Applied Biological Research 20 (2): 130-136; (2018)
DOI: 10.5958/0974-4517.2018.00017.4

EFFECT OF SEWAGE SLUDGE AND INORGANIC FERTILIZERS ON GROWTH PERFORMANCE OF BELL PEPPER (*Capsicum annum* var. Nishat-1) UNDER TEMPERATE CONDITIONS OF KASHMIR

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(Received 9 September, 2017; accepted 8 March, 2018)

ABSTRACT

A field experiment was conducted in *kharif* 2012 and 2013 in which different concentrations of sewage sludge alone and in combination with different recommended doses of fertilizers (RDF) were used to assess the growth performance of bell pepper (*Capsicum annum* var. Nishat-1) under Kashmir conditions. The experiment comprised of five treatments 100% RDF; 100% sewage sludge; 75% sewage sludge + 25% RDF; 50% sewage sludge + 50% RDF; 50% sewage sludge + 25% RDF. Physicochemical parameters of sewage sludge *viz.*, pH, EC, OC, N, P, K, Ca, Mg, Cu, Fe, Mn, Zn, Cd, Ni, Cr and Pb and pre- and post-experimental soil samples were within the permissible limits. The highest capsicum fruit yield was found in 100% RDF treatment (290.59 q ha^{-1}), followed by 276.59 q ha^{-1} in 50% sewage sludge + 50% RDF treatment, 246.05 q ha^{-1} in 100% sewage sludge, 231.62 q ha^{-1} in 75% sewage sludge + 25% RDF and least 222.28 q ha^{-1} in 50% sewage sludge + 25% RDF. Results revealed that the use of sewage sludge had no adverse impact on fruit quality and there is an option for its use in the improvement of plant growth and soil quality thereby shall help in reducing the environmental degradation.

Key words: *Capsicum annum*, fruit yield, quality, sludge, soil analysis

INTRODUCTION

Sewage sludge a bye product from municipal waste water treatment plants after digestion process and its management and safe disposal is an issue of critical vital importance for various environmental issues. In different countries it is used as a supplement to fertilizers and provides an opportunity for its secure use. The presence of significant nitrogen and phosphorus and other organic constituents in sludge makes it a valuable nutritive stimulant and therefore make it advantageous for improvement of plant growth and various soil characteristics (Berry, 1986, Lone *et al.*, 2013).

The response of various crops under treatments, with various concentrations of sewage sludge, has been earlier reported by many authors in India and abroad (Ahmed, *et al*., 2010, Nieminen, and Raisanen, 2013; Bourioug *et al*., 2015; Balkhair, and Ashraf, 2016; Wang Rong *et al*, 2016, Saha *et al.*, 2017). The efficacy of sewage sludge under temperate Kashmir conditions as an agricultural supplement for the assessment of growth performance of brinjal (Lone *et al.*, 2013) and maize (Bhat *et al.*, 2013) as well as its microbiological status and application in crop production (Lone *et al.*, 2012) have already been studied.

In Srinagar city, the summer capital of Jammu and Kashmir State a number of municipal sewage treatment plants releasing sludge as a bye-product, have been recently set up around the banks of world famous Dal lake. However, the sludge generated from these treatment plants is

unscientifically dumped along the banks of Dal lake thereby posing a great threat to the ecology and environmental quality of the lake as its nutrients usually get percolated into the water body leading to enhanced macrophytic growth. On the other hand, it acts as the fertilizer and also improves the physical condition of soil by decreasing bulk density, increasing soil aeration, water-holding capacity, aggregate stability, and promoting greater water infiltration (Lagae *et al*., 2009). As this sludge is not coming from any industrial source but is purely domestic with limited accumulation of heavy metals will be less hazardous to soil. To ensure the ecofriendly exploitation of the sludge and to reduce the pollution load of the water body a field experiment was carried out to assess the soil application of sludge on growth performance and quality characteristics of bell pepper (*Capsicum annum*) var. Nishat-1 one of the commonly grown fruit vegetable of Kashmir Himalayas.

MATERIALS AND METHODS

The experiment was conducted during summer (*Kharif*) 2012 and 2013 in experimental field at the Faculty of Agriculture, Wadura, SKUAST-Kashmir (34° 20/55.72" N and 74° 24/ 6.26" E, altitude of 1580 m masl). The area is characterized by temperate climatic conditions with mean maximum and minimum temperature during the growing season as 26.08 and 11.78°C, respectively.

Experimental details

The field experiment to assess the impact of sludge on morpho-physiological characteristics, yield and quality of *C. annum* var. Nishat-1, a commonly cultivated summer vegetable crop of Kashmir valley was laid in a completely randomized block design. The treatment combinations were: Recommended dose of fertilizers (RDF); 100% sewage sludge (6.0 t ha^{-1}); 75% sewage sludge (4.5 t ha^{-1}) + 25% RDF; 50% sewage sludge (3.0 t ha^{-1}) + 50% RDF and 50% sewage sludge (3.0 t ha^{-1}) + 25% RDF). Each treatment was replicated three times. The plot size of each treatment was 3.91 m^2 (1.7 m x 2.3 m) and seedlings were spaced at 60 x 45 cm as per the recommended package of practices. The fertilizers N, P and K were applied to the crop @ 120, 90 and 40 kg ha^{-1} in the form of urea, diammonium phosphate and muriate of potash, respectively. The sludge (collected from the banks of Dal lake) was dried before being put to use and mixed with the soil one week before the transplantation to favour mineralization of nutrients from the sludge and stabilization of the soil. The dosages of sludge treatments to experimental plots were prepared on the basis of N content of sludge and N requirement of the crop and was adjusted lower that RDF keeping in view nutritional (macro- and micro-nutrients) and other beneficial effects of sludge on soil properties.

Analysis of sludge, soil and fruits

Dried sludge and soil samples (collected from each plot at the depth of 10-30 cm before transplantation and after harvest) were analysed for pH, EC, total N by Kjeldahl method (Jackson, 1973), available P (Olsen *et al*., 1954) and organic carbon (Walkely and Black, 1934). Ca, Mg and K were determined using ammonium acetate method (Hesse, 1971). Cu, Zn, Fe, Mn, Ni, Cd, Cr and Pb were analyzed by using AAS (atomic absorption spectrophotometer). The fruit samples were harvested from each plot, dried in a hot air oven at 70°C for 48 h, 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 and Balasubramanian, 1987). The fruit samples were analyzed for TSS by using refractometer. Photosynthetic pigments in foliage were also estimated (Hiscox and Isrealstam, 1979). Total weight of fruits (kg $plot^{-1}$) at each picking was added to obtain the total fruit yield per plot and expressed as q ha^{-1}.

Statistical analysis

Pooled data of two years was subjected to ANOVA, followed by least significant difference (CD, $p \leq 0.05$) using R software statistical package (Gomez and Gomez, 1984).

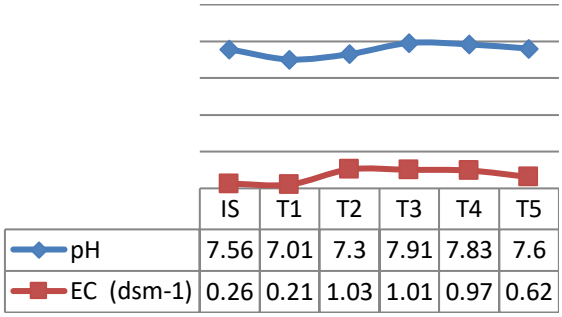
RESULTS AND DISCUSSION

Sludge composition and soil health

The sewage sludge had a pH of 6.6, EC of 2.08 dsm^{-1} and organic carbon content of 4.44%. The N, P and K contents in sludge were 1.50, 0.592 and 0.32%, respectively, followed by Ca (116.37 ppm) and Mg (67.3 ppm). The metal content in sludge *viz*., Cu, Zn, Fe, Mn, Ni, Cd, Pb and Cr were found to be 1.18, 6.82, 37.27, 25.96, 14.61, 2.80, 80.9 and 23.0 ppm, respectively. Similarly, soil samples of experimental field were analyzed before and after sludge application. The results revealed that sewage sludge amendments applied alone and in combination with fertilizers had significant impact on soil pH (Fig. 1) with highest value of 7.91 in 75% sewage sludge + 25% RDF treatment, followed by 50% sewage sludge + 50% RDF and 50% sewage sludge + 25% RDF treatment. The findings are line with Shahalam *et al.* (1998). Significant increase in EC was detected in soil after the experiment which might be due to the relatively higher EC in sewage sludge and formation of metallic salts-complexes of organic matter and heavy metals ((Vela *et al.*, 2007; Ahmed *et al.*, 2010; Lone *et al.*, 2013). The data revealed that the concentration of inorganic micro-elements (Fe, Mn, Cu and Zn) significantly increased in soil after the application of sludge alone or in combination with fertilizers. However, heavy metals (Pb, Ni, Cd and Cr) did not show any significant increase in soil.

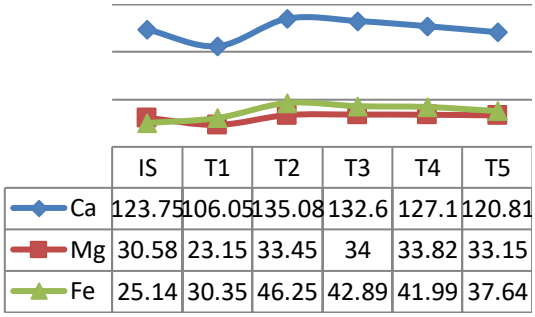
Crop growth and yield response

The sewage sludge or inorganic fertilizer additions significantly affected fresh/dry, root/shoot biomass as well as leaf area the crop. Compared to other treatments, the RDF treatment alone recorded



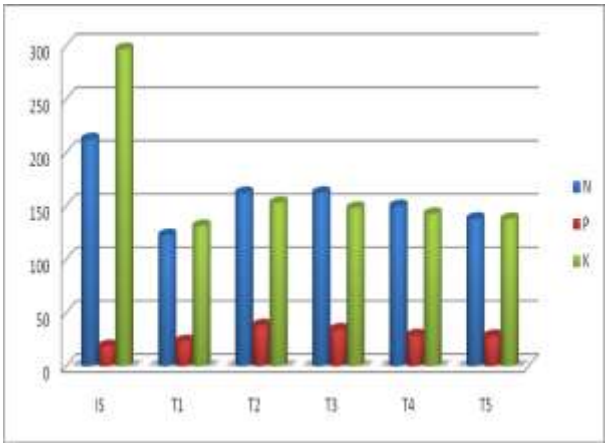
	IS	T1	T2	T3	T4	T5
pH	7.56	7.01	7.3	7.91	7.83	7.6
EC (dsm-1)	0.26	0.21	1.03	1.01	0.97	0.62

a) pH and EC

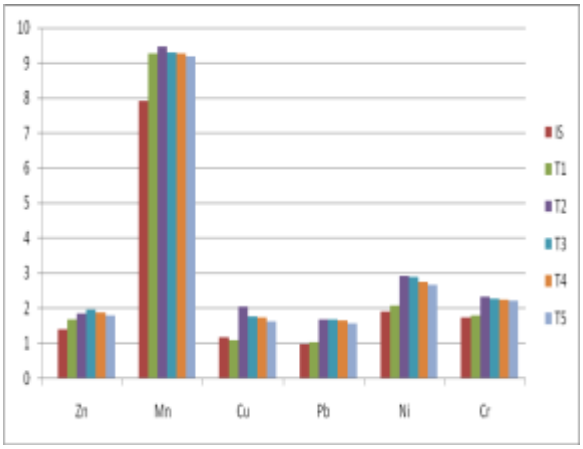


	IS	T1	T2	T3	T4	T5
Ca	123.75	106.05	135.08	132.6	127.1	120.81
Mg	30.58	23.15	33.45	34	33.82	33.15
Fe	25.14	30.35	46.25	42.89	41.99	37.64

b) Calcium, magnesium and iron



c) Nitrogen, phosphorus and potassium (kg ha^{-1})



d) Micro-nutrients and heavy metals (ppm)

Fig. 1: Some physicochemical characteristics of soil before and after experimentation; IS = Initial status; T_1 = Recommended dose of fertilizers (RDF); T_2 = 100% sewage sludge; T_3 = 75% sewage sludge + 25% RDF; T_4 = 50% sewage sludge + 50% RDF; T_5 = 50% sewage sludge + 25% RDF

Table 1: Effect of different doses of sewage sludge on growth and yield parameters of *Capsicum annum* var. Nishat-1

Treatment	Root length (cm)	Shoot length (cm)	Root fresh wt. (g)	Root dry wt. (g)	Shoot fresh wt. (g)	Shoot dry wt. (g)	Leaf area (cm^2)	Fruits (No. $plant^{-1}$)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Yield $plant^{-1}$ (g)	Yield ha^{-1} (q)
RDF	7.20	25.66	15.25	6.64	176	51.53	34.20	15.41	6.91	6.55	28.79	756.6	290.6
100% SS	6.90	21.00	14.22	4.09	149	31.00	22.50	13.75	5.75	6.08	27.43	640.7	246.1
75%SS + 25% RDF	5.60	21.34	13.25	3.90	142	28.58	21.20	13.08	6.41	5.41	27.26	601.9	231.6
50% SS + 50% RDF	7.11	23.58	14.78	4.39	152	38.59	28.20	15.08	6.08	6.08	27.76	720.3	276.6
50% SS + 25% RDF	5.10	21.62	10.28	4.10	122	23.53	22.60	12.75	5.41	5.08	26.93	576.4	221.3
$CD_{0.05}$	0.25	1.93	2.34	1.12	25.9	10.50	5.64	0.93	0.53	0.51	0.65	63.09	24.3

RDF = Recommended dose of fertilizers (RDF); SS = Sewage sludge

highest values for these parameters (Table 1). However, in other treatments the differences were marginal. The highest capsicum yield was recorded in RDF treatment (290.59 q ha^{-1}) which might me due to the application of balanced doze of inorganic fertilizers and organic manures to the soil, followed by 276.59 q ha^{-1} in treatment 50% sewage sludge + 50% RDF, 246.05 q ha^{-1} in 100% sewage sludge, 231.63 q ha^{-1} in 75% sewage sludge + 25% RDF treatment and least (221.28 q ha^{-1}) in treatment 50% sewage sludge + 25% RDF. Significant increase in growth parameters of crops on application of sewage sludge has also been reported by Bozkurt and Yarilgac, 2003).

The addition of sewage sludge has a positive effect on plant productivity, which may be due to additional nutrient content of sludge and lower cultivation cost is expected due to lesser utilization of chemical fertilizers (Chidankumar *et al.,* 2009). The carbohydrate, protein, ascorbic acid and TSS content of fruits were also significantly high (5.25%, 1.63%, 101.16 mg 100 g^{-1} and 9.61°Brix, respectively) in RDF treatment (Table 2). Mazen (2003), Gupta *et al.* (2010) and Oloyede *et al*. (2012) also reported increased levels of proteins, ascorbic acid and carbohydrate contents in several vegetables (*Corchorus, Eruca, Raphanus* and *Daucus* and *Lactuca*) treated with sewage sludge and waste water.

Significant effects of sewage sludge and/or inorganic fertilizer application were also observed in N, P and K content of the crop. The highest value of 1.96, 0.68 and 1.70% of N, P and K were observed in RDF treatment, followed by 50% sewage sludge + 50% RDF and 100% sewage sludge treatments (Table 3). The increase in total N content in foliage may be attributed to the increase in soil N due to sewage sludge. A similar result has been reported by Buchanand and Gliessnan (1991). Lacatus *et al.* (1994*)* have reported that K and P present in sludge have a positive effect on fruit sugar and acid content in tomato. A positive correlation between K level in soil and acid content in fruits has previously been reported (Davies and Winsor, 1967). The studies have revealed that increased N

Table 2: Effect of different doses of sewage sludge on fruit quality and foliar photosynthetic pigments of *Capsicum annum* var. Nishat-1

Treatments	Leaf			Fruit			
	Chl- a (mg g^{-1})	Chl- b (mg g^{-1})	Total Chl- (mg g^{-1})	TSS (°Brix)	Ascorbic acid (mg 100 g^{-1})	Carbohydrate (%)	Protein (%)
RDF	3.45	1.75	5.20	9.61	101.16	5.25	1.63
100% SS	2.62	1.34	2.96	8.38	99.12	5.00	1.42
75% SS + 25% RDF	2.52	1.29	3.81	9.23	99.26	4.32	1.28
50% SS + 50% RDF	2.93	1.65	4.58	8.66	106.28	5.09	1.30
50% SS + 25% RDF	2.45	1.78	4.23	9.34	96.19	5.11	1.43
$CD_{0.05}$	0.40	0.55	1.01	1.13	ns	ns	Ns

RDF = Recommended dose of fertilizers; SS = Sewage sludge; Chl = Chlorophyll; TSS = Total soluble solids

Table 3: Effect of waste water and sewage sludge treatments on the macronutrient, micro-nutrient status and heavy metals level in fruit of C*apsicum annum* var. Nishat-1

	Major nutrients (%)			Micronutrient cations (ppm)				Heavy metals (ppm)			
Treatments	N	P	K	Zn	Cu	Fe	Mn	Pb	Ni	Cd	Cr
RDF	1. 96	0.68	1.70	19.0	12.7	60.5	15.00	0.80	0.20	0.51	0.68
100% SS	1.55	0.36	1.49	26.48	17.1	85.2	20.50	1.23	0.60	0.71	1.50
75% SS + 25% RDF	1.52	0.32	1.45	25.44	16.5	80.0	18.70	1.15	0.53	0.68	1.45
50% SS + 50% RDF	1.81	0.55	1.60	24.79	16.2	75.0	18.20	1.11	0.48	0.62	1.39
50% SS + 25% RDF	1.45	0.30	1.42	24.67	15.5	72.0	18.10	1.10	0.45	0.52	1.37
$CD_{0.05}$	0.35	0.09	0.27	1.03	0.85	4.28	0.98	0.12	0.02	NS	NS

RDF = Recommended dose of fertilizers (RDF); SS = Sewage sludge

and K fertilization enhanced the total soluble solid content of fruits (Wright and Harris, 1985). The level of micro-nutrients (Zn, Cu, Fe and Mn) exhibited increase in sewage sludge amendment treatments with highest level observed in 100% sewage sludge treatment, followed by 75% sewage sludge + 25% RDF; 50% sewage sludge + 50% RDF and 50% sewage sludge + 25% RDF treatments and least in RDF treatment (Table 2). Similarly, heavy metals (Pb, Ni, Cd and Cr) exhibited large variations in various treatments with lowest level observed in RDF treatment. Similar findings have been reported in Brinjal (Lone *et al.*, 2013), kale and spinach (Sabia, 2013) under different amendments of sewage sludge and inorganic fertilizers. Thus, recycling of sewage sludge for agricultural use is one of the viable practicable environmental options for its management as it noticed that the addition of sludge to agricultural lands enhances growth and yield of crops which is mainly attributed to the nutrient rich nature of sewage sludge.

Acknowledgement: The authors express their gratitude to Jammu & Kashmir State Council, Department of Science and Technology, Government of Jammu & Kashmir, Srinagar (J&K) for providing the financial assistance to the project.

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