

Influence of varied crop residues and green biomass composts to *rabi* sorghum growing soils on uptake of major nutrients, microbial biomass and soil fertility status

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Abstract: A field experiment was conducted on *vertisols* (pH of 7.56 with organic carbon content of 0.55%) at Research Institute on Organic Farming, University of Agricultural Sciences, Raichur coming under northern Karnataka during *rabi* season of 2015-16 to study the Influence of varied crop residues and green biomass composts to *rabi* sorghum growing soils on uptake of major nutrients, organic carbon and soil fertility status. In general application of Cotton stalks, Redgram stalks, *Glyricidia*, combination of cotton and redgram stalks composts, FYM and combination of organic and inorganic fertilizers helped to buildup soil nutrients with respect to organic carbon, available nitrogen and phosphorus. Significantly higher nitrogen (227.3 kg ha⁻¹), phosphorous (75.7 kg ha⁻¹) and potassium (141.7 kg ha⁻¹) uptake by *rabi* sorghum was recorded with combined application of recommended FYM (3 t ha⁻¹) and NP fertilizers (50:25 kg N, P₂O₅ ha⁻¹) (T₁₄) followed by Cotton stalks +Redgram stalks + *Glyricidia* sp. with C:N ratio of 30:1 compost @ 50 kg N equivalent (T₁₂: 222.0, 74.0 and 132.3 kg ha⁻¹). The least uptake was recorded with absolute control (T₁₅: 127.0, 42.0 and 71.7 kg ha⁻¹). Similar trend was observed with organic carbon, available nitrogen and phosphorus. Combined application of recommended FYM (3 t ha⁻¹) and NP fertilizers (50:25 kg N, P₂O₅ ha⁻¹) followed by Cotton stalks +Redgram stalks + *Glyricidia* sp. with C:N ratio of 30:1 compost @ 50 kg N equivalent at the time of sowing recorded higher major nutrients uptake, microbial biomass and soil fertility status.

Keywords: Availability, Composts, Nutrients, Soil Fertility status, Sorghum, Uptake

INTRODUCTION

Productive agriculture is dependent upon sound soil nutrient management practices. Seventeen elements are known to be essential for plants. Over years of intensive cultivation and imbalanced fertilizer use, Indian soils have become deficient in several of these nutrients and are also impoverished in organic matter. Yields of various crops have reached a plateau or are on the decline. This is of serious consequence given increasing population and diminishing per capita land availability. Several methods of nutrient management have been practiced on farms, however, the best option for the farmer is an integration of organic and inorganic approaches to nutrient management. This far a lot of emphasis has been placed on the conservation and management of N-one of the earliest reported scarce plant nutrient. However, current studies across India

have shown a gradual and alarming depletion of potassium and increase in P fixation leading to sustainability concerns for these two nutrients. Among other nutrients S, Zn and B are also reaching deficient status in Indian soils (Ramakrishna Parama and Atheefa Munawery, 2012).

Sorghum is cultivated during both rainy (*kharif*) and post-rainy (*rabi*) season, mainly as a rainfed crop in India. Sorghum cultivation is gaining popularity due to its nature of extreme drought tolerance and is very nutritious just like corn and can be used as green fodder, dry fodder, hay or silage. Currently, the energy crises associated with hike in prices of nitrogen, phosphorus and potassium fertilizers has made the use of chemical fertilizers not only costly but also scarce at peak times of demand. It is imperative to make use of organic sources to maintain healthy crop growth and to obtain sustainable yield and quality. Cotton and red-

gram residues *viz.* crop by-products have low fodder value or waste of threshing yard, which have high carbon to nitrogen ratio (22 to 99:1) and less suitable for direct use. Further the quality of the conventional organic manure is poor. In addition to this some of the farmers are using these stalks as source of raw materials for production of composts without knowing exact proportion of mixing green biomass and its impact on crops and soil. Therefore, to develop a suitable technique for production of enriched organic manure with crop residues and green biomass, as a nutrient source and its effect on soil fertility status of soil, present investigation is necessary.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of 2015-16 at Research Institute on Organic Farming, University of Agricultural Sciences, Raichur situated in North Eastern Dry Zone of Karnataka at 16° 15' N latitude and 77° 20' E longitude with an altitude of 389 meters above the mean sea level. The experiment consisted of fifteen treatments, of which twelve treatments were based on recommended nitrogen supply through cotton stalks, redgram stalks, *Glyricidia*, combination of cotton and redgram stalks composts, FYM and combination of organic and inorganic fertilizers, RDF (50:25 N:P₂O₅ kg ha⁻¹) and one absolute control (Table 1). The experiment was laid in RCBD (Randomized Complete Block Design) with three replications.

The soil was deep black clayey in texture with pH and organic carbon content (7.56 and 0.55%, respectively). The soils were low in available nitrogen, high in available phosphorus and available potassium (140.28, 55.34 and 413.21 kg ha⁻¹, respectively). It was analyzed from the collected composite soil sample of 0 to 15 cm depth in experimental plot before sowing. Soil sample was air dried, powdered, passed through 2 mm sieve and analysed for physico-chemical and biological properties of soil. The pH, EC, OC, available soil nitrogen was estimated by alkaline potassium permanga-

nate method as outlined by Subbaiah and Asija (1956). Available phosphorus was determined by Olsen's method as outlined by Jackson (1967) using spectrophotometer. Available potassium was extracted with neutral normal ammonium acetate and the content was estimated by flame photometer (Jackson, 1967). Recommended packages of practices were adopted for crop production. All the data were analyzed statistically as outlined by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Uptake of nutrients: Significantly higher nitrogen, phosphorous and potassium uptake by *rabi* sorghum was recorded with application of recommended FYM (3 t ha⁻¹) and NP fertilizers (50:25 kg N, P₂O₅ ha⁻¹) application (T₁₄: 227.3, 75.7 and 141.7 kg ha⁻¹, respectively) followed by Cotton stalks +Redgram stalks + *Glyricidiasp.* with C:N ratio of 30:1 compost @ 50 kg N equivalent (T₁₂: 222.0, 74.0 and 132.3 kg ha⁻¹). The least uptake was recorded with absolute control (T₁₅: 127.0, 42.0 and 71.7 kg ha⁻¹) (Table 2). This could be attributed to application of FYM @3 t ha⁻¹ with inorganic fertilizers might have improved the nutritional environment in root zone as well as in the plant system leading to increased in uptake and translocation of nutrients especially nitrogen and phosphorous in the reproductive structure leading to higher content and uptake. Since uptake of nutrients is the function of grain and stover yield and their nutrient content, the significant improvement in content of these nutrients coupled with increased grain and stover yield and total uptake of nitrogen, phosphorous and potassium substantially was recorded. Increase in uptake of N was also due to increase in dry matter production and content. These results are in close conformity of Lalitha *et al.* (2015) who reported that among the organic manures, the residual left over with respect to the major nutrients was commensurate with respective nutrient content of different organic manures and depletion pattern of nutrients due to differential uptake by onion and other crops. The higher P was due to the influence

Table 1. Compost and treatment details.

Compost	Treatment No	Treatment details
C ₁	T ₁	Cotton stalks with the initial C:N of 96:1
C ₂	T ₂	Redgram stalks with the initial C:N of 80:1
C ₃	T ₃	<i>Glyricidia sp.</i> with the initial C:N of 22:1
C ₄	T ₄	Cotton stalks + <i>Glyricidia sp.</i> with initial C:N of 50:1
C ₅	T ₅	Cotton stalks + <i>Glyricidia sp.</i> with initial C:N of 40:1
C ₆	T ₆	Cotton stalks + <i>Glyricidia sp.</i> with initial C:N of 30:1
C ₇	T ₇	Redgram stalks + <i>Glyricidia sp.</i> with initial C:N of 50:1
C ₈	T ₈	Redgram stalks + <i>Glyricidia sp.</i> with initial C:N of 40:1
C ₉	T ₉	Redgram stalks + <i>Glyricidia sp.</i> with initial C:N of 30:1
C ₁₀	T ₁₀	Cotton stalks + Redgram stalks + <i>Glyricidia sp.</i> with initial C:N of 50:1
C ₁₁	T ₁₁	Cotton stalks + Redgram stalks + <i>Glyricidia sp.</i> with initial C:N of 40:1
C ₁₂	T ₁₂	Cotton stalks + Redgram stalks + <i>Glyricidia sp.</i> with initial C:N of 30:1
-	T ₁₃	Recommended NP fertilizers (50:25 N, P ₂ O ₅ kg ha ⁻¹)
-	T ₁₄	Recommended FYM (3 t ha ⁻¹) and NP fertilizers (50:25 N, P ₂ O ₅ kg ha ⁻¹)
-	T ₁₅	Absolute control

Table 2. Uptake of nitrogen, phosphorus and potassium by *rabi* sorghum as influenced by different composts.

Treatments	Nitrogen (kg ha ⁻¹)	Phosphorous (kg ha ⁻¹)	Potassium (kg ha ⁻¹)
T ₁ : C ₁ -Compost	176.3	49.0	100.6
T ₂ : C ₂ -Compost	186.7	51.7	104.7
T ₃ : C ₃ -Compost	193.0	61.0	114.0
T ₄ : C ₄ -Compost	176.3	56.0	106.2
T ₅ : C ₅ -Compost	186.0	58.0	107.4
T ₆ : C ₆ -Compost	194.7	59.0	107.6
T ₇ : C ₇ -Compost	185.3	55.0	113.0
T ₈ : C ₈ -Compost	193.7	60.0	116.9
T ₉ : C ₉ -Compost	201.3	64.0	117.3
T ₁₀ : C ₁₀ -Compost	186.3	65.0	122.3
T ₁₁ : C ₁₁ -Compost	205.0	66.7	126.9
T ₁₂ : C ₁₂ -Compost	222.0	74.0	132.3
T ₁₃ : Recommended NP fertilizers (50:25 kg N, P ₂ O ₅ ha ⁻¹)	221.0	72.7	119.1
T ₁₄ : Recommended FYM (3 t ha ⁻¹) and NP fertilizers (50:25 kg N, P ₂ O ₅ ha ⁻¹)	227.3	75.7	141.7
T ₁₅ : Absolute control	127.0	42.0	71.7
S.Em±	1.84	0.75	3.5
C.D. (P=0.05)	5.46	2.17	10.1

T₁ to T₁₂: Compost was applied @ 50 kg N ha⁻¹

Table 3. Population of different groups of microorganisms in soil after harvest of *rabi* sorghum as influenced by different composts.

Treatments	Bacteria (No X 10 ⁷ CFUg ⁻¹ of soil)	Fungi (No X 10 ⁴ CFUg ⁻¹ of soil)	Actinomycetes (No X 10 ³ CFUg ⁻¹ of soil)
T ₁ : C ₁ -Compost	33.1	26.2	18.1
T ₂ : C ₂ -Compost	35.9	28.0	18.2
T ₃ : C ₃ -Compost	40.9	31.6	20.1
T ₄ : C ₄ -Compost	35.8	26.2	18.2
T ₅ : C ₅ -Compost	37.6	26.8	18.9
T ₆ : C ₆ -Compost	40.3	27.6	20.5
T ₇ : C ₇ -Compost	38.1	28.6	18.7
T ₈ : C ₈ -Compost	40.0	30.4	19.7
T ₉ : C ₉ -Compost	41.8	37.1	22.2
T ₁₀ : C ₁₀ -Compost	42.6	35.1	21.5
T ₁₁ : C ₁₁ -Compost	44.7	36.0	22.8
T ₁₂ : C ₁₂ -Compost	47.3	37.4	24.6
T ₁₃ : Recommended NP fertilizers (50:25 kg N, P ₂ O ₅ ha ⁻¹)	40.5	33.2	20.7
T ₁₄ : Recommended FYM (3 t ha ⁻¹) and NP fertilizers (50:25 kg N, P ₂ O ₅ ha ⁻¹)	45.4	39.7	23.9
T ₁₅ : Absolute control	22.9	20.0	11.8
S.Em±	1.01	0.86	0.61
C.D. (P=0.05)	2.91	2.59	1.83

T₁ to T₁₂: Compost was applied @ 50 kg N ha⁻¹

of organics and organic acids produced during decomposition of organic materials in soils resulted in mineralizing the insoluble phosphate into more soluble phosphates (Bellaki *et al.*, 1997).

Soil microbial biomass: The soil beneficial microorganisms such as soil bacteria, fungi and actinomycetes population differed significantly due to different composts (Table 3) The application of recommended fertilizers (50:25 N: P₂O₅ kg ha⁻¹) + FYM @ 3 t ha⁻¹ plus recorded significantly highest soil bacteria (45.4 cfu × 10⁶ g⁻¹ of soil), fungi (39.7 cfu × 10⁴ g⁻¹ soil) and actinomycetes (23.9 cfu × 10³ g⁻¹ soil) populations at harvest. This could be due to cumulative effect of FYM in

increasing organic carbon content of soil which acted as carbon and energy source for microbes and their quick build up in the soil (Rita and Varde, 1998). Lowest soil bacteria (22.9 cfu × 10⁶ g⁻¹ of soil), fungi (20.0 cfu × 10⁴ g⁻¹ soil) and actinomycetes (11.8 cfu × 10³ g⁻¹ soil) populations were noticed in control as compared to other treatments. These results are in line with the findings of Deshpande *et al.* (2010) and Sharada (2013) who reported higher population of soil microflora *viz.*, bacteria, fungi, actinomycetes, free living nitrogen fixers and PSB at different growth stages of both greengram and *rabi* sorghum with combined application of organic manures along with panchagavya.

Table 4. Effect of different composts on pH, electrical conductivity (dS m⁻¹), organic carbon (g kg⁻¹) and available NPK (kg ha⁻¹) status in soil after harvest of *rabi* sorghum.

Treatments	pH	EC	OC	Avail. N	Avail. P ₂ O ₅	Avail. K ₂ O
T ₁ : C ₁ -Compost	6.9	0.35	6.1	184.7	61.3	468.7
T ₂ : C ₂ -Compost	7.0	0.34	6.1	194.0	66.0	487.0
T ₃ : C ₃ -Compost	7.1	0.35	6.2	200.7	74.7	493.0
T ₄ : C ₄ -Compost	7.2	0.35	6.1	186.0	65.3	473.0
T ₅ : C ₅ -Compost	7.3	0.33	6.2	188.0	66.7	479.0
T ₆ : C ₆ -Compost	7.2	0.36	6.1	195.0	67.7	485.0
T ₇ : C ₇ -Compost	7.3	0.35	6.2	194.7	71.7	492.3
T ₈ : C ₈ -Compost	7.3	0.36	6.1	204.0	76.0	497.0
T ₉ : C ₉ -Compost	7.1	0.35	6.1	212.7	77.0	496.0
T ₁₀ : C ₁₀ -Compost	7.3	0.35	6.2	204.3	71.7	501.3
T ₁₁ : C ₁₁ -Compost	7.3	0.36	6.1	217.0	75.7	511.3
T ₁₂ : C ₁₂ -Compost	7.2	0.36	6.3	224.7	81.3	518.7
T ₁₃ : Recommended NP fertilizers (50:25 kg N, P ₂ O ₅ ha ⁻¹)	7.4	0.40	5.8	185.0	65.0	455.7
T ₁₄ : Recommended FYM (3 t ha ⁻¹) and NP fertilizers (50:25 kg N, P ₂ O ₅ ha ⁻¹)	7.2	0.37	6.2	234.0	87.0	519.7
T ₁₅ : Absolute control	6.8	0.32	4.8	132.7	46.3	447.5
S.Em±	0.11	0.02	0.06	3.17	1.93	2.92
C.D. (P=0.05)	NS	NS	0.17	9.50	5.80	8.75

T₁ to T₁₂: Compost was applied @ 50 kg N ha⁻¹

Soil fertility status at harvest: Organic carbon content of the soil improved with the application of different composts and FYM in combination with chemical fertilizers (Table 3). The higher organic carbon content was mainly due to addition of carbon rich organic manures. Hundekar *et al.* (1997) reported that incorporation of organic residues like cotton, redgram and sorghum stubbles at rate of 5 t ha⁻¹ in combination with inorganic fertilizers significantly increased organic carbon and available N, P, K content of soil.

Available nitrogen content in soil increased with application of recommended FYM (3 t ha⁻¹) and NP fertilizers (50:25 kg N, P₂O₅ ha⁻¹) application (234.0 kg ha⁻¹) followed by Cotton stalks +Redgram stalks + *Glyricidiasp.* with C:N ratio of 30:1 compost @ 50 kg N equivalent (224.7 kg ha⁻¹) (Table 4). This may be attributed to addition of more nitrogen to soil through organics and its slow release pattern throughout the growth period, which might have minimized nitrogen loss. These results are in line with Reddy and Reddy (1998) and Manna *et al.* (2005) reported that uptake of phosphorus is synergistic with uptake of nitrogen and higher uptake could be due to solubilization effect of organic acids produced by phosphorous solubilizing bacteria and during decomposition of compost improved aeration and better root proliferation. Available nitrogen content of the soil was lower with the recommended NPK fertilizers (T₁₂). This may be due to the higher concentration of ammonical nitrogen in the fertilizers which might have lost either through volatilization or through denitrification process. The significant build up of available nitrogen due to different compost and chemical fertilizers along with FYM application could be attributed to increased activity due to microbes which releases the nutrients to soil.

Maximum available phosphorus content in soil with the application of recommended FYM (3 t ha⁻¹) and NP fertilizers (50:25 kg N, P₂O₅ ha⁻¹) application (87.0 kg ha⁻¹) followed by Cotton stalks +Redgram stalks + *Glyricidiasp.* with C:N ratio of 30:1 compost @ 50 kg N equivalent (81.3 kg ha⁻¹) (Table 3) may be attributed to more phosphorus added to soil. Similarly, Sharma and Saxena, 1985 reported that organic acids and carbon dioxide released during decomposition might have acted on native insoluble iron and aluminium phosphates resulting in release of insoluble phosphorus or might have chelated active Fe³⁺ and Al³⁺ reducing fixation or formation of insoluble iron and aluminium phosphates. The results of the present study also confirms the findings of Ravi Kumar (2009) and Katkar *et al.* (2012) that maximum build-up of soil P was observed under NPK+ farmyard manure. This might be attributed to build up of P in soil by its addition every year and solubilization of native P in the soil through release of organic acids from farmyard manure.

Potassium content of soil increased with the application of recommended FYM with fertilizers or organics alone (Table 4) which may be due to addition of more potassium (27 to 83 ka ha⁻¹) to the soil through composts alone or in combination with chemical fertilizers. Kihanda *et al.* (2007), Ravi Kumar (2009) and Katkar *et al.* (2012) also obtained similar results like that higher available K was by 18.6 per cent as compared to NPK treated plots. Continuous cropping without addition of K and imbalanced fertilization (N and NP) reduced the availability of K as compared to initial soil K status. Increase in available K might be due to the direct addition to the available K pool of the soil besides reduced K fixation and release of K due to the interaction of organic matter with clay.

Conclusion

The results of the investigation showed that application of recommended FYM @ 3 t ha⁻¹ 15 days before sowing along with 50 kg of nitrogen and 25 kg of phosphorus ha⁻¹ at the time of sowing recorded higher uptake (227.3, 75.7 and 141.7 kg ha⁻¹, respectively), soil bacteria (45.4 × 10⁷ cfu g⁻¹ of soil), fungi (39.7 × 10⁴ cfu g⁻¹ soil) and actinomycetes (23.9 × 10³ cfu g⁻¹ soil) populations at harvest and soil fertility status (234.0, 87.0 and 519.7 kg N P₂O₅K₂O ha⁻¹) followed by use of compost @ 3 t ha⁻¹ prepared with Cotton stalks + Redgram stalks + *Glyricidia* green biomass with initial C:N ratio of 30:1 of the mixed composting material. Currently, the energy crises associated with hike in prices fertilizers has made the use of chemical fertilizers not only costly but also scarce at peak times of demand. Hence, it is imperative to make use of organic sources to maintain healthy crop growth and to obtain sustainable yield and quality.

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