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Yield potential and economics of *rabi* sorghum (*Sorghum bicolor* L.) as influenced by different crop residues and green biomass composts

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Abstract: A field experiment was conducted on *vertisols* at Organic Farming Research Institute, University of Agricultural Sciences, Raichur coming under northern Karnataka during *rabi* season of 2015-16 to study the yield potential (q ha^{-1}) and economics of *rabi* sorghum (*Sorghum bicolor* L.) as influenced by different crop residues and green biomass composts. The experiment consisted of fifteen treatments, of which twelve treatments were based on nitrogen supply though different composts, one recommended dose of fertilizer, one recommended organic and inorganic fertilizers and another was absolute control. Significantly higher grain yield (39.9 q ha^{-1}) and stover yield (13.2 tha^{-1}) was recorded with application of FYM @ 3 t ha^{-1} + RDF (50:25 N:P_2O_5 kg ha^{-1})followed by recommended NP *fertilizers* (T_{13}: 37.2 q ha^{-1}) and Cotton stalks +Redgram stalks + *Glyricidiasp*. with C: N ratio of 30:1 compost @ 50 kg N equivalent (T_{12}: 36.6 q ha^{-1}). The lowest grain yield was recorded with absolute control (T_{15}: 18.4 q ha^{-1}). Significantly higher B:C (3.08) was recorded with RDF(50:25 N:P_2O_5 kg ha^{-1}) + FYM @ 3 t ha^{-1} application followed Cotton stalks +Redgram stalks + *Glyricidia sp.* with C: N ratio of 30:1 compost @ 50 kg N equivalent (T_{12}:2.90) over other treatments. Application of recommended FYM @ 3 t ha^{-1} 15 days before sowing along with 50 kg of nitrogen and 25 kg of phosphorus per hectare at the time of sowing recorded higher dry matter production, grain and stover yield and net returns and benefit: cost ratio.

Keywords: Cotton stalks, Compost, RDF, Red stalks, Sorghum

INTRODUCTION

Sorghum (*Sorghumbicolor* L.) is a fifth most important cereal crop in the world after wheat, maize, rice and barley (Taylor, 2003). Sorghum in India is cultivated during both rainy (*kharif*) and post-rainy (*rabi*) season, mainly as a rainfed crop. Maharashtra is the largest sorghum grower and producer followed by Karnataka, Madhya Pradesh and Andhra Pradesh. Sorghum is grown in 6.16 m. ha with a productivity of 5.45 m t and yield of 884 kg ha^{-1} in the country (Anonymous, 2014). 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. The agricultural wastes include leaves, straw, husk left in the field after harvest, hulls and shells removed during processing of crops at the mills as well as animal dung. Cotton (7.57 lha) and redgram (6.83lha) are major crops grown in northern Karnataka region during 2014-15 (Anonymous, 2015) and stalks of these crops are burnt after harvest causes environmental pollution. All these crop 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 enrichment is best remedy for maintaining soil quality as well as productivity of *rabi* sorghum. Keeping these points in view, the present investigation was carried out to study the efficacy of enriched composts on growth, productivity and economics of *rabi* sorghum.

MATERIALS AND METHODS

A field experiment was conducted during *rabi*season

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of 2015-16 at Organic Farming Research Institute, University of Agricultural Sciences, Raichursituated 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. A composite soil sample was collected from 0 to 15 cm depth in experimental plot before sowing. Soil sample was air dried, powdered, passed through 2 mm sieve and analysed for physic-chemical and biological properties of soil. The soil was deep black clayey in texture with pH of 7.56 with organic carbon content of 0.55%. The soils were low in available nitrogen (140.28 kg ha^{-1}) and high in available phosphorus (55.34 kg ha^{-1}) and high in available potassium (413.21 kg ha^{-1}). The experiment consisted of fifteen treatments, of which twelve treatments were based on recommended nitrogen supply through different composts with recommended FYM (3 t ha^{-1}) + fertilizers RDF (50:25 N:P_2O_5 kg ha^{-1}), RDF (50:25 N:P_2O_5 kg ha^{-1}) and one absolute control (Table 1).

The experiment was laid in RCBD (Randomized Complete Block Design) with three replications. Sorghum (M 35-1) was sown in the first fort night of October in 45 cm x 15 cm spacing and each treatment has a gross plot size of 4.5 m X 3.0 m. The required quantity of twelve types of composts and FYM was applied in to soil 15 days before sowing and entire dose of nitrogen and phosphorous fertilizers applied on the day of sowing and incorporated in to soil as per the university recommendation. Nutrient sources used were urea and diammonium phosphate, respectively. Recommended packages of practices were adopted for crop production. The cost of inputs, labour charges and prevailing market rates of farm produce were taken into consideration for working out cost of cultivation, gross returns and net returns per hectare. The analysis and interpretation of data were done using the Fisher's method of analysis and variance technique as given by Panse and Sukhatme (1967). The level of significance used in "F" and "t" test was at 5 % probability level and wherever "F" test was found significant, the "t" test was performed to estimate critical differences among various treatments.

RESULTS AND DISCUSSION

Dry matter production: The dry matter accumulation (g $plant^{-1}$) is the resultant of various growth attributing characters. In the present study, application of recommended FYM (3 t ha^{-1}) and NP fertilizers applied through DAP and urea (50:25 kg N, P_2O_5 ha^{-1}) recorded significantly higher dry matter accumulation per plant at 90 DAS and at harvest (T_{14}: 162.1 and 203.9 g $plant^{-1}$, respectively) over other treatments and was on par with recommended NP fertilizers (T_{13}: 154.2 and 196.1) or C_{12} compost @ 50 kg N equivalent (T_{12}: 151.1 and 192.4). Absolute control recorded significantly lower dry matter accumulation per plant (T_{15}: 90.4 and 131.6 g $plant^{-1}$, respectively). This might be attributed to initial vigorous growth of sorghum might be responsible for intercepting the sunlight to encourages the crop growth and indirectly boosted the plants to record higher plant height and growth attributes (Table 2). The source of nitrogen from FYM/Composts resulted in taller plants because nitrogen was found to increase number of nodes as well as inter node length and consequently plant height. This is attributed to luxuriant growth, increased plant height (275.3 cm), number of green leaves (7.8) and leaf area (15.5 dm^2 $plant^{-1}$) of plants utilized the resource efficiently resulting in higher dry matter accumulation (203.9 g $plant^{-1}$). These results are conformity with findings of Feisal *et al*. (2012) who reported that chicken manure resulted in an increase in growth attributes (plant height, stem diameter and number of leaves) as well as forage yield of sorghum. Chicken manure (5.0 ton/ha) produced higher fresh and dry forage at harvest than the control.

Yield and yield attributes: The grain (q ha^{-1}) and stover yield (t ha^{-1}) of *rabi* sorghum were significantly (P=0.05) influenced by the application of different crop residues and green biomass composts and inorganic fertilizers (Table 3). Significantly higher grain and stover yield was obtained with application of RDF

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	*Glyricidia sp.* with the initial C:N of 22:1
C_4	T_4	Cotton stalks + *Glyricidia sp.* with initial C:N of 50:1
C_5	T_5	Cotton stalks + *Glyricidia sp.* with initial C:N of 40:1
C_6	T_6	Cotton stalks + *Glyricidia sp.* with initial C:N of 30:1
C_7	T_7	Redgram stalks + *Glyricidia sp*. with initial C:N of 50:1
C_8	T_8	Redgram stalks + *Glyricidia sp*. with initial C:N of 40:1
C_9	T_9	Redgram stalks + *Glyricidia sp*. with initial C:N of 30:1
C_{10}	T_{10}	Cotton stalks + Redgram stalks + *Glyricidia sp.* with initial C:N of 50:1
C_{11}:	T_{11}:	Cotton stalks + Redgram stalks + *Glyricidia sp.* with initial C:N of 40:1
C_{12}	T_{12}	Cotton stalks + Redgram stalks + *Glyricidia sp.* with initial C:N of 30:1
-	T_{13}	Recommended NP fertilizers (50:25 N, P_2O_5 kg ha^{-1})
-	T_{14}	Recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 N, P_2O_5 kg ha^{-1})
-	T_{15}	Absolute control

Table 2. Total Dry matter production (g plant^{-1}) and length of earhead (cm) in *rabi* sorghum at different growth stages as influenced by different composts

Treatments	Dry matter production		Length of ear head (cm)
	90 DAS	At harvest	
T_1: C_1-Compost	127.3	169.0	18.5
T_2: C_2-Compost	131.8	175.0	19.4
T_3: C_3-Compost	137.3	179.4	20.3
T_4: C_4-Compost	128.1	169.7	18.2
T_5: C_5-Compost	130.0	171.4	18.9
T_6: C_6-Compost	131.4	172.8	19.3
T_7: C_7-Compost	133.0	173.9	16.4
T_8: C_8-Compost	135.5	176.4	17.6
T_9: C_9-Compost	137.3	178.1	20.0
T_{10}: C_{10}-Compost	144.9	185.4	17.3
T_{11}: C_{11}-Compost	146.9	186.9	17.8
T_{12}: C_{12}-Compost	151.1	192.4	21.2
T_{13}: Recommended NP fertilizers (50:25 kg N, P_2O_5 ha^{-1})	154.2	196.1	20.0
T_{14}: Recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1})	162.1	203.9	21.5
T_{15}: Absolute control	90.4	131.6	15.4
S.Em±	**4.10**	**4.85**	**0.29**
C.D. (P=0.05)	**12.15**	**14.5**	**0.85**

T_1 to T_{12}:Compost was applied @ 50 kg N ha^{-1}

Table 3. Yield attributes, grain yield and stover yield of *rabi* sorghum as influenced by different crop residues and green biomass composts

Treatments	Number of grains earhead^{-1}	Test weight (g 1000 grains^{-1})	Grain yield (q ha^{-1})	Stover yield (t ha^{-1})
T_1: C_1-Compost	2245.7	28.2	29.7	11.5
T_2: C_2-Compost	2584.8	30.5	30.7	11.8
T_3: C_3-Compost	2685.3	31.6	32.0	12.0
T_4: C_4-Compost	2185.6	29.2	31.0	11.7
T_5: C_5-Compost	2268.2	30.1	31.3	11.8
T_6: C_6-Compost	2489.5	31.6	31.3	11.7
T_7: C_7-Compost	2492.4	31.4	31.5	12.2
T_8: C_8-Compost	2645.3	31.6	32.5	12.4
T_9: C_9-Compost	2864.0	31.9	32.8	12.2
T_{10}: C_{10}-Compost	2901.5	32.2	34.0	12.6
T_{11}: C_{11}-Compost	2925.8	31.6	34.3	12.7
T_{12}: C_{12}-Compost	3014.2	33.2	36.6	12.9
T_{13}: Recommended NP fertilizers (50:25 kg N, P_2O_5 ha^{-1})	3128.2	33.0	34.2	12.2
T_{14}: Recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1})	3204.6	34.4	39.7	13.2
T_{15}: Absolute control	1685.6	23.6	18.4	9.5
S.Em±	**84.8**	**0.41**	**1.47**	**0.12**
C.D. (P=0.05)	**254.5**	**1.22**	**4.25**	**0.32**

T_1 to T_{12}:Compost was applied @ 50 kg N ha^{-1}

(50:25 N:P_2O_5 kg ha^{-1}) + FYM @ 3 t ha^{-1} (T_{14}:39.7q ha $^{-1}$and 13.2 t ha^{-1}, respectively) followed by Cotton stalks + Redgram stalks + *Glyricidia sp.* with initial C:N ratio of 30:1 compost @ 50 kg N equivalent (T_{12}: 36.6 q ha^{-1}& 12.9 t ha^{-1},respectively). The lowest was recorded with absolute control(T_{15}: 18.4 q ha^{-1}& 9.5 t ha^{-1}, respectively). Higher grain and stover yield recorded with recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1}) application might be attributed to better availability of nutrients and root development with the integrated use of organic and inorganic manures. Increased grain yield due to application of recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1}) and Cotton stalks +Redgram stalks + Glyricidia sp. with C: N ratio of 30:1 compost @ 50 kg N equivalent could also be improvement in yield parameters like number of grains per plant (3204.6), 1000 seeds weight (34.4 g). These results are in agreement with the findings of Guled *et al.* (2003) who reported that reported that application of FYM at 5 t ha^{-1} + farmer's practice significantly increased the *rabi* sorghum grain yield, Kobayashi *et al.* (2008) also noticed the higher grain yield in the plot that received successive application of organic manure

Table 4. Cost of cultivation, gross returns, net returns and B:C ratio of *rabi* sorghum as influenced by different crop residues and green biomass composts

Treatments	Cost of cultivation	Gross returns	Net returns	B: C ratio
	` ha^{-1}			
T_1: C_1-Compost	63781	100220	36439	1.57
T_2: C_2-Compost	58718	103420	44702	1.76
T_3: C_3-Compost	43211	107200	63989	2.48
T_4: C_4-Compost	53767	104000	50233	1.93
T_5: C_5-Compost	54641	104980	50339	1.92
T_6: C_6-Compost	48016	104780	56764	2.18
T_7: C_7-Compost	54829	106300	51471	1.94
T_8: C_8-Compost	54033	109300	55267	2.02
T_9: C_9-Compost	48783	109680	60897	2.25
T_{10}: C_{10}-Compost	45088	113600	68512	2.52
T_{11}: C_{11}-Compost	43538	114580	71042	2.63
T_{12}: C_{12}-Compost	41764	120960	79196	2.90
T_{13}: Recommended NP fertilizers (50:25 kg N, P_2O_5 ha^{-1})	40270	110720	70450	2.75
T_{14}: Recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1})	42082	129620	87538	3.08
T_{15}: Absolute control	30070	65800	35730	2.19
S.Em±	**2469**	**4635**	**3205**	**0.09**
C.D. (P=0.05)	**7397**	**13895**	**9610**	**0.26**

T_1 to T_{12}: Compost was applied @ 50 kg N ha^{-1}, Men and women labour @ Rs. 342 each, Bullock pair @ Rs. 500/day, Tractor hiring @ Rs. 500/hr, FYM @ Rs.1000 t^{-1}, Composts @ Rs. 2500 t^{-1}, Urea @ Rs. 5.72 kg^{-1}, DAP @ Rs. 25.32 kg^{-1}, Seeds @ Rs. 52 kg^{-1}, Sorghum grains @ Rs. 2600 q^{-1}, Stover @ Rs. 2000 t^{-1} **B:C:** Benefit-cost ratio.

for 26 years (rice and barley straw or straw compost) than the non-organic manure plot, Similar results are also obtained by Ibrahim *et al.* (2011) in sorghum, Nandapure *et al.* (2011) in sorghum and wheat, Pholsen *et al*. (2004) in sorghum and Zafar *et al*. (2012) in maize.

Economic feasibility: Maximum gross returns was recorded with recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1}) application (T_{14}: Rs.1,29,620 ha^{-1}) over other treatments and was on par with C_{12} compost @ 50 kg N equivalent (T_{12}: Rs. 1,20,960 ha^{-1}). The lowest gross return (Rs. 65800 ha^{-1}) was obtained with the absolute control (T_{15}). While net return and B:C ratio were also higher with recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1}) application (T_{14}: Rs. 87,538 ha^{-1} and 3.08, respectively) over other treatments and was on par with C_{12} compost @ 50 kg N equivalent (T_{12}: Rs. 79,196 ha^{-1} and 2.90, respectively). The least net return and B:C ratio were obtained with absolute control and C_1 compost @ 50 kg N equivalent (T_{15}:Rs. 35,730 ha^{-1} and 1.57, respectively). The higher gross returns in recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1}) application could be attributed to the significantly more marketable grain and stover yield associated with better availability of nutrients. Similar results were recorded by Arjun and Anil (2009) who reported that application of FYM 5 t ha^{-1} + RDF recorded highest benefit cost ratio of 1.51 as compared to application of FYM 5 t ha^{-1} alone (1.10) in maize. Highest net returns and B:C ratio with recommended FYM (3 t ha^{-1}) and NP fertilizers (50:25 kg N, P_2O_5 ha^{-1}) application due to reduced cost of cultivation as compared to different composts alone (Table 4). Lower yield caused reduced gross and returns in absolute control. These results are in line with Krishnamurthy (2003) who reported that maximum gross return, net return and benefit-cost ratio with the application of *Glyricidia* green biomass and poultry waste in 1:1 proportion compost at 125 kg N equivalent plus 125 kg N through fertilizer followed by Compost of *Eupatorium* green biomass + poultry waste (1:1 w/w) compost at 125 kg N equivalent plus 125 kg N through fertilizer compared to control in rose red onion.

Conclusion

From this study it can be concluded that application of recommended FYM @ 3 t ha^{-1} 15 days before sowing along with 50 kg of nitrogen and 25 kg of phosphorus per hectare at the time of sowing recorded higher dry matter production, grain and stover yield and net returns and benefit: cost ratio. However, to realize the similar benefits of recommended package, in terms of dry matter production, grain yield, net returns and B:C ratio, substitution of recommended dose of N can be made through the 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. Sustainable yield and soil health index were higher in organic sorghum production system over fertilizers alone in addition to this the future challenge is supply of sufficient organic manures required to replenish nutrient requirement at large scale.

It can be overcome by composting of cotton and red-gram stalks in this region.

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