Short communication

Effect of sludge based compost on bhindi (*Abelmoschus esculentus* (L.) Moench) and amaranth (*Amaranthus dubius* Mart.) and soil fertility

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Abstract

Two field experiments were conducted to assess the effects of varying levels of substitution of organic manures with composted effluent sludge of gelatin industry on growth, yield, and nutrient uptake of bhindi (*Abelmoschus esculentus* (L.) Moench and amaranth (*Amaranthus dubius* Mart.). Sludge compost induced earliness in flowering and improved bhindi yield (p=0.01%) whereas the effect was not significant for amaranth. Lead (945 to 1085 mg kg^{-1}), nickel (300 to 600 mg kg^{-1}), and cadmium (22 to 48 mg kg^{-1}) were detected in amaranth foliage regardless of the treatments, while these were absent in the bhindi pods. High soil sodium levels were detected in the bhindi plots receiving 75% manure through sludge compost although variations in soil pH, available phosphorous, potassium, calcium, magnesium, sulphur, iron, manganese, copper, zinc, boron, aluminium, nickel, cadmium, chromium, and lead levels were not pronounced. Soil analysis after amaranth, however, revealed significant differences between treatments for pH (5.48 to 6.56), available phosphorous (70 to164 mg kg^{-1}), calcium (304 to 526 mg kg^{-1}), manganese (range 59 to 118 mg kg^{-1}), copper (4 to 10 mg kg^{-1}) and zinc (4 to 13 mg kg^{-1}). Mixed response of bhindi and amaranth indicate the need to undertake long-term trials based on continuous application of sludge-based compost before going for its commercial application.

Keywords: Effluent sludge, Gelatin, Heavy metals, Residual soil fertility.

Processing effluent sludge into compost manure for use in agricultural production exemplifies a strategy for converting wastes to resources. However, amending agricultural soils with processed solid waste or sludge may lead to accumulation of heavy metals such as cadmium and zinc (Yuran and Harrison, 1986). It is, therefore, essential to assess the presence/accumulation of heavy metals in soils and plants as well as it's impact on crop production before recommending sludge-based compost for application in crop fields. Nitta Gelatin India Ltd, Cochin, Kerala, a firm engaged in processing of animal bones for extracting gelatin approached the Kerala Agricultural University for conducting a trial on effluent sludge based compost. The study was carried out on two vegetable crops, namely bhindi (*Abelmoschus esculentus* (L.) Moench) and amaranth (*Amaranthus dubius* Mart.). The objective was to assess the influence of sludge compost on biometrical characters including yield, plant nutrient content, and residual soil fertility. Edible plant parts and surface soil samples (0 to 20 cm) were analyzed for presence of trace elements and heavy metal toxicity. The field study was conducted in the seed production plots at Vellanikkara during 2009–2010. Sludge compost (1.22% N, 4.20% P and 1.55% K) supplied by M/S Nitta Gelatin and farm yard manure (FYM: 1.10% N, 1.81% P and 0.71% K) procured locally were used.

Bhindi ('Arka Anamika') was raised during the monsoon (June-September) season of 2009 and amaranth ('Co 1')

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during the second crop season (November-March) of 2009–10. The treatments included recommended crop management practices (bhindi: 12 Mg FYM ha^{-1} + 50:8:25 kg NPK ha^{-1}; amaranthus: 50 Mg FYM ha^{-1} + 100:50:50 kg NPK ha^{-1}; KAU, 2007), and 25, 50, 75, and 100% substitution of recommended doses of FYM (12 and 50 Mg ha^{-1} for bhindi and amaranthus respectively) with sludge compost (balance quantities of FYM and NPK as per recommendations). The trial was laid out in a randomized block design with five replications and having a gross plot size of 202.5 m^2 and 220 m^2 for bhindi and amaranth respectively. Bhindi was planted at 60 x 45 cm spacing and amaranth at 60 x 30 cm. Pre-treatment and post-harvest soil samples were drawn from between rows of treatments and was composited treatment- and replication-wise. The soil samples were analyzed for organic carbon, available phosphorous, potassium, calcium (Ca), magnesium (Mg), sulphur (S), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B), sodium (Na), aluminium (Al), nickel (Ni), cadmium (Cd), chromium (Cr) and lead (Pb). Soil organic carbon was estimated by wet digestion method (Walkley and Black, 1934) and available P by Bray and Kurtz (1945). Available K, Ca, Mg, and Na were extracted by neutral normal CH_3COONH_4 and K and Na estimated by flame photometry and Ca and Mg by atomic absorption spectrophotometry (AAS). Available S was extracted with 0.15% $CaCl_2.2H_2O$ (Williams and Steinberg, 1959) and estimated by turbidimetry (Jackson, 1958). All other elements were extracted by 0.1N HCl and estimated using AAS. Marketable pods were also analyzed for N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn, B, Na, Al, Ni, Cd, Cr, and Pb following standard procedures. N in pods was estimated by Micro Kjeldhal method. For estimating other mineral element concentrations, dried and powdered pods were digested with di-acid (HNO_3:$HClO_4$ at 2:1 ratio) and estimated P by vanado-molybdate yellow colour method, K and Na by flame photometry, S by turbidimetry and other elements by AAS. The data on available nutrients in soil elemental composition of pods were subjected to analysis of variance to identify the variations if any between the treatments.

Bhindi plants receiving 100% of manure through sludge compost showed earliness in flowering compared to other treatments (Table 1), which however, was not the case with amaranth where early flowering, is not a desired trait. Sludge application significantly increased the number of fruits /plant (p=0.05) and yield (p=0.01) in bhindi but the effect again was not significant for amaranth. Plant height, number of branches, leaf length and width, and leaf/stem ratio did not show much variations among the treatments for amaranth. While seasonal variations in soil nutrient accumulation may partially explain the inter-specific variations (bhindi and amaranth) observed, this calls for conducting more detailed studies to elucidate crop responses to composted sludge application before recommending the same for commercial application.

Chemical composition of bhindi pods and amaranth leaves showed significant differences among the treatments (Table 2). Plants receiving recommended doses of fertilizers had the highest K concentrations.

Table 1. Biometric characters of bhindi (var. *'Arka Anamika'*) and amaranth (var. *'Co-1'*) in response to sludge compost.

Treatment	Bhindi			Amaranth	
	Days to flowering	Fruit/plant	Yield (kg ha^{-1})	Days to flowering	Yield (kg ha^{-1})
Recommended practices[1]	47.9[a]	17.36[d]	9.585[c]	22.64	49.404
25% manure through sludge compost	47.2[b]	19.88[c]	10.370[b]	21.92	52.585
50% manure through sludge compost	45.8[c]	21.96[b]	11.537[a]	22.66	50.483
75% manure through sludge compost	45.8[c]	23.52[a]	11.755[a]	21.68	59.515
100 % manure through sludge compost	45.7[c]	21.78[b]	11.833[a]	21.88	45.803
CV %	21.3	26.52	28.20	12.3	34.5

Values with the same superscript do not differ significantly. [1]KAU (2007)

Table 2 Mineral composition of bhindi (var. *'Arka Anamika'*) and amaranth (var. *'Co-1'*) in response to sludge compost.

	Bhindi					Amaranth			
	N (%)	K (%)	Fe (mg kg^{-1})	Mg (%)	Mn (mg kg^{-1})	N (%)	K (%)	Fe (mg kg^{-1})	Mn (mg kg^{-1})
Recommended practices[1]	2.24	3.28^{a}	126.8^{bc}	0.354^{ab}	53.40	0.66^{a}	0.17	719.0	233.30^{c}
25% manure through sludge compost	1.70	3.18^{ab}	136.8^{b}	0.368^{a}	52.36	0.58^{ab}	0.2	561.6	158.48^{d}
50% manure through sludge compost	2.64	3.03^{b}	164.4^{a}	0.356^{ab}	37.38	0.44^{c}	0.2	512.6	194.5^{cd}
75% manure through sludge compost	2.00	3.04^{b}	113.0^{c}	0.352^{b}	44.50	0.53^{bc}	0.2	529.8	288.8^{b}
100 % manure through sludge compost	2.34	3.03^{b}	132.0^{b}	0.318^{c}	37.58	0.55^{abc}	0.2	668.2	383.8^{a}
CV %	41.60	14.06	30.79	9.89	34.97	45.4	13.3	50.9	47.9

Values with the same superscript do not differ significantly. [1]KAU (2007)

Fe was highest in the pods of plants receiving 50% of manure recommendation through sludge compost and Mg was highest in the 25% sludge compost treatment. Pods in general were free from heavy metals like Pb, Ni, Cr, and Cd. Unlike bhindi, amaranth did not show much variability in foliar chemical composition, except for N and Mn. However, presence of heavy metals in relatively higher concentrations (e.g., Pb: 945 to 1085; Ni: 300 to 600; and Cd: 22 to 48 mg kg^{-1}) in amaranth foliage, which is the edible plant part, is a matter of concern. Unlike amaranth which is a leafy vegetable, edible immature pods were used for chemical analysis in bhindi and this might will explain the non-detectable levels of Pb, Ni, Cr, and Cd in bhindi.

Application of sludge compost caused a significant accumulation of Na in the soil (31.36 to 36.28 kg ha^{-1}) in the bhindi trial and the highest Na content was observed for plots receiving 75% of manure requirement through sludge compost. Significant difference between treatments was observed for organic carbon (0.728 to 0.76 %). However, no such differences among treatments were observed for pH, available P, K, Ca, Mg, S, Fe, Mn, Cu, Zn, B, Al, Ni, Cd, Cr, and Pb. Soil nutrient analysis after amaranth crop, however, revealed a steady increase in pH of the plots receiving full dose of sludge manure (5.48 to 6.56). Available P (70.31 to 164.33) also increased with application of sludge with maximum value for plots receiving 75% of manure requirement through sludge compost. Ca (303.84 to 525.77 mg kg^{-1}), Mn (59.27 to 117.52 mg kg^{-1}), Cu (3.82 to 10.19 mg kg^{-1}), and Zn (3.93 to12.82 mg kg^{-1}) also showed considerable variations among the treatments, but there was no significant difference with respect to organic C, K, B, S, Fe and Mg content of soil. Overall, variations in the soil chemical attributes did not follow a predictable pattern and was dependent on the crop grown and the nature of the chemical element in question.

On a final note, application of sludge compost improved the yield of bhindi whereas in amaranth, the effect was less pronounced. Being a crop that responds better to organic manure, amaranth ought to have produced higher yields on sludge compost application, but such a trend was not discernible. Regardless of the treatments Pb, Ni and Cd were detected in amaranth leaves but not in bhindi pods. Residual nutrient status exhibited a variable pattern after bhindi and amaranth crop and other than the variability in plant uptake, chance of variation in chemical composition of the compost may be a factor contributing to the soil nutrient status.

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