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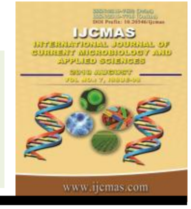

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Residual Effect of Segregated and Unsegregated Urban Solid Waste Compost on Yield and Nutrient Uptake by Cowpea (*Vigna unguiculata* L.)

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A B S T R A C T

A pot experiment was conducted during *kharif*-2016 at Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Bangalore (Karnataka) to study the residual effect of segregated and unsegregated urban solid waste compost on yield and nutrient uptake by cowpea (*Vigna unguiculata* L.). The experiment was laid out under Randomized complete block design with three replication and eleven treatments. Among the treatments, the application of 100 per cent NPK + segregated urban solid waste compost (10 t ha^{-1}) significantly increased the growth parameters (number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area, pod weight $plant^{-1}$, pod length and nodule count), yield and uptake of nutrients (macro and secondary nutrients) by grain and haulm of cowpea as compared to application of chemical fertilizer alone. However, micronutrients uptake was recorded significantly higher in treatment which received 100 per cent NPK + unsegregated urban solid waste compost @ 10 t ha^{-1}.

Introduction

Pulses are major source of protein for vegetarian which is considered as poor man's protein. Besides an important source of protein content, pulses also improves the soil health and mitigates climate changes. Among the pulses, cowpea is important leguminous crop which is extensively grown in arid and semiarid region of India. It contains 20-25 % protein and also has ability to fix atmospheric nitrogen in soil in association with symbiotic bacteria under favourable conditions (Yadav, 1986). In Karnataka, the productivity of cowpea is low (420 kg ha^{-1}) as compared to the national productivity of 567 kg ha^{-1}. The major constraint of low productivity in Indian agriculture is imbalanced supply of nutrient. In context of sustainable agriculture and soil health, the combine application of organic and inorganic fertilizer is the suitable approach to improve soil nutrients and crops productivity (Nigussie *et al.*, 2015).

In modern intensive agriculture, the potential supply of nutrients from soil is not adequate to sustain higher yield and thus external application of nutrient from inorganic and organic sources is inevitable. The addition of urban solid waste compost to soil allows the reduction of the applied levels of chemical fertilizer and may increase the efficacy of chemical fertilizers. Therefore, the use of MSW compost is gradually increasing in agricultural areas. MSW compost application contributes soil organic matter is utilized scientifically through segregation and composting results in mitigating environment pollution. Segregation of urban solid waste compost able to reduce heavy metal contamination and maintain the quality of compost which helps to improve the growth and parameters of crops. Organic matter on decomposition increased the efficiency of nutrients and has long lasting effect of compound produced on crop yield and soil properties (Eghball *et al.*, 2004). Keeping these points in view, the present investigation was carried out with an objective yield and uptake of nutrient by cowpea (*Vigna unguiculata* L.) as influenced by residual segregated and unsegregated urban solid waste compost.

Materials and Methods

A pot experiment was conducted during *kharif*- 2016 using cowpea (*Vigna unguiculata*) variety IT-38956-1 as a test crop. In the previous year (*kharif* -2015), the finger millet crop was taken as a first crop in the pot (8 kg soil pot^{-1}) for study and the experimental soil was treated with segregated, unsegregated compost and FYM along with 100, 50 and 50 kg N, P_2O_5 and K_2O ha^{-1}, respectively. Segregated and unsegregated compost were prepared using drum composting method. Segregated compost contain organic urban solid waste such as vegetables, fruits, flower, dry leaves etc. and unsegregated compost contains organic and inorganic urban solid waste without separation. The compost was ready within 75-80 days using microbial culture. Segregated compost has less concentration of heavy metals as compared to unsegregated compost.

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 under Randomized Complete Block design with eleven treatments and was replicated thrice. The residual treatments were T_1: 100% NPK + FYM @ 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.

After experimental preparations, initial soil samples were collected to analyze initial soil properties. The soil samples were analyzed for pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, calcium, magnesium and sulphur. The experimental soil was found acidic with pH (5.96), EC (0.11dSm^{-1}) and organic carbon (0.36 per cent). The available nitrogen was low (194.12 kg ha^{-1}), medium in available P_2O_5 (35.36 kg ha^{-1}) and low in available K_2O (87.6 kg ha^{-1}). The exchangeable calcium [2.84 cmol (p^{+}) kg^{-1}], exchangeable magnesium [1.32 cmol (p^{+}) kg^{-1}] and available sulphur content (0.22 kg ha^{-1}) were found higher. After harvesting of finger millet, cowpea was grown in the same experimental soil in pots without disturbing the treatments to study residual effect of urban solid waste compost.

Growth and yield parameters of cowpea such as plant height, number of leaves plant^{-1}, number of branches plant^{-1}, leaf area, nodule number, root biomass plant^{-1}, number of pods plant^{-1}, pod length, number of grains pod^{-1}, test weight and pod weight plant^{-1} haulm were recorded at harvest of cowpea. Grain and haulm yield of cowpea were recorded in each pot and expressed as g pot^{-1}.

The grain and haulm samples of cowpea were grind and digested to measure content of N by Micro Kjeldahl method (Jackson, 1973), P by Vanado-molybdophosphoric acid (Jackson, 1973), K by flame photometer (Black, 1965), Ca and Mg by Versenate titrimetry method (Jackson, 1973) and S by Turbidimetry method (Jackson, 1973). The micronutrients in the grain and haulm of cowpea were analyzed using Atomic absorption spectrophotometry (Lindsay and Norwell, 1978). The nutrients uptake by cowpea was calculated from their contents in the plants multiplied by grain and haulm yield and expressed in g $plant^{-1}$ or mg $plant^{-1}$.

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.*, (1972).

Results and Discussion

Growth and yield attributes of cowpea

The application of segregated and unsegregated USW compost along with chemical fertilizer increased the growth and yield attributes viz., plant height, number of leaves $plant^{-1}$, number of branches $plant^{-1}$, leaf area, nodule number, root biomass $plant^{-1}$, number of pods $plant^{-1}$, pod length, number of grains pod^{-1}, test weight and pod weight $plant^{-1}$ at harvest of cowpea (Table 2 and 3). There was no significant difference noticed in case of growth parameters *viz*., plant height (cm) and root biomass $plant^{-1}$ whereas the significant difference was observed in case of number of branches $plant^{-1}$, number of leaves $plant^{-1}$, leaf area, pod length and nodule number. The application of 100 per cent NPK + segregated compost (T_5) significantly increased the growth and yield parameters of cowpea followed by 100 per cent NPK + unsegregated compost (T_6) as compared to application of organic and inorganic fertilizers alone. Significantly increased the growth and yield attributes of cowpea might be due to increased availability of nitrogen, phosphorus, potassium and other nutrients from continuous mineralization of compost throughout the crop growth period. The application of FYM combined with 50 per cent NPK had significant residual effect on pod yield of cowpea over inorganic fertilizer alone (Dubey and Verma, 1999). Similar results were reported by Sukumari (1997) and Joshi *et al.*, (2016).

Yield of cowpea

A significantly higher grain yield (13.33 g pot^{-1}) was recorded in T_5 (100 % NPK + segregated compost) which was found on par with T_6 (100 % NPK + unsegregated compost) recorded 13.28 g pot^{-1} grain yield (Table 2). Application of FYM alone (10 t ha^{-1}) recorded the lowest grain yield of 11.95 g pot^{-1}.The application of 100 per cent NPK + segregated compost produced 10.35 and 9.30 per cent yield increment over the application of FYM @ 10 t ha^{-1} and 100 per cent NPK alone, respectively. The similar trend was follow in case of haulm yield of residual cowpea.

The grain yield pot^{-1} increased by the application of 100 per cent NPK + segregated urban solid waste compost might be due to 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.Combined application of FYM and poultry manure with 50 per cent NPK significantly increased the grain and haulm yield of residual cowpea as documented by Dubey and Verma (1999). Iqbal *et al.,* (2015) also reported that an optimum combination of organic as well as inorganic fertilizers has the potential to increase the forage yield of maize.

Uptake of major nutrients by grain and haulm of cowpea

The application of segregated compost along with 100 per cent NPK increased the uptake of nutrients by grain and haulm of cowpea (Table 3 and 4). Significantly higher uptake of nitrogen by grain and haulm of cowpea having values of 0.54 g plant^{-1}and 0.173 g plant^{-1}, respectively was recorded in T_5 (100 % NPK + segregated compost) on par with T_6 (100 % N + unsegregated compost) recorded 0.52 g plant^{-1} and 0.172 g plant^{-1}, respectively. The uptake of phosphorus by grain (0.057 g plant^{-1}) and haulm (0.032 g plant^{-1}) of cowpea significantly higher in the treatment T_5 (100 % NPK + segregated compost) on par with T_6 (100 % N + unsegregated compost) which recorded 0.056 g plant^{-1} and 0.031 g plant^{-1}, respectively. Similarly, significantly higher uptake of potassium by grain and haulm of cowpea having values of 0.45 g plant^{-1} and 0.158 g plant^{-1}, respectively was recorded in T_5 (100 % NPK + segregated compost).

Table.1 Chemical composition of segregated, unsegregated urban solid waste compost and Farmyard Manure (FYM)

Parameters	Farmyard manure (FYM)	Segregated urban solid waste compost	Unsegregated urban solid waste compost
pH (1:10)	7.2	7.35	7.84
EC (dSm^{-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	0.15	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
Pb (mg kg^{-1})	ND	23.87	43.62
Cr (mg kg^{-1})	ND	12.53	21.34

ND = Not detected

Table.2 Residual effect of segregated and unsegregated urban solid waste composts on growth of cowpea

Treatments	Plant height (cm)		No. of leaves plant^{-1}	No. of branches plant^{-1}	Root biomass plant^{-1} (g)	Leaf area Plant^{-1} (cm^2)	Nodule Number	Pod length (cm)
	30 DAS	90 DAS						
T_1	16.33	37.50	22.67	7.67	0.81	276.70	24.33	15.00
T_2	15.25	35.83	20.17	6.33	0.74	262.72	20.67	13.79
T_3	15.58	36.08	21.00	6.50	0.76	248.18	21.00	13.83
T_4	14.79	35.50	19.50	5.83	0.73	234.65	18.00	12.93
T_5	17.25	38.83	23.00	7.83	0.82	284.82	28.67	15.20
T_6	16.58	38.00	22.83	7.67	0.81	276.51	27.00	15.00
T_7	16.33	37.00	22.67	6.83	0.80	271.29	24.00	14.56
T_8	15.83	36.25	22.50	6.67	0.79	252.95	23.00	14.27
T_9	15.42	36.17	21.00	6.50	0.77	248.00	22.67	14.10
T_{10}	15.67	35.58	19.67	5.00	0.75	240.14	18.33	13.17
T_{11}	16.25	36.33	20.50	5.67	0.76	246.87	19.33	14.53
S. Em ±	0.70	1.62	0.56	0.25	0.03	1.20	1.67	0.52
CD (5%)	NS	NS	1.77	0.80	NS	3.80	5.28	1.63

Table.3 Residual effects of segregated and unsegregated urban solid waste composts on yield and yield parameters of cowpea

Treatments	Number of pods plant^{-1}	Number of grainpod^{-1}	Test weight (g)	Pod weight plant^{-1} (g)	Grain yield pot^{-1} (g)	Haulm yield (g pot^{-1})
T_1	16.00	10.40	11.62	8.51	13.28	12.13
T_2	15.67	9.37	10.63	7.05	12.42	10.52
T_3	14.33	8.63	10.64	7.45	12.19	10.82
T_4	13.67	7.03	10.22	5.31	11.95	10.34
T_5	16.67	11.23	11.79	9.19	13.33	12.17
T_6	16.33	11.00	11.73	8.96	13.20	12.18
T_7	15.33	9.90	11.55	7.87	13.12	12.00
T_8	15.00	8.90	10.93	8.41	12.30	11.80
T_9	14.33	8.23	10.84	6.81	12.12	11.14
T_{10}	13.33	7.93	10.54	5.77	11.94	10.98
T_{11}	14.33	8.43	10.81	5.81	12.09	10.71
S. Em ±	0.38	0.34	0.08	0.56	0.10	0.83
CD (5 %)	1.22	1.07	0.25	1.76	0.34	NS

Table.4 Residual effect of segregated and unsegregated urban solid waste composts on major, secondary and macronutrient uptake by grain of cowpea

Treatments	Uptake of major and secondary nutrients by grain of cowpea (g plant^{-1})						Uptake of micronutrients by grain of cowpea (mg plant^{-1})			
	N	P	K	Ca	Mg	S	Cu	Mn	Zn	Fe
T_1	0.52	0.053	0.41	0.064	0.032	0.036	0.32	0.99	0.45	2.17
T_2	0.43	0.047	0.35	0.049	0.026	0.027	0.25	0.78	0.37	1.77
T_3	0.42	0.045	0.36	0.046	0.023	0.026	0.30	0.85	0.40	1.86
T_4	0.28	0.039	0.28	0.033	0.019	0.021	0.19	0.56	0.24	1.47
T_5	0.54	0.057	0.45	0.072	0.038	0.040	0.34	0.99	0.46	2.34
T_6	0.52	0.056	0.43	0.067	0.037	0.037	0.39	1.01	0.51	2.41
T_7	0.50	0.052	0.39	0.062	0.032	0.035	0.32	0.88	0.41	2.02
T_8	0.46	0.047	0.37	0.055	0.029	0.029	0.34	0.88	0.42	1.98
T_9	0.45	0.045	0.35	0.053	0.026	0.026	0.29	0.72	0.32	1.66
T_{10}	0.40	0.041	0.34	0.038	0.021	0.022	0.23	0.60	0.25	1.53
T_{11}	0.43	0.043	0.35	0.043	0.022	0.024	0.27	0.67	0.28	1.60
S. Em ±	0.006	0.0004	0.007	0.001	0.001	0.0009	0.006	0.01	0.009	0.18
CD (5%)	0.020	0.0015	0.024	0.005	0.003	0.0029	0.020	0.03	0.030	0.57

Table.5 Residual effect of segregated and unsegregated urban solid waste composts on major, secondary and micronutrient uptake by haulm of cowpea

Treatments	Uptake of major and secondary nutrients by haulm of cowpea (g plant^{-1})						Uptake of micronutrients by haulm of cowpea (mg plant^{-1})			
	N	P	K	Ca	Mg	S	Cu	Mn	Zn	Fe
T_1	0.169	0.031	0.153	0.106	0.038	0.059	0.25	1.19	0.48	2.64
T_2	0.140	0.026	0.118	0.064	0.021	0.040	0.14	0.93	0.39	1.37
T_3	0.143	0.027	0.123	0.069	0.023	0.044	0.19	1.03	0.44	2.43
T_4	0.130	0.024	0.107	0.061	0.017	0.034	0.11	0.64	0.31	1.01
T_5	0.173	0.032	0.158	0.125	0.042	0.062	0.26	1.24	0.57	2.60
T_6	0.172	0.031	0.155	0.118	0.038	0.059	0.30	1.41	0.60	3.37
T_7	0.167	0.030	0.145	0.100	0.034	0.054	0.21	1.12	0.51	2.28
T_8	0.161	0.030	0.140	0.082	0.033	0.052	0.24	1.28	0.55	2.82
T_9	0.151	0.028	0.124	0.076	0.029	0.046	0.18	0.88	0.41	1.85
T_{10}	0.142	0.026	0.115	0.066	0.022	0.037	0.13	0.72	0.35	1.32
T_{11}	0.145	0.026	0.125	0.075	0.029	0.039	0.15	0.78	0.36	1.55
S. Em ±	0.01	0.002	0.011	0.008	0.008	0.003	0.012	0.07	0.03	0.16
CD (5%)	0.03	0.006	0.034	0.025	0.002	0.011	0.040	0.24	0.10	0.53

The increase in nitrogen content may be due to the complimentary effect of organics upon mineralization increased nitrogen availability in the soil results in uptake by cowpea. This is in agreement with the findings of Narayana Reddy and Krishnaiah (1999) who reported that with the application one tonne of organic manure about one third of total nitrogen is available to first crop and rest of nitrogen is available to the succeeding crop as residual effect. The results are in accord with the findings of Rostami *et al.,* (2012) and Mohammadreza *et al.,* (2010) reported an increase nitrogen content and uptake in soyabean with the application of municipal solid waste compost. The increase in P uptake in cowpea haulm in treatment T_5 (100% NPK + segregated compost) might be due to larger quantities of P supplied through inorganics as well as organics sources *viz*., segregated, unsegregated urban solid waste compost and FYM and enhanced availability due to mineralization of organic sources. Narayana Reddy and Krishnaiah (1999) also reported that with the application one tonne of organic manure about half of total P is available to first crop and rest of P is available to the succeeding crop. The increased uptake of potassium may be attributed to more accessibility of the nutrients from the added organic and inorganic fertilizers and the solubility action of organic acids produced during the decomposition of organic materials, thus resulting in more release of both of native and applied K nutrients (Bellaki *et al*., 1997).

Uptake of secondary nutrients by grain and haulm of cowpea

The treatment T_5 (100% NPK + segregated compost) showed the superiority over other treatments for the uptake of Ca, Mg and S (Table 3 and 4). Significantly higher uptake of calcium by grain and haulm of cowpea having values of 0.072 g plant^{-1}and 0.125 g plant^{-1}, respectively was recorded in T_5 (100 % NPK + segregated compost) on par with T_6 (100 % N + unsegregated compost) which recorded 0.067 g plant^{-1}and 0.061 g plant^{-1}, respectively. Significantly higher uptake of magnesium by grain and haulm of cowpea having values of 0.038 g plant^{-1}and 0.042 g plant^{-1}, respectively was recorded in T_5 (100 % NPK + segregated compost). Significantly higher uptake of sulphur by grain and haulm of cowpea having values of 0.040 g plant^{-1} and 0.062 g plant^{-1}, respectively was recorded in T_5 (100 % NPK + segregated compost) on par with T_6 (100 % N + unsegregated compost) which recorded 0.037 g plant^{-1}and 0.059 g plant^{-1}, respectively.

Calcium and magnesium uptake was significantly higher in cowpea haulm which might be due to the higher calcium and magnesium content in segregated urban solid waste compost that release Ca and Mg nutrients into soil solution as a result of mineralization of applied organics as reported by Srikanth (1997). Sunitha *et al.,* (2010) reported that availability of secondary nutrient status (Ca and Mg) concentration and uptake of nutrients were significantly influenced by native as well as the applied sources. The increase in sulphur uptake may be attributed to residualeffect of applied organic which might have resulted in slow and steady release of sulphur from native as well as the applied sources.The results are in accordance with the findings of Math (2001).

Uptake of micronutrients by grain and haulm of cowpea

The uptake of micronutrients by grain and haulm of cowpea have significantly influenced by residual treatments (Table 3 and 4). Significantly higher uptake of Fe, Cu, Mn and Zn by grain (2.41, 0.39, 1.01 and 0.51g plant^{-1}) and haulm (3.37, 0.30, 1.41 and 0.60 mg plant^{-1}) of cowpea, respectively was recorded in treatment T_6 (100 % N + unsegregated compost) (Table 5).

The treatment which received of 100 per cent NPK + unsegregated urban solid waste compost @ 10 t ha^{-1} recorded significantly higher micronutrient uptake by grain and haulm of cowpea. Increase in uptake might be due to application of organics enhanced microbial population in soil which in turn released chelating agent's leads to increase in concentration of micronutrients in cowpea. Similar findings were by Rangaraj *et al.*, (2007). Davari and Sharma (2010) indicated that application of FYM has significantly increased the uptake of Zn, Fe, Mn and Cu by rice.

In conclusion, the application of urban solid waste compost and inorganics to finger millet crop resulted into a residual effect on cowpea crop. Treatment (T_5) which is comprised of 100 per cent NPK + segregated urban solid waste compost @ 10 t ha^{-1} significantly increased the yield and uptake of nutrients like N, P, K, Ca, Mg and S by cowpea grain and haulm. However, Treatment T_6 (100 per cent NPK + unsegregated urban solid waste compost @ 10 t ha^{-1}) recorded higher uptake of micronutrients *viz*., Mn, Fe, Cu and Zn as compared to inorganic treatment alone.

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