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ROLE OF ORGANIC MANURES WITH INORGANIC AND VARIOUS BIOFERTILIZERS ON GROWTH AND YIELD OF TURMERIC (*CURCUMA LONGA* L.)

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ABSTRACT

The Department of Horticulture at the College of Agriculture, Central Agricultural University, Imphal conducted a field experiment in 2021–2022 to investigate the "Role of organic manures with inorganic and various biofertilizers on growth and yield of turmeric". The trial used a randomised block design with three replications & thirteen different treatments. The combination of nitrogenous biofertilizers (BF); (*Azotobacter chroococcum*), PSB (*Bacillus polymyxa*), KMB (*Fraturia aurantea*) with manures (compost, vermicompost, mustard cake & neem cake), as well as three levels of NPK, including 100%, 75% and 50% were used in this investigation. A significant difference of the rhizome yield was noticed when inorganic with organic manures and various biofertilizers combination was compared with recommended NPK 100%. The best significant treatment was vermicompost + NPK (100%) + BF (yield 38.50 t ha^{-1}) as compared to NPK 100% (150:60:150 kg/ha) (yield 24.98 t ha^{-1}). Maximum length of secondary fingers (5.83 cm) was recorded with the combination of neem cake + NPK (100%) + BF. The highest plant height (169.87 cm), number of tillers/clump (3.11), number of leaves/clump (17.14) and leaves length (73.01 cm) at 150 DAP, weight (120.32 g) of secondary fingers and breadth (2.00 cm) of secondary fingers were found in vermicompost + NPK (100%) + BF. Mustard cake + NPK (100%) + BF resulted in maximum breadth of leaves (19.10 cm) at 150 DAP. Maximum number of secondary fingers (10.17) was found in neem cake + NPK (75%) + BF and maximum breadth of mother rhizome (3.45 cm) was obtained in neem cake + NPK (50%) + BF. Maximum no. and weight of mother rhizome (2.63 and 51.17 g, respectively) were obtained in vermicompost + NPK (75%) + BF. Vermicompost + NPK (50%) + BF gave rise to the longest length of mother rhizome (4.58 cm). In light of the results, it can be said that using vermicompost + NPK (100%) + BF in turmeric increases most of the growth and yield parameters.

Key words : Biofertilizers, Growth, Organics, Turmeric, Vermicompost.

Introduction

Turmeric (*Curcuma longa* L.), is the most popular spices & mainly used for flavouring and colouring many foods. The family of turmeric includes the genus *Curcuma* which,–originated in Tropical South East Asia. It is a perennial herbaceous plant. It is one of the most valuable spices in the world, that known in India as "Haldi". Turmeric is used in both developed and developing nations in various ways which closely associated with human civilization and religion. Turmeric has several therapeutic benefits and has been used for a long time to treat inflammatory diseases. It is well known for its antimutagenic, anticarcinogenic, antioxidant and chemotherapeutic capabilities in addition to being antimalarial, anti-inflammatory and antitumor forming. Due to its extensive use in spices, colour for the textile industry and cosmetics, the demand for turmeric is rising (Shah, 1997). The importance of turmeric in medicine took a new turn when it was discovered that it is very rich in particular type of phenolic compounds called curcuminoids (Shipa and Nivedita, 2009).

Recently, biofertilizers have become one of the most promising sources of plant nutrients. The role of different biofertilizers like *Azospirillum* and *Azotobacter* cultures

is fixing the atmosphere nitrogen. Application of biofertilizers containing *Azospirillum* is beneficial for fixing a significant amount of atmospheric nitrogen and supplying it to the crop while also improving soil fertility. The uptake of phosphorus, which is easily fixed in the soil, increased by the application of PSB (Wang and Qiu, 2006). To encourage, nurture and support sustainable farming for healthier and more profitable production, a plan for the appropriate use of chemical fertilizers, organic manures and biofertilizers must be adopted. The use of biofertilizers has been observed to be effective in enhancing the yield and reducing the requirement of inorganic sources of nutrients. Insoluble phosphates can be converted into soluble forms by a wide range of soil bacteria and fungi that secrete organic acids (Roy and Hore, 2011).

Organic fertilizers such as farmyard manure (FYM), neem cake, vermicompost and decomposed green leaf manure as well as biofertilizers such as *Azospirillum*, phosphobacteria and vesicular arbuscular mycorrhiza (VAM), can sustain yields while improving soil health. The practice of Integrated Nutrient Management, which combines the application of organic and inorganic fertilizers, increases soil fertility, productivity and water holding capacity while also enhances the characteristics of the soil *viz*., physical, chemical and biological. The organic supply will aid in keeping the soil's equilibrium.

Materials and Methods

During the period 2021 to 2022, this experiment was laid out at an experimental location of Horticulture Department, College of Agriculture, CAU, Manipur (India). The University is geographically located at an altitude of 850 m above mean sea level at $24^0$45" North latitude and $93^0$56" South longitude. The soil at the experimental plots was clay with pH 5.24 (acidic) and 1.18% organic carbon. In the soil, available N, P_2O_5 and K_2O were 238.33, 31.79 and 196.50 kg per hectare, respectively. Three replications were used in the RBD design of the experiment. Raised beds were prepared measuring 3.0 x 1.0 m^2 & 15 cm height. Spaced 25 cm apart, turmeric rhizomes were planted. @ 10 and 5 tons of compost and vermicompost respectively and @ 3 tons each of mustard cake and neem cake were applied per hectare as basal dose of organic manures during final land preparation. "Recommended dose of inorganic fertilizers was 150:60:150 kg NPK per hectare" (Medda, 2000). The complete fertilizer quantity was administered in three separate stages. Following planting, one-third of nitrogen (N) and the entire phosphorous (P) amount were applied after 15 days. Subsequently, two more splits of one-third N and one-half potassium (K) were employed after 45 and 90 days from the initial installment. Inorganic sources such as Urea, Single Super Phosphate (SSP), and Muriate of Potash (MOP) were utilized for N, P and K, respectively. A combination of biofertilizers *viz*., *Azotobacter*, phosphorus solubilizing bacteria & potassic mobilizer was soil-applied @ 20 kg ha^{-1} with organic manures. Vibrant rhizomes seed (@ 30-35 g size) were blended with *Trichoderma viride* (@ 5 g kg^{-1}) and Acacia gum as adhesive in water within a plastic tray. After soaking, rhizome bits were dried in shady area. Turmeric rhizomes treated with fungicide and planted at 4-5 cm dept in late May 2021. Paddy straw mulch was applied right after planting, followed by 3-4 manual weeding sessions. Irrigation was administered based on need. Turmeric was harvested eight months post-planting, and various growth (at 90 and 150 DAP) as well as yield attributes were observed on five plant selected randomly $replication^{-1}$. Rhizome yield was assessed per plot at harvest, with per-hectare yield calculated from net plot basis, accounting for the crop's presence in 75 per cent of the total cropped area (Chanchan *et al*., 2018). Observations on growth parameters in five randomly selected turmeric plants were recorded at 90 and 150 days after planting. Rhizome characters and yield parameters were recorded at harvest.

Data analysis

The experimental data obtained were subjected to statistical analysis by adopting Fisher's method of analysis of variance technique. Significance of difference in the treatment effect was tested through 'F' test at 5% level of significance and CD (critical difference) was calculated, wherever the results were significant. The standard error of mean [S.Em (±)] and the value of critical difference (CD) to compare the difference between means are provided in the tables of the results.

Results and Discussion

Growth parameters

Data showed in Table 1 and Fig. 1, the combination of inorganic with organic manures and different biofertilizers had a significant role on growth characters of turmeric at 90 and 150 DAP.

Plant height (cm)

The highest plant height (116.53 cm) at 90 DAP was seen in plants treated with vermicompost + NPK (100%) + BF, followed by the application of compost + NPK (100%) + BF (112.73 cm). While, the shortest height of plant (87.33 cm) was achieved in vermicompost + NPK (50%) + BF, then control; NPK 100% (90.64 cm). The

Fig. 1 : Variation of growth characters of turmeric at 90 and 150 DAP.

Table 1 : Role of organic manures with inorganic and various biofertilizers on growth characters of turmeric.

Treatment details	Plant height in cm		No. of tillers clump^{-1}		No. of leaves clump^{-1}		Leaves length in cm		Leaves breadth in cm	
	90 DAP	150 DAP	90 DAP	150 DAP	90 DAP	150 DAP	90 DAP	150 DAP	90 DAP	150 DAP
Compost + NPK 100% + BF	112.73	160.81	1.13	2.89	10.42	16.11	59.53	68.41	15.97	17.70
Compost + NPK 75% + BF	96.53	150.05	1.00	2.66	10.13	15.52	56.40	65.60	16.33	17.29
Compost + NPK 50% + BF	90.64	136.17	0.67	2.02	9.31	12.24	56.53	66.20	16.13	17.12
Vermicompost + NPK 100% + BF	116.53	169.87	1.24	3.11	10.11	17.14	62.67	73.01	15.53	17.20
Vermicompost + NPK 75% + BF	107.20	153.01	1.40	2.83	10.87	15.59	58.47	65.87	16.08	19.00
Vermicompost + NPK 50% + BF	87.33	140.02	0.87	2.14	8.30	13.11	54.47	66.07	15.33	18.30
Mustard cake + NPK 100% + BF	110.93	165.15	1.16	2.36	9.62	14.63	59.83	66.37	15.77	19.10
Mustard cake + NPK 75% + BF	103.33	163.22	1.44	2.54	10.21	15.20	59.00	68.40	16.10	16.87
Mustard cake + NPK 50% + BF	100.33	125.53	0.50	1.56	8.10	12.29	57.73	67.12	15.53	16.77
Neem cake + NPK 100% + BF	100.53	161.81	1.25	3.06	10.52	15.82	61.47	68.22	14.03	18.67
Neem cake + NPK 75% + BF	110.87	158.08	1.58	2.84	9.81	14.73	57.33	66.71	15.23	18.30
Neem cake + NPK 50% + BF	104.41	141.26	0.51	1.90	8.31	12.85	58.90	64.40	14.83	17.83
NPK 100% (150:60:150 kg/ha)	94.60	130.56	0.70	1.62	8.86	14.20	53.27	63.64	14.33	16.80
S.Em (±)	**3.25**	**4.53**	**0.08**	**0.13**	**0.37**	**0.50**	**1.74**	**2.83**	**0.48**	**0.56**
CD at 5%	**9.48**	**13.23**	**0.24**	**0.38**	**1.07**	**1.45**	**5.09**	**NS**	**1.40**	**1.63**

Biofertilizers (BF): *Azotobacter chroococcum, Bacillus polymixa* & *Fraturia aurantea*

highest height of plant (169.87 cm) was seen in vermicompost + NPK 100% + BF at 150 DAP, followed by mustard cake + NPK (100%) + BF (165.15 cm). While, mustard cake + NPK (50%) + BF showed the lowest plant height (125.53 cm), then,-(control) NPK 100% came in second (130.56 cm).

Number of tillers/clump

Neem cake + NPK (75%) + BF produced the most tillers number per clump (1.58), followed by mustard cake + NPK (75%) + BF (1.44) at 90 DAP. Neem cake + NPK (50%) + BF and mustard cake + NPK (50%) + BF both had the lowest number of tillers per clump (0.50) and (0.51), respectively. The combination of vermicompost + NPK (100%) + BF produced the most tillers number per clump (3.11) at 150 DAP, followed by the application of neem cake + NPK (100%) + BF (3.06). While, mustard cake + NPK (50%) + BF had the fewest number of tillers per clump (1.56) and was followed by recommended NPK 100% (1.62).

Number of leaves/clump

The combined application of neem cake + NPK (100%) + BF had the maximum number of leaves per clump (10.87) at 90 DAP, followed by vermicompost + NPK (75%) + BF (10.52). Vermicompost + NPK (50%) + BF and mustard cake + NPK (50%) + BF were found with the minimum leaves per clump (8.10 and 8.30, respectively). At 150 DAP, vermicompost + NPK (100%) + BF had the maximum number of leaves per clump (17.14), followed by compost + NPK (100%) + BF (16.11). In contrast, compost + NPK 50% + BF and mustard cake + NPK (50%) + BF both produced the minimum number of leaves/clump (12.24 and 12.29, respectively).

Length of leaves (cm)

Vermicompost + NPK (100%) + BF and neem cake + NPK (100%) + BF both produced the longest leaves (62.67 cm) and (61.47 cm) at 90 DAP. While, the recommended NPK (100%) produced the shortest length of leaves (53.27 cm), followed by vermicompost + NPK

(50%) + BF (54.47 cm). The combination of vermicompost + NPK (100%) + BF and compost + NPK (100%) + BF produced the longest leaves (73.01 cm) and (68.41 cm) at 150 DAP. While, the recommended NPK (100%) was determined to have the shortest leaves (63.64 cm), followed by neem cake + NPK (50%) + BF (64.40 cm).

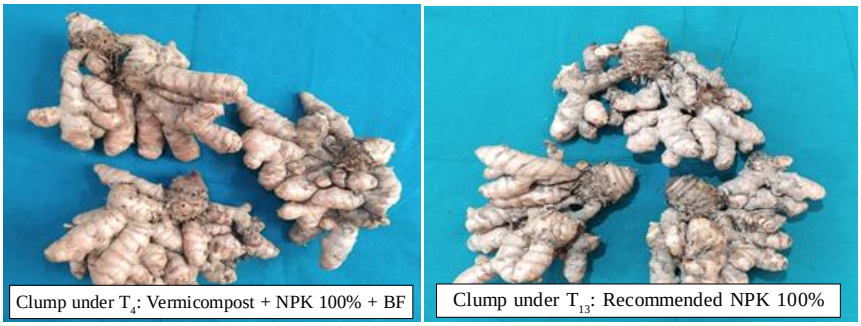

Fig. 2 : Variation of Clump in T_4 and T_{13}.

Breadth of leaves (cm)

Compost + NPK (75%) + BF had the widest leaves at 90 DAP (16.33 cm). While, neem cake + NPK (100%) + BF had the smallest leaf breadth (14.03 cm). Mustard cake + NPK (100%) + BF was found to have the widest leaves at 150 DAP (19.10 cm), followed by vermicompost + NPK (75%) + BF (19.00 cm). While, mustard cake + NPK (50%) + BF and NPK (100%) were observed with the smallest breadth of leaves (16.77 cm and 16.80 cm, respectively).

The addition of organic manures, such as compost, vermicompost and neem cake, along with a biofertilizer combination would have had a more stimulating effect on nutrient uptake, which in turn increased growth parameters recorded plant height, no. of leaves plant^{-1} and no. of tillers clump^{-1}, which ultimately led to a higher dry weight of turmeric rhizomes. The current investigations support earlier findings in turmeric (Amala *et al*., 1019 and Velmurugan, 2002). In terms of plant height and dry matter accumulation by plants over inorganic nitrogen, organic manure continued to be superior to inorganic fertilizers. This might be due to the beneficial ability of organic manure to supply nutrients for a longer period of time than chemical fertilizers, which ultimately results in a crop growing more quickly and accumulating more dry matter (Singh *et al*., 2017). Vermicompost releases more nutrients than most organic manures, potentially leading to abundant leaves and tillers. This promoting nutrient availability could be the prime driver of increased foliage and tiller growth and yield as well as quality of turmeric. The current investigations are similar with results of Nirmalatha (2009) and Chanchan *et al*. (2018). For turmeric, Patil and Kunde (1988) and Balashanmugan (1994) recorded above-ground plant growth responses to biofertilizers identical to those utilised in the current study.

Yield attributes

Data showed in Tables 2 and 3 and Fig. 2, the combination of inorganic with organic manures and different biofertilizers had significantly role on characters of secondary finger, characters of mother rhizome and yield of turmeric at harvest.

No. of secondary finger

Neem cake + (75%) NPK + BF had the most secondary fingers (10.70), whereas vermicompost + (100%) NPK + BF had the most (9.83). Vermicompost + NPK (50%) + BF and compost + NPK (50%) + BF both produced the least amount of secondary fingers (3.60 and 4.73, respectively).

Weight of secondary finger in gram

Maximum weight of secondary finger (120.32 g) was observed in vermicompost + NPK (100%) + BF followed by neem cake + NPK (100%) + BF (110.08 g). While, minimum weight of secondary finger (23.13 g) was recorded in compost + NPK (50%) + BF followed by mustard cake + NPK (50%) + BF (39.31 g).

Length of secondary finger in cm

The maximum length of secondary finger (5.83 cm) was achieved in neem cake + NPK (100%) + BF followed by vermicompost + NPK (100%) + BF (5.67 cm). While, minimum length of secondary finger (4.32 cm) was obtained in mustard cake + NPK (50%) + BF followed by compost + NPK (50%) + BF (4.49 cm).

Breadth of secondary finger (cm)

Maximum breadth of secondary finger (2.00 cm) was obtained in vermicompost + NPK (100%) + BF followed by neem cake + NPK (100%) + BF (1.90 cm). While, minimum breadth of secondary finger (1.27 cm) was found in vermicompost + NPK (50%) + BF followed by compost + NPK (50%) + BF (1.33 cm).

No. of mother rhizome

Maximum no. of mother rhizome (2.63) was recorded in vermicompost + NPK (100%) + BF. While, minimum number of mother rhizome (1.97) was recorded in neem cake + NPK (100%) + BF.

Weight of mother rhizome in gram

Maximum weight of mother rhizome (51.17 g) was recorded in vermicompost + NPK (75%) + BF followed

Table 2 : Role of organic manures with inorganic and various biofertilizers on characters of secondary finger.

Treatment details	Secondary finger characters			
	No. of secondary finger	Weight in g	Length in cm	Breadth in cm
Compost + NPK 100% + BF	6.62	63.60	4.96	1.68
Compost + NPK 75% + BF	7.30	79.90	4.83	1.52
Compost + NPK 50% + BF	3.60	23.13	4.49	1.33
Vermicompost + NPK 100% + BF	9.83	120.32	5.67	2.00
Vermicompost + NPK 75% + BF	8.62	101.95	5.50	1.78
Vermicompost + NPK 50% + BF	4.73	79.30	4.52	1.27
Mustard cake + NPK 100% + BF	7.90	91.32	5.52	1.66
Mustard cake + NPK 75% + BF	9.42	60.60	5.10	1.50
Mustard cake + NPK 50% + BF	7.31	39.31	4.32	1.87
Neem cake + NPK 100% + BF	6.20	110.08	5.83	1.90
Neem cake + NPK 75% + BF	10.17	104.32	5.43	1.83
Neem cake + NPK 50% + BF	8.21	57.48	4.80	1.65
NPK 100% (150:60:150 kg/ha)	6.15	61.31	4.93	1.70
S.Em (±)	**0.38**	**2.43**	**0.27**	**0.13**
CD at 5%	**1.11**	**7.09**	**0.79**	**0.37**

Table 3 : Role of organic manures with inorganic and various biofertilizers on characters of mother rhizome and yield of turmeric.

Treatment details	Mother rhizome characters			Yield attributes		
	Number	Weight in g	Length in cm	Breadth in cm	Per plot (kg 3.0 m^{-2})	($t\ ha^{-1}$)
Compost + NPK 100% + BF	2.30	44.28	4.30	3.35	14.63	36.57
Compost + NPK 75% + BF	2.17	42.22	4.00	3.34	12.28	30.70
Compost + NPK 50% + BF	2.27	42.02	4.26	3.28	9.82	24.55
Vermicompost + NPK 100% + BF	2.23	49.83	4.02	3.37	15.40	38.50
Vermicompost + NPK 75% + BF	2.63	51.17	4.19	3.20	13.36	33.40
Vermicompost + NPK 50% + BF	2.20	50.52	4.58	3.36	11.72	29.30
Mustard cake + NPK 100% + BF	2.20	45.90	4.23	3.25	12.93	32.32
Mustard cake + NPK 75% + BF	2.33	45.55	4.36	3.29	11.32	28.30
Mustard cake + NPK 50% + BF	2.30	46.11	4.25	3.40	9.90	24.77
Neem cake + NPK 100% + BF	2.40	50.33	4.23	3.29	14.02	35.05
Neem cake + NPK 75% + BF	2.40	44.97	4.08	3.23	12.70	31.76
Neem cake + NPK 50% + BF	1.97	50.29	4.29	3.45	10.62	26.55
NPK 100% (150:60:150 kg/ha)	2.30	43.37	4.08	3.26	9.99	24.98
S.Em (±)	**0.21**	**1.45**	**0.24**	**0.19**	**0.89**	**2.22**
CD at 5%	**NS**	**4.23**	**NS**	**NS**	**2.59**	**6.47**

by vermicompost + NPK (50%) + BF (50.52 g). While, minimum mother rhizome weight (42.02 g) was found in compost + NPK (50%) + BF nearest by vermicompost + NPK (75%) + BF (42.22 g).

Length of mother rhizome (cm)

The highest length of mother rhizome (4.58 cm) was found in vermicompost + NPK (50%) + BF. While, lowest length of mother rhizome (4.00 cm) was seen in compost + NPK (75%) + BF.

Breadth of mother rhizome (cm)

Maximum breadth of mother rhizome (3.45 cm) was achieved in neem cake + NPK (50%) + BF. While, minimum breadth of mother rhizome (3.20 cm) was found in vermicompost + NPK (75%) + BF.

Yield/plot (kg)

Highest yield/plot (15.40 kg per 3.0 m^2) was achieved in vermicompost + NPK (100%) + BF followed by compost + NPK (100%) + BF (14.63 kg per 3.0 m^2). While, lowest yield/plot (9.82 kg per 3.0 m^2) was observed with compost + NPK (50%) + BF followed by mustard cake + NPK (50%) + BF (9.90 kg per 3.0 m^2).

Yield/hectare (t)

The greatest yield (38.50 t ha^{-1}) was achieved using vermicompost + NPK (100%) + BF, followed closely by compost + NPK (100%) + BF (36.57 t ha^{-1}). Conversely, the smallest yield (24.55 t ha^{-1}) was seen in compost + NPK (50%) + BF, with mustard cake + NPK (50%) + BF slightly higher (24.77 t ha^{-1}) in comparison.

The application of vermicompost increases the activity of helpful bacteria such as N_2 fixers and mycorrhizal fungi, which play vital role in phosphate mobilisation and fixation of N_2, leading to more uptakes by plant and better development and yield (Kale *et al*., 1992). Vermicompost enhances nutrients status and the overall health of the soil (Sreenivas *et al*., 2000). It is also well known for containing all the necessary plant nutrients and providing a constant supply of these nutrients throughout the entire crop period (Jat and Ahlawat, 2004). Vermicompost has a positive impact on the availability of all vital plant nutrients during the crop period was also reported (Sharma *et al*., 2004). Applying compost to the soil enhances its tilth and aeration, boosts its ability to retain water and stimulates. When compared to using only NPK (100%) without any organic input, the action of microorganisms makes the plant food elements in the soil easily accessible to the crop. Vermicompost has a positive impact on the soil environment, which in turn increases proliferous root development and better absorption of moisture and nutrients, leading to higher biomass production (Vadiraj *et al*., 1998). Higher yields of rhizomes may be the results of more preferential photosynthate inflow to the sink, which may be the reason of the rise in photosynthates. The recent works are similar with previous study (Kumar *et al*., 2016). The explanation for the greater yield of ginger may be due to the combined application of organic manures and biofertilizers, which enhanced soil microbial activity and helped to sustain soil fertility and productivity. Turmeric's soil microbial activity and biomass quickly increased by the use of organic manures were also discovered (Dinesh *et al*., 2010). Greater growth parameters influenced by organic manures and biofertilizers may be the reason for higher values for rhizomes qualities. These parameters enhance the process of photosynthesis, which helps in the production of food. Similar research finding was also reported (Manhas and Gill, 2010). The combined use of biofertilizers has notably enhanced the vegetative growth and yield of turmeric. This improvement can be attributed to the production of various growth-promoting hormones through microbial activities facilitated by the biofertilizers. Moreover, the availability of essential plant nutrients, made possible by these microbial activities, has significantly contributed to overall plant development. The outcomes of the current study align with the findings reported (Kumar *et al*., 2022). The increase in photosynthetic activity, chlorophyll production, nitrogen metabolism and auxin levels within the plants can be attributed to the availability of nutrients derived from bio-fertilizers and organic manure. This factor may be responsible for the observed outcome, leading to an ultimate increase in plant growth and yield. Similar research finding was also reported (Khedkar *et al*., 2023). The efficacy of organic manures was not entirely proven by their sole application during the secondary fingers' development stage. It was believed that the generation of secondary fingers in the reproductive phase was significantly influenced by organic manures, specifically vermicompost and bio-fertilizers. Similarly, the maximum no. of secondary fingers (7.6) was observed with the application of 100% chemical fertilizers combined with bio-fertilizers and vermicompost (Khedkar *et al*., 2023 and Sahoo *et al*., 2020).

Conclusion

The growth and yield parameters of turmeric were influenced by the application of different combinations of organic materials (compost, vermicompost, mustard cake and neem cake) and biofertilizers (Azotobacter, Phosphorus-solubilizing bacteria, and Potassic Mobilizer) results showed that when Vermicompost was combined with NPK at 100% and biofertilizers (BF), it significantly increased various growth parameters such as plant height, the number of tillers per clump, the number of leaves per clump and the length of leaves at 150 days after planting (DAP). Additionally, this combination also had a positive impact on yield parameters, including the weight and breadth of secondary fingers and the overall yield in tons per hectare.

References

Amala, D., Prabhakar B.N., Padma M. and Triveni S. (2019). Effect of integrated nutrient management on yield, quality and economics of turmeric (*Curcuma longa* L.) var. IISR Pragathi. *J. Pharmacog. Photochem.*, **8**, 3112-3114.

Balashanmugam, P.V. (1994). Studies on the influence of *Azospirillum*and phosphobacteria on growth, yield and

quality of turmeric (*Curcuma domestica* Val.) cv. BSR-1. *Ph. D Thesis*, Tamil Nadu Agricultural University, Coimbatore.

Chanchan, M., Ghosh K. and Hore K. (2018). Influence of manures, biofertilizers along with graded levels of inorganic nitrogen and phosphorous on growth, yield and quality of turmeric (*Curcuma longa* L.). *J. Crop Weed*, **14**, 113-118.

Dinesh, R., Srinivasan V., Hamza S. and Manjusha A. (2010). Short-term incorporation of organic manures and biofertilizers influences biochemical and microbial characteristics of soils under an annual crop [Turmeric (*Curcuma longa* L.)]. *Bioresource Technology*, **101**, 4697-4702.

Jat, R.S. and Ahlawat I.P.S. (2004). Effect of vermicompost, biofertilizer and phosphorus on growth, yield and nutrient uptake by gram (*Cicer arietinum*) and their residual effect on fodder maize (*Zea mays*). *Indian J. Agricult. Sci.*, **74**, 359-361.

Kale, R.O., Mallesh B.C., Bano K. and Basvaraj D.J. (1992). Influence of vermicompost application on the available micronutrients and selected microbial population in a paddy field. *Soil Biol. Biochem.*, **24**, 1317-1320.

Khedkar, S.P., Mali P.C., Khandekar R.G., Salvi V.G., Salvi B.R. and Malshe K.V. (2023). Influence of bio-fertilizers and organic manures on growth and yield of turmeric. *The Pharma Innov. J.*, **12(8)**, 2825-2830.

Kumar, K.R., Rao S.N. and Kumar N.R. (2016). Effect of organic and inorganic nutrient sources on growth, quality and yield of turmeric (*Curcuma longa* L.). *Green Farming*, **7**, 889-892.

Kumar, S., Chanchan M., Devi A.B., Devi N.S. and Singh N.G. (2022). Influence of graded levels of inorganic with organics and biofertilizers on growth and yield of turmeric (*Curcuma longa* L.). *The Pharma Innov. J.*, **11(9)**, 2086-2090.

Manhas, S.S. and Gill B.S. (2010). Effect of planting materials, mulch levels and farmyard manure on growth, yield and quality of turmeric (*Curcuma longa* L.). *Indian J. Agricult. Sci.*, **80**, 501-506.

Medda, P.S. (2000). Influence of nitrogen and potassium on growth and yield of turmeric in the alluvial plains of West Bengal. *M.Sc. (Hort.) Thesis*, Bidhan Chandra Krishi Viswavidyalaya, West Bengal.

Nirmalatha, J.D. (2009). Standardization of organic manures and effect of microbial inoculants on growth, yield and quality of kasthuri turmeric (*Curcuma aromatic* Salisb.). *Ph.D. (Hort.) Thesis*, Kerela Agricultural University, Thrissur, 270.

Patil, B.R. and Kunde K.B. (1988). Fertilizer use efficiency and use of biofertilizers of enhanced ginger yield under field conditions. *J. Maharashtra Agricult. Univ.*, **13**, 58-62.

Roy, S.S. and Hore J.K. (2011). Effect of organic manures and bio-fertilizers on growth, yield and quality of turmeric intercropped in arecanut garden. *J. Plantation Crops*, **39**, 01-05.

Sahoo, B.B., Dalei B.B., Phonglosa and Senapati N. (2020). Aptitude of vermicompost and bio-fertilizers on crop growth, yield and economics of turmeric (*Curcuma longa* L.). *Int. J. Curr. Microbiol. Appl. Sci.*, **9(6)**, 138-146.

Shah, N.C. (1997). Traditional uses of turmeric (*Curcuma longa*) in India. *J. Medicinal and Aromatic Plant Sci.*, **19(4)**, 948-54.

Sharma, V., Kanwar K. and Dev S.P. (2004). Efficient recycling of obnoxious weed plants (*Lantana camara* L.) and congress grass (*Parthenium hysterophorus* L.) as organic manure through vermicomposting. *J. Indian Soc. Soil Sci.*, **52**, 112-114.

Shilpa, J. and Niveditha K.J. (2009). Health benefits of spices. *Spices India*, **22**, 19-21.

Singh, D., Kumar R., Walia S.S., Brar A.S. and Singh R. (2017). Productivity and economics of turmeric (*Curcuma longa* L.) in response to nitrogen applied through different sources in conjunction with biofertilizer consortium. *J. Appl. Nat. Sci.*, **9**, 497-501.

Sreenivas, C., Muralidhar S. and Rao M.S. (2000). Vermicompost: a viable component of IPNSS in nitrogen nutrition of ridge gourd. *Annals Agricult. Res.*, **21**, 108-113.

Vadiraj, B., Siddagangaiah D. and Potty S.N. (1998). Response of coriander (*Coriandrum sativum* L.) cultivars to graded levels of vermicompost. *J. Spices Aromatic Crops*, **7**, 141-143.

Velmurugan, M. (2002). Effect of Organic manures and biofertilizers on growth, yield and quality of turmeric (*Curcuma Longa* L.) cv. Bsr2. (*Doctoral dissertation*, Tamil Nadu Agricultural University, Tamil Nadu.

Wang, B. and Qiu Y.L. (2006). Phylogenetic distribution and evaluation of mycorrhizas in land plants. *Mycorrhiza*, **16**, 299-363.