Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2020, Volume 33 Issue 1, Page 171-175

Recycling leaf litter as nutrient source in tuber crops in a selected agroforestry system of southern Kerala

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ARTICLE INFO

Article history:
Received 30 January 2020
Revision Received 20 March 2020
Accepted 8 April 2020

Key words: agroforestry, litter, nutrient, recycling, tuber, vermicompost, yield

ABSTRACT

The field experiment to assess the response of tuber crops to vermicomposted leaf litter in agroforestry systems was laid out in randomized block design during March to November 2013. The composted litter, enriched with NPK biofertiliser consortium was used as nitrogen source in five understory tuber crops, cassava, arrow root, tannia, taro, and amorphophallus in an agroforestry homegarden at 50 per cent substitution of recommended doses of nitrogen. The results revealed positive response of the tuber crops to litter compost application and yielded similar or slightly higher yields than the conventional practice of chemical fertilizer application. Comparative analysis of yields in terms of amorphophallus equivalent yields revealed amorphophallus to be the best responding crop and economic analysis also recorded a higher benefit cost ratio, 3.36, while it ranged from 1.14 to 1.66 in the other crops. Soil available P, K status and microbial activity varied significantly with the inclusion of litter compost in the treatments although the extent of variation differed with the species. Thus, taking into account the economics and improvements in soil fertility with litter compost application, litter recycled through vermicomposting technology can be recommended as a potential nutrient source for tuber cultivation in agroforestry systems.

1. Introduction

Agroforestry gardens are characterized by high organic matter production especially on account of the litter from the perennial components included in the system. Litter decomposition is the major avenue of sustaining soil fertility in a tree based ecosystem by providing organic and inorganic elements for nutrient cycling processes and controls nutrient returns to the ecosystem (Wang *et al.*, 2008). Nevertheless, the practices of clean cultivation have led to the removal of the fallen litter from the system. The in situ recycling and nutrient enrichment that would have occurred within the system are forfeited with the removal of these biowastes. In the present decade when focus is on organic production of food crops, exploitation of all available organic inputs for nutrient management is a need of the hour. It is at this juncture that the possibility of recycling the litter through composting assumes significance. Leaf litter on decomposition offer ample scope for nutrient recycling and the slow release coincides with the requirements of the crop. Research works on the recycling and use of litter as organic sources in crop production have little been exploited while agricultural crop residues are widely popularized in farming. Tuber crops are well known for their adaptability to varying shading intensities and are recommended as understorey crops in multistrata agroforests (Nair, 1983; Raj and Lal, 2014). Being 7-9 month duration crops, these can benefit from the nutrient release from litter.

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Suja *et al.*, 2012 have reported tuber crops to respond adequately to organic nutrition. In this background, an investigation on the use of leaf litter as nutrient source in tuber crops was taken up in an agroforestry homegarden of Southern Kerala, India.

2. Materials and methods

The field experiment was carried out in a selected agroforestry homegarden in the western ghat tract of Elampal Panchayat, Kollam district, southern Kerala during 2013-'14. The garden falls in the agroecological unit, 12 South central foothills of Kerala, ((latitude 9016'N, longitude 76037'E, altitude 91.44m above MSL)) and enjoys a warm humid tropical climate with mean maximum temperature of 35.130 C and minimum temperature of 23.130 C. The soil was slightly acidic with high organic carbon, available P and K status. The response to vermicomposted litter was assessed in five selected tuber crops commonly grown as understorey crops in agroforestry systems, and these formed the treatments of the experiment. The treatments comprised of : T1- elephant foot yam (Amorphophallus paeniifolius), T2- cassava (Manihot esculenta), T3- arrow root (Maranta arundinaceae), T4-, tannia (Xanthosoma sagittifolium) and T5- (Colocasia esculenta).

The litter from the tree components were composted in cement tanks (2 m x 1m x 0.75m) roofed with asbestos sheets using red worms, Eisenia foetida species of earthworms. The vermicomposted litter was enriched with Plant Growth Promoting Rhizobacteria I @ 2 kg 100 kg-1 compost and the nutrient content of the equivalent basis, at 50 per cent substitution of the recommendations for the crops (Table 1) in the selected tuber crops. The conventional practice of 100 per cent chemical fertilizer application was maintained in each crop species as check for comparison.

The varieties used were Cassava (Sree Vijaya), Amorphophallus (Sree Padma), Arrow root (local), Tannia (local), Taro (Thamarakannan local). A plot size of 5m x 4m was adopted and plant density maintained at the recommended spacing (KAU, 2011). Other cultural practices recommended by the Kerala Agricultural University for each crop were followed in the cultivation. The remaining quantity of N, P and K were applied using chemical fertilisers. The tuber crops, cassava, tannia, taro and arrowroot were planted in June 2013 while amorphophallus was planted in March 2013 so as to accommodate the dormancy shown by this species. Observations on the plant growth and yield were recorded and soil analysed for the chemical parameters as per standard procedures.

As the crops belonged to different botanical families and species, statistical comparison between the crops in their biometric and yield characters was not meaningful and hence the Amorphohallus Equivalent Yields were computed for yield comparison.

Amorhophallus Equivalent Yield (AEY)
= Yield of crop x (Market price of crop/ Market price of Amorphophallus)

Statistical analysis was done to assess the influence of the compost application on soil properties and wherever significant, critical differences were computed.

Table. 1 Spacing and nutrient doses adopted for the selected tuber crops

Crop	**Spacing (cm x cm)**	**Organic manure**	**NPK dose (kg ha^{-1})**
Cassava	90 x 90	12.5 tha^{-1}	100:100:100
Amorhophallus	90 x 90	2.5 kgpit^{-1}	100:50:150
Tannia	90 x 90	25 t ha^{-1}	80:50:150
Taro	60 x 45	12 tha^{-1}	80:25:100
Arrowroot	30 x 15	10 tha^{-1}	50:25:75

3. Results and Discussion

Response of tuber crops to litter compost application

Observations on the biometric parameters, yield and yield attributes were recorded at periodic intervals and are presented in Tables 2 and 3.

Although statistical comparison was not done, it was observed that with the conventional practice where more of chemical fertilizers were used, better vegetative growth was observed in the early months except in cassava. The rapid release of nutrients from chemical fertilizers to meet the early requirements of the crops would have been responsible for this better growth. A regular increase in plant height and number of leaves were observed with the growth of the crops.although in tannia and taro wherein it is reasoned that the first formed leaves turn yellow and droop as the crop matures and it is the later formed leaves that decided the plant height. The observations on plant height and leaf number at harvest could not be tabulated because in elephant foot yam, taro and tannia, the stage of harvest is when majority of the leaves have turned yellow, drooped and dried.

Table 3. reveals the different yield attributing characters of the selected crops. The number of tubers plant-1, length and girth of the tubers were recorded at harvest both in the experimental plots and control, The yield attributes and yields of the tuber crops were found be better under integrated management compared to that under 100 percent chemical fertilizer application except in taro. Yields were nearly 33.48, 26.0, 25.5 and 43.27 per cent higher under integrated management in amorphophallus, cassava, arrow root and tannia respectively than with chemical fertilizers alone The differences in the crop duration (taro 5.5 months and other tubers 7- 9 months) would have influenced the response of crops to litter composts.

Better growth and yields in amaranthus with vermicompost application has been reported by Arunkumar (2000), in brinjal with neem vermicompost (Gajalakshmi and Abbasi, 2004) and in red gram with guava vermicompost (Vasanthi *et al.* 2013). Harishma (2017) observed the positive response of amaranthus to litter compost and documented 35–45 per cent yield increase with the substitution of 50 per cent RDN as vermicompost recorded compared to 100 per cent chemical fertilizer application. The use of earthworms for composting has additional advantages apart from the nutrient contents in the composted litter; including higher microbial populations and diversity, plant growth promoting hormones, enzymes, acceptable C:N ratio and good homogenous consistency (Sinha, 2009) all of which would favourably influence plant growth and productivity.

Table 2 Plant height and number of leaves at 3, 5 and 7 MAP

Treatments	**3 MAP**		**5MAP**		**7MAP**	
	Plant height (m)	**No. of leaves plant^{-1}**	**Plant height (m)**	**No. of leaves plant^{-1}**	**Plant height (m)**	**No. of leaves plant^{-1}**
Under INM with litter compost						
Amorphophallus	1.01	41.0	1.17	45.5	1.25	50.8
Cassava	2.09	76.4	2.35	89.5	2.41	102.6
Arrow root	0.71	7.8	0.76	14.3	0.79	18.1
Tannia	0.73	6.4	0.79	6.7	0.81	6.5
Taro	0.42	4.1	0.48	4.9	0.51	5.1
With chemical fertilizers						
Amorphophallus	1.21	46.0	1.35	50.0	1.46	54.0
Cassava	1.85	72.0	2.10	90.0	2.3	98.0
Arrow root	0.80	6.0	0.86	12.0	0.75	15.0
Tannia	0.85	5.0	0.90	6.0	0.65	5.0
Taro	0.56	5.0	0.61	5.0	0.60	4.0

Table 3. Yield and yield attributes of tuber understory crops in response to litter compost

Treatments	No. of tubers plant^{-1}	Length/ height of tuber (cm)	Girth of tuber (cm)	Tuber yield kg plant^{-1}	Yield t ha^{-1}	*AEY
INM with litter compost						
Amorphophallus	5.25	15.72	51.18	6.82	36.62	36.62
Cassava	11.00	41.60	17.68	4.54	11.74	5.87
Arrow root	4.25	27.05	4.63	0.52	7.45	2.51
Tannia	10.50	10.65	5.12	1.20	7.45	9.93
Taro	18.75	8.93	3.70	0.85	1.70	1.98
with chemical fertilizers						
Amorphophallus	5.70	14.5	48.6	4.75	27.56	27.56
Cassava	7.6	30.5	18.2	3.75	9.32	4.66
Arrow root	6.1	20.1	4.5	0.48	6.00	2.00
Tannia	9.5	8.6	5.1	0.85	5.20	6.93
Taro	16.6	7.0	3.2	0.98	2.10	2.45

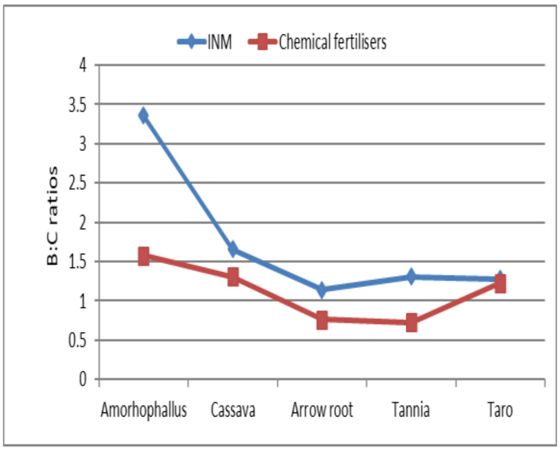
Price Rs. kg^{-1}: Amorphohallus :30 Cassava: 15 Tannia : 40 Taro : 35 Arrow root:10

Among the tuber crops, amorphophallus was found to record maximum per plant yields but this is due to the inherent genetic nature of the crop. The crop yields tubers of larger size compared to the other tuber species. The yields per hectare were also the highest in amorphophallus. The crop relative yields were computed to compare the performance of the different tubers and it was evident that amorphophallus was superior in yield compared to all other crops included in the study (Table 3). Benefit cost ratios (Fig. 1) computed also reflect higher returns with use of compost and this could be attributed to the higher yields recorded. In both nutrient management systems, amorphophallus crop revealed to be more profitable than the other tubers.

Changes in soil chemical and biological properties

Table 4 illustrates the changes in the chemical and biological properties of soil due to tuber cropping with litter compost as nutrient source

Assessment of the changes effected revealed significant variations in soil pH, organic carbon, available K and soil microbial populations. Litter additions declined soil pH except in tannia plots while increase in EC was observed in all crop soils. Porter *et al.* (1980) had observed organic matter to lower soil pH and this has been attributed to the release of hydrogen ions that were associated with organic anions or by nitrification in an open system. Available P and K status were found to increase with arrow root, tannia and taro cultivation from the initial status. Soil microbial count increased irrespective of the crop species cultivated. Kumar (1998) and Arunkumar (2000) have reported similar increases in soil nutrient status on the application of compost in soil. Suja *et al.* (2012) reported 10-20 per cent higher yields in amorphophallus and yams under organic farming compared to conventional practices and attributed this to the overall improvement in the soil physico- chemical and biological properties. In the present study also it can be



interpreted that the improvement in the soil properties had a bearing on the growth and yielding ability of the tuber crops as inclusion of litter in nutrient management recorded higher yields compare to 100% chemical fertilizer application

The study brings to light the potential of including litter compost as a source of nutrient in tuber cultivation. The understorey tuber crops investigated with the exception of taro was found to perform better under integrated

Table. 4 Variations in soil properties with litter compost application in tuber crops

Treatments	With litter compost								
	Soil pH	EC (mmhos cm^{-1})	Organic Carbon %	Available N $kgha^{-1}$	Available P $kgha^{-1}$	Available K $kgha^{-1}$	Actinomycetes ($x10^4$)	Bacteria ($x10^8$)	Fungi ($x10^6$)
Elephant foot yam	5.41	0.23	0.87	267.61	124.99	143.15	36.00	24.00	23.33
Cassava	5.47	0.16	1.19	267.28	160.06	147.07	31.00	37.00	22.33
Arrow root	4.97	0.18	0.96	313.61	250.09	223.89	90.33	39.67	22.33
Tannia	5.79	0.18	1.31	334.50	228.07	215.52	58.00	45.00	25.33
Taro	4.78	0.15	1.39	330.32	253.07	233.67	65.67	26.00	23.67
CD(0.05)	0.394	ns	0.36	Ns	ns	44.07	3.05	2.55	0.987

nutrient management with litter compost than sole chemical fertilizer application. Thus it can be concluded that the leaf litter in agroforestry systems that otherwise goes as waste can be gainfully employed for tuber cultivation.

4. Acknowledgement

The authors gratefully acknowledge the financial assistance received from the Western Ghat Development Cell, Govt. of Kerala and the physical support from Kerala Agricultural University for the implementation of the project on which the paper is based.

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