Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 12	No. 2	pp. 367-370	2013

Original Research Paper

Studies on Efficacy of Sewage Sludge as an Agricultural Supplement for the Assessment of Growth Performance of Brinjal (*Solanum melongena* var. Local long)

F. A. Lone, Sabia Zaffar, Nousheen Qureshi, A. Q. Rather and N. A. Kirmani*
Division of Environmental Sciences, S.K. University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar-191 121, J&K, India
*Division of Soil Sciences, S.K. University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar-191 121, J&K, India

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 5-4-2012
Accepted: 27-6-2012

Key Words:
Agricultural supplement
Sewage sludge
Solanum melongena
Growth performance

ABSTRACT

Application of sewage sludge in agriculture is gaining momentum in many countries and is considered as an efficient waste management option. Sewage sludge is enriched with organic matter, nutrients and trace metals that can improve plant growth and soil fertility. In the present study an experiment was carried out wherein different concentrations of sewage sludge alone and in combination with different recommended doses of fertilizers (RDF) were used to assess the growth performance of brinjal (*Solanum melongena* var. Local long), a commonly cultivated vegetable of Kashmir valley. The field experiment was carried out during summer (Kharif) 2010 and involved five treatments (T1 = Recommended dose of fertilizers; T2 = 100% Sewage Sludge; T3 = 75% Sewage Sludge + 25% RDF; T4 = 50% Sewage Sludge + 50% RDF; T5 = 50% Sewage Sludge + 25% RDF) each with three replications. The data regarding chemical analysis of sewage sludge and pre and post experiment soil samples with respect to pH, EC, OC, N, P, K, Ca, Mg, Cu, Fe, Mn, Zn, Cd, Ni, Cr, Pb is within permissible limits. The highest yield of brinjal was recorded in T1 (327.67q/ha), followed by 290.21q/ha in T4. Fruit quality parameters viz. carbohydrate and protein contents did not exhibit any significant variation between various treatments. On the other hand ascorbic acid content of fruit, foliar photosynthetic pigments (total chlorophyll) and morphological parameters recorded different values in different treatments. Results revealed that application of sewage sludge did not have any adverse impact on fruit quality and can be used for the improvement of plant growth and soil quality. By utilizing sewage sludge in agriculture, environmental degradation can be minimized.

INTRODUCTION

Sewage sludge is an insoluble residue generated from wastewater treatment plants after digestion process and its management is a matter of great concern. In many countries sludge produced is applied to the agricultural land as a means of disposal and can be an alternative option of fertilizers. The substantial N and P concentration in sludge renders it a useful fertilizer and its organic constituents makes it beneficial for improvement of soil conditioning properties (Berry 1986). In the recent past, a number of sewage treatment plants releasing sewage sludge as an end product, have been set up in Srinagar city of Kashmir. According to Jammu and Kashmir Lakes and Waterways Development Authority [LAWDA], approximately 2.0 million litres of sewage sludge is generated per day in Srinagar city (Anonymous 2010). The sludge generated from the treatment plants is dumped along the banks of Dal Lake and its constituents usually get leached into the water body leading to enhanced macrophytic growth, thereby posing a grave threat to the ecology of the lake. To avoid the pollution load of the lake ecosystem and to ensure its eco-friendly management a study was carried out to assess the soil application of sludge on growth performance and quality characteristics of brinjal (*Solanum melongena* var. Local long), one of the commonly grown fruit vegetable of Kashmir.

MATERIALS AND METHODS

Study area: The experiment was conducted during summer (Kharif) 2010. *In-vivo* part of the present research study was carried out in the experimental fields of FOA/RRS, SKUAST-K, Wadura, Sopore, Kashmir (33°14' and 30°25' N and 74°38' E at 1593 above MSL). The area is characterized by temperate climatic conditions with mean maximum and minimum temperature during the growing season as 26.08°C and 11.78°C respectively.

Experimental design and crop: The study was carried out to assess the impact of sewage sludge on growth, yield and quality of brinjal (*Solanum melongena* var. Local long). The experiment was laid in completely randomized block design and involved five treatments (T1 = Recommended dose of

fertilizers; T2 = 100% Sewage Sludge; T3 = 75% Sewage Sludge + 25% RDF; T4 = 50% Sewage Sludge + 50% RDF; T5 = 50% Sewage Sludge + 25% RDF), each with three replications. The plot size of each treatment was 3.91m^2 (1.7m × 2.3m) and seedlings were sown at the spacing of 60 × 45 cm as recommended in the package of practices. The fertilizers N, P and K (kg/ha) were applied to the crop at the rates of 150, 120 and 120 respectively. The sludge for application in the field was collected from the banks of Dal Lake, dried before being put to use and mixed with the soil one week before transplantation to favour mineralization of nutrients from the sludge and soil stabilization. The dosages of sludge treatments to experimental plots were prepared on the basis of N content of sludge and N requirement of the crop.

Sludge and soil analysis: Dried sludge and soil (collected from each plot at the depth of 0-30 cm before transplantation and after harvest) samples were analysed for pH, EC, total N (Kjeldahl method) (Jackson 1974), available P (Olsen 1954) and organic carbon (Walkely & Black 1934). Ca, Mg and K were determined using ammonium acetate method (Hesse 1971). Cu, Zn, Fe, Mn, Ni, Cd, Cr and Pb were analysed by using AAS (Atomic Absorption Spectrophotometer).

Plant tissue analysis: Fruit samples were harvested from each plot, dried in a hot air oven at 70°C for 48 hours, powdered in a grinder and subjected to chemical analysis for the estimation of carbohydrate (Dobois et al. 1956), protein (Lowry et al. 1951) and ascorbic acid contents (Sadasivam & Balasubramanian (1987). Fruit samples were also analyzed for TSS by using Refractometer. Photosynthetic pigments in the foliage were estimated (Hiscox & Isrealstam 1979).

Fruit yield: Fruits were harvested when ripe at different intervals. Total weight of fruits (kg/plot) at each picking was added to obtain the total fruit yield per plot and expressed as quintals per hectare (q ha^{-1}).

Statistical analysis: Data recorded during the experiment were subjected to ANOVA, followed by least significant difference (LSD) test at $p \leq 0.05$ using R software statistical package (Gomez & Gomez 1984).

RESULTS AND DISCUSSION

Recycling of sewage sludge for agricultural use is one of the viable practicable environmental options for its management as it has been seen that addition of sludge to agricultural lands enhances growth and yield of crops which is mainly attributed to the nutrient rich nature of sewage sludge.

Characterization of sludge and soil: Samples of sewage sludge were analyzed in order to determine different chemical characteristics and characterized as pH of 7.71, EC of 2.76 µS and organic carbon content of 3.66% (Table 1). The macronutrient level (N, P, K) ranged from 1.05%, 30mg/kg and 208mg/kg respectively, followed by Ca (92mg/kg) and Mg (62mg/kg). The metal content of sludge was found to be 0.175, 6.62, 50.32, 25.29, 47.27,130.4, 60.0 mg/kg corresponding to Cu, Zn, Fe, Mn, Ni, Cd, Pb respectively. Cr concentration on the other hand was below detection limit. Similar results regarding the characterization of sewage sludge were also reported by De Maria et al. (2010).

Table 1: Chemical characterization of sewage sludge.

Parameter	Value
pH	7.71
EC (µS)	2.76
Organic Carbon (%)	3.66
Total N (%)	1.5
Avail P (mg/kg)	30
Avail K (mg/kg)	208
Cu (mg/kg)	0.175
Zn (mg/kg)	6.62
Fe (mg/kg)	50.32
Mn (mg/kg)	25.79
Ni (mg/kg)	47.17
Ca (mg/kg)	92
Mg (mg/kg)	62
Cd (mg/kg)	130.4
Cr (mg/kg)	BDL*
Pb (mg/kg)	60

*BDL (Below Detection Limit)

Similarly, soil samples of the experimental field were analyzed before and after the sludge treatments to establish any marked changes in different parameters. Texture of soil was loamy and sludge amendments alone and in combination with different fertilizer doses, did not result in any significant changes in the pH values of soil (Shahalam et al. 1998), however, significant increase in EC was detected in soil after the experiment (Casado-Velaa et al. 2007) (Table 2), which might be attributed to the relatively higher EC of sewage sludge and formation of metallic salts-complexes of organic matter and heavy metals (Ahmed et al. 2010). The composition of macroelements (N, P, K) exhibited increased trends in the fertilizer and sludge amended treatments, because these nutrients get incorporated into the soil resulting in their higher quantities. Data also show that the concentration of inorganic microelements (Fe, Mn, Cu, Zn) significantly increased in the soil after the application of different doses of sludge alone and in combination with fertilizers.

Crop growth and yield parameters: Data regarding the morphological growth parameters affected by sludge treatments alone and in combination with the fertilizers is presented in Table 3. Data indicate that T1 recorded the highest values of root biomass, shoot biomass and leaf area, while the root length was highest for T2 (100% Sewage Sludge)

Table 2: Chemical characterization of soil before and after the experiment.

Treatments		pH	EC (dsm^{-1})	N kg/ha	P kg/ha	K kg/ha	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
Before the Experiment		7.00	0.36	605	40	290	1.47	12.12	1.59	1.10
After the Experiment	T_1	7.08	0.82	910	51	411	2.86	14.05	2.25	1.18
	T_2	7.07	0.74	729	43	348	3.44	16.38	2.75	1.25
	T_3	7.05	0.80	794	46	335	3.29	16.75	2.49	1.12
	T_4	7.08	0.66	751	50	340	3.75	14.95	2.51	1.23
	T_5	7.08	0.59	760	47	326	3.12	15.33	2.37	1.27
	CD	NS	0.10	9.40	3.38	11.45	0.34	0.52	0.31	0.08

Table 3: Effect of different doses of sewage sludge on growth parameters of brinjal (*Solanum melongena* var. local long)

Treatment	Root fresh wt. (g)	Root dry wt. (g)	Shoot fresh wt. (g)	Shoot dry wt. (g)	Root length (cm)	Shoot length (cm)	Leaf area (cm)
T1	49.11	23.71	308.00	88.63	10.66	93.33	107.1
T2	37.87	17.91	230.00	65.96	11.33	93.33	90.8
T3	37.02	18.28	205.00	58.06	9.66	90.66	77.8
T4	29.08	17.18	188.00	50.40	11.00	70.00	73.4
T5	29.08	17.18	188.00	50.40	11.00	70.00	72.8
CD	4.21	0.70	6.15	3.92	0.90	4.12	3.41

Table 4. Effect of different doses of sewage sludge on yield of brinjal (*Solanum melongena* var. local long).

Treatment	Fruit no./plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Yield/plant (g)	Yield/plant (kg)	Yield/ha (q)
T1	9.66	12.30	4.33	88.42	854.13	12.81	327.67
T2	7.75	10.33	3.33	86.33	669.05	10.03	256.67
T3	7.75	10.33	3.16	85.33	661.30	9.91	253.69
T4	8.90	9.33	3.16	85.00	756.50	11.34	290.21
T5	7.66	10.66	3.16	85.00	651.10	9.76	249.78
CD	0.71	00.31	0.21	3.42	14.37	0.20	2.70

Table 5: Effect of different doses of sewage sludge on fruit quality and foliar photosynthetic pigments of brinjal (*Solanum melongena* var. local long).

Treatment	Fruit				Leaf		
	TSS (°Brix)	Ascorbic acid (mg/100g)	Carbohydrate (%)	Protein (%)	Chlorophyll *a* (mg/g tissue)	Chlorophyll *b* (mg/g tissue)	Total chlorophyll (mg/g tissue)
T1	6.6	14.6	4.35	1.47	0.83	0.45	1.21
T2	6.3	11.8	3.97	1.37	0.77	0.60	1.37
T3	7.8	10.6	3.90	1.40	0.79	0.64	1.45
T4	8.1	16.0	3.94	1.40	0.83	0.44	1.19
T5	7.0	10.0	3.91	1.44	1.06	0.92	2.03
CD	0.42	2.86	0.93	0.38	0.03	0.08	0.06

and shoot length for both T1 and T2. Significant increase in growth parameters of fruit crop on application of sewage sludge has also been reported (Bozkurt & Yarilgac 2003). The results of sludge amendment on crop yield (q/ha) are presented in Table 4. Data show that the highest yield (327.67 q/ha) was recorded in T1 (Recommended dose of fertilizers), followed by T4 (290.21 q/ha). The mean yield of brinjal followed the sequence $T_1 > T_4 > T_2 > T_3 > T_5$. These results reveal that addition of sewage sludge has a positive effect on plant productivity, as no negative impact was recorded in the crop yield. This is probably due to additional nutrient content of sludge; thereby a lower cultivation cost is expected due to lesser utilization of chemical fertilizers (Chidankumar et al. 2009).

Fruit quality and foliar photosynthetic pigments: Fruit quality parameters viz., carbohydrate and protein were highest in T1, but statistically at par with other treatments (Table 5). K and P found in sludge have a positive effect on fruit

sugar and acid content (Lacatus et al. 1994). Ascorbic acid content of fruit recorded the highest value in T4 (50% Sewage Sludge + 50% RDF), which can be attributed to the P and K contents in sludge and RDF. A positive correlation between the K level in the soil and the acid content of the fruit has also been reported (Davies & Winsor 1967). High sugar and high acid contents generally have a favourable effect on taste. Flavour of tomatoes is associated with high soluble solids. In the present study TSS also recorded significantly higher values in fruits obtained from sludge amended treatments. However, a non-significant decrease in TSS content was recorded in the treatment T2. Studies have shown that increased N and K fertilization increased the solid content of fruits (Wright & Harris 1985). The foliar photosynthetic pigments (total chlorophyll) recorded the highest value in T5 (50% Sewage Sludge + 25% RDF).

CONCLUSION

The study concludes with the finding that sewage sludge can be managed in an eco-friendly manner by its utilization in agro-ecosystems. However, in-depth studies need to be carried out for assessment of heavy metal content in sewage sludge and its uptake in the fruits.

ACKNOWLEDGEMENT

The authors are highly thankful to J&K State Council for Science and Technology, Department of Science and Technology for funding the project under which this research work was carried out.

REFERENCES

Ahmed, H.K., Fawy, H.A. and Abdel-Hady, E.S. 2010. Study of sewage sludge use in agriculture and its effect on plant and soil. Agric. Biol. J. N. Am., 1(5): 1044-1049.

Anonymous 2010. An unpublished report from J&K Lakes and Waterways Development Authority, Srinagar.

Bozkurt, M. A. and Yarilgac, T. 2003. The Effects of sewage sludge applications on the yield, growth, nutrition and heavy metal accumulation in apple trees growing in dry conditions. Turk J. Agric. For., 27: 285-292.

Berry, C.R 1986. Reclamation of severely devastated sites with dried sewage sludge in the Southeast city. In: Cole, D.W., Henry, C.L. and Nutter, W.L. (Eds): The Forest Alternative for Treatment and Utilization of Municipal and Industrial Wastes, pp. 497-507, University of Washington.

Casado-Velaa, J., Sellésa, S., Díaz-Crespob, C., Navarro-Pedreñob, J., Mataix-Beneytob, J. and Gómezb, I. 2007. Effect of composted sewage sludge application to soil on sweet pepper crop (*Capsicum annuum* var. annuum) grown under two exploitation regimes. Waste Management, 27(9): 1509-1518.

Chidankumar, C.S., Chandraju, S. and Nagendraswamy, R. 2009. Impact of distillery spent wash irrigation on the yields of top vegetable creepers. World Applied Science Journal, 6(9): 1270-1273.

Davies, J.N. and Winsor, G.W. 1967. Effect of nitrogen, phosphorus, potassium, magnesium and liming on the composition of tomato fruit. J. Sci. Food Agric., 18: 459-466.

De Maria, I.C., Chiba, M.K., Costa, A. and Berton, R.S. 2010. Sewage sludge application to agricultural land as soil physical conditioner. Revista Brasileira de Ciência do Solo, 34(3): 967-974.

Dubois, M., Gilles, K.N., Rebers, P.A. and Smith, F. 1956. Colorimetric method for determination of sugars and related substances. Analytical Chemistry, 28: 300-356.

Galdos, M.V., De Maria, I.C., and Camargo, O.A. 2004. Atributos quimicos e producao de milho em um Latossolo Vermelho eutroferrico tratado com lodo de esgoto. R. Bras. Ci. Solo, 28: 569-577.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. 2nd ed., A Wiley-Interscience Publication, John Wiley and Sons, New York.

Hesse, P.R. 1971. A Text Book of Soil Chemical Analysis. John Murray Ltd., London, UK, pp. 528.

Hiscox, J.D. and Isrealstam, G.F. 1979. A method for the extraction of chlorophyll from leaf tissue without maceration. Can. J. Bot., 57: 1332-1334.

Jackson, M. 1973. Soil Chemical Analysis. Prentice Hall Inc., London, U.K.

Kizilogu, F.M., Turan, M., Sachin,U., Kuslu,Y and Dursun, A. 2008. Effects of untreated and treated wastewater irrigation on some chemical properties of cauliflower (*Brassica oleracea* L. var. botrytis) and red cabbage (Brassica *oleracea* L. var. rubra) grown on calcareous soils in Turkey. Agricultural Water Management, 95(6): 716-724.

Lacatus, V., Botez, C., Chelu, M., Mirghis, R. and Voican, V. 1994. The influence of organic and mineral fertilizers on tomato quality for processing. Acta Hort., 276: 329-332.

Lemainski, J. and Silva, J.E. 2006. Utilizacao do biossolido da CAESB na producao de milho no Distrito Federal. R. Bras. Ci. Solo, 30: 741-750.

Lowry, O.H., Rosebrought, N.J. and Farr, A.L. 1951. Protein measurement with the folin phenol reagent. J. Biol. Chem., 193: 265-275.

Olsen, S.R., Cole, J.V., Watanabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular 939, USDA, Washington.

Sadasivam, S. and Theymoli Balasubramanian 1987. In: Practical Manual in Biochemistry. Tamil Nadu Agricultural University Coimbatore. pp. 14.

Shahalam, A., Abu Zahara, M.B. and Jaradat, A. 1998. Wastewater irrigation effect on soil, crop and environment: A pilot scale study at Ibrid, Jordan. Water, Air, Soil Pollution, 106: 425-445.

Wright, D.H. and Harris, N.D. 1985. Effect of nitrogen and potassium fertilization on tomato flavour. J Agric. Food Chem., 33: 355-358.

Walkley, A. and Black, I.A.1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci., 34: 29-38.