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Research Article

Effect of organic manures on growth, yield and quality of turmeric (*Curcuma longa* L)

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Abstract
The use of organic manures in the agricultural plays a vital role in improving the quality of turmeric as well as improving the soil health. Turmeric is having a close relation with human health; hence demand of organically grown turmeric is increasing tremendously. A field trial was conducted to study the effect of different organic manures (generally recommended fertilizer dose, farmyard manure, vermicompost, press mud compost, poultry manure, sugarcane trash, wheat straw, turmeric trash and *jeevamrut*) on the yield and curcumin content of turmeric Cv. *Phule Swarupa* on Inceptisol at Agricultural Research Station, Dist-Sangli, Maharashtra, India. The trial was conducted on the fixed site of soil for the continuous of five years (2009-2013). The maximum dry yield (62.42 q ha^{-1}) of the turmeric was recorded by application of the general recommended dose of fertilizer (GRDF) *i. e.* 25 MT FYM + 200:100:100 kg $N:P_2O_5:K_2O$ ha^{-1} which was at par with the vermicompost (11.36 T ha^{-1}). The highest number of leaves per tiller and number of tillers per plant, plant height and curcumin content was recorded in the GRDF, which was at par with vermicompost. The highest benefit: cost ratio (1.59) was also noticed in GRDF, which was at par with the application of vermicompost (1.54) on a nitrogen basis. The soil available nutrient status was taken into consideration during experimentation. The application of vermicompost (11.36 T ha^{-1}) along with Phosphate Solubilizing Bacteria and *Azospirillium* @ 5 kg ha^{-1}, respectively at the time of planting was found superior for higher dry yield (55.45 q ha^{-1}), net monetary returns (Rs. 137035) and maintenance of soil fertility for organic cultivation of turmeric.

Keywords: *Curcuma longa,* growth, Organic cultivation, quality, turmeric, yield.

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INTRODUCTION

The turmeric (*Curcuma longa* L) is the important spice crop of India known as golden spice. The medicinal and cosmetic uses of turmeric are increasing significantly over the years. In the world, due to an increase in health consciousness peoples are mostly prefer organically produced products for daily consumption. Turmeric is a rhizomatous crop, requires heavy application of nutrients for boosting the yield. Being a long duration crop, it extracts a lot of nutrients from the soil. After the enforcement of the green revolution in India, the use of chemical fertilizers for agriculture uses is increasing day by day. But in the present era, there is a need for judicious and balanced use of chemical fertilizers. The injudicious use of these fertilizers creates the problem of the ecological balance of the environment as well as soil health. There is need to adopt the balanced use of organic manures and bio-fertilizers to maintain the ecological balance and better management of soil health, The use of organic manures and bio-fertilizers helps to improve soil health and these are environment friendly. Several workers reported the importance of several bio-fertilizes and organic manures in turmeric in relation to soil health, quality and productivity of the crop (Velmurugan *et al.,* 2009; Kumar *et al.,* 2018).

The concept of organic farming is getting popularity in the world for sustainable production and improvement of quality of the turmeric (Sadanandan *et al.*, 1998). The continuous use of an imbalanced dose of chemical fertilizers affects soil health as well as responsible for soil and environmental pollution. The majority of turmeric growers were attracted towards organic farming as it will help to improve soil structure and fertility. The use

of organic manures helps to improve soil structure and fertility. The judicious use of organic manures helps to increase the porosity of the soil, improves water holding capacity and drainage which will be helpful for the better rhizome development in the turmeric (Kale *et al*., 1991). Organic manure plays an important role in maintaining the physical and chemical properties of the soil. It also helps in improving soil microflora and accelerates their activities in the soil. The different biological process in the soil plays a vital role in the mineralization of organic carbon and recycling of nutrients (Kumar *et al*., 2018).

The turmeric grown in North Coastal hilly areas of India is mainly cultivated under rainfed conditions without any application of fertilizers. The farmers in this zone are cultivating turmeric for two to three years instead of eight to nine months and incurred persistent losses during cultivating turmeric. This is mainly because of lack of proper knowledge in usage of nutrient sources and limited information on organic turmeric cultivation (Kumar *et al*., 2016).

There are various sources of organic manures which are having a different effect on growth, yield and quality of turmeric (*Curcuma longa* L). It is necessary to study the best source of organic manures for the commercial organic cultivation of turmeric. Hence, the experiment was conducted to study the effect of different organic manures on growth and yield of turmeric.

MATERIALS AND METHODS

The field experiment was conducted to study the effect of organic manures on growth and yield of turmeric (Cv. Phule Swarupa) on vertisols consequently for five years on the same location at Instruction cum research farm of Agricultural Research Station, Kasbe Digraj, Sangli (Maharashtra) during 2009-2013. The experimental initial soil status was alkaline pH (8.18), electric conductivity 0.45 dS m^{-1}, Organic carbon 0.60 % with low available nitrogen (190 kg ha^{-1}), phosphorus (9.61 kg ha^{-1}) and very high available potassium (415 kg ha^{-1}) and micronutrients Fe 2.20 µg g^{-1}, Mn 2.32 µg g^{-1}, Zn 0.46 µg $g^{-1}$and Cu 1.47 µg g^{-1}.The field experiment was laid in a randomized block design with three replications. The treatments (T_1 to T_9) comprised general recommended fertilizer dose, farmyard manure, vermicompost, press mud compost, poultry manure, sugarcane trash, wheat straw, turmeric trash and *jeevamrut*. All the organic manures were applied on the basis of the recommended dose of nitrogen (200 kg ha^{-1}). The *jeevamrut* fertilizer was prepared by using cow dung @ 10 kg, Indian cow urine @ 5 lit, Jaggery @ 2 kg, gram flour@ 2 kg and soil around turmeric rhizomes @ 2 kg in 2000 lits of water which is fermented for eight days and applied @ 200 lit ha^{-1} of this solution during each irrigation. The major nutrient contents in the organic sources used are given in Table 1.

Generally, the crop is planted in the month of June and harvested after completion of nine months in the month of March during the experimental years. The initial representative soil samples (0-15 cm soil depth) were collected from experimental site and at the time of harvest of turmeric during 2009-10 to 2013-14. These samples were analyzed for various chemical parameters. The soil samples for general analysis were dried in shade and ground to fine so that it can pass through 2 mm sieve. The pH and EC from soil samples is analyzed in 1 -2.5 soil suspension (Jackson, 1973), organic carbon content of soil was determined by Walkley and Black method (Nelson and Sommers, 1982), alkaline permanganate method is used for analysis of available N (Subbiah and Asija, 1956), 0.5 M $NaHCO_3$ extraction (Olsen-P) method for available P (Olsen *et al*. 1954), flame photometer method with 1N neutral NH_4OAc extraction for available K (NH_4OAc K) (Knudsen *et al*., 1982) while DTPA extractable micronutrients (Fe, Mn, Cu, Zn) were determined by method suggested by Lindsay and Norvell (1978). The statistical analysis was carried out by procedure suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The study revealed that different sources of organic manures showed an effect on growth yield and quality of turmeric.

Vegetative growth: The maximum height of turmeric (95.37 cm) was recorded in the application

Table 1. Nutrients content and quantity applied of different organic manures.

Treatments	Nutrient content (%)			Quantity of organic manure applied (t ha^{-1})
	N	P	K	
T_1 : Control (GRDF 25 MT FYM ha^{-1} + 200:100:100 kg NPK ha^{-1}).	--	--	--	25.00
T_2 : RDN (FYM)	0.56	0.35	0.76	35.71
T_3 : RDN (V.C.)	1.76	0.86	1.00	11.36
T_4 : RDN (PMC)	1.68	2.72	1.56	11.90
T_5 : RDN (Poultry manure)	3.03	2.63	1.40	6.60
T_6 : RDN (Sugarcane trash)	0.50	0.20	0.70	40.00
T_7 : RDN (Wheat straw)	0.49	0.25	1.28	40.00
T_8 : RDN (Turmeric trash)	0.25	0.75	1.25	80.00
T_9 : Jeevamrut	0.01	0.02	0.20	2000 lit

Table 2. Turmeric fresh as well as dry rhizome yield as influenced by the application of different organic manures.

Treatments	Fresh rhizome Yield (q ha^{-1})						Dry rhizome Yield (q ha^{-1})					
	2009	2010	2011	2012	2013	Pooled Mean	2009	2010	2011	2012	2013	Pooled Mean
T_1	394	253	300	312	301	**312.12**	78.80	50.66	60.00	62.48	60.16	**62.42**
T_2	331	194	234	199	181	**227.69**	63.59	38.81	49.17	44.16	42.33	**47.61**
T_3	353	193	263	264	248	**264.24**	78.37	38.51	53.97	55.13	51.29	**55.45**
T_4	385	225	231	185	170	**239.19**	57.06	45.03	46.18	37.16	34.11	**43.91**
T_5	305	194	233	179	163	**214.90**	59.80	38.81	47.01	36.16	32.96	**42.95**
T_6	250	171	200	186	169	**195.28**	47.23	34.07	40.07	37.08	33.74	**38.44**
T_7	241	157	182	157	141	**175.59**	49.25	31.40	37.33	32.12	28.97	**35.81**
T_8	265	181	203	163	150	**192.27**	54.08	36.14	39.23	31.54	29.03	**38.00**
T_9	223	137	155	150	126	**158.16**	44.66	26.96	32.48	29.80	25.81	**31.94**
S. E.±	19.4	14.26	13.22	11.53	10.76	**11.36**	3.82	2.87	2.72	2.43	2.36	**6.32**
C. D. 5%	58.17	42.75	39.66	34.57	32.26	**32.78**	11.47	8.6	8.17	7.28	7.08	**11.11**

of a recommended dose of fertilizer to turmeric, which was at par with the application of vermicompost (90.17 cm). However, the significantly (at 0.05 %) the maximum number of leaves per tiller and number of tillers per plant (12.28 and 4.76 Nos, respectively) was recorded in recommended dose of fertilizer to turmeric followed by vermicompost (10.70 and 3.72 Nos, respectively) (Table 3). The vegetative growth in turmeric was obtained and it may be due to an increase in the activity of enzymes like chitinases and proteases which break down the organic-rich compounds. The activities of microflora and microfauna population in the soil is increased which increases the availability of macro and micronutrients especially by application of vermicompost, FYM, organic and inorganic fertilizers (Kumar *et al*., 2018). These results are in conformity with Poapst *et al.* (1970), who reported that earthworm's cast shows hormone-like activity and stimulates plant nutrient uptake and metabolism resulted in an increase in plant growth. The vegetative growth of the turmeric as influenced by the use of various organic manures (FYM and Vermicompost) revealed an increase in crop yield as well as improvement in the physical, chemical and biological properties of soils (Dudhat *et al*., 1997).

The highest curcumin (5.19 %) was recorded in the recommended dose of fertilizer to turmeric which was at par with an application of farmyard manure, vermicompost and press mud cake while the significantly (at 0.05 %) highest curcumin yield (323.96 kg ha^{-1}) was recorded in the recommended dose of fertilizer to turmeric which was followed by application of vermicompost (Table 4). The curcumin content in the turmeric is mainly responsible for the quality of turmeric, which varies according to the colour intensity of the curcumin. The curcumin content in the rhizomes was varied with the nutrient status in soil (Rao and Swami, 1984). Kumar *et al.* (2016) reported that the increased content of curcumin cv. Roma is attributed due to the increase in the availability of micronutrients from different organic sources supplied in the form of FYM, vermicompost and neem cake.

Yield and economics: The maximum dry rhizome yield (62.42 q ha^{-1}) was recorded in the application of a recommended dose of fertilizer to turmeric which was at par with the application of vermicompost (55.45 q ha^{-1}), however fresh rhizome yield was significantly (at 0.05 %) highest in the application of a recommended dose of fertilizer to turmeric (312. 12 q ha^{-1}) which was followed by vermicompost (264.24 q ha^{-1}) (Table 2). It means that with the application of organic manure, the dry recovery of the turmeric increases. It was increased by 1 % from 20 to 21 %, which contributes to increasing the marketable yield of the turmeric. Kumar *et al*., (2016) reported that organic manures are significantly beneficial for the dry yield of rhizomes in comparison to inorganic sources of nutrients. The dry recovery of turmeric is a varietal character, however it is also influenced by several other factors like soil moisture, duration of crop, manures and fertilizers applied and soil health. The variation in dry recovery due to integrated nutrient management and other related factors varies from 16 to 37.4 % was reported by Aiyadurai (1966).

The highest gross returns (Rs. 4,10,588) was obtained with the application of vermicompost which was at par with an application of a recommended dose of fertilizer and farmyard manure while the maximum B:C ratio (1.59) was observed in the application of a recommended dose of fertilizer to turmeric which was at par with vermicompost (1.54) (Table 5). These results are in conformity with several workers (Roy and Hore, 2011; Nanda *et al.,* 2012). Balashanmugam *et al*. (1989) reported an increase in fresh turmeric rhizome yield from 25,550 kg ha^{-1} to 32,370 kg ha^{-1} with an increase in FYM from 0 to 25 tonnes ha^{-1} in CO-1 turmeric cultivar. Sadanandan *et al*., (1998) noticed an increase in 37 per cent in the fresh yield of turmeric over control with 40 tonnes ha^{-1} application of compost or cattle manure in the soil. The field experiment conducted by Sharma *et al*. (2003) in a clay loam soil at Jabalpur, Madhya Pradesh and studied the effect of organic manures and chemical fertilizers alone and in combination with each other on the yield of turmeric. They reported that

Table 3. Height, number of leaves per tiller and number of tillers per plant of turmeric as influenced by the application of different organic manures.

Treat-ments	Height (cm)						No. of leaves / tiller						No of tillers per plant					
	2009	2010	2011	2012	2013	Pooled Mean	2009	2010	2011	2012	2013	Pooled Mean	2009	2010	2011	2012	2013	Pooled Mean
T_1	93.33	71.06	111.17	101.20	100.07	95.37	14.40	11.66	13.00	11.73	10.60	12.28	5.20	4.00	6.00	4.27	4.33	4.76
T_2	95.76	60.50	94.17	90.00	90.07	86.10	11.26	9.66	11.33	9.87	9.47	10.32	4.06	3.00	4.33	2.73	2.80	3.38
T_3	109.16	61.10	101.40	85.87	93.33	90.17	12.06	9.66	12.00	9.93	9.87	10.70	4.53	3.33	5.00	2.80	2.93	3.72
T_4	87.06	66.06	92.03	95.07	88.87	85.82	6.80	10.66	11.33	10.00	9.00	9.56	2.80	3.33	4.33	3.73	2.60	3.36
T_5	88.56	61.36	93.60	87.07	85.13	83.14	10.46	9.66	11.33	9.33	8.73	9.90	3.20	3.33	4.33	3.47	2.47	3.36
T_6	79.90	56.33	83.90	80.47	86.27	77.37	8.13	8.66	11.00	9.07	8.87	9.15	1.46	2.66	3.33	2.67	2.47	2.52
T_7	75.36	53.93	78.97	75.40	81.07	72.95	7.73	8.33	9.00	8.13	8.20	8.28	1.26	2.33	3.00	2.13	2.33	2.21
T_8	83.16	58.16	84.93	78.47	84.53	77.85	8.93	9.00	9.67	9.07	8.53	9.04	2.20	2.66	3.67	2.93	2.40	2.77
T_9	62.40	50.00	69.73	69.93	76.00	65.61	8.66	7.66	8.67	7.87	6.27	7.83	1.66	2.00	2.67	1.87	1.60	1.96
S. E.±	14.46	2.74	3.86	4.90	4.05	2.49	0.98	0.56	0.22	0.53	0.46	0.28	0.17	0.29	0.15	0.16	0.16	0.18
C. D. 5%	NS	8.20	11.57	14.69	12.16	7.20	2.96	1.68	0.67	1.61	1.40	0.81	0.53	0.88	0.45	0.49	0.48	0.52

Table 4. Curcumin and Curcumin yield of turmeric as influenced by application of different organic manures.

Treat-ments	Curcumin (%)						Curcumin yield (kg ha^{-1})					
	2009	2010	2011	2012	2013	Pooled Mean	2009	2010	2011	2012	2013	Pooled Mean
T_1	5.27(13.26)	5.21(13.19)	5.17(13.14)	5.15(13.12)	5.13(13.10)	5.19(13.16)	415	264	310	322	309	323.96
T_2	5.18(13.15)	5.20(13.18)	5.14(13.10)	5.08(13.03)	5.06(13.00)	5.13(13.09)	329	202	253	224	214	244.49
T_3	5.12(13.07)	5.15(13.11)	5.13(13.08)	5.06(13.00)	5.02(12.95)	5.10(13.04)	401	198	277	279	257	282.58
T_4	5.14(13.10)	5.17(13.14)	5.11(13.06)	5.08(13.02)	5.05(12.99)	5.11(13.06)	293	233	236	189	172	224.62
T_5	4.92(12.81)	4.99(12.90)	4.94(12.84)	4.92(12.82)	4.85(12.73)	4.92(12.82)	294	194	232	178	160	211.57
T_6	4.72(12.55)	4.76(12.60)	4.75(12.59)	4.82(12.68)	4.78(12.64)	4.77(12.61)	223	162	190	179	161	183.09
T_7	4.73(12.56)	4.79(12.64)	4.76(12.61)	4.72(12.55)	4.71(12.53)	4.74(12.58)	233	150	178	152	136	169.82
T_8	4.77(12.61)	4.81(12.67)	4.85(12.73)	4.82(12.68)	4.78(12.64)	4.81(12.67)	258	174	190	152	139	182.57
T_9	4.42(12.23)	4.51(12.25)	4.61(12.40)	4.64(12.45)	4.54(12.31)	4.54(12.33)	197	122	150	138	117	144.83
S. E.±	0.04	0.061	0.02	0.012	0.013	0.05	17.13	8.46	11.83	12.91	10.98	12.07
C. D. 5%	0.13	0.18	0.06	0.038	0.039	0.14	49.48	24.l2	34.40	37.78	31.30	34.85

* figures in the parenthesis indicates the arc sine transformed values

Table 5. Cost of cultivation, gross returns and B:C ratio of turmeric as influenced by application of different organic manures.

Treat-ments	Cost of cultivation (Rs.)						Gross returns (Rs.)						B:C Ratio					
	2009	2010	2011	2012	2013	Pooled Mean	2009	2010	2011	2012	2013	Pooled Mean	2009	2010	2011	2012	2013	Pooled Mean
T_1	125569	185837	393927	325655	332720	272742	275800	303960	600000	374900	418280	394588	2.19	1.63	1.52	1.15	1.45	1.59
T_2	125176	149600	398353	310465	339340	264587	222565	232860	540870	353307	423300	354580	1.77	1.55	1.35	1.14	1.25	1.41
T_3	141408	164100	419853	309365	332840	273513	274295	231060	593670	441013	512900	410588	1.94	1.40	1.41	1.42	1.54	1.54
T_4	113983	184950	366923	279035	282290	245436	199710	270180	507980	297253	341100	323245	1.75	1.46	1.38	1.06	1.21	1.37
T_5	117219	173600	416153	328265	342340	275515	209300	229080	517110	289253	329600	314869	1.78	1.32	1.24	0.88	0.96	1.24
T_6	119319	115600	373353	285465	286340	236015	165305	204420	440770	296640	337400	288907	1.38	1.77	1.18	1.04	1.18	1.31
T_7	119564	116000	372353	284465	285340	235544	172375	188400	410630	256987	289700	263618	1.44	1.62	1.10	0.90	1.02	1.22
T_8	120955	126000	372353	284865	285740	237983	189280	216840	431530	252293	290300	276049	1.56	1.72	1.16	0.88	1.02	1.27
T_9	110559	110600	338353	300465	301340	232263	156310	161760	357280	238400	258100	234370	1.41	1.46	1.05	0.79	0.86	1.11
S. E.+						17280						20141						0.05
C. D. 5%						49877						58134						0.15

Table 6. pH, EC and 0rganic carbon content of soil as influenced by application of different organic manures.

Treat-ments	pH						EC (dS m^{-1})						Organic carbon (%)					
	2009	2010	2011	2012	2013	Pooled Mean	2009	2010	2011	2012	2013	Pooled Mean	2009	2010	2011	2012	2013	Pooled Mean
T_1	8.48	8.4	8.12	7.91	7.97	8.18	0.37	0.38	0.36	0.35	0.26	0.34	0.62	0.64	0.68	0.77	0.70	0.68
T_2	8.39	8.34	8.02	7.96	8.02	8.15	0.38	0.34	0.32	0.35	0.25	0.33	0.75	0.79	0.8	0.84	0.81	0.80
T_3	8.2	8.08	7.97	7.94	8.05	8.05	0.36	0.31	0.31	0.33	0.26	0.31	0.72	0.77	0.68	0.62	0.69	0.70
T_4	8.31	8.24	8.05	7.91	8.06	8.11	0.37	0.31	0.32	0.34	0.22	0.31	0.76	0.81	0.75	0.69	0.75	0.75
T_5	8.31	8.23	8.15	7.89	8.04	8.12	0.36	0.31	0.33	0.35	0.22	0.31	0.74	0.78	0.65	0.57	0.67	0.68
T_6	8.2	8.11	8.1	8.21	8.11	8.15	0.37	0.3	0.27	0.30	0.23	0.29	0.78	0.84	0.72	0.65	0.74	0.75
T_7	8.21	8.12	8.18	8.23	8.12	8.17	0.39	0.34	0.32	0.38	0.19	0.32	0.8	0.86	0.68	0.52	0.69	0.71
T_8	8.12	8.04	8.15	8.17	8.08	8.11	0.36	0.31	0.30	0.31	0.20	0.30	0.78	0.82	0.70	0.57	0.70	0.71
T_9	8.13	8.05	8.18	8.29	8.18	8.17	0.35	0.29	0.25	0.28	0.15	0.26	0.70	0.74	0.40	0.54	0.56	0.59
S. E.+	0.15	0.05	0.03	0.04	0.01	0.02	0.015	0.025	0.01	0.01	0.01	0.01	0.023	0.038	0.021	0.01	0.01	0.02
C. D. 5%	NS	0.16	0.09	0.13	0.03	0.07	NS	NS	0.03	0.03	0.02	0.03	0.069	0.11	0.063	0.04	0.03	0.05

Table 7. Available N, available P and available K of soil as influenced by application of different organic manures.

Treat-ments	Available N (kg ha^{-1})						Available P (kg ha^{-1})						Available K (kg ha^{-1})					
	2009	**2010**	**2011**	**2012**	**2013**	**Pooled Mean**	**2009**	**2010**	**2011**	**2012**	**2013**	**Pooled Mean**	**2009**	**2010**	**2011**	**2012**	**2013**	**Pooled Mean**
T_1	290	265	256	247	256	263	13.46	10.96	11.55	11.87	11.46	11.86	516	506	555	588	550	543
T_2	250	227	227	229	228	232	10.27	8.45	9.5	10.11	9.35	9.54	480	464	520	555	513	506
T_3	221	197	226	235	219	220	10.78	8.98	9.3	11.38	9.89	10.07	498	478	494	527	500	500
T_4	229	205	215	234	218	220	10.45	8.76	10.5	11.85	10.37	10.39	509	497	501	494	497	500
T_5	283	253	240	233	242	250	10.78	8.88	9.25	12.67	10.27	10.37	439	421	451	499	457	453
T_6	189	179	201	210	197	195	8.98	7.98	8.5	9.34	8.61	8.68	412	401	431	466	433	429
T_7	126	112	160	213	162	155	8.06	7.45	8	9.56	8.34	8.28	409	391	422	479	431	426
T_8	173	153	180	215	183	181	9.45	9.01	8.25	8.78	8.68	8.83	449	430	436	449	438	440
T_9	190	174	156	217	182	184	8.49	7.6	7.5	7.99	7.70	7.86	416	403	411	441	418	418
S. E.±	15.90	5.73	3.26	2.76	5.23	6.67	0.64	0.11	0.33	0.42	0.56	0.25	20.88	7.98	8.55	9.26	7.4	8.32
C. D. 5%	47.68	17.16	9.84	8.28	15.69	19.25	1.92	0.34	1.02	1.25	1.67	0.72	62.62	23.93	26.01	27.76	22.2	24.03

the application of chemical fertilizers reduced the yield in turmeric in succeeding years while application of organic manures either vermicompost or FYM improved the yield of turmeric by 7 to 10 per cent over the preceding year.

Soil studies: The lowest pH (8.05) was recorded by vermicompost, which was at par with press mud cake, turmeric trash and poultry manure. The release of organic acids during the process of decomposition may be attributed to the decline in soil pH (Amusan *et al*., 2011).The significantly maximum EC (0.34 dS m^{-1}) was recorded in the recommended dose of turmeric which was at par with the application of vermicompost, press mud cake, poultry manure and farmyard manure (Table 6). The increase in EC of soil might occur due to more solubilization of fixed nutrients. The maximum organic carbon (0.80 %) was recorded in the application of farmyard manure which was at par with press mud cake and sugarcane trash. During vermicomposting, the C: N ratio was narrowed down substantially over normal compost. The lower C: N ratio ensures immediate release of nitrogen to plant when applied to the soil. (Chaudhary *et al*., 2004).

The maximum available N (262.74 kg ha^{-1}) was observed in the application of recommended dose of turmeric which was at par with poultry manure. Significantly maximum available P (11.586 kg ha^{-1}) observed in the application of a recommended dose of turmeric which was followed by application of press mud compost while the significantly maximum available K (543.02 kg ha^{-1}) was observed in the application of a recommended dose of turmeric followed by application of farmyard manure (Table 7). Increase in available nutrients with vermicompost or FYM application due to mineralization of nutrients from organic manures in soil (Yaduvanshi, 2001). Sharma *et al*., (2009) noticed that enhancement in available nutrient content in soil with the use of organics. Sreenivas *et al.* (2000) recorded that use of vermicompost, FYM and biofertilizers improve the overall soil health, nutrient reaction and their availability. Sharma *et al.* (2004) reported favourable influence of vermicompost, organic and inorganic fertilizers on the availability of all essential plant nutrients during the crop period.

Conclusion

The application of vermicompost (11.36 T ha^{-1}) along with phosphate solubilizing bacteria and *Azospirillium* @ 5 kg ha^{-1}, respectively at the time of planting to turmeric was found superior. The use of vermicompost continuously in the same field in preceding years improved soil condition, which is useful for higher net monetary returns and maintenance of soil fertility in organic cultivation of turmeric.

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