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Nutrient Uptake and Agronomic Efficiencies of Leaf Litter Compost as Nitrogen Source in Vegetable Cowpea (*Vigna unguiculata* subsp. *unguiculata*)

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ABSTRACT

Nutritional security overrides food security and the present day agriculture focusses more on sustainable and regenerative agriculture in which use of organic inputs assumes prime significance. The search for viable alternatives to the chemical sources of nutrients demands production of the organic nutrient inputs in large quantities. Organic nutrition is expensive on account of the low nutrient contents and large quantum needed and hence unless produced *in situ*, turn out to be highly expensive. Organic wastes in the form of crop residues are available in plenty in agricultural fields. Tree leaf litter is another biowaste considered as menace under off farm situations. Rapid resource recycling techniques offer immense potential for the safe disposal of the litter and conversion to quality manures. In this background an experiment was conducted to assess the efficacy of litter composts as nitrogen sources in vegetable cow pea (V*igna unguiculata* subsp. *unguiculata*) in terms of the agronomic efficiencies and nutrient uptake. The field experiment was conducted in College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University during December 2018 to March 2019 in randomized block design with three replications. The treatments included the compost of the two tree species litter prepared by composting with different decomposer organisms and additives and enriched with the biofertilizer, PGPR Mix I. The results of the experiment revealed the highest vegetable yields (7.80 t ha^{-1}) in the treatment involving mango leaf litter composted with glyricidia leaves and earthworms on par with Kerala Agricultural University package of practices recommendation for cowpea and it was 2.7 times that in absolute control. The total nutrient uptake was the highest with mango litter co-composted with poultry manure as nutrient input. Agronomy efficiency indices, in terms of nitrogen were significantly superior for the treatments including mango litter composts and hence prove a suitable nutrient input in vegetable cowpea cultivation.

Key words: Agronomic indices, Co-composting, Cashew, Enrichment, Litter compost, Mango.

Leaf litter are available in plenty in tree based ecosystems and are often considered as a menace especially in gardens, sidewalks, lawns and playgrounds in urban and suburban locations (Vasanthi *et al.,* 2013). The common method of the disposal of biowastes is by burning, but the practice is dissuaded on account of the air pollution that follows. Resource recycling techniques offer immense potential for the safe disposal of the litter and conversion to quality manures. This assumes importance in the present decade when organic farming practices are being promoted and organic manures are needed in large quantities.

Homestead agroforestry systems are characterized by an intimate combination of agricultural crops and trees raised in and around the farmer's dwellings. Mango (*Mangifera indica*) and cashew (*Anacardium occidentale*) are two commonly grown multipurpose trees in the homesteads of Kerala, with an average annual litter input of 0.82 and 0.72 kg m^{-2} respectively (Isaac and Nair, 2006). The utilization of leaf litter after composting as nutrient sources in crop production reduces the need for external nutrient inputs ensuring safe production, especially in vegetables and these have been reported to have beneficial effects on yield and quality of crop (Chaudhary *et al.,* 2004). It is in this background that an experiment was conducted to assess the efficacy of litter composts as nitrogen (N) sources in vegetable cow pea (V*igna unguiculata* subsp. *unguiculata*) in terms of the agronomic efficiencies and nutrient uptake.

The experiment was conducted in the Instructional Farm, College of Agriculture Vellayani, Thiruvananthapuram, Kerala in randomized block design with three replications during December 2018 to March 2019. Seeds of Bhagyalakshmy, the vegetable variety of cowpea, were sown in plots of 3.0 m x 1.5 m at a spacing of 30 cm x 15 cm. Litter composts of mango and cashew leaves prepared by different composting methods (Table 1) and enriched with biofertilizer

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consortium, plant growth promoting rhizobacteria (PGPR Mix I) @ 20 g kg^{-1} and rock phosphate @ 150 g kg^{-1} constituted the treatments T_1 to T_8, the package of practices (POP) recommendations of Kerala Agricultural University, T_9 and absolute control of no fertilizer, T_{10}. PGPR Mix I is a consortium containing N fixers, *Azospirillum lipoferum*, *Azotobacter chroococcum*, P solubilizer, *Bacillus megaterium* and K solubilizer, *Bacillus sporothermodurans.* The NPK contents in the different enriched composts and the time taken for compost production are detailed in Table 2.

The enriched composts were used as N source at 50 per cent substitution of the POP recommendation (20 kg N ha^{-1}) *i.e*., 10 kg N ha^{-1} and the remaining 10 kg N through urea. Farm yard manure was applied @ 20 t ha^{-1} in all treatments, P and K (30 and 10 kg ha^{-1} respectively) through the chemical sources, rajphos and muriate of potash. In the control treatment, entire dose of N, P and K were given through chemical fertilizers. All cultural operations were carried out as per POP recommendations and the yield and dry weights were recorded. Nutrient contents were analysed in the oven dried samples (70 ± 5 °C) adopting the standard procedures for N (microkjeldahl method), P (vanadomolybdo phosphoric yellow colour method) and K (flame photometry) described by Jackson (1973). The agronomic indices of nitrogen use efficiency were calculated using the formula (Dobermann, 2007).

i. Agronomic Efficiency (AE) = $(Y - Y_0)/F$
ii. Physiological Efficiency (PE) = $(Y - Y_0)/(U - U_0)$
iii. Apparent Recovery Efficiency (ARE) = $(U - U_0)/F$
iv. Partial Factor Productivity (PFP) = Y/A

where,
Y - Yield from treated plot
Y_0 - Yield from control plot
U - Nutrient uptake in treated plot
U_0 - Nutrient uptake in control plot
F - Fertilizer rate
A - Applied and indigenous nutrients

The data were subjected to statistical analysis and critical differences were computed where ever the variations were found to be significant (Snedecor and Cochran, 1975).

Vegetable yield

The effect of enriched litter compost on vegetable yield are depicted in Fig 1. Litter composts recorded significant variations in pod yields and the significantly highest yield (7.80 t ha^{-1}) was recorded with application of mango litter composted with glyricidia + earthworms (T_7), on par with T_5, poultry manure composted mango litter (7.14 t ha^{-1}), T_9, 100 per cent chemical fertilizer application (7.10 t ha^{-1}) and T_1 - poultry manure composted cashew litter compost (6.50 t ha^{-1}). The yield in T_7 was nearly 2.7 fold of that in the absolute control (T_{10}).

Organic manures are often referred to as slow release fertilizers. However, the results of the study revealed that mango litter composts (T_5, T_6 and T_7) and co-composted cashew litter (T_1) could record yields on par with the POP recommendation (T_9) in which chemical fertilizers were used. As the quantity of nutrients applied through the different sources remained the same, the results provide insight to the better availability of nutrients from the composts and

Table 1: Treatment details.

Treatments	Details
T_1	Cashew leaf litter co-composted with poultry manure @ 10% w/w
T_2	Cashew leaf litter composted with compost inoculum (CI) + vermicomposting (EW)
T_3	Cashew leaf litter co-composted with glyricidia leaves in 1:1 + vermicomposting (EW)
T_4	Naturally decomposed cashew litter compost
T_5	Mango leaf litter co-composted with poultry manure @ 10% w/w
T_6	Mango leaf litter composted with compost inoculum (CI) + vermicomposting (EW)
T_7	Mango leaf litter co-composted with glyricidia leaves in 1:1 + vermicomposting (EW)
T_8	Naturally decomposed mango litter compost
T_9	Control (KAU POP)
T_{10}	Absolute control (No fertilizers)

(T_1 to T_8- composts were enriched with biofertilizer and rock phosphate).

Table 2: Chemical properties of enriched litter compost.

Composted leaf litters	Cashew (%)				Mango (%)			
	N	P	K	Composting period (days)	N	P	K	Composting period (days)
Co-composting with poultry manure	2.05	1.55	0.65	183	2.33	1.74	0.65	159
Composting with CI + EW	1.59	1.61	0.53	144	2.15	1.68	0.62	110
Co-composting with glyricidia leaves in 1:1+ EW	1.96	1.88	0.59	187	2.43	2.02	0.67	126
Natural decomposition	1.12	1.59	0.47	243	1.31	1.67	0.51	219

hence suitability as nutrient source in cowpea. Vermicomposting of mango litter after enrichment with glyricidia leaves was found to register the highest yield. The better performance of glyricidia + earthworms composted mango litter may be attributed to the beneficial effects of worm worked compost. Vermicompost prepared out of the mixture of crop residues amended with cow-dung in the ratio of 1:1 also exhibits higher nutrient content (Barik *et al*., 2011). Sinha *et al.* (2010) reported that vermicompost is not only a source of major and minor nutrients, but also rich in diverse microbial population, plant growth promoting hormones, enzymes with acceptable C: N ratio and good homogenous consistency. The nutrient availability from vermicompost is also rated as high. Higher microbial activity in the litter composts would have created an environment conducive for growth and better yields in cowpea. Sreeja (2015) illustrated the efficacy of mineral enriched vermicompost in conjunction with PGPR Mix I in increasing the yield in yard long bean. In the present study, yields were significantly the lowest with naturally decomposed cashew litter which may be due to the higher lignin content (27.5 %) and wider C : N of the compost (20.3) used. The plant growth inhibiting effect of lignin has been documented earlier (Maia *et al*., 2013). Yields were also low in vermicomposted cashew litter. Lignin is a factor that slows down the mineralization of nutrients from crop residues on the time scale of a cropping season (Frei, 2013). This would have interfered with the nutrient availability from the litter used as nutrient source in the experiment.

Nutrient uptake

The effect of enriched litter compost on nutrient uptake in cowpea is given in Table 3.

Nitrogen

Application of enriched litter composts resulted in significantly higher N uptake in cowpea. The highest N uptake (84.65 kg ha^{-1}) was with T_8 (naturally decomposed mango compost) on par with all the treatments except T_3, T_4 and T_{10}. The lowest N uptake (33.70 kg ha^{-1}) was recorded in absolute control treatment (T_{10}).

Phosphorus

The effect of enriched leaf litter compost applied on P uptake of cowpea was found to be significant. Poultry manure co-composted mango litter compost (T_5) registered maximum

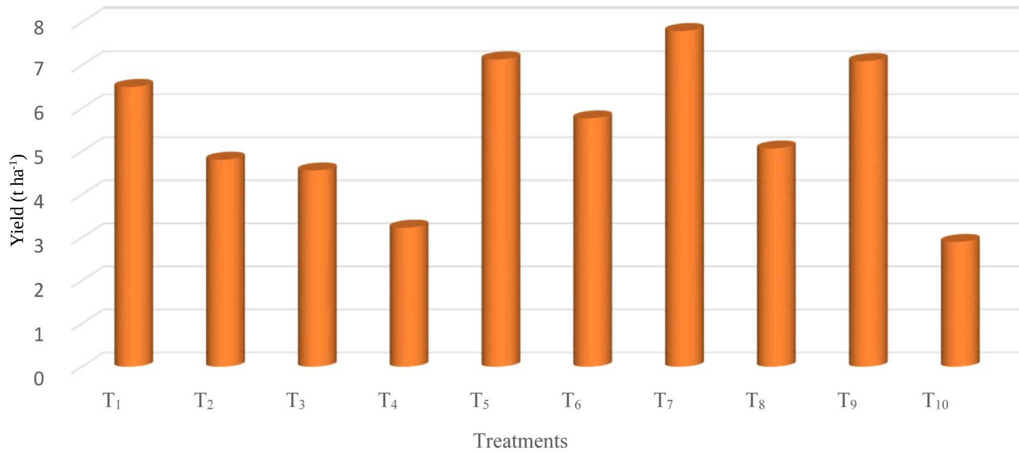

Fig 1: Variations in vegetable yields of cowpea as influenced by litter composts.

Table 3: Nutrient uptake and nutrient use efficiencies in cowpea in response to litter compost application.

Treatments	Nutrient uptake kg ha^{-1}			Agronomic indices of NUE kg kg $^{-1}$ pod			
	N	P	K	AE	PE	ARE	PFP
T_1 (PM composted cashew)	64.51	20.21	50.85	26.99	17.11	1.54	4.43
T_2 (CI + EW composted cashew)	64.93	11.00	52.58	14.35	9.26	1.56	3.28
T_3 (Glyricidia + EW composted cashew)	56.67	14.40	47.50	12.43	10.22	1.14	3.11
T_4 (Naturally decomposed cashew)	60.97	15.01	40.68	2.44	2.18	1.36	2.20
T_5 (PM composted mango)	83.16	25.85	54.97	31.82	14.26	2.47	4.87
T_6 (CI + EW composted mango)	79.36	18.78	79.02	21.49	9.67	2.28	3.93
T_7 (Glyricidia + EW composted mango)	77.25	13.54	70.85	36.71	16.69	2.17	5.31
T_8 (Naturally decomposed mango)	84.65	23.63	58.45	16.25	6.00	2.54	3.45
T_9 (Control)	78.63	14.20	61.35	31.48	14.00	2.24	4.83
T_{10} (Absolute control)	33.70	7.57	19.29	-	-	-	1.98
SE m (±)	7.30	1.52	5.43	6.83	2.788	0.38	0.59
CD (0.05)	21.853	4.566	16.255	20.661	8.432	-	1.778

uptake (25.85 kg ha^{-1}) and it was on par with T_8 (naturally decomposed mango), 23.63 kg ha^{-1}. Application of enriched cashew litter compost prepared by CI + EW composting recorded the lowest P uptake (11.0 kg ha^{-1}), on par with T_{10} (7.57 kg ha^{-1}).

Potassium

Potassium uptake was significantly higher (79.02 kg ha^{-1}) in plants fertilized with enriched mango litter composts prepared by CI + EW (T_6) on par with T_7 (mango litter + glyricidia + EW). The lowest K uptake (19.29 kg ha^{-1}) was registered in absolute control (T_{10}).

Compost prepared by different composting methods significantly influenced the total nutrient uptake of the plant. The uptake of N was highest in T_8 naturally decomposed and it is interpreted that the higher vegetative dry matter would have resulted in the higher uptake values. As nutrient content in the compost was lower (Table 2), a larger quantity of the compost was required and the slow release from the compost due to the higher lignin content would have favoured the vegetative growth in the later stages with lesser number of pods. The highest P uptake values recorded in mango leaf litter + poultry manure and K uptake in mango litter + CI + EW correspond to the better plant growth as evidenced by the higher biomass production. The inclusion of CI pretreated + EW composted and enriched mango litter resulted in better total nutrient uptake and higher yields compared to chemical application. Kannan and Singaram (2009) reported that addition of compost enriched with mussoorie rock phosphate and mixed microbial inoculum increased the number of nodules, nitrogenase activity of nodules and grain and straw yield of green gram. It is also interpreted that the addition of organic matter and improvement in the chemical and biological properties of soil with the compost application created a conducive environment for better uptake.

Agronomic Indices

The data on effect of enriched composts on agronomic indices, *viz*., AE, PE, ARE and PFP of cowpea for N are depicted in Table 3. In general the nutrient use efficiencies in vegetable cowpea were comparatively higher for the mango litter composts than cashew, except PE for N.

Agronomic efficiency

Application of enriched composts as nutrient source had significant influence on the AE in cowpea for N. The treatment T_7 (mango litter + glyricidia + EW) recorded significantly higher AE of 36.71 kg pod kg^{-1} N and was followed by the treatment T_5 (mango litter + poultry manure), the efficiency being 31.82 kg pod kg^{-1} N. The treatment (T_5) was on par with all the treatments except T_2, T_3 and T_4 for N. The higher AEs of the enriched earthworm + glyricida composted mango litter reflects the direct production effect of the compost in vegetable cowpea and indicate the productivity improvement gained with the use of the compost. It is interpreted that the significantly highest pod yield in T_7 would have contributed to the higher AE. Increased nitrogen use efficiency with integrated nutrient management (N enriched compost + PGPR) in sunflower was reported (Arif *et al*., 2017) and the combination was recommended to optimize N uptake efficiency.

Physiological efficiency

Physiological efficiency of cowpea computed was found to vary significantly with the application of the different enriched composts. Significantly higher PE (17.11 kg pod per N uptake) was recorded in the treatment T_1 (cashew litter + poultry manure) on par with T_7 (mango litter + glyricidia + EW) the value being 16.69 kg pod kg^{-1} N uptake. T_1 was comparable with all the treatments except T_4 and $T_{8.}$ The higher PE stipulate the ability of cowpea to convert the nutrient acquired from the specific sources into economic yield. The treatment T_4 (naturally decomposed cashew) recorded the lowest values of 2.18 kg pod kg^{-1} N bringing to light the low internal conversion efficiency of cowpea from this source.

Apparent recovery efficiency

ARE is the increase in nutrient uptake *i.e.*, difference between the nutrient uptake of fertilized crop to unfertilized crop in relation to unit quantity of nutrient applied. The variations recorded were found to be non significant, indicating that irrespective of the source used, the increase in N uptake with each quantum of the nutrient applied remained same.

Partial factor productivity

Significant variations were observed in the PFP of N and was were significantly higher for the treatment T_7 (mango litter + glyricidia + EW) with values of 5.31 kg pod kg^{-1} N. It was on par with the treatments T_1, T_5, T_6 and T_9 and the treatment T_{10} (absolute control) recorded the lowest value of 1.98 kg kg^{-1} N. Partial factor productivity is the ratio of yield to the total nutrients received including both, applied as well indigenous. The higher PFP in T_7 may be ascribed to the higher pod yields in response to the nutrient received and also the initial nutrient status of the soil. The lowest PFP in T_{10} may be due to the lowest yield recorded as no nutrients were applied other than the basal dose of FYM and the indigenous nutrient content in soil.

CONCLUSION

Based on the results it can be concluded that composting the otherwise neglected leaf litter biowastes of mango and cashew offers immense scope for utilisation as a nutrient input in crop production. The nutrient uptake and agronomic efficiencies with the use of leaf litter composts in vegetable cowpea revealed the maximum uptake and nutrient use efficiencies with mango litter, composted with glyricidia followed by vermicomposting, indicating its suitability for use as N source at 50 per cent of the package of practices recommendation in cowpea.

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