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Growth and yield of finger millet as influenced by crop residue composting

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Abstract
A field experiment was conducted during *rabi,* 2018-19 at Students Farm, College of Agriculture. Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. The experimental soil was sandy clay loam texture with pH 7.46, EC 0.36 dS m-^{1} and OC (0.67%). The soil was low in available nitrogen (260.0 kg ha^{-1}), medium in available phosphorus (45.1 kg ha^{-1}) and high in available potassium (521.0 kg ha^{-1}). The experiment was laid out in a randomized block design with eight treatments and replicated thrice. The results revealed that, conjunctive use of inorganics and organics through crop residue composting significantly influenced the growth, yield attributes and yield of finger millet. Application of 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate recorded significantly higher growth parameters and yield attributing characters *viz;* plant height (107.1 cm), number of tillers m^{-2} (192.2), leaf area (834.9 cm^{2} plant^{-1}), dry matter production (10202 kg ha^{-1}) and number of panicles per m^{-2} (158), number of fingers ear head^{-1} (8.5), ear head length (9.1 cm), number of grains panicle^{-1} (854), weight of ear head (11.7 g), and test weight (3.29 g)over rest of the treatments.
Higher grain (3540 kg ha^{-1}) and straw yield (5899 kg ha^{-1}) were registered with 75% RDN+ 25% N through cotton stubbles vermicompost + 2% rockphosphate and it was on par with 75% RDN + 25% N through cotton stubbles vermicompost (3402 kg ha^{-1} and 5753 kg ha-^{1} respectively), 75% RDN+ 25% N through redgram stubbles vermicompost + 2% rockphosphate (3231 kg ha^{-1} and 5595 kg ha^{-1} respectively) and 75% RDN+ 25% N through redgram stubbles vermicompost (3114 kg ha^{-1} and 5542 kg ha^{-1} respectively). The lowest grain (1453 kg ha^{-1}) and straw yield (3737 kg ha^{-1}) were recorded with control plot that consisted of no nitrogen application.

Keywords: Finger millet, integrated nutrient management, crop residue composting, redgram, cotton stubbles vermicompost, FYM. vermicompost

Introduction
Finger millet (*Eleusine coracana* L. Gaertn) commonly known as "nutritious millet" is the fourth important small millet crop grown globally after sorghum, pearl millet and foxtail millet. In India, ragi is the sixth important cereal after rice, wheat, maize, sorghum and pearl millet, being cultivated over an area of 1.19 million hectares with a production of 1.98 million tonnes and productivity of 1661 kg ha^{-1} respectively (Agricultural statistics at a glance, 2016).In Telangana, it is cultivated in an area of 1000 hectares, with a production of 1000 tonnes and productivity of 1000 kg ha^{-1} respectively. (Indiastat.com, 2016). Among different states of India, Karnataka ranked first both in area and production, while, Tamilnadu recorded highest productivity followed by Karnataka during *Rabi* 2016-17.
Prolonged use of chemical fertilizers alone in intensive cropping system pose serious problems to soil fertility and results in harmful effects on soil physico-chemical and biological properties that deter sustainable crop production. It is widely recognized fact that neither use of organic manures alone nor chemical fertilizers can achieve sustainability under the modern intensive farming. Organic manures are the key components in INM of millets under rained conditions. The normal requirement of FYM for different crops ranges from 5 to 15 t ha^{-1}. However, the availability of organic manures is decreasing due to reduction in cattle population and hence, an alternate and locally available organic fertilizer source needs to be explored to meet the demand and for avoiding complete reliance on organic manures. Recycling of crop residues/stubbles into useful manure is a sound option and is the need of the hour, apart from being an environmentally viable technology.
In Telangana state, cotton, red gram and castor are the major *kharif* crops cultivated under rainfed situations. The stubbles of these crops are generally very strong and pose serious problem for removal and hence, burnt for ease and to facilitate towards timely land preparation for the *rabi* crops. Burning of crop residues/stubbles leads to loss of nutrients and organic matter apart from damaging microflora present in the topsoil.

Crop residues form the alternate potent organic source for nutrient substitution through composting and it reduces the pollution generated through burning them.

Keeping, the above points in view the present experiment was initiated to evaluate the effect of compost prepared from cotton and redgram stubbles in combination with inorganic fertilizers on growth and yield of finger millet.

Material and Methods

A field experiment was conducted during *rabi*, 2018-19 at Student Farm, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad under irrigated conditions. The soil of the experimental site was sandy clay loam with soil pH (7.46), EC (0.36dS m^{-1}) and OC (0.67%). The soil was low in available nitrogen (260.0 kg ha^{-1}), medium in available phosphorus (45.1 kg ha^{-1}) and high in available potassium (521.0 kg ha^{-1}). This experiment was laid out in a Randomized block design with three replications and eight treatments. The size of gross and net plots were 4.5 m x 4.0 m and 3.3 m x 3.6 m respectively. There were eight treatments that comprised of comprised of T_1- 100% RDF (60:30:30 - N: P_2O_5: K_2O kg ha^{-1}), T_2- control without nitrogen T_3- 75% RDN + 25% N through FYM, T_4-75% RDN + 25% N through red gram stubbles vermin compost, T_5- 75% RDN + 25% N through cotton stubbles vermin compost, T_6- 75% RDN + 25% N through red gram stubbles vermin compost + 2% rock phosphate, T_7 - 75% RDN +25% N through cotton stubbles vermin compost + 2% rock phosphate, T_8- 75% RDN +25% N through farmers practice vermin compost. The ragi variety GPU-28 was used in the present experiment.

GPU-28 variety seeds were directly sown on 29th September during 2018 adopting a spacing 30 cm x 10 cm. The RDF for finger millet was 60:30:30 NP and K kg ha^{-1}. Entire P (SSP) and K (MOP) fertilizer were applied as basal and N (Urea) was applied in two equal splits, 50% as basal and remaining 50% at 30 DAS. In integrated nutrient management treatments (T_3, T_4, T_5, T_6, T_7 & T_8), 25 per cent nitrogen was applied through organic manures as basal and remaining as that of recommended dose of fertilizers (100% RDF).

Table 1: Details of the nutrient content and amount of material added in nutrient management treatments

S. No.	Organic source	Nutrient content (%)			Quantity of organics added (tha^{-1})
		N (%)	P (%)	K (%)	
1.	Vermi compost prepared from red gram	2.20	2.15	0.98	0.68
2.	Vermi compost prepared from red gram stubbles +2% rock phosphate	2.35	2.60	1.08	0.63
3.	Vermi compost prepared from cotton stubbles	2.0	1.08	0.99	0.75
4.	Vermi compost prepared from cotton stubbles +2% rock phosphate	2.10	1.32	0.98	0.71
5.	Farmers practice of vermin compost	1.68	0.44	0.40	0.88
6.	FYM	0.50	0.22	0.41	3.0

The organics were applied as per the treatments (Table. 1) and incorporated before sowing of the crop. Sowing was done adopting spacing of 30 × 10 cm. A total rainfall of 96.8 mm was received in 7 rainy days during *rabi*, 2018-19. Pre emergence herbicide Pendimethalin (30% EC) @ 1.0 kg a.i. ha^{-1} was sprayed one day after sowing in optimum soil moisture to prevent the growth of weeds. Two hand weeding's were done at 20 and 40 DAS. As a common practice in all the treatments. The insecticide acep hate @ 1.5 g $litre^{-1}$ of water was sprayed at 50 DAS to control stemborer incidence. On an average a total of six irrigations were given during crop growth period. The crop was harvested at physiological maturity when all the ear heads turned to brown and seeds were easily detachable. The border rows from each plot were harvested first by leaving the net plot area. Later the ear heads from each net plot area was harvested after separating those representative hills for recording biometrical observations. The crop was harvested on 30th January, 2019. Bio-metric observations on the morpho- physiological parameters were taken on tagged five representative plants selected at random from each treatment of net plot and the mean values are presented.

Results and Discussion

Growth parameters

Among the different treatments, application of 75% RDN + 25% N through cotton stubbles vermi compost + 2% rock phosphate significantly increased plant height (107.1 cm which was on par with T_5- 75% RDN + 25% N through cotton stubbles vermi compost (104.9cm) and both the treatments were significantly superior over all other treatments (Table 2). While, the control plot registered lowest plant height (77.9 cm).

The improved plant height registered in treatments (T_7, T_5, T_6 and T_4) applied with vermi compost prepared with crop residues was probably due to the mineralization of organic sources which increased the availability of nutrients in soil that enhanced cell division and elongation thus, resulting in greater shoot growth as compared to 100% inorganics and control (without nitrogen fertilizer).

Further, the conjunctive use of organic and inorganic sources improved soil properties and prolonged the availability of nutrients throughout crop growth period reflecting in better plant height. Giribabu *et al*. (2010) [6], Pallavi *et al*. (2014) [8] and Prakasha *et al*. (2017) [8].

Significantly higher number of tillers m^{-2} were recorded with T_7- 75% RDN + 25% N through cotton stubbles vermi compost + 2% rock phosphate (196.2 tillers m^{-}) and was on par with T_5 - 75% RDN + 25% N through cotton stubbles vermi compost (188.3 tillers m^{-2} (Table 2). While the lowest number of tillers were recorded in control plot (135.5 tillers m^{-}).

Improved tiller number in treatment consisting of 25% N substitution through crop residue composting (cotton and red gram stubbles) was due to the improved availability of nutrients that paved for higher photosynthesis through better assimilation of carbon from atmosphere (Pallavi *et al*., 2014) [8].

There was a marked increase in leaf area of finger millet with application of 75% RDN + 25% nitrogen through cotton stubbles vermi compost + 2% rock phosphate maintained its superiority and registered highest leaf area (834.9cm^2 $plant^{-1}$). However, it was on par with T_5 - 75% RDN + 25% nitrogen through cotton stubbles vermi compost (834.9 cm^2 $plant^{-1}$), T_6 - 75% RDN + 25% N through red gram stubbles vermi compost + 2% rock phosphate (782.2 cm^2 $plant^{-1}$) and 75% RDN + 25% N through red gram stubbles vermi compost

(782.6 cm^2 $plant^{-1}$), T_3 - 75% RDN + 25% N through FYM (776.5 cm^2 $plant^{-1}$), T_8- 75% RDN + 25% N through farmers practice vermi compost (753.3.3 cm^2 $plant^{-1}$) followed by T_1 - 100% RDF (748.32 cm^2 $plant^{-1}$). The lowest area (686.1cm^2 $plant^{-1}$) was registered with control plot that received no nitrogen application. (Table 2).

Leaf area is the measure of photosynthetic potential. Higher leaf area registered in the treatments T_7 and T_5 were due to the steady and adequate availability of nutrient release through organics that resulted in improved tillers m^{-2} (Sudheendra Saunshi *et al*. (2014) [11] and Narayana Hebbal *et al*. (2018) [7].

Dry matter production in finger millet is the result of cumulative and complementary effect of plant height, leaf area and tiller number. Higher dry matter accumulation under T_7 (75% RDN + 25% N through cotton stubbles vermi compost + 2% rock phosphate) over other treatments was due to the increased plant height, number of tillers and leaf area as evident from respective data (Table 2). The treatment T_7- 75% RDN + 25% N through cotton stubbles vermi compost + 2% rock phosphate maintained its superiority over all other treatments and recorded significantly highest dry matter accumulation (10202.2 kg ha^{-1}) but it was on par with T_5 - 75% RDN + 25% N through cotton stubbles vermi compost (9531.1 kg ha^{-1}) and T_5 was on par with T_6 -75% RDN + 25% N through red gram stubbles vermi compost + 2% rock phosphate (9068.9 kg ha^{-1}), T_4-75% RDN + 25% N through red gram stubbles vermi compost (8776.7 kg ha^{-1}). The treatment T_6 was on par with T_8 - 75% RDN + 25% N through farmers practice vermi compost (8443.3 kg ha^{-1}) and T_3 with application of 75% RDN + 25% N through FYM (8393.3 kg ha^{-1}) followed by 100% RDF (7602.2 kg ha^{-1}). While the lowest dry matter accumulation (5210.0 kg ha^{-1}) was recorded in control plots (Table 2).

Further complete decomposition of organic matter in treatments consisting of 25% substitute through organics has resulted in the optimum release of nutrients due to their narrow C: N ratio that matched well with the crop nutrient requirement at critical stages resulting in greater plant height, leaf area that positively reflected in greater dry matter accumulation (Basavaraju *et a*l. 2009) [3].

Table 2: Growth parameters yield attributes and yield of finger millet as influenced by crop residue composting

Treatments	Plant height (cm)	Tillers (m^{-2}) 60 DAS	Leaf area (cm^2 $plant^{-1}$)	Dry matter (kg ha^{-1})	Panicles m^{-2}	No. of fingers ear $head^{-1}$	Ear head length (cm)	No. of grains $panicle^{-1}$	Weight of ear head (g)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T_1- 100% RDF	94.6	158.5	748.3	7602.2	138	7.3	8.4	782	9.5	2.90	2551	4868	34.5
T_2- control without nitrogen	77.9	135.5	668.1	5210.0	103	6.2	7.3	621	7.4	2.45	1453	3737	27.9
T_3- 75% RDN + 25% N through FYM	96.7	168.8	772.5	8393.3	140	7.8	8.5	792	9.6	3.13	2895	5254	35.5
T_4- 75% RDN + 25% N through redgram stubbles vermicompost	97.9	176.0	782.6	8776.7	149	8.1	8.7	822	10.6	3.15	3114	5542	36.1
T_5- 75% RDN + 25% N through cotton stubbles vermicompost	104.9	188.3	812.2	9531.1	154	8.4	9.0	842	11.1	3.22	3402	5753	37.2
T_6-75% RDN + 25% N through redgram stubbles vermicompost + 2% rockphosphate	98.9	184.0	782.2	9068.9	151	8.2	8.7	830	10.6	3.16	3231	5595	36.6
T_7- 75% RDN + 25% N through cotton stubbles vermicompost + 2% rockphosphate	107.1	192.2	834.9	10202.2	158	8.5	9.1	854	11.7	3.29	3540	5899	37.5
T_8- 75% RDN + 25% N through farmers practice vermicompost	95.0	171.1	753.3	8443.3	144	7.8	8.6	795	9.8	3.04	2917	5252	35.6
S.Em ±	2.9	8.6	23.2	432	3.6	0.2	0.3	21.4	0.4	0.1	201	312	1.2
CD (P=0.05)	7.6	22.4	59.0	1085.0	9.2	0.5	1.1	55.6	1.0	0.3	522	811	3.1

*RDF: 60:30:30 - N: P_2O_5: K_2O kg ha^{-1}

Yield attributes and Yield

The yield attributes *viz.*, of number of panicles $hill^{-1}$, number of fingers ear $head^{-1}$, ear head length (cm), number of seeds ear $head^{-1}$, 1000- seed weight, grain yield, straw yield and harvest index differed significantly due to nutrient management practices through crop residue composting. Higher number of panicles m^{-2} (158), fingers ear $head^{-1}$ (8.5), ear head length (9.1 cm), number of grains $panicle^{-1}$ (854), weight of ear head (11.7 g), and test weight (3.29 g) compared to all other treatment combinations and control. In the treatments consisting of 25% N substitute through organics might be due to prolonged and adequate supply of nutrients coinciding with the critical crop growth stages reflecting in improved growth and yield attributes (Basavaraj Naik *et a*l. (2017) [4] and Ananda *et al*. (2017) [2].

Significantly higher grain (3540 kg ha^{-1}), straw yield (5899 kg ha^{-1}) and harvest index (37.5%) were registered with T_7- 75% RDN +25% N through cotton stubbles vermi compost + 2% rock phosphate and it was on par with T_5- 75% RDN +25% N through cotton stubbles vermi compost, T_6- 75% RDN +25% N through red gram stubbles vermi compost + 2% rock phosphate and T_5- 75% RDN +25% N through red gram stubbles vermi compost (Table 2). Improved yield in the present study with treatment consisting of conjunctive application of inorganics + 25% N through organics was probably due to higher uptake of nutrients that led to better translocation of photosynthates from source to sink (Narayan Hebbal *et al*. 2018 [7] and Prakasha *et al*. 2018) [9].

Application of 75% RDN +25% N through cotton stubbles vermi compost + 2% rock phosphate resulted in improved growth parameters, yield attributes and yield due to slow and steady release of nutrients throughout the growing period of crop coupled with reduced nutrient losses through volatilization and leaching common with application of inorganics alone. Addition of rock phosphate to stubbles showed more rapid decrease in C: N ratio than that of untreated compost. Improved growth parameters, yield attributes and yield under T_7 treatment was due to the fact that cotton substrate used in present study is known to hold more moisture that allows quick microbial activity leading to better decomposition and higher recovery of compost from stubbles as compared to red gram (Giraddi 2008) [5].

Conclusions

From the above results it could be concluded that on red soils of Southern Telangana regions application of 75% RDN

+25% N through cotton stubbles vermicompost + 2% rockphosphate to finger millet results in higher growth parameters, yield attributes, grain and straw yield

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