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PHYSICOCHEMICAL AND BIOLOGICAL CHARACTERIZATION OF VERMICOMPOST PREPARED FROM DIFFERENT RESIDUES OF AGROFORESTRY COMPONENT

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ABSTRACT

The present study was conducted in the year 2018-19 at DBSKKV, Dapoli, Maharashtra (India) with aim to physico-chemically and biologically characterize the vermicomposts prepared from the residues obtained from different agroforestry sources. *Eisenia foetida* was used in vermicomposting. The residues of 14 easily available agroforestry plant species were collected and prepared in different randomized blocks. Among the various species evaluated, *Megathyrsus maximus, Eluecine coracana, Themenda species, Setaria sphacelata, Gmelina arborea* and *Termenelia tomentosa* proved significantly superior in yielding higher and enriched vermicompost. Maximum decomposition during partial decomposition study for 120 days was observed in cereal and grass species. The 20 released earthworms in each treatment showed a population of 876.5 and 646.5 in *M. maximus* and *O. sativa* residues. The maximum recovery of vermicompost was observed in *Bridelia retusa, T. tomentosa, M. maximus* and *S. sphacelate.* Significant improvements in colour and bulk density were noticed in cereal, grass and nutritious plantation species (*T. tomentosa*). Maximum improvement in some physicochemical characteristics [pH, EC, OC, available NPK, total NPK] and microbial activities [CO_2 evolution and bacterial, actinomycete and fungal populations] were observed in easily decomposed and nutritious species (*T. tomentosa, G. arborea).* Significantly high dehydrogenase activity, soil microbial biomass carbon and nitrogen, total N, total C and C:N ratio were observed in *M. maximus, E. coracana, G. arborea* and *T. tomentosa*. These species are recommended for producing quality vermicompost and its production on the farmers field.

Keywords: Bacteria, C:N ratio, CO_2, colour, dehydrogenase, vermi-composting

INTRODUCTION

Agroforestry residues/litters from farmer's fields and plantation crops constitute a potential source of carbon and plant nutrient recycling through vermicomposting. Vermicompost plays a major role in improving the growth and yield of different field crops, vegetables, flower and fruit crops. It contains high quantity of plant available nutrients, disease-suppressive microorganisms, humic acids and growth-promoting hormones (Reinecke and Viijoen, 1990; Lim and Wu, 2015). Vermicompost is a mixture of worm castings, organic materials including humus like earthworms, cocoons and other microorganisms obtained during feeding activity of earthworms on organic materials (Wani *et al*.,

2013). Earthworm *Eisenia foetida* dominantly survives at medium to low temperature and can adopt as vermicomposting agent in tropical and subtropical regions also. Vermicomposting involves an aerobic bio-oxidation and non-thermophilic process of organic waste decomposition. Earthworms fragment and mix the decomposing substrate and enrich it as well as promote microbial activity (Bhat *et al*., 2015). The production of vermicompost is depends on the availability of easily decomposable organic matters.

The on-farm vermicompost production is an important feature of organic and sustainable crop production which helps in maintaining the crop and soil health. Vermicompost is used in agriculture both as an organic fertilizer and as soil amendment due to the presence of large biological components and abundantly available nutrients. The recycling of agroforestry litters and residue can mitigate the persistent organic residue problems in India. On the basis of the availability of litter and residues sources, these can be used for production of vermicompost. Hence, the present study was aimed to recycle the agro-forestry litters/residues available at farms through use of *Eisenia foetida* for vermicompost production.

MATERIALS AND METHODS

The experiment was conducted at All India Coordinated Research Project on Agroforestry, Dr. BSKKV, Dapoli, Maharashtra (India) in the years 2018 & 2019. Fresh cow dung was collected from nearby farmer's house. Fourteen agroforestry plant species litters/residues *viz*., Guinea grass (*Megathyrsus maximus*), Setaria grass (*Setaria sphacelata*), fulgavat (*Themenda* sp.), mangium (*Acacia mangium*), glyricidia (*Glyricidia sepium*), coconut (*Cocos nucifera*), mango (*Mangifera indica*), jambhul (*Synzygium cumini*), asana *(Bridelia retusa)*, ain (*Termenelia tomentosa*), bamboo *(Dendrocalamus stocksii)*, rice (*Oryza sativa*), finger millet (*Eluecine coracana*) and shivan (*Gmelina arborea)* were collected locally. These substrates were put in separate trough and arranged in a randomized block design. Each treatment was replicated three times. The troughs used were 90 cm high and 2 60 cm wide. *Eisenia foetida* earthworms were collected from local farmer's field and multiplied at University Vermicomposting Unit, Dr. BSKKV, Dapoli. Twenty earthworms were released in each trough after partially decomposing the agroforestry litters. Partial decomposed waste materials and cow dung slurry (in 10:1 ratio) were spread in trough layer by layer. After introducing 20 earthworms in each treatment, The material was properly moistened by frequently spraying water using hand sprinkler. The populations of earthworm were observed in the upper layer of vermibed. The vermibeds were covered by dry banana leaves to avoid sunlight. Each day the desired amount of water was sprinkled to maintain the humidity level of 50% and facilitate the effective functioning of earthworms in vermibeds. The vermibeds were protected from predators, ants and other insects throughout production period. Weight loss of composting materials was computed daily as per Xiong *et al*. (2008):

Weight loss per day (%) = (Weight loss during the measured days/initial weight) x 100

After 40-45 days, the whole vermicompost from vermibed and castings were analysed. The castings were manually collected and separated from earthworms. The collected casting (compost) were packed in polythene bag and stored in cool and shady place. Experimental vermicompost samples were air-dried, powdered and passed through < 2 mm sieve for determination of physicochemical properties. Electrical conductivity, soil reaction, organic carbon and available NPK were determined as per Jackson (1973). The populations of bacteria, fungi and actinomycetes were determined by serial dilution plate technique (Dhingra and Sinclair, 1993). For assessing the microbial populations, nutrient agar medium, rose Bengal agar medium and Ken Knight medium were used for estimation of bacterial, fungal and actinomycete populations, respectively. Soil microbial biomass carbon and nitrogen were determined by chloroform fumigation technique

(Brookes *et al.,* 1985). CO_2 evolution of soil was determined by alkali trap method (Anderson, 1982). The vermicompost dehydrogenase enzyme activity was determined by triphenyl formazan (TPF) produced by the reduction of 2,3,5-triphenyl tetrazolium chloride (TTC) [Klein *et al.,* 1971]. Bulk density of soil was determined by core technique (Blake and Hartge, 1986), while vermicompost colour was measured by using Munsell Soil Color Charts (Munsell, 2000).

Oven-dried plant samples were ground to required fineness, digested for N, P, K, S, Zn and Fe determinations. The nitrogen was estimated by Microkjeldhal method (AOAC, 1990). Phosphorus was estimated by vanado-molybdo-phosphoric yellow colour method and potassium by triacid extract on flame photometer (Jackson, 1973). The total carbon was determined by dry combustion method (Tiessen and Moir, 1993). The experimental data was subjected to the analysis of variances and treatment means were compared. The significant differences were tested at 5% level of significance as per Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The use of *Eisenia foetida* for vermicomposting of various agroforestry residues revealed that 50% decomposition of *Setaria sphacelata* occurred in 60 days, followed by *Gliricidia sepium* in 105 days. The other species *viz*., *Megathyrsus maximus*, *Themenda* sp., *Oryza sativa* and *Eluecine coracana* showed 50% decomposition in 120 days (Table 1). The lowest decomposition was achieved in *Cocos nucifera* substrate, followed by *Acacia mangium* and *Synzygium cumini* in 120 days. During degradation, the ingestion of organic materials by earthworm would partially degrade the materials by mechanical action in their gut as well as by microbial and enzymatic activities (Svensson and Friberg, 2007). The maximum earthworm population was observed in *M. maximus* (876.5) substrate, followed by *O. sativa* (646.5). However, the highest number (21.5) of large sized earthworms were observed in *Terminalia tomentosa* treatment, followed by Guinea grass. Nogales *et al*. (1999) evaluated the suitability of residue biosolids and cattle manure as substrates for vermicomposting and

Table 1: Weight loss (%) of agroforestry residues during vermicomposting

Treatments	Weight loss (%)								
	0 DAI	15 DAI	30 DAI	45 DAI	60 DAI	75 DAI	90 DAI	105 DAI	120 DAI
Megathyrsus maximus	12.18	29.47	37.72	41.40	43.18	46.18	47.49	49.81	50.79
Setaria sphacelate	13.59	27.42	43.67	46.64	50.23	52.38	54.43	57.47	62.78
Themenda species	11.87	23.55	28.64	31.58	39.66	42.23	44.22	45.60	50.50
Acacia mangium	13.99	4.93	6.21	7.45	9.80	10.59	12.17	13.81	16.67
Gliricidia sepium	12.92	20.00	36.49	40.18	44.82	47.35	49.80	51.94	54.35
Cocos nucifera	10.24	0.49	1.12	3.58	5.16	7.89	8.78	11.33	13.92
Mangifera indica	10.48	3.45	11.02	12.38	16.08	18.33	19.58	22.06	24.54
Synzygium cumini	11.47	8.02	11.66	12.46	14.17	16.10	16.85	19.44	20.80
Bridelia retusa	11.12	8.20	11.55	16.28	17.39	17.92	19.70	22.37	24.92
Termenelia tomentosa	13.05	14.65	16.02	19.45	26.09	26.63	26.97	32.53	35.87
Dentrocalamus stocksii	8.95	7.91	15.94	17.40	18.81	19.71	24.82	33.88	36.51
Oryza sativa	13.22	15.08	26.17	28.23	37.60	39.22	41.15	45.04	50.09
Eluecine coracana	5.40	5.14	8.87	11.90	15.20	16.40	23.14	45.33	67.31
Gmelina arborea	9.02	4.11	4.61	6.05	7.35	10.39	13.24	22.73	29.16
Mean	11.92	13.59	20.52	23.09	26.91	28.71	30.50	33.77	36.81
SE+	0.53	1.61	1.92	2.61	2.79	2.32	2.68	3.16	3.85
$CD_{0.05}$	1.62	4.92	5.87	7.98	8.52	7.10	8.20	9.66	11.77
CV (%)	6.69	18.49	14.64	17.53	15.97	12.38	13.20	13.23	14.173

Table 2: Weight loss, substrate decomposition and vermicompost production from agro-forestry residues

Treatments	Initial litter weight (kg)	Weight of decomposed material		Production of vermi-compost (kg)	Vermicompost production (%)		Earthworm production (No.)		Total earth-worms (No.)
		(kg)	% of initial wt.		Compost recovery	Decomposed material	Large (>10 cm)	Small (<10 cm)	
M. maximus	16.76	6.85	40.87	1.90	11.34	27.73	19.0	857.5	876.5
S. sphacelate	19.46	7.17	36.85	1.88	9.66	26.22	18.0	454.5	472.5
Themenda sp.	17.41	7.64	43.88	1.98	11.37	25.91	16.5	569.5	586.0
A. mangium	19.70	11.51	58.43	0.81	4.11	7.04	18.0	116.5	134.5
G. sepium	21.05	8.51	40.43	1.55	7.36	18.21	14.5	437.5	452.0
C. nucifera	17.50	10.91	62.34	1.77	10.11	16.22	18.5	570.5	589.0
M. indica	14.51	8.77	60.44	1.92	13.23	21.89	16.5	333.5	350.0
S. cumini	15.59	8.95	57.41	1.33	8.53	14.86	15.5	204.5	220.0
B. retusa	16.87	8.72	51.68	3.11	18.44	35.66	15.5	281.0	296.5
T. tomentosa	19.23	8.54	44.41	3.12	16.22	36.53	21.5	428.5	450.0
D. stocksii	14.50	6.88	47.45	1.80	12.41	26.16	18.0	168.0	186.0
O. sativa	20.21	8.38	41.46	2.05	10.14	24.46	13.0	633.5	646.5
E. coracana	14.89	6.75	45.33	1.31	8.80	19.40	18.5	488.0	506.5
G. arborea	15.69	7.42	47.29	1.42	9.05	19.13	17.0	395.0	412.0
Mean	17.73	8.57	48.45	1.93	11.77	22.82	17.04	421.2	-
SE±	0.74	0.57	-	0.25	-	-	1.41	57.27	-
$CD_{0.05}$	2.26	1.74	-	0.76	-	-	4.30	174.97	-
CV (%)	6.02	9.65	-	19.19	-	-	11.60	19.09	-

Note: The number of earthworms released in each treatment at initial stage were 20.

found that organic materials serve as readily available feed materials to the worms so they multiply their populations. The minimum earthworm population was observed in *A. mangium* treatment, followed by *Dendrocalamus stocksii* and *S. cumini* [Table 2]. Less time taken in weight loss of some residues appears due to the presence of less lignin content in them (Chaudhari and Bhattacharjee, 2002). The potential of organic inputs to supply nutrients depends on the quality of lignin/polyphenol to N ratio which seems to be the most robust ratio for predicting mass loss and nitrogen release during residue decomposition (Mafongoya *et al.,* 2008). The significantly high vermicompost production over initial plant residue was found in *Bridelia retusa* (18.44%), followed by *T. tomentosa* (16.22%), whereas maximum vermicompost production over decomposed material was found in *T. tomentosa* (36.53%) and *B. retusa* (35.66%) which were at par. The lowest vermicompost production was noticed in *A. mangium* at both the levels i.e. over-plant residue (4.11%) and decomposed material (7.04%), followed by *G. sepium* at both the level (Table 2). The agroforestry residues and bedding materials contain easily metabolizable organic matter as well as low concentration of growth retarding substances which favour fast growth of earthworm in substrate leading to higher vermicompost yield (Joshi *et al*., 2015). The increase in temperature and moisture, less lignin and higher association of microbial community during residue decomposition revealed enhanced decomposition rate and weight loss (Martinez *et al.,* 2013) which ultimately increases the production of vermicompost (Manohar *et al*., 2016).

The nutrients content in vermicompost showed significant variations in various treatments during compost preparation at 0, 20 and 45 DAI (Table 3). Maximum N content in vermicompost at 45 DAI was found in *T. tomentosa* (1.83%), *G. sepium* (1.82%) and *Gmelina arborea* (1.80%) which were at par with each other. The maximum P content in vermicompost at 45 DAI was noticed in *Themenda* sp. (0.57%), followed by *T. tomentosa* (0.56%) and *M. maximus* (0.56%). The maximum P content in vermicompost at 45 DAI was observed in *S. cumini* (1.35%), *M. maximus* (1.34%) and *G. arborea* (1.34%) which were at par with each other. The lowest content of 1.58% N and 1.16% K in vermicompost at 45 DAI was found in *D. stocksii,* whereas lowest content of P (0.48%) was found

Table 3: NPK content in various decomposed materials and vermicomposts

Treatments	Colour	Bulk density (Mg m^{-3})	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
			Decomposed material		Vermi-compost	Decomposed material		Vermi-compost	Decomposed material		Vermi-compost
			0 DAI	20 DAI	45 DAI	0 DAI	20 DAI	45 DAI	0 DAI	20 DAI	45 DAI
M. maximus	Very dark brown	0.28	1.00	1.00	1.76	0.39	0.45	0.56	0.86	0.93	1.34
S. sphacelata	Brown	0.30	0.74	1.12	1.74	0.38	0.44	0.49	0.92	0.86	1.32
Themenda sp.	Very dark brown	0.28	0.88	1.19	1.72	0.41	0.45	0.57	0.60	0.79	1.33
A. mangium	Light brown	0.34	0.78	1.26	1.29	0.36	0.41	0.48	0.48	0.61	1.18
G. sepium	Dark brown	0.30	1.07	1.79	1.82	0.39	0.43	0.49	0.77	0.97	1.19
C. nucifera	Black	0.29	0.88	1.07	1.43	0.42	0.46	0.54	0.73	1.04	1.33
M. indica	Dark brown	0.29	1.01	1.32	1.39	0.42	0.48	0.51	0.55	0.71	1.23
S. cumini	Black	0.31	1.03	1.03	1.48	0.41	0.49	0.50	0.85	0.90	1.35
B. retusa	Dark brown	0.33	0.86	1.06	1.71	0.43	0.47	0.53	0.89	1.01	1.30
T. tomentosa	Black	0.32	1.05	1.73	1.83	0.41	0.48	0.56	0.85	0.97	1.31
D. stocksii	Dark brown	0.35	0.96	1.19	1.33	0.38	0.45	0.51	0.57	0.66	1.16
O. sativa	Dark grey	0.32	0.73	1.14	1.72	0.45	0.48	0.53	0.77	1.02	1.23
E. coracana	Very dark brown	0.27	0.96	1.20	1.73	0.39	0.45	0.54	0.92	0.81	1.34
G. arborea	Black	0.28	1.03	1.72	1.77	0.42	0.48	0.56	0.83	0.91	1.33
Mean	-	0.30	0.93	1.29	1.62	0.40	0.45	0.52	0.75	0.86	1.28
SE+	-	0.007	0.03	0.017	0.04	0.01	0.004	0.004	0.016	0.017	0.03
$CD_{0.05}$	-	0.022	0.09	0.052	0.12	0.02	0.013	0.013	0.048	0.052	0.08
CV (%)	-	3.47	4.52	1.89	3.41	1.98	1.28	1.16	2.95	2.79	2.53

in *A. mangium*. Grass agroforestry residue species showed faster decomposition than tree species residues probably due to low lignin content which improved microbial activity thereby increased nutrient mineralization during vermicomposting process (Hait and Tare, 2011).

The vermicompost prepared from various agroforestry species showed variations in their colour. Normal black colour compost was observed in *G. arborea*, *T. tomentosa* and *C. nucifera* whereas compost obtained from *M. maximus*, *Themenda* sp. and *Eluecine coracana* were very dark

Table 4: Chemical properties of vermi-composts prepared from various agroforestry residues

Treatments	pH (1:2.5)	EC (dSm^{-1})	Organic carbon (%)	NH_4^+- N (mg kg^{-1})	Available P (mg kg^{-1})	Available K (mg kg^{-1})
M. maximus	6.81	0.82	22.65	325.17	30.66	5460.47
S. sphacelate	7.04	0.69	21.85	323.01	29.30	5324.97
Themenda sp.	7.10	0.78	21.70	325.70	30.02	2625.10
A. mangium	6.91	0.21	17.25	277.71	24.38	2356.30
G. sepium	6.85	0.73	23.09	340.42	30.69	5234.10
C. nucifera	7.23	0.30	20.08	327.49	25.27	4015.02
M. indica	6.76	0.41	18.63	272.83	27.48	5227.22
S. cumini	6.96	0.93	19.94	295.63	29.08	4346.49
B. retusa	6.93	0.40	20.79	286.37	25.54	2925.88
T. tomentosa	6.82	0.39	22.19	315.48	29.35	5496.51
D. stocksii	6.61	0.34	16.74	290.68	22.94	2389.63
O. sativa	6.92	0.47	18.51	289.83	23.85	4076.83
E. coracana	7.18	0.53	21.20	329.91	30.45	5496.96
G. arborea	7.25	0.53	23.06	322.69	30.05	5201.33
Mean	6.91	0.54	20.54	295.17	27.78	4298.34
SE+	0.16	0.01	0.44	9.33	0.73	142.56
$CD_{0.05}$	0.50	0.04	1.37	28.53	2.25	435.47
CV (%)	3.36	3.91	3.09	4.28	3.74	4.69

brown. The dark colour compost reflects the inherent quality of material used and formation of humus compound (Wani *et al*., 2013). The bulk density of composted materials from various agro-substrates ranged from 0.27 to 0.34 Mg m^{-3} (Table 3). The compost from *G. arborea* had significantly higher pH value (7.25) while maximum electrical conductivity (0.93 dSm^{-1}) was found in compost from *S. cumini.* The maximum organic carbon (23.09%), NH_4^+-N (340.42 mg kg^{-1}) and available P (30.69 mg kg^{-1}) was in compost from *G. sepium* while maximum available K (30.69 mg kg^{-1}) was in compost from *E. coracana*. The lowest pH (6.91), EC (0.21 dSm^{-1}), organic carbon (17.25%), ammoniacal N (277.71 mg kg^{-1}) and available K (22.94 mg kg^{-1}) were observed in compost from *A. mangium;* whereas the lowest available P (22.94 mg kg^{-1}) was in compost from *D. stocksii* (Table 4). The quality and nutritious agroforestry residue species affected the quality of the vermicompost prepared (Kanchilakshmi *et al*., 2015). The mineralization of N and P into nitrites/nitrates and orthophosphates and bioconversion of organic materials into intermediate species of organic acids seems to have decreased the pH and salinity of vermicompost (Ndegwa and Thompson, 2000). The ratio of NO_3^- to NH_4^+ in vermicomposts are important to understand the leaching capacity of N, a reliable indicator of the maturity and stability of vermicomposts. It also indicates nitrification and vermicompost maturity (Dominguez and Gomez-Brandon, 2013).

Significantly higher bacterial populations were noticed in compost prepared from *E. coracana*, followed by *M. maximus*, *Themenda* sp., *G. sepium* and *S. phacelata* at 45 DAI than other agroforestry residues (Table 5). Maximum fungal population (112.9 x 10^4 CFU g^{-1} soil) at 45 DAI was found in compost from *G. sepium*. Maximum actinomycetes population (189.6 x 10^4 CFU g^{-1} soil) at 45 DAI was noticed in *S. phacelata*. Low bacterial, actinomycete and fungal populations were in composts from *A. mangium* and *D. stocksii*. which may be ascribed to slow decomposition and non-availability of readily available food for microbes during composting and slow mineralization of nutrients due to high lignin content in these residues. Devi *et al*. (2009) reported that vermicomposts may contain bacteria, fungi and actinomycetes population of 126 x 10^6, 28 x 10^4 and 93 x 10^5 CFU g^{-1}, respectively. Total bacterial counts can exceed 10^{10} CFU g^{-1}. It has been reported that vermicomposts contain populations of both nitrifying and denitrifying bacteria (Pathma and Sakthivel, 2012).

Table 5: Bacterial, fungal and actinomycete population (x 10^4 CFU g^{-1} soil) in decomposed materials and vermicompost from various agroforestry substrates

Treatments	Bacteria			Fungi			Actinomycetes		
	Decomposed material		Vermi-compost	Decomposed material		Vermi-compost	Decomposed material		Vermi-compost
	0 DAI	20 DAI	45 DAI	0 DAI	20 DAI	45 DAI	0 DAI	20 DAI	45 DAI
M. maximus	209.4	222.8	236.7	81.1	91.6	111.3	163.1	178.0	183.2
S. sphacelate	186.2	191.3	232.9	57.2	65.6	109.7	144.3	151.6	189.6
Themenda sp.	137.6	143.7	236.2	40.8	49.7	107.1	126.4	136.7	175.8
A. mangium	147.8	154.1	192.7	26.3	33.2	84.2	102.9	121.9	158.4
G. sepium	180.8	183.1	235.3	71.1	76.6	112.9	158.7	167.6	186.9
C. nucifera	118.4	125.7	215.3	63.2	67.4	94.5	150.2	168.4	181.5
M. indica	146.7	155.2	218.8	65.3	76.7	97.5	103.4	110.2	170.6
S. cumini	167.0	173.1	225.5	57.7	65.7	103.7	116.4	126.2	180.9
B. retusa	175.7	188.0	218.1	42.4	53.8	96.8	128.4	138.3	163.0
T. tomentosa	193.8	211.0	228.1	52.2	70.8	112.2	123.4	130.9	160.8
D. stocksii	153.1	163.3	208.0	27.8	36.6	85.1	103.1	120.1	154.9
O. sativa	186.0	192.8	213.1	71.2	83.8	102.6	124.6	134.2	157.5
E. coracana	214.2	222.4	238.1	86.3	80.8	108.3	186.6	193.7	184.6
G. arborea	200.0	202.6	216.0	76.1	89.7	110.2	135.9	144.5	169.0
Mean	171.3	179.4	222.5	55.5	64.3	102.6	136.6	147.2	172.6
SE±	1.7	1.5	5.1	1.3	0.8	2.6	1.0	1.2	5.1
$CD_{0.05}$	5.1	4.5	15.6	3.9	2.5	8.0	3.1	3.8	15.6
CV (%)	1.4	1.2	3.3	3.1	1.8	3.6	1.1	1.2	4.2

Table 6: CO_2 evolution and dehydrogenase enzyme activities of during vermicomposting

Treatments	CO_2 evolution (mg 100 g^{-1} soil)			DHA (µg TPF g^{-1}soil 24 hr^{-1})		
	Decomposed material		Vermicompost	Decomposed material		Vermicompost
	0 DAI	20 DAI	45 DAI	0 DAI	20 DAI	45 DAI
Megathyrsus maximus	248.13	283.38	319.38	217.20	258.03	314.57
Setaria sphacelate	244.58	280.56	310.43	218.41	280.93	309.37
Themenda sp.	242.33	264.00	320.54	191.51	248.10	297.08
Acacia mangium	228.28	263.91	274.96	185.79	277.66	275.82
Gliricidia sepium	250.80	266.20	314.60	218.43	264.37	313.72
Cocos nucifera	245.22	283.80	310.72	213.37	265.70	309.10
Mangifera indica	235.40	259.41	313.14	179.61	273.53	301.47
Synzygium cumini	256.59	277.73	311.39	209.75	273.18	315.18
Bridelia retusa	217.80	261.35	308.27	190.33	277.63	300.63
Termenelia tomentosa	235.73	277.73	317.78	215.67	265.26	310.81
Dendrocalamus stocksii	223.22	262.98	288.09	207.56	270.70	304.02
Oryza sativa	243.11	264.98	312.66	216.12	282.96	302.97
Eluecine coracana	248.29	276.89	319.51	228.21	278.98	316.33
Gmelina arborea	244.20	262.43	302.54	220.63	171.41	310.68
Mean	240.26	270.37	308.85	208.03	4.65	305.83
SE±	5.27	3.92	7.39	5.65	14.22	4.45
$CD_{0.05}$	16.11	11.97	22.59	17.25	2.43	13.59
CV (%)	3.10	2.05	3.39	3.84	258.03	2.06

During vermicomposting process, significantly high activities of both respiration rate (in terms of CO_2 evolution) and dehydrogenase enzyme on 45 DAI were observed by use of *Eluecine coracana* (319.51 mg 100 g^{-1} soil and 316.33 µg TPF g^{-1} soil 24 hr^{-1}, respectively), followed by *M. maximus* (319.38 mg 100 g^{-1} soil and 314.57 µg TPF g^{-1} soil 24 hr^{-1}, respectively) and *Termenelia tomentosa* (317.78 mg 100 g^{-1} soil and 310.817 µg TPF g^{-1} soil 24 hr^{-1}, respectively), though highest respiration rate was found in *Themenda* sp. treatment (320.54 mg 100 g^{-1} soil) but it was at par with above treatments. The dehydrogenase activity (indicator of microbial abundance) increased with increase in the amounts of vermicompost substitution and enhanced O_2 levels during decomposition of residues and organic matter (Broz *et al*., 2016). The lowest values of respiration rate and dehydrogenase enzyme activity were found in vermicompost prepared from *Acacia mangium* and *Dendrocalamus stocksii* (Table 6), which may be attributed to the slow decomposition rate of residues and less mineralization of nutrients due to inference from lignin and other inhibitory compounds (Garg *et al*., 2006). The consumption of available carbon as a source of energy by earthworms and other microorganisms may have decreased the large fraction of total organic carbon in the form of CO_2 (Wani *et al*., 2013). The perusal data on MBC, MBN, microbial C:N ratio, total C, total N and C:N ratio revealed significant variations among the various treatments. The C:N ratio of microbial biomass in test residues ranged from 4.0 to 5.5. Significantly narrow microbial C: N ratio was found in treatment *M. maximus*, followed by *S. sphacelata*, *Themenda* sp., *E. coracana* and *G. sepium* than other residues. Microbial biomass is the most active and dynamic pool of soil organic matter which acts as transient nutrient sink and is responsible for release of nutrients from organic matter for plant use. The improvement in C:N ratio reflected higher microbial activity and faster mineralization. narrower C:N values are good for higher nutrient availability while wider C:N ratios are not suitable and cause higher microbial immobilization (Brooks *et al*., 1985). The C:N ratio of prepared vermicompost ranged from 15.49 to 19.96 with maximum improvements in vemicomposts from *M. maximus*, followed by *Themenda* sp., *G. sepium*, *S. sphacelata*, *E. coracana* and *T. tomentosa* which were at par with (Table 7). The lower total carbon, total nitrogen and C:N ratio in vermicompost was

Table 7: Microbial biomass carbon (MBC), microbial biomass nitrogen (MBN), microbial C:N ratio, total carbon, total nitrogen and C:N ratio of vermicompost prepared from various agroforestry residues

Treatments	MBC ($\mu g\ g^{-1}$)	MBN ($\mu g\ g^{-1}$)	Microbial C:N ratio	Total C (%)	Total N (%)	C:N ratio of vermicompost
Megathyrsus maximus	1234.5	307.1	4.0	27.18	1.76	15.49
Setaria sphacelate	1090.0	266.6	4.1	27.70	1.74	15.92
Themenda species	1125.3	272.5	4.1	26.93	1.72	15.70
Acacia mangium	967.7	177.6	5.5	25.75	1.29	19.96
Gliricidia sepium	1212.9	279.0	4.4	28.85	1.82	15.85
Cocos nucifera	1040.1	210.6	4.9	27.75	1.43	19.47
Mangifera indica	984.8	208.7	4.7	27.08	1.39	19.55
Synzygium cumini	1084.9	242.6	4.5	26.80	1.48	18.17
Bridelia retusa	1175.1	251.6	4.7	28.84	1.71	16.91
Termenelia tomentosa	1187.3	267.8	4.4	29.65	1.83	16.24
Dendrocalamus stocksii	995.3	191.7	5.2	26.25	1.33	19.81
Oryza sativa	1018.8	239.0	4.3	28.90	1.72	16.85
Eluecine coracana	1182.3	279.8	4.2	27.78	1.73	16.10
Gmelina arborea	1209.4	273.3	4.4	30.33	1.77	17.13
Mean	1107.7	247.7	4.5	27.84	1.62	17.37
SE±	14.0	3.4	0.1	0.62	0.04	17.38
$CD_{0.05}$	42.6	10.4	0.3	1.86	0.12	1.98
CV (%)	1.8	2.0	2.7	3.11	3.41	5.30

observed in *A. mangium* and *D. stocksii* perhaps due to the slow mineralization of nitrogen in vermicompost. The carbon mineralization and its loss by the action of microbes might be responsible for nitrogen enhancement (Viel *et al*., 1987) and nitrogen transformations by earthworms during vermicomposting, by enhancing nitrogen mineralization (Atiyeh *et al*., 2000). It also depends on many other factors like C:N ratio, nutrients, moisture level, microbes, decomposition process, etc. (Schnitzer, 1991). The improvement in C:N ratio might be due to high decomposition, microbial activities and mineralization in terms of carbon to nitrogen helps for high humus formation and contributed quality vermicompost (Wani *et al*., 2013).

Conclusion: The study revealed that the quality vermicompost can be prepared by using various agroforestry species like *Megathyrsus maximus, Eluecine coracana, Themenda* sp., *Setaria sphacelata, G. arborea* and *T. tomentosa.* These substrates influenced physicochemical and biological properties of vermicompost and are recommended for vermicomposting and its production. These species are easily available in farmer's field so can mitigate the manure problems. The use of *Eisenia foetida* for vermicomposting of agroforestry residues on the basis of their nutrient content may reduce the burden of synthetic fertilizers. The wastes from agroforestry plants raised on marginal lands can be used for recycling and conversion of quality manure. Among the various species, grasses (*M. maximus, Themenda* sp. and *S. sphacelata*) and cereals (*E. coracana*) decomposed fast and are nutritious species (*Gmelina arborea, Termenelia tomentosa*) so can be preferred for quality vermicomposting and recycling.

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