DOI : 10.5958/2349-4433.2024.00067.2

J Krishi Vigyan 2024, 12(2) : 372-378

Reviving Soils with Leaf Litter Composts for Enhanced Yields in Amaranthus

Harishma S J, Sheeba Rebecca Isaac* and Devika Viswanathan
College of Agriculture, Vellayani, Thiruvananthapuram 695 522, Kerala
Kerala Agricultural University

ABSTRACT

Leaf litters are potential organic nutrient inputs and assume prime importance in the present era of eco-friendly farming. An experiment was conducted at College of Agriculture, Vellayani to evaluate the efficacy of composted litter as nutrient source in Amaranthus and the changes elicited in soil properties. The treatments included litter composts of jack and coconut leaves prepared with different enhancers of decomposition and enriched with PGPR Mix I biofertilizers and were laid out in RBD replicated thrice. Litter compost application was found to have favourable influences on soil available nutrient status and microbial population. Vegetable yields (20.20 Mg/ha) and economic returns (B:C ratio- 1.92. were significantly higher in the substitution of 50% RDN with coconut leaf litter compost [composting inoculum (liquid) + earthworms]. The increase in yields ranged from 3 to 46 per cent with compost application over the control. Hence, it was concluded that conversion of leaf litter to valuable organic manures through composting and inclusion in production package of amaranthus ensures reduction of chemical nitrogen input usage by 50 per cent, triggers microbial activity and sustains fertility in soil.

Key Words : Amaranthus, Coconut, Compost, Jack, Leaf litter, Soil, Yield

INTRODUCTION

Soil is the most important natural resource base for crop production. Organic and inorganic inputs are critical in agriculture and a balanced use is proclaimed as the most effective means of ensuring sustainable production. The search for alternative nutrient inputs brings to focus the organic manures that are locally available. Apart from the biowastes generated in the livestock and poultry sector, those generated in the different cropping systems can also be effectively utilized in crop production.

Leaf litter in tree-based ecosystems serves as a mulch and adds to the soil nutrient status on decomposition. Even so, under non-farm situations, the litter is a menace (Vasanthi et al, 2013) and are often removed by burning, a practice that attenuates air pollution. Nutrient accretion from leaf litter on decay have been documented, but natural decomposition is a time consuming process and might take from five months to even more than a year for the release of nutrients (Isaac and Nair, 2006). However, composting converts the litter into a valuable nutrient input in crop production. The research work aimed to assess the efficacy of coconut (*Cocos nucifera*) and jack (*Artocarpus heterophyllus*) litter composts in amending soil properties and effect on the vegetative growth and yield of the leafy vegetable, Amaranthus (*Amaranthus tricolor*).

MATERIALS AND METHODS

The experiment was carried out in the Instructional Farm, College of Agriculture Vellayani, Thiruvananthapuram, Kerala. The site located at 8° 30'N latitude, 76° 54' E longitude and at an altitude of 29 m above mean sea level enjoys a warm humid tropical climate. A total of 288.5 mm rainfall was received during the period of study. The mean minimum and maximum temperatures recorded were 24.70 and 32.62^{o} C respectively.

Leaf litters of coconut and jack collected from bearing trees were cleaned of extraneous material and composted, based the technologies

Corresponding Author's Email - sheebarebecca@yahoo.co.in
Present address : Regional Agricultural Research Station, Kumarakom, Kottayam 686 563

Table. 1 Composting methods adopted (Harishma, 2017)

Treatments	Composting method	
T_1	Jack leaf litter + poultry manure	Co-composting- litter mixed with poultry manure @ 10% w/w
T_2	Jack leaf litter + Composting inoculum (CI) powder + earthworms	CI powder (*Lactobacillus*, *Pseudomonas putida*, *Bacillus subtilis*, *Isaria farinosa*, *Trichoderma viride* and *Pencillium griseofulvum*) was added @20g/kg litter mixture*, and earthworms were released 2 weeks later
T_3	Jack leaf litter (CI) liquid	CI (*Bacillus subtilis*) was added to the litter mixture*, @ 1000mL m^{-3}
T_4	Thermochemical jack leaf litter compost	Chemical decomposition of well ground, litte with HCl(0.25 N) followed by KOH (0.5 N) at 100^o C and ambient pressure
T_5	Coconut leaf litter + poultry manure	Co-composting of litter with poultry manure @ 10% w/w
T_6	Coconut leaf litter + CI (liquid) + earthworms	CI (*Bacillus subtilis*) was added to coconut litter + fresh cow dung*, @ 1000mL/m^3 and earthworms were released 2 weeks later
T_7	Coconut leaf litter + CI (powder)	CI (powder) added to litter + fresh cow dung mix*, @ 20g/kg litter
T_8	Thermochemical coconut leaf litter compost	Chemical decomposition of well ground, litte with HCl (0.25 N) followed by KOH (0.5 N) at 100^o C and ambient pressure

*litter was mixed with fresh cow dung in 4:1 ratio

found best for coconut and jack litters (Harishma, 2017) as detailed in Table 1. The prepared composts were dried in shade, sieved and enriched with the biofertilizer, Plant Growth Promoting Rhizobacteria (PGPR Mix I) @ 10g/kg and rock phosphate @ 150g/kg. The consortium contained N fixers, *Azospirillum lipoferum, Azotobacter chroococcum,* P solubilizer, *Bacillus megaterium,* and K solubilizer, *Bacillus sporothermodurans*. In addition, leaf litter composted by thermo-chemical digestion (Sudharmaidevi et al, 2017) was also included as treatments in the field experiment.

The experiment followed the randomised block design, and comprised nine treatments in three replications. Soil was sandy clay loam in texture and according to the ratings of Kerala Agricultural University (KAU, 2016), was very strongly acidic, medium in organic carbon and available potassium (K), low in nitrogen (N) and high in available phosphorus (P). Liming was done @ 350 kg/ha to correct soil acidity. At the time of final land ploughing, farm yard manure was incorporated @ 50 t/ha uniformly in all plots. Seedlings of Amaranthus red, variety 'Arun', were transplanted at six leaf stage at a spacing of 30 cm between rows and 20 cm between plants in a row. The composts were used to substitute 50 per cent of the recommended dose of N (RDN) *i.e.*, 100 kg N/ha and the remaining half, through chemical fertilizer, urea (46 % N). Phosphorus and K @ 50 kg/ha each were given as Rajphos (20% P_2O_5) and muriate of potash (60% K_2O). In the control treatment, chemical fertilizers alone were used. The crop was raised following the package recommendations (KAU, 2016). First harvest was taken 30 days after transplanting (DAT) and subsequent harvests, as and when the leaves were of satisfactory growth for consumption. The yields at each harvest was recorded, summed to compute total yields and expressed in Mg/ ha.

Table 2. Effect of enriched litter compost on soil chemical and biological properties

Treatment	pH	EC (dS/ m)	Soil organic carbon (%)	Available nutrients (kg/ ha)			Microbial count (cfu / g soil)		
				N	P	K	Bacteria (x 10^6)	Fungi (x 10^4)	Actinomycetes (x 10^5)
T_1 - Jack leaf litter + poultry manure	5.53	0.43	0.89	213.25	128.03	265.93	35.6	24.3	13.5
T_2 - Jack leaf litter + CI (powder) + earthworms	5.70	0.57	0.85	267.61	144.21	219.82	41.3	23.5	15.3
T_3 -Jack leaf litter + CI (liquid)	5.80	0.60	0.76	221.61	132.06	315.37	42.1	20.3	12.3
T_4 - Thermochemical jack leaf litter compost	6.10	0.53	0.74	271.79	161.60	365.92	44.6	20.3	11.5
T_5 - Coconut leaf litter + poultry manure	5.83	0.53	0.83	237.06	140.16	156.05	42.6	22.8	15.7
T_6 - Coconut leaf litter + CI (liquid) + earthworms	5.40	0.57	1.12	239.51	142.78	186.46	67.8	24.7	14.8
T_7 - Coconut leaf litter + CI (powder)	5.70	0.57	0.92	288.62	134.62	199.02	45.6	21.3	11.6
T_8 - Thermochemical coconut leaf litter compost	5.97	0.57	0.75	225.79	153.14	377.07	33.7	15.5	12.1
T_9 - Control	5.40	0.60	0.71	244.14	141.61	241.01	42.6	16.5	10.5
SE m ±	0.43	0.086	0.07	12.68	18.65	63.99	4.9	1.5	1.0
CD(0.05)	-	-	0.142	-	-	97.515	10.44	3.31	2.26

Table 3. Effect of enriched litter composts on growth, yield and economics of cultivation

Treatment	Plant height (cm)				LAI			Total yield (Mg/ha)	Net returns ₹ /ha	B: C ratio
	30 DAT	45 DAT	60 DAT	At final harvest	30 DAT	45 DAT	60 DAT			
T_1 - Jack leaf litter + poultry manure	44.70	59.70	29.67	32.67	0.84	0.87	0.27	16.22	92264	1.61
T_2 - Jack leaf litter + CI (powder) + earthworms	43.33	54.80	34.17	37.57	0.66	0.84	0.30	17.96	110136	1.69
T_3 -Jack leaf litter + CI (liquid)	40.33	53.60	28.07	31.67	0.67	0.74	0.24	14.91	66483	1.42
T_4 - Thermochemical jack leaf litter compost	42.70	53.47	30.47	33.50	0.66	0.79	0.27	14.20	49526	1.30
T_5 - Coconut leaf litter + poultry manure	46.87	57.80	32.57	35.93	0.74	0.80	0.29	14.58	67991	1.45
T_6 - Coconut leaf litter + CI (liquid) + earthworms	47.63	59.80	35.03	38.10	0.79	0.86	0.33	20.20	144874	1.92
T_7 - Coconut leaf litter + CI (powder)	43.33	54.53	29.43	31.97	0.66	0.74	0.24	14.48	63829	1.42
T_8 - Thermochemical coconut leaf litter compost	42.03	53.60	31.37	33.87	0.70	0.71	0.28	15.29	68115	1.42
T_9 - Control	41.67	53.47	26.23	28.63	0.61	0.63	0.21	13.77	63436	1.45
SE m ±	1.42	1.17	2.08	2.48	0.05	0.05	0.03	1.53	22891	0.15
CD (0.05)	3.008	2.473	4.404	4.627	0.119	0.105	0.050	3.236	48528.2	0.319

Soil samples collected were initially dried in shade, sieved and then oven dried at 105° C. These were subjected to analysis by adopting standard procedures. *viz*., available N (Subbiah and Asija, 1956), organic C, available P and K (Jackson, 1973) and microbial counts (Johnson and Curl, 1972). The data were statistically analysed and where ever variations were found to be significant, critical differences were computed (Snedecor and Cochran, 1975) for comparison.

RESULTS AND DISCUSSION

Impact on soil properties

The perusal of the data on soil chemical and biological properties (Table 2) revealed significant improvements with litter compost application. Soil organic C content varied significantly with the treatments. The organic carbon C (1.12%) was the highest in the soil treated with coconut leaf litter composted with CI (liquid) + earthworms (T_6) and was superior, while the lowest (0.71%) was assessed in the control (T_9).

The variations in available nutrient content in the soil were found to be non significant, except for K. (Table 2). However, the status was found improved from the initial values. Soil K content varied significantly with different treatments, and was the highest (377.07 kg/ha) in the thermochemical digested coconut leaf litter (T_8) application on par with T_4 (thermochemical jack leaf litter compost) and T_3 [jack leaf litter + CI (liquid)] The lowest soil K status (186.46 kg/ha) was noted in T_6(coconut leaf litter composted with CI (liquid) + earthworms.

Total microbial count (bacteria, fungi and actinomycetes) in soil varied significantly with the nutrient sources applied (Table 2) and the counts were significantly the highest in T_6 except actinomycetes which was maximum in T_5 but on par with T_6. Among composts, thermochemically digested jack and coconut litter composts (T_4 and T_8) and the treatment without compost (T_9) recorded the lowest counts.

Growth and yield in amaranthus

The litter composts exerted significant influence on the plant height in Amaranthus (Table 3). Coconut litter compost prepared using CI (liquid) + earthworms (T_6) produced taller plants at all the growth stages, while at 30 and 45 DAT, T_6 it was on par with T_5(coconut leaf litter + poultry manure) and T_1 (jack leaf litter + poultry manure). At 60 DAT and at final harvest, T_6 was found on par with T_2, T_5 and T_8. Plants were shortest at all stages in the control (T_9), which was given 100 per cent RDN as inorganic fertilizers.

The variations in leaf area index (LAI) were significant at 30, 45 and 60 DAT (Table 3). Maximum LAI was recorded in T_1 (jack leaf litter + poultry manure) treated plants at 30 and 45 DAT (0.84 and 0.87 respectively) and was on par with T_6 (0.79) and T_5 (0.74) at 30 DAT and on par with T_6 (0.86), T_2(0.84), T_5(0.80) and T_4 (0.79) at 45 DAT. The lowest LAI values at 30 and 45 DAT were observed in control, T_9 (0.61 and 0.63, respectively). At 60 DAT, the LAI recorded highest in T_6(0.33) and lowest in T_9, control (0.21).

Amaranthus leaf yield (20.20 Mg/ha) was the highest in plants manured with coconut litter compost prepared using CI (liquid) + earthworms the highest yield, on a par with jack litter composted with CI (powder) + earthworms (17.96 Mg/ha). Plants treated with thermochemical digested litter of jack and coconut also showed lower yields (14.20 and 15.29 Mg/ha respectively).The significantly lowest yield of 13.77 Mg/ha was recorded in 100 per cent inorganic fertilizer applied plots (T_9). Economic analysis also revealed the application of coconut leaf litter composted with CI (liquid) + earthworms maximum to be more profitable, with net returns of ₹144874/ ha and a benefit cost ratio of 1.92.

Substitution of the N dose with litter composts proved beneficial in Amaranthus in terms of growth and yield compared to the package recommendation. Yields were nearly 3 to 46 per cent per cent higher than in control. The addition of compost in soil instead of chemical fertilizers triggers microbial activity, mineralisation, improves aeration, soil moisture status, regulates soil temperature (Jagadeesha *et al,* 2019) all of which favours nutrient uptake and plant growth. This holds true for all treatments in which compost was used to substitute the chemical fertilizer.

Organic manures are regarded as sources of all essential nutrients (Sharma *et al,* 2022) and the organic nature of the material has favourable influences on soil properties. The addition to the root zone also enhances rhizosphere activities, the key regulators of plant growth and nutrition. The amelioration with compost application are evident from the data in Table 2.

Among the treatments, T_6 [coconut leaf litter + CI (liquid) + earthworms] was found to recorded the highest yield (20.20 Mg/ha), on par with jack litter composted with CI (powder) + earthworms, (17.96 Mg/ha), 45 and 35 per cent greater than in control. The better performance could be attributed to the properties of the vermicomposted litter. Vermicompost, in addition to being an organic fertilizer, is rich in microbial populations and diversity, growth hormones, enzymes and of homogenous consistency (Sinha, 2009). The nutrient availability from vermicompost is also rated as high. It was evinced that the application of earthworm worked litter promoted the dissemination of important microorganisms. Maheswarappa *et al* (2014) enumerated the microbial counts in coconut leaf vermicompost and illustrated that it harboured higher population of microorganisms, many of them with plant-beneficial attributes. This coupled with the NPK bio fertilizers with enrichment, would have favourably influenced Amaranthus growth. The economic part of the crop is the leaves and shoot, and hence the source itself is the sink. All growth promoting factors thus directly contributes to the yield. Co- composted litter (poultry manure added) could also evoke better growth on account of the nutrient contents in it. The vegetative characters, plant height and LAI were initially higher in co-composted litter applications but declined indicating the lowered regrowth with the cuttings done in these treatments. Nevertheless, it remained the highest in T_6 indicating the prolonged beneficial effect of vermi composting application has on soil. Further the microbial association in these treatments (composting inoculum added as, powder/ liquid) also augmented soil microbial activities in favour of Amaranthus growth until final harvest. The results corroborate the earlier reported better growth and yields with vermicompost application: pseudostem compost in banana (Patel *et al,* 2012), guava litter vermicompost in red gram (Vasanthi *et al*, 2013) and mango litter compost in vegetable cowpea (Das *et al,* 2020).

Exploring the effects of thermochemically digested leaf litter, it was found that the low nutrient contents limited its impacts on soil fertility and hence uptake leading to comparatively lower yields (14.20 and 15.29 Mg/ha) irrespective of the litter species.

The results on the changes in soil properties clearly indicate the amelioration possible with the addition of leaf litter composts. The soil organic carbon build up and increase in available nutrient status from the initial values recorded on application of vermicomposted litter is in consonance with the reports of Maheswarappa *et al* (2014) and Jain and Kalamdhad (2020). Available N and P status remained comparable with different litter composts, but, available K content varied markedly. It was significantly high in soils treated with thermochemical compost which might be due to the KOH used for chemical treatment in thermochemical digestion as reported by Sudharmaidevi *et al* (2017). Leno (2017) also reported the increased K status in the soil with the application of thermochemically digested compost in banana.

The increase in microbial count in soil can be attributed to the presence of the microbes in the compost and the organic material as such would have augmented the population in soil whereas, thermochemically composted litter applied plots recorded the lowest counts as these were acid-alkali digested and did not have much microbes in it other than that inherent in soil. A better actinomycete count what was present in soil. The comparable actinomycete count noted could be due to the affinity of these microbes to multiply under extreme soil condition such as high salinity and alkalinity as reported by Hamdali *et al* (2008).

The maximum B:C ratio realized in Amaranthus with the application of coconut leaf litter compost prepared with the inoculation of CI (liquid) and earthworms was on account of the maximum yields obtained. Thermo-chemically digested jack litter was the least profitable due to the higher cost incurred in the production. It is interpreted that as the nutrient contents in the thermochemical digest was lower compared to the other composts, it was required in larger quantity which added to the cost, at the expense of the returns.

CONCLUSION

The study has brought to light the prospects of recycling leaf litters of jack and coconut as composts *via* microbial + vermicomposting and the positive influences on soil properties and yields in Amaranthus. The highest yield and returns were realized with the use of coconut litter compost [CI (liquid) + earthworms] to substitute 50 per cent RDN and was on par with the N source of jack litter compost [CI (powder) + earthworms].

ACKNOWLEDGEMENT

The authors gratefully acknowledge Kerala Agricultural University for the physical and financial support rendered for the Master's thesis work of the first author of which this paper is based on.

REFERENCES

Das R, Isaac S R and Thampatti M K C (2020). Efficacy of enriched leaf litter compost as nutrient source in vegetable cowpea (*Vigna unguiculata* sub sp. *unguiculata*). *J Soils Crops* **30**(1): 63-68.

Gopal M, Gupta A, Palaniswami D R and Thomas G V (2010). Coconut leaf vermiwash: a bio-liquid from coconut leaf vermicompost for improving the crop production capacities of soil. *Curr Sci* **98**(9): 1202-1210.

Hamdali H, Hafidi M, Virolle M J and Ouhdouch Y (2008). Growth promotion and protection against damping-off of wheat by two rock phosphate solubilizing actinomycetes in a P-deficient soil under greenhouse conditions. *Appl Soil Ecol* **40**: 510-517.

Harishma S J (2017). *Leaf litter recycling in homestead agroforestry systems*. M.Sc. (Ag) Thesis, Kerala Agricultural University, Thrissur.

Isaac S R and Nair M A (2006). Litter dynamics of six multipurpose trees in a homegarden in southern Kerala, India. *Agrofor Syst* **67**: 203-213.

Jackson M L (1973). *Soil Chemical Analysis* (2nd Edition), Prentice Hall of India, New Delhi, 498p.

Jagadeesha N, Srinivasulu G B, Shet R M, Umesh M R, Kustagi G, Ravikumar B, Madhu L and Reddy V C (2019). Effect of Organic Manures on Physical, Chemical and Biological Properties of Soil and Crop Yield in Fingermillet-Redgram Intercropping System. *Int J Curr Microbiol App Sci* **8**(05): 1378-1386. doi: https://doi.org/10.20546/ijcmas.2019.805.157

Jain M S and Kalamdhad, A S (2020). Soil Revitalization via Waste Utilization: Compost Effects on Soil Organic Properties, Nutritional, Sorption and Physical Properties *Environ. Technol Innov* 18: 100668 https://doi.org/10.1016/j.eti.2020.100668

Johnson L F and Curl E A (1972). *Methods for Research in the Ecology of Soil Borne Plant Pathogen*. Burgers publication Co., Minneapolis, 247p.

KAU [Kerala Agricultural University] (2016). Package of Practices Recommendations: *Crops* (15th Ed.). Kerala Agricultural University, Thrissur.

Leno N (2017). *Evaluation of customized organic fertilizer in relation to labile carbon dynamics nutrient release characteristics and productivity of banana*. Ph.D. (Ag) Thesis, Kerala Agricultural University, Thrissur.

Maheswarappa H P, George V, Thomas S, Gupta A, Bhat R and Palniswami P (2014). Productivity and nutrient status of coconut (*Cocos nucifera*) as influenced by integrated nutrient management with vermicomposted coconut leaves. *Indian J Agron* **59**(3): 455-459.

Patel KK, Anand V, Kaswala AR, Italiya A, Pawar SL, Patel JM, Kolambe BN, and Patil

RG (2012). Comparative performance of FYM, biocompost and banana pseudostem based vermicompost on productivity of banana. *Asian J Hort* **7**(1) : 140-143.

Sharma R, Kandel S, Khadka S and Chaudhary S (2022). Nutrient contents in different sources of organic manures of different farms in Bhaktapur district of Nepal. *J Agric Nat Resour* **5**(1): 150-156.

Sinha R V (2009). Earthworms vermicompost: a powerful crop nutrient over the conventional compost and protective soil conditioner against the destructive chemical fertilizers for food safety and security. *American-Eurasian J Agric Environ Sci* **5**: 1-55.

Snedecor G W and Cochran W G (1975). *Statistical Methods* (16th Ed.). Oxford and IBH Publishing Co., Calcutta, 458p.

Subbiah B V and Asija G L A (1956). A rapid procedure for the estimation of available nitrogen in soil. *Curr Sci* **25**: 259-360.

Sudharmaidevi C R, Thampatti K C M and Saifudeen N (2017). Rapid production of organic fertilizers from degradable waste by thermochemical processing. *Int J Recycling Org Waste Agric* **6**: 1-11.

Vasanthi K, Chairman K and Singh R (2013). Vermicomposting of leaf litter ensuing from trees of mango (*Mangifera indica)* and guava *(Psidium guujuvu)* leaves. *Int J Adv Res* **1**(3): 33-38.

Received on 20/4/2024 Accepted on 19/5/2024