Nutrient dynamics of cotton and red gram residue compost

Globally, sustainable management of agricultural waste is a great challenge, especially in developing nations like India with a burgeoning population, production rate and economic growth. India generates more than 500 million tonnes of crop residues annually[1]. Residue burning is a major environmental concern contributing to global warming, health issues, loss of valuable nutrients and soil biota. Intensive cultivation with the use of high-analysis straight inorganics alone has resulted in imbalanced fertilization, multiple nutrient deficiencies and soil degradation. There is an ushering need for alternate sources of organics due to the shortage of good quality farmyard manure (FYM) owing to the decline in cattle population in rural areas.

Crop residues are considered as waste materials in economic terms, but have huge potential as a good source of elemental carbon, organic content and an ideal raw material for composting, equivalent to animal manure. Composting is a simple and viable on-farm technology that transforms organic waste into valuable manure duly following the 3R concept – reduce, recycle and reuse.

Cotton and red gram are extensively cultivated crops in Telangana, India. The present study was taken up during *kharif* 2018 to document the nutrient dynamics of crop residues (cotton and red gram). Due to labour shortages and increased usage of combine harvesters for timely seeding of subsequent crops, farmers turn to residue burning. Hence management of crop residues is the need of the hour to curtail the ill-effects of residue burning, apart from maintenance of soil organic carbon and organic matter, the major determinants of soil microbes and nutrient cycling mechanisms.

This study was initiated at the Student Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, geographically located at 17°19′19.2″N lat., 78°24′39.2″E long. and altitude of 542.3 m msl. Four pits (P_1, P_2, P_3 and P_4) of dimensions 1 m × 1 m × 1 m were filled with chaffed crop residues (Figure 1) @ 40 kg per pit, viz. red gram (P_1), cotton (P_2), red gram + rock phosphate @ 2% (P_3) and cotton + rock phosphate @ 2% (P_4) (Figure 2). About 25% of well-decomposed FYM (10 kg) per pit and earthworms (*Eusinea foetida* @ 2 kg equivalent to 550–600 nos) were introduced per pit and optimum moisture and temperature were maintained. This process was initiated on 6 June 2018 and vermicompost was harvested after 85 days (6 September 2018). The recovery of vermicompost from crop residues, viz. red gram (P_1), cotton (P_2), red gram + rock phosphate @ 2% (P_3) and cotton + rock phosphate @ 2% (P_4) was cotton stubbles + rock phosphate 2% was 26.2, 33.8, 32.5 and 39.4 kg respectively. During composting, the samples were drawn at 45, 60 and 80 days (Figure 3) respectively, from individual pits (4 nos) and analysed for total carbon using the loss on ignition method[2], the micro-Kjeldahl method for nitrogen[3], vanado-molybdo phosphoric yellow colour method for phosphorus[4] and by standard procedures for potassium[3]. The total carbon and C : N ratio were estimated using the following formulae

$$\text{Total organic carbon (\%)} = \frac{\text{Total organic matter}}{1.724}.$$

$$\text{C : N ratio} = \frac{\text{Total carbon content}}{\text{Total nitrogen content}}.$$

An overview of the data (Table 1) indicated that the nutrient (N, P and K) and carbon contents of compost varied with the starter material (crop residues). The initial N, P and K content of red gram residues was 0.74%, 0.28% and 0.89% respectively, while it was 0.86%, 0.30% and 0.92% respectively in cotton residues. The C : N ratio of red gram and cotton residues before composting was 58.00 and 48.74 respectively.

The nutrient (N, P and K) and carbon contents varied with the type of crop residue and with the addition of rock phosphate over sole crop residue at a given period of time (Table 2). There was gradual improvement in the nutrient content with composting and the highest value was recorded at 80 days. Among the types of residue, red gram registered relatively higher nutrient (N, P and K) and carbon contents compared to cotton. It was evident that the addition of rock phosphate had considerably increased the nutritional and carbon content when compared to no application.

Higher nutrient content (N, P and K) in red gram residues + rock phosphate (2.35%, 2.60% and 1.08%) compost could be ascribed to the reduction in loss of nitrogen through the immobilization and formation of nitrogen complexes with the inorganic constituents of rock phosphate[5] and conversion of unavailable forms of P to available forms, apart from solubilization of K due to organic acids enhanced by phosphorus-solubilizing microorganisms[6,7].

Figure 1. Cotton and red gram crop residues.

Table 1. Nutrient content (%) of cotton and red gram residues before composting

Crop residue	Nutrient content (%) N	P	K	Total C	C : N ratio
Cotton	0.86	0.30	0.92	41.92	48.74
Red gram	0.74	0.28	0.89	42.94	58.02

Table 2. Nutrient dynamics of cotton and red gram residue compost

Compost	Days after composting	Nutrient content (%)				
		N	P	K	Total C	C : N ratio
Cotton stubbles vermicompost	45	1.22	0.90	0.54	33.71	27.6
Cotton stubbles vermicompost + rock phosphate		1.29	1.02	0.68	32.41	25.1
Cotton stubbles vermicompost	60	1.33	0.96	0.73	33.59	25.2
Cotton stubbles vermicompost + rock phosphate		1.54	1.04	0.75	31.99	20.7
Cotton stubbles vermicompost	80	2.00	1.08	0.99	30.71	15.3
Cotton stubbles vermicompost + rock phosphate		2.10	1.32	0.98	30.41	14.4
Red gram stubbles vermicompost	45	1.33	1.02	0.70	34.62	26.0
Red gram stubbles vermicompost + rock phosphate		1.29	1.06	0.73	33.34	25.8
Red gram stubbles vermicompost	60	1.73	1.14	0.91	32.94	19.0
Red gram stubbles vermicompost + rock phosphate		1.96	1.24	0.99	30.99	15.8
Red gram stubbles vermicompost	80	2.20	2.15	0.98	31.41	14.2
Red gram stubbles vermicompost + rock phosphate		2.35	2.60	1.08	30.95	13.1

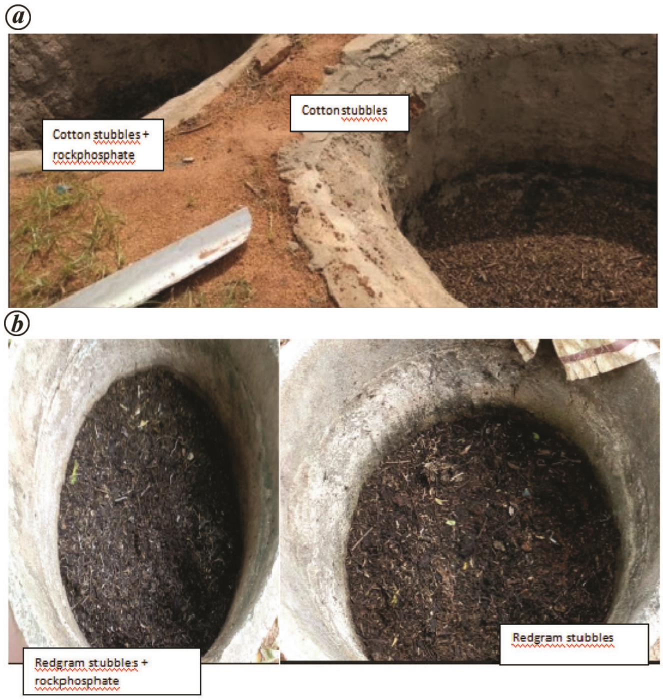

Figure 2. (***a***) Cotton and (***b***) red gram residue compost pits.

Figure 3. Overview of different stages of compost.

The decrease in carbon content over time in crop residues was caused by the loss of carbon dioxide from total organic carbon by microbial respiration and mineralization of organic matter, which resulted in an increase in total nitrogen. A part of the carbon in the decomposing residues is released as CO_2 and a part is assimilated by the microbial biomass, as a source of energy[8].

Addition of rock phosphate showed more rapid decrease in C : N ratio over no application.

At 45 days wider C : N ratio was recorded. The ratio in both crop residues decreased gradually over time, with the lowest recorded at 80 days. Addition of rock phosphate reduced the C : N ratio compared to no application. The C : N ratio is important in regulating the available nitrogen, total organic matter and rate of organic matter decay. Low C : N ratio indicates an increase in the organic matter stabilization and reflects satisfactory decomposition of organic waste and addition of rock phosphate during composting has a positive effect on the rate of degradation and humification[9].

Among the crop residues used in the present study, low C : N ratio was observed with red gram residues + rock phosphate (13.1), followed by red gram residues alone (14.1) and cotton + rock phosphate (14.4). The preference of earthworms to feeding depends on several factors, including the substrate used for decomposition and high nitrogen supply that results in higher rate of decomposition[10]. Reduction in C : N ratio was due to the respiratory activity of earthworms and microorganisms and an increase in nitrogen due to the mineralization of organic matter and excretion of nitrogenous waste[11].

Based on the findings of this study, it can be concluded that red gram and cotton crop residue compost is a promising organic manure with high nutritional and carbon contents.

Conflict of interest: The authors declare that they have no conflict of interest.

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