Journal of Applied and Natural Science 9 (1): 497 - 501 (2017)

JANS

Productivity and economics of turmeric (*Curcuma longa* L.) in response to nitrogen applied through different sources in conjunction with bio-fertilizer consortium

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Received: February 16, 2016; Revised received: December 6, 2016; Accepted: February 18, 2017

Abstract: A Field investigation was carried out to study the effects of organic (FYM) and inorganic nitrogen alone or in combination with bio-fertilizer consortium (*Azotobacter*, PSB and PGPR) on growth, yield attributes, yield and economics of turmeric (*Curcuma longa* L.) during 2012-13 at Punjab Agricultural University, Ludhiana. The treatments were comprised of 75, 100 (25 t ha^{-1} FYM ~ 125 kg N ha^{-1}) and 125 per cent of recommended N and control. Results revealed that application of organic manure (FYM) had beneficial effects on the growth, yield attributes and yield of turmeric. The maximum yield of 204.4 q ha^{-1} was obtained with application of 125 per cent of recommended organic manure combined with the bio-fertilizers, which was statistically at par with that of 100 per cent of recommended organic manure alone or in combination with the bio-fertilizers. Application of bio-fertilizers improved the growth and yield of turmeric to some extent.

Keywords: Bio-fertilizers, FYM, Inorganic nitrogen, Turmeric

INTRODUCTION

Turmeric (*Curcuma longa* L.) is an annual herbaceous plant, belongs to family *Zingiberaceae*. Turmeric is a long duration crop, takes long time to sprout and has slow initial growth. There are various factors responsible for increasing the productivity of turmeric, but use of optimum dose of nitrogen has vital importance (Borah and Langthasa, 1994). It is now an established fact that the continuous use of synthetic fertilizer adversely affects the soil health, soil biological system and often fails to sustain the productivity even with higher doses of inorganic fertilizers. Moreover, the efficiency of the applied fertilizers is affected by various aspects like nitrogenous fertilizers suffer more than 50 per cent losses due to denitrification, leaching etc (Pandey and Kumar, 1989). Similarly, phosphorus becomes unavailable to the plants due to the fixation with the soil colloids (Bhati *et al.*, 2011). Hence, to overcome these losses of inorganic fertilizers and to reduce the dependence soly on inorganic fertilizers, bio -fertilizers can play an important role as they are capable of fixing atmospheric nitrogen and solubilising the phosphorus to make it available to the plants. Keeping all these points in view, it was considered worthwhile to study the effect of bio-fertilizers integrated with organic and inorganic nitrogen on turmeric with the objective that biofertilizers may helps to improve yield attributes, yield and net return.

MATERIALS AND METHODS

The experiment was conducted during 2012-13 at Punjab Agricultural University, Ludhiana. It was laid out in randomised complete block design with 13 treatments and 4 replications. The treatments was, T_1 -75 % of recommended N organic, T_2 - 100 % of recommended N organic (25 t ha^{-1} FYM equivalent to 125 kg N ha^{-1}), T_3 - 125 % recommended N organic, T_4 - 75 % recommended N organic + bio-fertilizers, T_5 - 100 % recommended N organic + bio-fertilizers, T_6 - 125 % recommended N organic + bio-fertilizers, T_7 - 75 % recommended N inorganic, T_8 - 100 % recommended N inorganic, T_9 - 125 % recommended N inorganic, T_{10} - 75 % recommended N inorganic + bio-fertilizers, T_{11} - 100 % percent recommended N inorganic + bio-fertilizers , T_{12} - 125 % recommended N inorganic + bio-fertilizers and T_{13} – Control (without organic and inorganic nitrogen and bio-fertilizers). A uniform dose of 25 kg ha^{-1} each of phosphorus and potassium were applied before planting. Farmyard manure (as a source of organic N) was applied as per the treatments and thoroughly mixed with the soil before planting of crop. Urea as a source of inorganic nitrogen was applied in four equal splits i.e. planting, 75, 100 and 125 days after planting (DAP) as per treatments. The biofertilizer consortium (10 kg ha^{-1}) comprising of *Azotobacter,* phosphate solubilizing bacteria (PSB) and plant growth promoting rhizobacteria (PGPR) applied at the time of sowing.

ISSN : 0974-9411 (Print), 2231-5209 (Online)

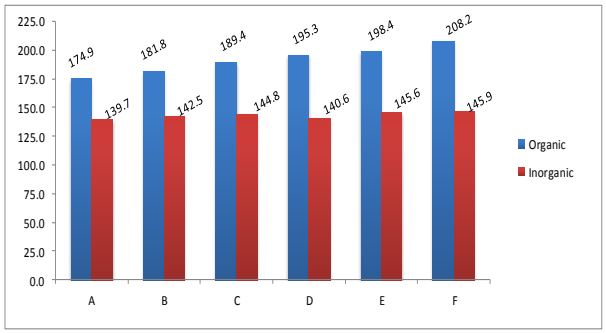

Fig. 1. *Effect of different treatments on weight of fresh rhizome per plant of turmeric.*

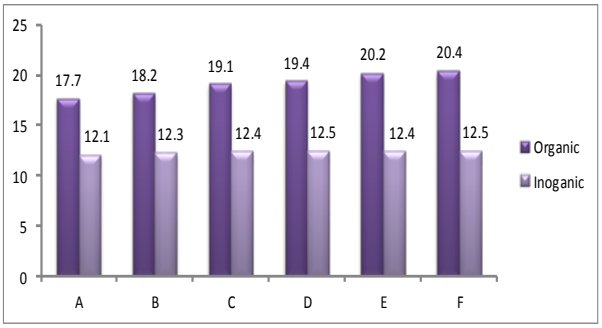

Fig. 2. *Effect of different treatments on fresh rhizome yield (t ha^{-1}) (A) 75 per cent of recommended N; B)75 per cent of recommended N + Bioferilizers; C)100 per cent of recommended N;D) 100 per cent of recommended N + Bio-fertilizers; E) 125 per cent of recommended N; F)125 per cent of recommended N + Bio-fertilizers.*

The soil of the experimental field was loamy-sand, low in organic carbon 0.21 % (Walkley and Black's rapid titration method, Piper 1966) and available nitrogen 182.4 kg ha^{-1} (Alkaline potassium permanganate method , Subbiah and Asija, 1956) available phosphorus 12.9 kg ha $^{-1}$ (0.5 N sodium bicarbonate extractable P by the method of Olsen *et al.,* 1954) and potassium 194.6 kg ha $^{-1}$ (Neutral ammonium acetate extractable K, Mervin and Peech 1950) status were medium. The soil pH (7.9) and electrical conductivity (0.20 dSm^{-1}) values were within the normal range. The planting was done during first week of May at a spacing of 30 cm x 20 cm using 20 q ha^{-1} of rhizomes. Mulching was done with the rice straw using 6.25 t ha^{-1} immediately after sowing of the crop. The harvesting of the turmeric was done manually at second fortnight of January. Statistical analysis of the data, collected at different growth stages of crop was done as suggested by Corchran and Cox (1967). The treatment comparisons were made at 5 per cent level of significance.

RESULTS AND DISCUSSION

Emergence count: The data (Table 1) showed significant effects on emergence count at 30 and 45 DAP, whereas the results were non-significant at 60 DAP. This may be due to better moisture holding capacity (although the irrigations were uniform) of farm yard manure (FYM) (Padmapriya and Chezhiyan, 2009) over the inorganic fertilizers. The effect of bio-fertilizers on emergence count when compared with the treatments where bio-fertilizers were not applied, were found to be non significant. The results showed that the organic source of nitrogen helped faster emergence at initial stages.

Plant height and dry matter accumulation: The application of N through FYM showed significant increase in plant height and dry matter accumulation (Table 1) over the treatments where nitrogen was applied through inorganic source and control. The plant height and dry matter accumulation was significantly increased by the application of 100 and 125 per cent of recommended organic manure over lower dose. The application of bio-fertilizers recorded very little improvement when applied either with organic or inorganic sources of nitrogen. Among the different treatments, maximum plant height and dry matter accumulation was observed with the treatments having 125 per cent of recommended organic manure which

Table 1. Effect of different treatments on the growth of turmeric.

Treatment	Emergence count (%)			Plant height (cm)	Dry matter accumulation (q/ha)	No. of tillers per plant
	30 DAP	45 DAP	60 DAP			
T_1 - 75 % Rec Orgn	24.4	53.4	94.4	44.1	30.9	2.0
T_2 - 100 % Rec Orgn	24.9	55.8	96.3	47.3	33.2	2.1
T_3 - 125 % Rec Orgn	25.1	56.7	94.0	49.1	34.8	2.3
T_4 - 75 % Rec Orgn + Bio	24.3	54.7	95.0	45.6	31.8	2.1
T_5 - 100 % Rec Orgn + Bio	24.6	55.5	94.1	47.9	33.8	2.1
T_6 - 125 % Rec Orgn + Bio	25.9	57.0	94.4	50.3	35.5	2.4
T_7 - 75 % Rec Inorgn	21.5	51.9	93.7	40.9	25.1	1.9
T_8 - 100 % Rec Inorgn	22.3	52.1	94.2	41.6	25.9	1.8
T_9 - 125 % Rec Inorgn	22.2	52.3	94.1	42.6	26.9	1.9
T_{10} - 75 % Rec Inorgn + Bio	21.7	52.4	92.1	41.9	26.1	2.0
T_{11} - 100 % Rec Inorgn + Bio	22.5	53.0	93.5	42.4	26.8	1.9
T_{12} - 125 % Rec Inorgn+ Bio	22.5	53.1	92.4	42.9	27.2	2.0
T_{13} - Control	20.7	51.6	94.0	34.9	24.2	1.9
CD (p=0.05)	1.8	2.0	N S	3.2	3.0	NS

Rec. Orgn. – Recommended organic manure, Bio – Bio-fertilizers, Rec. Inorg. – Recommended inorganic nitrogen

Table 2. Effect of different treatments on the yield attributes of turmeric.

Treatment	Mothers rhizome	Primary rhizome	Secondary rhizome	Total rhizome	Weight of rhizomes / plant (g)
T_1 - 75 % Rec Orgn	1.3	6.1	7.1	14.5	174.9
T_2 - 100 % Rec Orgn	1.1	5.8	7.3	14.3	189.8
T_3 - 125 % Rec Orgn	1.3	6.3	7.7	15.1	198.4
T_4 - 75 % Rec Orgn + Bio	1.3	5.7	6.0	12.5	181.8
T_5 - 100 % Rec Orgn + Bio	1.3	5.6	8.1	14.9	195.3
T_6 - 125 % Rec Orgn + Bio	1.1	6.1	8.6	15.7	208.2
T_7 - 75 % Rec Inorgn	1.2	5.8	7.0	13.2	139.7
T_8 - 100 % Rec Inorgn	1.3	5.8	6.5	13.4	142.5
T_9 - 125 % Rec Inorgn	1.3	6.5	6.6	14.3	144.8
T_{10} - 75 % Rec Inorgn + Bio	1.4	6.1	7.5	14.8	140.6
T_{11} - 100 % Rec Inorgn + Bio	1.2	5.9	5.0	11.9	144.6
T_{12} - 125 % Rec Inorgn+ Bio	1.1	5.2	6.3	12.6	145.9
T_{13} - Control	1.1	5.7	7.9	14.6	128.6
CD (p=0.05)	NS	NS	NS	NS	17.3

Rec. Orgn. – Recommended organic manure, Bio – Bio-fertilizers, Rec. Inorg. – Recommended inorganic nitrogen

Table 3. Effect of different treatments on the fresh yield, processed yield and economics of turmeric.

Treatment	Fresh yield (q/ha)	Percent increase over control	Processed yield (q/ha)	Percent increase over control
T_1 - 75 % Rec Orgn	177.5	56.7	23.7	65.7
T_2 - 100 % Rec Orgn	191.2	68.8	28.3	97.9
T_3 - 125 % Rec Orgn	202.4	78.6	30.9	116.0
T_4 - 75 % Rec Orgn + Bio	181.7	60.4	24.7	72.7
T_5 - 100 % Rec Orgn + Bio	193.7	71.0	29.4	105.5
T_6 - 125 % Rec Orgn + Bio	204.4	80.4	31.2	118.2
T_7 - 75 % Rec Inorgn	121.5	7.2	17.4	21.6
T_8 - 100 % Rec Inorgn	124.0	9.4	18.6	30.0
T_9 - 125 % Rec Inorgn	124.3	9.7	18.7	30.7
T_{10} - 75 % Rec Inorgn + Bio	122.9	8.5	17.9	25.1
T_{11} - 100 % Rec Inorgn + Bio	124.9	10.2	18.6	30.0
T_{12} - 125 % Rec Inorgn+ Bio	125.4	10.7	19.4	35.6
T_{13} - Control	113.3	-	14.3	-
CD (p=0.05)	14.7	-	3.4	-

Rec. Orgn. – Recommended organic manure, Bio – Bio-fertilizers, Rec. Inorg. – Recommended inorganic nitrogen

was at par with the 100 per cent of recommended organic manure with or without the bio-fertilizers. The increase in plant height and dry matter accumulation was non-significant with the increase in level of inorganic nitrogen even along with bio-fertilizers. The organic manure maintained its superiority over the inorganic fertilizers in terms of plant height and dry matter accumulation by plant over the inorganic nitrogen. This may be due to the beneficial effect of organic manure to provide nutrient over longer period than the inorganic fertilizers, which eventually leads to higher growth rate and more dry matter accumulation by the crop (Gill *et al*., 1999).

Number of tillers per plant: The number of tillers per plant (Table 1) did not show any significant difference with the increase in levels of both organic and inorganic nitrogen, alone and when they were applied in combination with the bio-fertilizers. This showed that the number of tiller per plant was not influenced by the source of nitrogen and the application of bio-fertilizers. Yamgar *et al.,* (2001) reported that higher doses even with split application of inorganic nitrogen at different week after planting failed to influence the tillers per plant of turmeric.

Number of rhizomes per plant: The data (Table 2) showed that the number of mother, primary, secondary rhizome individually or total number of rhizomes per plant was not significantly influenced by the source of nitrogen applied i.e. either organic or inorganic nitrogen alone and in combination with bio-fertilizers. Selvarajan and Chezhiyan (2001) also observed that integrated fertilizer management and different levels of organic manure (FYM) had non-significant effect on number of rhizomes per plant.

Weight of rhizomes per plant: The increase in the rhizome weight per plant (Table 2) was significantly more under the treatments where nitrogen was applied through organic sources alone and in combination with the bio-fertilizers as compared to the inorganic nitrogen and control. The maximum fresh weight of rhizome per plant was obtained (198.37 g and 208.23 g) with the treatment having 125 per cent of recommended organic manure with (T_6) and without (T_3) which is at par with the 100 per cent of recom-

Table 4. Effect of different treatments on the economics of turmeric.

Treatment	Total Cost (Rs /ha)	Total Returns (Rs/ ha)	Benefit : Cost
T_1 - 75 % Rec Orgn	1,95,968	3,36,000	1.7
T_2 - 100 % Rec Orgn	2,03,268	3,92,000	1.9
T_3 - 125 % Rec Orgn	2,06,368	4,34,000	2.1
T_4 - 75 % Rec Orgn + Bio	1,97,868	3,50,000	1.8
T_5 - 100 % Rec Orgn + Bio	2,04,768	4,06,000	2.0
T_6 - 125 % Rec Orgn + Bio	2,07,668	4,34,000	2.1
T_7 - 75 % Rec Inorgn	1,79,368	2,38,000	1.3
T_8 - 100 % Rec Inorgn	1,80,868	2,66,000	1.5
T_9 - 125 % Rec Inorgn	1,81,768	2,66,000	1.5
T_{10} - 75 % Rec Inorgn + Bio	1,79,768	2,52,000	1.4
T_{11} - 100 % Rec Inorgn + Bio	1,81,968	2,66,000	1.5
T_{12} - 125 % Rec Inorgn+ Bio	1,82,168	2,66,000	1.5
T_{13} - Control	1,75,068	1,96,000	1.1
CD (p=0.05)	-	-	-

Rec. Orgn. – Recommended organic manure, Bio – Bio-fertilizers, Rec. Inorg. – Recommended inorganic nitrogen

mended organic manure with (T_5) or without (T_2) the bio-fertilizers respectively. The increase in the fresh weight of rhizome per plant was non-significant with the treatments having nitrogen applied through inorganic sources alone and with the application of bio-fertilizers. Gill *et al.* (2001) observed that different levels and time of application of nitrogen had non-significant effect on the fresh weight of rhizomes per plant. Gill *et al.* (1999) also reported that the increase in levels of FYM resulted in significant increase in the weight of fresh rhizome per plant.

Fresh and processed yield: The data on fresh and processed yield (Table 3) showed that the yield was significantly higher under the treatments having organic manure as compared to inorganic nitrogen and control. The maximum fresh yield and processed yield was obtained with the 125 per cent of recommended organic manure along with bio-fertilizers which was statistically at par with that of 100 per cent of recommended organic manure with (T_5) or without bio-fertilizers (T_2). The increase in the fresh rhizome yield ranged from 56 (T_1) to 80 (T_6) per cent and processed yield (65.7 to 118.2 %) with the application of organic manures when compared with control. The data also showed that the fresh and processed rhizome yield was statistically at par with the different levels of inorganic nitrogen with or without bio-fertilizers. Gill *et al*. (1999) observed that increase in the level of FYM significantly increased the fresh rhizome yield of turmeric. Kandiannan and Chandaragir (2006) also observed that different levels of inorganic nitrogen had non-significant effect on the dry rhizome yield of turmeric.

Economics: The data (Table 3) showed that the cost benefit ratio was higher under the application of organic manures when compared with the inorganic nitrogen and control. This was due to higher fresh and processed rhizome yield of turmeric under the organic manures. The maximum cost benefit ratio of 2.1 was obtained with the application of 125 per cent of organic manure along with the bio-fertilizers. Bio-fertilizers increased the total returns and benefit cost ratio by increasing the fresh and processed rhizome yield when compared to the treatment having no bio-fertilizers.

Conclusion

This was concluded from the study that organic manure (FYM) has beneficial effects on the growth and yield of turmeric. The crop growth was better, yield and net returns were significantly more with the application of 25 t ha^{-1} organic manure (FYM) as compared to lower doses and the treatments where nitrogen was applied through inorganic source (Urea) and control. The increase in the growth and yield was non-significant with different levels of inorganic nitrogen. This showed that turmeric did not respond to inorganic fertilizers alone under Punjab conditions. The application of biofertilizers slightly improved the growth and yield of turmeric.

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