losses, reduces weed menace, regulates soil temperature (Dass *et al*., 3) and helps protect the germinating rhizomes from desiccation especially during early growth period of hot and dry months (May and June). Similarly, growth characters, yield attributes and yield of turmeric were improved with farmyard manure application (Gill *et al*., 6).

The availability of quality organic manure to sustain the productivity is a matter of concern, therefore the combined use of both organic manure and chemical fertilizer in required quantity assumes special significance as complementary and supplementary to each other especially for the high yielding crops with higher nutrient requirements (Kumar *et al*., 10; Kumar *et al*., 12; Dass *et al*., 4). The application of organic manure with nitrogen (N) fertilizer is known to stimulate mineralizable N fractions and increase the efficiency of inorganic N fertilizer in the soil. The response of turmeric to integrated N management in relation to straw mulching has not been adequately studied, hence the current field investigation was made to study the integrated effect of chemical fertilizers and organic manures along with straw mulching on growth, yield and quality of turmeric.

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MATERIALS AND METHODS

The three-year field experiment was conducted at the Research Farm of Punjab Agricultural University, Ludhiana, during *kharif* season of 2011-12, 2012-13 and 2013-14. The experimental site is characterized by sub-tropical and semi-arid type of climate with hot and dry summer (April to June), hot and humid monsoon period (July to September), mild winter (October to November) and cold winter (December to January). The experimental site is situated at 30° 56' N latitude with 75° 52' E longitude with a mean height of 247 m above the mean sea level. The rainfall during the crop growing season was 1280.5, 409.7 and 807 mm in 2011-12, 2012-13 and 2013-14, respectively. The planting of turmeric (var. 'Punjab Haldi 1') was done in the last week of April every year with basal dose of 25 kg ha^{-1} each of phosphorus (P_2O_5) in the form of single super phosphate and potash (K_2O) in the form of muriate of potash. The planting was done on flat bed at spacing of 30 cm × 20 cm, respectively. Pendimethalin 0.975 kg ha^{-1} was applied within two days of planting and three manual hoeing (at 50, 75, 100 days after planting) were also undertaken to keep the weeds under check. Immediately after planting, irrigation was given and subsequently 9, 13 and 11 irrigations were given as per requirement of the crop during 2011-12, 2012-13 and 2013-14, respectively. Soil of experimental field was loamy-sand texture, low in organic carbon (0.20%) and available nitrogen (125.4 kg ha^{-1}) and medium in available phosphorus (19.5 kg ha^{-1}) and potassium (208.7 kg ha^{-1}). Soil pH (7.8) and electrical conductivity (0.21dS m^{-1}) were within the normal range. The content of available Zn, Mn, Fe, and Cu (1.76, 3.57, 4.58 and 0.24 mg kg^{-1}, respectively) in soil was sufficient for crop production. The NPK content of farmyard manure was 1.10, 1.16 and 0.98% N, 0.43, 0.48 and 0.41% P and 0.82, 0.77 and 0.91% K during 2011-12, 2012-13 and 2013-14, respectively.

The experiment was laid-out in a randomized complete block design (RCBD) with four replications. The treatments consisted of two levels of mulch (0 and 6.25 t ha^{-1} through paddy straw) and five combinations of organic manure (FYM) and N fertilizer (urea) as sources of nitrogen (N_1: whole N through FYM at planting (equivalent to 125 kg N ha^{-1}), N_2: 2/3 N (83.5 kg N ha^{-1}) through FYM at planting + 1/3 N through urea (41.5 kg N ha^{-1} in two equal splits at 75 and 100 days after planting), N_3: 1/2 N (62.5 kg N ha^{-1}) through FYM at planting + 1/2 N through urea (62.5 kg/ha in two equal splits at 75 and 100 DAP), N_4: 1/3 N (41.5 kg/ha) through FYM at planting + 2/3 N through urea (83.5 kg N ha^{-1} in two equal splits at 75 and 100 days after planting), N_5: 1/4 N (31 kg/ha) through FYM at planting + 3/4 N through urea (94 kg N ha^{-1} in three equal splits at 75, 100 and 125 DAP) during 2011-12 and N5: whole N through urea (125 kg ha^{-1} in three equal splits at 75, 100 and 125 DAP) during 2012-13 and 2013-14. Paddy straw was used as mulch during 2011-12 and 2012-13, however during 2013-14, mulching treatments were not repeated due to significant and apparent response of mulching during the first two study years. The crop was harvested during second week of January every year. Observations on vegetative growth, *viz.*, plant height and number of tillers $plant^{-1}$ were recorded at the time of maximum growth, *i.e.* last week of October, whereas, the data on yield and rhizome characters were recorded at harvesting stage. The curcumin content of processed rhizomes from each plot was determined following the method as described by Thimmaiah (16). Analysis of variance was performed on the data sets using SPSS 17 software and significant effects ($p \leq 0.05$) were noted.

RESULTS AND DISCUSSION

The fresh rhizome yield increased significantly with mulch application, which was 85 and 35% higher over no mulch application during 2011-12 and 2012-13, respectively (Table 3). Significantly higher number of mother, primary and secondary rhizomes per plant was recorded in mulch over no-mulch treatment during both the years (2011-12 and 2012-13), which might have enhanced the fresh rhizome yield. Similarly, rhizome weight per plant was 71 and 57% higher with mulch application as compared to no mulch during 2011-12 and 2012-13, respectively. Higher plant growth in terms of plant height and tillers with mulch application (Table 1) might have contributed to enhance the production of yield attributes and rhizome yield significantly. The positive effects of mulch application on growth and yield may possibly be due to modification in the soil environment, *viz.* moderating soil temperature during early growth of the crop which coincides with hot-dry months of May and June that conserves the soil moisture, increases microbial activities and nutrient availability. The beneficial effects of mulch application on rhizome yield, weight and number of rhizomes per plant, plant height and tillering have also been reported by various studies (Junior *et al*., 8; Gill *et al*., 6; Manhas, 13; Verma and Sarnaik, 17). Curcumin content was improved with mulch application, however, the differences were non-significant during both the years.

Applying recommended dose of N (125 kg /ha) through organic manure (FYM @ 25 t ha^{-1}) resulted in the highest fresh rhizome yield of 22.36, 23.17 t/ha that was 33.9 and 47.3% higher than application of 100% recommended dose of N (RDN) through urea, during 2012-13 and 2013-14, respectively (Table 3).

Table 1. Effect of different nitrogen sources on growth of turmeric as affected by INM treatments.

Treatment	Plant height (cm)			Tillers/ plant		
	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
Straw mulch (t/ha)						
0.0	94.9	99.8	-	1.6	1.4	-
6.25	119.3	114.4	-	2.0	1.6	-
CD (P = 0.05)	9.5	5.5	-	0.3	NS	-
Nitrogen combination						
N1: Whole N organic (eqv. to 125 kg/ha)	109.8	110.6	98.6	2.0	1.3	2.5
N2: 1/3 N organic (41.5 kg/ha) + 2/3 N inorganic (83.5 kg/ha)	108.0	103.0	78.0	1.8	1.2	2.0
N3: 1/2 N organic (62.5 kg/ha) + 1/2 N inorganic (62.5 kg/ha)	108.3	105.6	90.2	1.8	1.2	2.2
N4: 2/3 N organic (83.5 kg/ha) + 1/3 N inorganic (41.5 kg/ha)	109.5	115.6	91.8	1.8	1.3	2.4
N5*: 1/4 N organic (31 kg/ha) + 3/4 N inorganic (94 kg/ha) N5**: Whole N chemical fertilizer	99.8	100.7	71.3	1.7	1.2	2.1
CD (P = 0.05)	NS	8.6	12.9	NS	NS	0.35

NS = Non significant, Interaction = NS, N*: 2011-12, N**: 2012-13 and 2013-14

Increase in fresh rhizome yield with farmyard manure might be due its beneficial effects in terms of additional supply of plant nutrients besides nitrogen as well as improvement in physical and biological properties of soil (Chaudhary *et al*., 2). Further, integration of fertilizer nitrogen with FYM to substitute 67, 50, 33 and 25% of recommended N was statistically at par with the application of FYM alone during 2011-12. However, fresh rhizome yield decreased significantly when FYM was substituted with fertilizer N beyond 50% of RDN and the fresh rhizome yield decreased by 8.7 with 75% substitution of FYM during 2011-12 and drastically decreased by 33.9 and 47.3% during 2012-13 and 2013-14, respectively with complete omission of FYM and N-supply through urea only (Table 3). Substitution of 50% (60 kg/ha) of RDN through FYM has also been reported in nutrient exhaustive crop like rice to achieve the grain yield comparable to that of 100% of RDN, *i.e.* 120 kg/ha under similar soil fertility conditions (Kumar *et al*., 13). Application of FYM possibly reduced the nitrogen losses and enhanced the nutrient availability especially in long-duration crops. Nambiar and Abrol (15) also observed a declining trend in productivity of turmeric crop as a consequence of continuous application of chemical fertilizers, which could be checked by the use of organic manure. This imbalance of nutrients has adverse effect on the absorption of other nutrients, which ultimately affects growth and yield of the crop. The higher doses of fertilizer nitrogen (urea) have also shown many adverse impacts on the beneficial soil micro-flora and fauna, particularly the soil diazotrophic count which is drastically altered in terms of number as well as diversity (Gosal *et al*., 7). Turmeric growth in terms of plant height, number of tillers and number of mother, primary and secondary rhizomes also showed similar trends as in case of fresh rhizome yield. Different combination of integrated nitrogen sources had non-significant effect on growth and yield attributes of turmeric during 2011-12 (Tables 1 & 2). However, during 2012-13 plant height and rhizome weight per plant (Tables 1 & 2) and during 2013-14 plant height, number of tillers and number of secondary rhizomes (Table 1) declined significantly when N was applied through fertilizer alone as compared to whole organic manure. Quality parameter, *i.e.* curcumin content, which is a genetically governed trait, did not show significant difference with the combined use of farmyard manure and N fertilizer when compared with organic manure alone (Table 2). Earlier, Kandiannan and Chandaragir (11) and Gill *et al.* (6) observed that different nitrogen levels had non-significant effect on curcumin content of turmeric. The interaction effects between mulch and integrated nitrogen sources were found to be non-significant as all the treatments of N combinations had recorded better growth and yield under straw mulching against the respective treatment under no straw mulching. Therefore, it can be concluded that straw mulching has beneficial effects on growth and

Table 2. Effect of different nitrogen sources on yield attributes of turmeric as affected by INM treatments.

Treatment	Mother rhizome/ plant			Primary rhizomes/ plant			Secondary rhizomes/ plant		
	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
Straw mulch (t/ ha)									
0.0	1.7	2.21	-	6.8	8.4	-	6.5	8.0	-
6.25	2.1	2.74	-	8.8	10.5	-	11.2	11.1	-
CD (p = 0.05)	0.30	0.34		1.2	1.2		1.4	1.0	
Nitrogen combination									
N1: Whole N organic (eqv. to 125 kg/ha)	2.0	2.4	2.1	8.4	9.4	8.3	9.4	9.8	10.1
N2:1/3 N organic (41.5 kg/ha) + 2/3 N inorganic (83.5 kg /ha)	1.8	2.6	2.1	7.5	9.1	7.4	8.9	8.8	8.3
N3:1/2 N organic (62.5 kg/ha) + 1/2 N inorganic (62.5 kg/ha)	1.9	2.3	2.0	7.7	9.4	7.0	8.9	10.0	9.2
N4:2/3 N organic (83.5 kg/ha) + 1/3 N inorganic (41.5 kg/ha)	1.9	2.4	2.3	8.3	10.0	8.9	9.3	10.5	10.7
N5*: 1/4 N organic (31 kg/ha) + 3/4 N inorganic (94 kg/ha) N5**: Whole N chemical fertilizer	1.7	2.7	1.9	7.2	9.3	6.6	7.7	8.6	7.5
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	1.4

NS = Non significant, Interaction = NS, N*: 2011-12, N**: 2012-13 and 2013-14

Table 3. Effect of nitrogen sources on yield and quality of turmeric as affected by INM treatments.

Treatment	Rhizome weight/ plant (g)			Fresh rhizome yield (t/ha)			Curcumin content (%)		
	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14
Straw mulch (t/ha)									
0.0	181.8	224.7	-	14.03	17.05	-	2.9	3.1	-
6.25	311.6	352.4	-	25.96	23.01	-	3.3	3.3	-
CD (p = 0.05)	36.7	29.7		2.62	2.07		NS	NS	
Nitrogen combination									
N1: Whole N organic (eqv. to 125 kg/ha)	271.4	330.0	354.8	20.60	22.36	23.17	3.4	3.4	3.8
N2:1/3 N organic (41.5 kg/ha) + 2/3 N inorganic (83.5 kg/ha)	236.0	261.0	239.8	19.79	17.92	18.51	2.9	3.1	3.2
N3:1/2 N organic (62.5 kg/ha) + 1/2 N inorganic (62.5 kg/ha)	245.3	284.7	328.7	20.28	21.44	21.95	3.1	3.2	3.5
N4:2/3 N organic (83.5 kg/ha) + 1/3 N inorganic (41.5 kg/ha)	260.1	299.3	337.5	20.32	21.73	22.49	3.2	3.3	3.7
N5*: 1/4 N organic (31 kg/ha) + 3/4 N inorganic (94 kg/ha) N5**: Whole N chemical fertilizer	220.6	268.0	241.8	18.99	16.70	15.73	2.8	3.0	3.4
CD (p = 0.05)	NS	46.0	29.2	NS	3.27	2.38	NS	NS	NS

NS = Non significant, Interaction = NS, N*: 2011-12, N**: 2012-13 and 2013-14

yield of turmeric irrespective of N sources and their integrations.

Paddy straw mulching (6.25 t/ha) proved beneficial in turmeric cultivation as it enhanced the growth, rhizome yield and quality. Besides, it has also the potential to conserve the soil moisture and reduce the weed infestation. Integration of nitrogen sources to manage the nitrogen requirement of turmeric is also important as availability of organic sources is a big constraint, whereas total dependence on chemical fertilizers alone caused negative impact on the productivity. This study has shown that RDN in turmeric can be managed by integrating 50% each through chemical fertilizer, *i.e.* urea and FYM without any adverse effect on growth and yield of turmeric. Therefore, applying only half of RDN through FYM (instead of 100% RDN through FYM) and rest of the N through urea will not only sustain the turmeric productivity but also encourage area expansion under turmeric with the available quantity of FYM.

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