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Effect of Sewage Sludge, Urban Compost, Poultry Manure and Chemical Fertilizers on Soil Heavy Metal Status in Brinjal-Cauliflower Cropping System

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ABSTRACT

Keywords

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Soil application of sewage sludge, urban compost and poultry manure in vegetable production offers an alternative technique for its disposal and management. The present study was taken up to evaluate the effect of sewage sludge, urban compost and poultry manure on heavy metal content of soil in brinjal-cauliflower cropping sequence. The three organic manures were applied each at 2.5 and 5.0 t/ha, 100% RDF and combination of fertilizer levels (75% RDF) with manures at different levels and a control treatment, arranged in a randomized block design (RBD) with three replicates. Addition of manures with fertilizers resulted in increased DTPA extractable micronutrient content of the soil in both the seasons and residual effect of previous season. Among the treatments application of poultry manure @ 5.0 t ha⁻¹+75% RDF increased the DTPA extractable micronutrient (Fe, Mn and Zn) content in soils. There was a significant build-up of Cu, Cd, Ni, Cr and Pb in soil at sewage sludge @ 5.0 t ha⁻¹+75% RDF application. All the heavy metal concentrations in soil were below the safe limits.

Introduction

Large scale urbanization is leading to increased production of urban compost and sewage sludge in India. Its disposal and management in a cost effective and environment friendly way is one of the serious problems of the country.

Soil application offers a good promise for using the waste material in agriculture. Sewage sludge is a residue mixture of organic and inorganic solids derived after municipal waste water treatment, it offers the possibility of recycling plant nutrients, provides organic material, improves soil fertility along with

physical properties and enhances crop yields (Robert *et al.*, 2011). Animal wastes have been used as a nutrient source in crop production for thousands of years. Addition of poultry manure to soils not only helps to overcome the disposal problems but also enhances the physical, chemical and biological fertility of soils (McGrath *et al.*, 2009). However, sewage sludge, poultry manure and urban compost may contain high amount of toxic heavy metals such as Cd, Ni, Cr and Pb. The problem of waste disposal on the land must be evaluated by historical evidence, which indicates that the animal and

properly treated municipal wastes can be utilized at rates required for optimum crop growth with a minimum of chemical hazard to the environment. The present study aimed at evaluating the effect of manures and fertilizers on heavy metal content of soils in brinjal-cauliflower cropping system.

Materials and Methods

A field experiment was conducted during kharif 2013 and rabi 2013-14 at college farm, Rajendranagar. Data pertaining to the properties of experimental soil are presented in table 1. The soil was sandy loam in texture and slightly alkaline in reaction. It was low in available nitrogen, medium in available phosphorus, potassium and low in organic carbon. The experiment was laid out in a randomized block design with the 14 treatments, each being replicated thrice consisting of two levels of each of sewage sludge, urban compost and poultry manure @ 2.5, 5.0 t ha⁻¹ and combination of 75 percent RDF. The organic manures *i.e.*, poultry manure (PM), urban compost (UC) and sewage sludge (SS) procured from poultry station, Rajendranagar, Hyderabad, SELICO private company gandemguda, Rangareddy and Amberpet sewage treatment plant, respectively. All these manures were analyzed for their chemical composition viz., N, P, K, and OC, pH, EC and available micronutrients (Table 2). All these manure were applied as per the treatments. Nitrogen, phosphorus and potassium were applied through urea, SSP and muriate of potash, respectively while the total quantity of phosphorus and potassium were applied as basal and nitrogen was applied in three equal splits viz. 1/3 as basal, 1/3 at flowering and the remaining 1/3 at fruit formation to brinjal. Thirty days old seedlings of brinjal (hybrid) were transplanted on ridges at a spacing of 60 cm x 60 cm. Soil samples collected after harvest of brinjal were analyzed for their

DTPA extractable micronutrients and heavy metals by AAS.

During rabi season cauliflower was grown to know the manures and fertilizers effect on soil to assay the cumulative and residual effects on cauliflower from earlier brinjal crop. Each earlier treatments plot was divided into two; among them, one plot was used to get cumulative effect on cauliflower, other one was used to get residual effect on cauliflower. However, the crop was grown without addition of any manure and fertilizer for residual sub plot. Cumulative sub plot was applied with fertilizers and manures as per the crop recommendation and treatments. After harvest of the cauliflower crop post harvest soil samples were analyzed for their DTPA extractable micronutrients and heavy metals. The data recorded on various parameters during the course of investigation and the summed up data were statistically analyzed following the analysis of variance for randomized block design as suggested by Panse and Sukhatme (1978).

Results and Discussion

Effect of manures and fertilizers on DTPA extractable micronutrients status

The data on various DTPA extractable micronutrients viz., Fe, Mn, Zn and Cu after harvest of brinjal and cauliflower crop are presented in table 3. Among manure treatments, the mean Fe, Mn, Zn and Cu contents were significantly increased with increase in levels of manure application from 2.5 to 5.0 t ha⁻¹.

Among the treatments for kharif 2013 application of PM @ 5.0 t ha⁻¹ along with 75% per cent RDF recorded the highest values for available micronutrients namely Fe, Mn and Zn (6.20, 8.0 and 1.75 mg kg⁻¹ respectively). SS @ 5.0 t ha⁻¹ along with 75%

per cent RDF recorded the highest values for available Cu (2.04 mg kg⁻¹). The lowest values were recorded in the control.

During the cauliflower grown in cumulative plots, T14 (PM @ 5 t ha⁻¹ + 75% RDF) recorded the highest values for available micronutrients namely Fe, Mn and Zn (6.36, 8.21 and 1.89 mg kg⁻¹ respectively and T12 (S S@ 5 t ha⁻¹+75% RDF) recorded higher Cu content 2.12 mg kg⁻¹.

Among the treatments in residual cauliflower, T14 recorded the highest values for available micronutrients namely Fe, Mn and Zn (6.10, 7.85 and 1.65 mg kg⁻¹ respectively and T12 recorded higher Cu content 1.92 mg kg⁻¹. The lowest content of micronutrients was found in control treatment.

In both the seasons, addition of manures resulted in increasing the available

micronutrients like Fe, Mn, Cu and Zn in the soil significantly. Numerically, maximum available DTPA-extractable micronutrient (Fe, Mn and Zn) contents were noticed with PM and lowest with control. Among the manures, available micronutrient contents were highest in PM treated plots. This effect might be due to the formation of complexes with micronutrients by the organic compounds present in PM. Further, the complexing properties of PM might have prevented the precipitation and fixation of Fe, Mn and Zn and kept them in slowly available form. Poultry manure, sewage sludge enriched urban compost, urban compost and FYM were found performed better in terms of improving micronutrients status of soil than other sources (Ananda *et al.*, 2006). Increase in available micronutrients due to application of organic manures was reported by Deepak (2008).

Table.1 Salient characteristics of experimental soil

S.No	Characteristics of soil
I	Physical properties
a.	Bulk density (Mg m ⁻³)
b.	Mechanical composition (%)
	Sand
	Silt
	Clay
	Textural class
c.	Water holding capacity (%)
II.	Physico-chemical properties
a.	Soil reaction (pH)
b.	Electrical conductivity (EC) (dSm ⁻¹)
c.	Cation exchange capacity (CEC) [cmol (p ⁺) kg ⁻¹]
III.	Chemical properties
a.	Organic carbon (%)
b.	Available nitrogen (kg N ha ⁻¹)
c.	Available phosphorus (kg P ₂ O ₅ ha ⁻¹)
d	Available potassium (kg K ₂ O ha ⁻¹)
III	Enzymatic activity
a.	Urease (µg of NH ₄ ⁺ -N released g ⁻¹ soil h ⁻¹)
b.	Dehydrogenase (µg of TPF produced g ⁻¹ soil d ⁻¹)
c.	Acid phosphatase (µg of p-nitrophenol released g ⁻¹ soil h ⁻¹)
d	Alkaline phosphatase (µg of p-nitrophenol released g ⁻¹ soil h ⁻¹)

Table.2 Characteristics of urban compost, sewage sludge and poultry manure

S.No	Character	Urban compost	Sewage sludge	Poultry manure
Physico- chemical properties				
1	pH	7.13	6.80	7.10
2	EC (dS m ⁻¹)	1.52	1.60	1.20
3	OC (%)	23.00	29.00	33.10
Total major nutrient status (%)				
4	N	0.90	1.60	2.80
5	P	0.32	0.93	1.38
6	K	0.54	0.60	1.46
DTPA extractable micronutrients and heavy metals (mg kg⁻¹)				
7	Fe	189.0	260.0	324.0
8	Mn	30.0	55.0	76.5
9	Zn	19.0	28.8	59.0
10	Cu	14.0	19.4	16.2
11	Cd	1.30	1.56	0.56
12	Ni	1.42	5.30	2.69
13	Cr	5.29	6.24	2.13
14	Pb	4.23	5.60	2.04
Total micronutrients and heavy metals (mg kg⁻¹)				
15	Fe	3250.0	6290.0	1270.0
16	Mn	210.0	758.0	298.0
17	Zn	81.0	423.4	80.0
18	Cu	87.9	345.6	64.2
19	Cd	19.5	60.8	18.0
20	Ni	12.2	61.5	15.0
21	Cr	58.2	99.4	10.2
22	Pb	54.0	120.0	73.2

Table.3 Effect of sewage sludge, urban compost, poultry manure and chemical fertilizers on soil DTPA extractable Micronutrient (mg kg⁻¹) status in brinjal-cauliflower cropping system

Treatments	Brinjal				Cauliflower (cumulative)				Cauliflower (residual)			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
T1-Control	5.05	6.80	0.69	0.29	4.90	6.65	0.50	0.17	4.94	6.44	0.52	0.18
T2-RDF	5.33	6.90	0.96	0.42	5.43	7.10	1.06	0.50	5.26	6.72	0.89	0.34
T3- UC @ 2.5 t ha ⁻¹	5.61	7.01	1.22	0.70	5.75	7.17	1.30	0.81	5.51	6.85	1.20	0.56
T4- UC @ 5 t ha ⁻¹	5.85	7.13	1.38	0.83	5.96	7.23	1.43	0.92	5.73	7.03	1.26	0.70
T5- SS @ 2.5 t ha ⁻¹	5.80	7.16	1.50	1.14	5.90	7.26	1.58	1.20	5.68	7.08	1.37	1.04
T6- SS @ 5 t ha ⁻¹	5.94	7.40	1.60	1.79	6.08	7.59	1.70	1.88	5.82	7.26	1.48	1.70
T7- PM @ 2.5 t ha ⁻¹	5.89	7.20	1.58	0.92	6.02	7.33	1.64	1.03	5.79	7.14	1.45	0.81
T8- PM @ 5 t ha ⁻¹	6.10	7.62	1.66	1.50	6.24	7.72	1.73	1.58	5.94	7.37	1.55	1.34
T9- UC @ 2.5 t ha ⁻¹ + 75% RDF	5.73	7.18	1.33	0.88	5.94	7.28	1.42	0.98	5.60	7.05	1.30	0.76
T10- UC @ 5 t ha ⁻¹ +75% RDF	6.05	7.26	1.48	1.04	6.18	7.38	1.56	1.10	5.84	7.15	1.41	0.95
T11- SS @ 2.5 t ha ⁻¹ +75% RDF	5.96	7.29	1.60	1.26	6.13	7.51	1.70	1.34	5.78	7.20	1.51	1.10
T12- SS @ 5 t ha ⁻¹ +75% RDF	6.14	7.80	1.70	2.04	6.28	7.98	1.80	2.12	6.02	7.65	1.60	1.92
T13- PM @ 2.5 t ha ⁻¹ +75% RDF	6.04	7.35	1.66	1.11	6.18	7.54	1.72	1.20	5.89	7.23	1.55	1.02
T14- PM @ 5 t ha ⁻¹ +75% RDF	6.20	8.00	1.75	1.71	6.36	8.21	1.89	1.85	6.10	7.85	1.65	1.60
Mean	5.83	7.29	1.44	1.12	5.96	7.42	1.50	1.19	5.70	7.15	1.34	1.00
S.E m(±)	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.03
CD(0.05)	0.03	0.03	0.04	0.06	0.04	0.05	0.05	0.07	0.02	0.07	0.05	0.05

Note: RDF: recommended dose of fertilizer UC: urban compost SS: sewage sludge PM: poultry manure

Table.4 Effect of sewage sludge, urban compost, poultry manure and chemical fertilizers on soil DTPA extractable heavy

Treatments	Brinjal				Cauliflower (cumulative)				Cauliflower (residual)			
	Cd	Ni	Cr	Pb	Cd	Ni	Cr	Pb	Cd	Ni	Cr	Pb
T1-Control	tr	0.20	0.100	0.79	tr	0.18	0.080	0.74	tr	0.17	0.080	0.71
T2-RDF	tr	0.22	0.120	0.86	tr	0.23	0.120	0.88	tr	0.20	0.093	0.78
T3- UC @ 2.5 t ha ⁻¹	0.023	0.27	0.137	1.10	0.030	0.28	0.153	1.20	0.020	0.25	0.120	1.06
T4- UC @ 5 t ha ⁻¹	0.042	0.30	0.157	1.25	0.049	0.31	0.183	2.00	0.038	0.28	0.137	1.13
T5- SS @ 2.5 t ha ⁻¹	0.059	0.34	0.200	1.18	0.067	0.36	0.233	1.30	0.054	0.30	0.183	1.12
T6- SS @ 5 t ha ⁻¹	0.091	0.36	0.230	2.40	0.101	0.4	0.263	2.50	0.085	0.35	0.200	2.30
T7- PM @ 2.5 t ha ⁻¹	0.021	0.28	0.117	1.01	0.028	0.29	0.127	1.10	0.016	0.26	0.100	0.90
T8- PM @ 5 t ha ⁻¹	0.040	0.31	0.140	1.23	0.048	0.33	0.153	1.35	0.034	0.29	0.120	1.20
T9- UC @ 2.5 t ha ⁻¹ + 75% RDF	0.026	0.28	0.163	1.30	0.034	0.31	0.173	1.42	0.022	0.27	0.147	1.26
T10- UC @ 5 t ha ⁻¹ +75% RDF	0.046	0.31	0.183	2.00	0.054	0.33	0.207	2.52	0.041	0.29	0.160	1.80
T11- SS @ 2.5 t ha ⁻¹ +75% RDF	0.064	0.35	0.207	1.80	0.071	0.37	0.243	2.00	0.058	0.33	0.187	1.35
T12- SS @ 5 t ha ⁻¹ +75% RDF	0.101	0.38	0.240	2.60	0.111	0.42	0.277	2.72	0.096	0.36	0.220	2.50
T13- PM @ 2.5 t ha ⁻¹ +75% RDF	0.025	0.29	0.127	1.20	0.031	0.33	0.137	1.31	0.020	0.27	0.110	1.14
T14- PM @ 5 t ha ⁻¹ +75% RDF	0.042	0.33	0.163	1.54	0.051	0.35	0.180	1.66	0.036	0.30	0.147	1.40
Mean	0.041	0.30	0.163	1.45	0.048	0.33	0.181	1.62	0.037	0.28	0.143	1.33
S.E m(±)	0.001	0.01	0.032	0.09	0.002	0.01	0.040	0.04	0.003	0.01	0.030	0.10
CD(0.05)	0.002	0.04	0.092	0.25	0.003	0.03	0.115	0.13	0.002	0.03	0.086	0.31

Metal (mg kg⁻¹) status in brinjal-cauliflower cropping system

Note: RDF: recommended dose of fertilizer UC: urban compost SS: sewage sludge PM: poultry manure tr: traces

Effect of manures and fertilizers on DTPA extractable heavy metal status in soil

The results pertaining to the effect of fertilizers, sewage sludge, poultry manure and urban compost on DTPA extractable heavy metal status of soil are presented in table 4. The mean values of DTPA extractable Cd, Ni, Cr and Pb contents significantly increased with increase in manure levels from 2.5 to 5.0 t ha⁻¹.

During kharif 2013, application of organic manures showed significant increase in DTPA extractable Cd, Ni, Cr and Pb contents over control. SS @ 5.0 t ha⁻¹ +75 % RDF recorded higher values of DTPA extractable heavy metal contents. The values found with this level were 0.101, 0.38, 0.240 and 2.60 mg kg⁻¹ for Cd, Ni, Cr and Pb, respectively.

During the cauliflower grown in cumulative plots, T12 (SS @ 5 t ha⁻¹+75% RDF) recorded the highest values for available heavy metals namely Cd, Ni, Cr and Pb 0.111, 0.42, 0.277 and 2.72 mg kg⁻¹ respectively.

Among the treatments in residual cauliflower, T12 (SS @ 5t ha⁻¹+75% RDF) recorded the highest values for available micronutrients namely Cd, Ni, Cr and Pb 0.096, 0.36, 0.220 and 2.50 mg kg⁻¹ respectively.

Influence of sources of nutrients significantly different in the heavy metal content of soil after brinjal and cauliflower. Statistically, highest heavy metal contents were noticed with sewage sludge and lowest with control. Among the manures, the SS increased the heavy metal status in soil. The increase in heavy metal content may be attributed to slow mineralization of organic matter in sludge where the released metals are in more soluble forms in the treated soils. The DTPA-extractable heavy metals were increasing with

the increased applications of sewage sludge (Kavitha, 2007). Sridhar *et al.*, (2006) also reported that the heavy metal status in the soil significantly increased with the increasing levels of sewage sludge and chemical fertilizers application. The results are in conformity with findings of Lone *et al.*, (2013) and Trisha Roy *et al.*, (2013).

In all the treatments available Cd content contributed 0.016 to 0.111 mg kg⁻¹ in soil, considering 0.01 to 7.0 mg kg⁻¹ as normal range (Page, 1974). Available Ni content in soil ranged from 0.17 to 0.42 mg kg⁻¹ whereas, its critical limit was 10.0 to 1000.0 mg kg⁻¹ in normal soils (Page, 1974). In soil, the available Cr content in soil ranged from 0.080 to 0.277 mg kg⁻¹ whereas, its normal range was 5.0 to 3000.0 mg kg⁻¹ (Page, 1974). Available lead content in soil ranged from 0.71 to 2.72 mg kg⁻¹, whereas its critical limits were 2.0 to 200.0 mg kg⁻¹ (Page, 1974).

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