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Effect of Segregated and Unsegregated Urban Solid Waste Drum Composts on Growth, Yield and Nutrient Uptake by Finger Millet (*Eleusine coracana L.*)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A greenhouse experiment was conducted in Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore to study the effects of segregated and unsegregated urban solid waste drum compost on plant height, number of leaves, ear head weight, ear head length, 1000 grain weight, grain yield and straw yield in finger millet (*Eleusine coracana L.*) during kharif-2015. The results revealed that plant height, number of leaves, ear head weight, ear head length, 1000 grain weight, grain yield and straw yield and uptake content were significantly improved by the application of 100% NPK+ segregated urban solid waste compost (10 t ha^{-1}) followed by 100% NPK+ unsegregated urban solid waste compost (10 t ha^{-1}) as compared to the treatment which include only in inorganics.

Keywords: Segregated; unsegregated urban solid waste compost; growth; yield; nutrient uptake.

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1. INTRODUCTION

“Finger millet (*Eleusine coracana* (L.) Gaertn) is an important cereal that belongs to the grass family Poaceae, subfamily Chloridoidae. It is estimated that finger millet accounts for some 10 per cent of the 30 million tons of millet produced globally” [1]. “It is also known as Ragi or African millet ranks fourth in importance among millets in the world after sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*) and foxtail millet (*Setaria italica*). It is grown globally on more than 4 million hectares and is the primary food source for millions of people in tropical dry land regions. It also has nutritional qualities superior to that of rice and is on par with wheat” [2]. “The crop is also adapted to a wide range of tropical soils, ranging from red lateritic to sandy loams and black heavy Vertisols” [1]. “In India, it is cultivated on 1.8 m ha with average yields of 1.3 t ha^{-1}. In Karnataka, finger millet is grown in an area of 0.76 m ha producing 1.32 million tonnes with a yield of 1715 kg ha^{-1}” [3].

Any solid or semi-solid material or object that is the result of human or animal activity that is abandoned as worthless or undesired material is referred to as urban solid waste. It is a very diverse collection of trash that can come from residential, commercial, industrial, or agricultural activity. The manufacture of compost for soil amendment or as an organic fertilizer source from municipal solid waste (MSW) has, nevertheless, shown to be a safe and efficient method for accelerating the decomposition and stabilization of biodegradable components of bio-waste.

“Municipal solid waste (MSW) is a substantial by-product of urban lifestyle that is growing faster than urbanization as the world shifts more quickly to an urban future. According to World Bank study, urban MSW has grown by over 70% globally, which puts countries in the most difficulty” [4]. “As a result of the high rates of organic waste generation and their open dumpsite in landfills, there are certain negative impacts on the environment, economy, and social life. One of the eco-friendliest methods for keeping organic contaminants out of landfills is composting” [5]. “Recycling waste through composting is an environmentally favorable substitute, which can be used as a source of plant nutrients” [6]. “The main objectives of sustainable waste management are resource conservation, protection of the environment, and human health. Goals also include preventing the export of issues related to trash into the future and maintaining long-term soil fertility. Municipal solid waste contains high soil organic matter, which becomes more significant as an organic amendment for restoring soil fertility and enhancing soil biological, physical, and chemical properties. Compost made from municipal solid waste reduces the harmful effects of salt-affected soils and functions as a soil conditioner significantly enhancing crop production” [4].

“Urban solid waste compost contains about 51 percent organic waste, which helps to improve crop yield and quality. If used scientifically through segregation and composting, it can reduce the need for chemical fertilisers while also improving soil fertility and reducing environmental pollution. Keeping these points in view, the present investigation was studied aiming to partially replace chemical fertiliser with segregated and unsegregated urban solid waste compost and study its effect on growth parameters, grain yield, straw yield and uptake in finger millet (*Eleusine coracana L*.)” [7].

2. MATERIALS AND METHODS

A pot culture experiment was conducted to study the effect of segregated and unsegregated urban solid waste drum compost on growth parameters, grain yield, straw yield and uptake in finger millet (*Eleusine coracana L*.) variety GPU-48. The experiment was conducted in Department of Soil Science and Agricultural Chemistry, Gandhi Krishi Vignana Kendra, Bangalore (India) during kharif-2015. The pot (8 kg soil pot^{-1}) study where the soil was treated with segregated, unsegregated urban compost and farm yard manure (FYM).

“The soil used in this experiment was treated with segregated and unsegregated compost that were prepared with the use of urban solid waste containing organic waste such as vegetables, fruits, flower, dry leaves and saw dust etc. were separated and transferred into drum composter. Drum composter is a method of preparation of compost using biodegradable organic waste in an air circulated horizontal rotatory drum container. Using drum composter, the compost is prepared within 75-80 days and it is called segregated urban solid waste compost which is having less concentration of heavy metals. The unsegregated urban solid wastes containing both organic and solid waste are transferred into the drum composter without separation. The compost was prepared aerobically as followed in

Table 1. Physical and chemical composition of segregated, unsegregated urban solid waste compost and FYM used in the pot culture experiment [7]

Parameters	FYM	Segregated compost	Unsegregated compost
Physical properties			
Moisture (%)	20.12	23.65	22.03
Colour	Brown	Black	Black
Bulk density (g cm^{-3})	0.98	1.01	1.04
Chemical properties			
pH (1:10)	7.2	7.35	7.84
EC (dS m^{-1})	1.22	1.12	1.51
Organic carbon (%)	17.77	29.16	24.17
C: N ratio	29.01	17.78	19.18
N (%)	0.61	1.64	1.22
P (%)	0.18	0.45	0.32
K (%)	0.52	1.11	0.91
Ca (%)	0.68	1.47	0.95
Mg (%)	0.27	0.74	0.56
S (%)	0.21	0.76	0.64
Zn (mg kg^{-1})	13.86	118.07	143.17
Cu (mg kg^{-1})	2.2	42.11	44.23
Fe (mg kg^{-1})	520.3	3529.11	3604
Mn (mg kg^{-1})	38.12	350.67	366.33
Ni (mg kg^{-1})	18.21	12.75	23.42
Cd (mg kg^{-1})	ND	ND	ND
Pd (mg kg^{-1})	ND	23.87	43.62
Cr (mg kg^{-1})	ND	12.53	21.34

the segregated urban solid waste compost preparation" [7]. The chemical composition of segregated, unsegregated urban solid waste compost and farm yard manure (FYM) is presented in (Table 1).

The experiment was laid out in a Complete Randomized Design (CRD) with three replications. The treatments were T_1 - 100% NPK + FYM at 10 t ha^{-1} (Package of Practice); T_2 - Segregated compost (10 t ha^{-1}); T_3 - Unsegregated compost (10 t ha^{-1}); T_4 - FYM (10 t ha^{-1}); T_5- 100 % NPK + Segregated compost; T_6 - 100% NPK + Unsegregated compost; T_7 - T_2 + 50% NPK; T_8- T_3 + 50% NPK; T_9 -T_4 + 50% NPK; T_{10} - 50% NPK; T_{11} - 100% NPK.

2.1 Statistical Analysis

"The data obtained from the study were subjected to statistical analysis of variance method at 5 per cent level of significance as per the procedure given by Sundaraj et al." [8].

3. RESULTS AND DISCUSSION

The results revealed that plant height and number of leaves/plant was significantly influenced by various treatment combinations at 30, 60 and 90 DAS. Significantly higher plant height of 31.47, 76.90, 110.82 cm and 8.58, 10.50, 11.17 was recorded in T_5 (100 % NPK + Segregated drum compost) which was found on par with T_6 (100 % NPK+ Unsegregated drum compost) 29.92, 73.65, 103.70 cm and 8.33, 10.33, 10.70. The lower nutrient content was recorded in T_4 (FYM alone @ 10 t ha^{-1}) is presented in (Table 2). The increase in plant height with segregated drum compost followed by unsegregated drum compost may be attributed to increase in cell multiplication and elongation due to increased supply of 100 per cent NPK + Segregated drum compost @ 10 t ha^{-1}. Similar results were found in finger millet crop which reported by Kibria and Ham [9], Kavitha and Subramanian [10]. "The compost serves as a source of energy for microorganisms, boost the availability and concentration of nutrients in the soil and release nutrients in a manner easily absorbed by plants its increases growth and yield of plant" [11].

Number of leaves increased due to residual effect of 100 per cent NPK + Segregated drum compost, which might be due to increased availability of nitrogen, phosphorus, potassium and other nutrients throughout the crop growth stages through as a result of continuous mineralization and its uptake. Similar results found in cowpea [7].

The result indicated that grain and straw yield of finger millet was increased significantly to a maximum yield of 8.10 and 14.48 g/pot in T_5 (100 % NPK + Segregated drum compost) followed by T_6 (100 % NPK + Unsegregated drum compost @ 10 t ha^{-1}) 7.91 and 13.63 g/pot. The lower grain and straw yield recorded 6.33 and 10.82 g/pot in T_4 (FYM alone @ 10 t ha^{-1}) is presented in (Table 3).

"Significantly higher grain and straw yield of finger millet was recorded on combined application of 100 per cent NPK + Segregate drum compost. This may be ascribed to enough nutrients being provided to the crop and thus improving soil physical, microbial, chemical and nutritional properties which encourages proliferous root system resulting in better absorption of water and nutrient from soil and thus resulting in higher grain and straw yield and nutrient uptake. MSW compost with sewage sludge compost acts as a source of nutrients, it has a beneficial residual effect on nutrient contents in soil, and finally yields" [12]. The results are in conformity with Bhanu Prakash et al. [13] Dimambro et al. [14]. "Improvement in yield component of wheat and maize with the application of urban compost and sewage sludge" [15]. "The urban waste application contributes to increase the growth of corn plants" [16].

Ear head and 1000 grain weight of finger millet crop varied significantly, the treatment T_5 which received (100 % NPK + Segregated drum compost) recorded significantly higher ear head weight of 11.43 (g hill^{-1}), 3.58 g. Which was on par with T_6 (100 % NPK + Segregated drum compost) 11.24 (g hill^{-1}), 3.48 g. The lower grain and straw yield recorded 9.38 (g hill^{-1}) and 2.84 g in T_4 (FYM alone @ 10 t ha^{-1}). Significantly higher ear head length and number of finger per ear head of finger millet of 5.40 cm and 5.60 was recorded in T_5 (100 % NPK + Segregated drum compost) on par by T_6 (100 % NPK + Unsegregated drum compost) 5.28 cm and 5.43. The lower ear head length and number of finger per ear head 4.55 cm and 4.17 was recorded in T_4 (FYM alone @ 10 t ha^{-1}) is presented in (Table 3).

Application of segregated drum compost waste compost significantly influenced the ear head length, ear head weight, 1000 grain weight and number of finger per ear head of finger millet crop. Significantly higher ear head length and ear head weight were recorded in segregated drum compost treatment which could be ascribed to the slow and steady rate of nutrient release into the soil to match the adsorption pattern of finger millet. The compost application can increase soil organic carbon three-fold and microbial activity double [17].

"By adding organic matter to the soil, compost improves soil macronutrient levels that support plant metabolism and raises long-term soil productivity. Composts containing high amounts of available nitrogen (N) often result in more rapid plant growth and yield, whereas composts with more N bound up in the organic fraction exhibit surplus growth response over successive seasons. Urban solid waste compost its ability to make nutrients (macro and micro-nutrients) more readily available to crop plants upon mineralization and supply of the nutrient to the crop throughout the vegetation period of crop result in increase the plant growth and yield" [11]. "The increased number of ears with the application of MSW compost and sewage sludge in wheat" [14]. "The increased number of ear heads, ear head length and ear head weight in finger millet with application of enriched liquid bio-digester manure" [18].

Significantly higher uptake of nitrogen, phosphorus, potassium, calcium, magnesium and sulphur in finger millet grain of 0.18, 0.02, 0.11, 0.046, 0.026 and 0.045 g/pot was recorded in T_5 (100 % NPK + segregated drum compost) followed by treatment T_6 (100 % N + Unsegregated drum compost) which recorded 0.16, 0.017, 0.09, 0.036, 0.019 and 0.035 g/pot. The lower uptake in grain was recorded in T_4 (FYM alone @ 10 t ha^{-1}) of 0.05, 0.008, 0.05, 0.012, 0.007 and 0.013 g/pot is presented in (Table 4).

This might be attributed to the treatment which sufficiently supplied the nutrients as per crop requirement and release of N from organic amendments through mineralization, which in turn resulted in increased yield and thereby increased uptake. The results are in line with the work done by Lima et al. [19] reported that "nutrient content in soil and uptake in rice increase as compost application rates increased. The benefits to the soil of adding organic matter as well as N with compost can increase longer-term soil productivity". "The MSW compost inoculated with Trichoderma has a great way to improve the soil nutrient status (N, P, K, and S), soil fertility, and crop productivity which left a long impact on the soil" [20]. Similar findings were observed by Roohi et al. [11] segregated "urban solid waste compost is increases major nutrient uptake due to the complimentary effect of organics upon mineralization increased major and secondary nutrients availability in the soil results in uptake by cowpea". "The nutrient content in soil and uptake in rice tended to increase as MSW compost application rates increased in the previous crop. The application of MSW compost and green manure does not replace chemical fertilization but is used in association with fertilizers can satisfy the necessity of crop nutrients" [12].

Similar findings were observed by Grigatti et al. [21] "organic manure increases P availability and uptake by plants". "The availability of secondary nutrient status (Ca, Mg and S) concentration and uptake of nutrients were significantly influenced by native as well as the applied sources" [22]. "The increase in sulphur uptake may be attributed to residual effect of applied organic which might have resulted in slow and steady release of sulphur from native as well as the applied sources". [22]

"The increase nitrogen content and uptake in soya bean with the application of municipal solid waste compost" [23]. The increase in P uptake in maize with the application phosphate solubilizing fungi and different phosphorus levels [24]. The potassium uptake by maize roots improved markedly with inoculation of bacteria in the tested soils compared to corresponding controls [25]. The present results are in consonance with the findings of Rostami et al. [26].

Table 2. Effect of quality of segregated and unsegregated urban solid waste drum composts on growth of finger millet in different stages

Treatments	Plant height (cm)			No. of leaves /plant		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	27.77	73.27	97.92	8.33	10.17	10.57
T_2	22.68	66.6	82.77	8.00	8.57	9.07
T_3	23.67	63.87	85.48	8.17	9.2	9.64
T_4	19.72	66.18	80.3	7.17	8.27	8.53
T_5	31.47	76.9	110.82	8.58	10.5	11.17
T_6	29.92	73.65	103.7	8.33	10.33	10.7
T_7	27.08	63.92	96.45	7.83	10.03	10.23
T_8	25.23	73.15	93.7	8.17	10.04	10.14
T_9	25.15	71.82	87.55	7.83	9.37	10.07
T_{10}	22.87	64.38	83.18	7.67	9.03	9.31
T_{11}	23.15	69.88	87.13	8.00	9.5	9.91
S. Em ±	1.35	2.53	2.84	0.21	0.39	0.28
CD @ 5 %	3.95	7.42	8.34	0.61	1.15	0.83

Table 3. Effect of quality of segregated and unsegregated urban solid waste drum composts yield and yield attributes of finger millet at harvest

Treatments	Grain yield (g / pot)	Straw yield (g / pot)	Earhead weight (g hill $^{-1}$)	1000 grain weight (g)	Earhead length (cm)	No. of finger per earhead
T_1	7.81	12.62	10.73	3.45	5.15	5.24
T_2	6.84	11.34	9.87	2.88	4.68	4.48
T_3	6.44	10.70	9.68	2.86	4.63	4.33
T_4	6.33	10.82	9.38	2.84	4.55	4.17
T_5	8.10	14.48	11.43	3.58	5.40	5.60
T_6	7.91	13.63	11.24	3.48	5.28	5.43
T_7	7.48	12.06	10.70	3.36	4.88	5.17
T_8	7.45	11.90	10.67	3.25	4.80	5.11
T_9	7.23	11.58	10.28	3.13	4.75	4.84
T_{10}	6.58	11.17	10.01	2.94	4.67	4.50
T_{11}	7.11	11.72	10.20	3.05	4.71	4.67
S. Em ±	0.04	0.12	0.17	0.14	0.16	0.26
CD (5%)	0.11	0.35	0.49	NS	0.47	0.75

Table 4. Effect of segregated and unsegregated urban solid waste compost on of major and secondary nutrients uptake of finger millet grain

Treatments	Finger millet Grain					
	Nutrient uptake (g / pot)					
	N	P	K	Ca	Mg	S
T_1	0.15	0.013	0.08	0.025	0.016	0.025
T_2	0.07	0.009	0.06	0.018	0.008	0.015
T_3	0.05	0.008	0.05	0.016	0.01	0.015
T_4	0.05	0.008	0.05	0.012	0.007	0.013
T_5	0.18	0.02	0.11	0.046	0.026	0.045
T_6	0.16	0.017	0.09	0.036	0.019	0.035
T_7	0.14	0.011	0.07	0.021	0.013	0.022
T_8	0.13	0.01	0.06	0.021	0.012	0.021
T_9	0.13	0.008	0.06	0.019	0.008	0.020
T_{10}	0.09	0.009	0.05	0.018	0.012	0.018
T_{11}	0.13	0.012	0.06	0.022	0.01	0.017
S. Em ±	0.01	0.001	0.008	0.005	0.002	0.004
CD (5%)	0.03	0.004	0.024	0.014	0.006	0.011

4. CONCLUSION

The Application of Segregated urban solid waste drum compost to finger millet crop significantly improved the quality of growth, yield and nutrient uptake were noticed as compared to inorganic fertilizer alone. Nutrient uptake in grain in finger millet increases as compost application rates increased. The benefits to the soil of adding organic matter as well as N with compost can increase longer-term soil productivity. Composts with high levels of available N tend to show more immediate plant response in terms of growth, yield and uptake while compost with more N tied up in the organic fraction shows a carry-over growth response in subsequent seasons.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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