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Original Research Paper

Studies on the Growth Performance, Mineral Composition and Yield of Bottle Gourd Under Irrigation with Grey Water

F. A. Lone, Nousheen Qureshi, N. A. Kirmani*, S. H. Sidiquii, Sabia Zaffar and R. A. Shah*****
Division of Environmental Sciences, *Division of Soil Sciences, **Division of Agri-Statistics, S. K. University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar-191 121, J&K, India
***Department of Biosciences, Jamia Millia Islamia, New Delhi, 110 025, India

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ABSTRACT

As freshwater resources are getting scarce, wastewater use is becoming an attractive option for conserving available water supplies. Wastewater use can have many applications like irrigation of agricultural land, aquaculture, landscape irrigation, urban and industrial uses, recreational and environmental uses, and artificial groundwater recharge, etc. The major objective of wastewater use in agriculture is to optimize its benefits both as resource of water and the nutrients it contains. In the present study, an experiment was conducted to assess the growth performance of bottle gourd (*Lagenaria siceraria* Mollin var. Shalimar improved) under irrigation with different concentrations of domestic wastewater (grey water) alone and in combination with recommended dose of fertilizers. This field experiment was carried out for two consecutive years 2008-09 and involved 5 treatments (T_1 –T_5) with three replications in RCBD. Before being put to use, wastewater was stabilized for 20-25 days in open containers. The results show that yield (kg/ha) of the plots (T_3) irrigated with 50% wastewater and 50% recommended dose of fertilizers was statistically at par with the plots (T_1) irrigated with tap water and recommended dose of fertilizers. T_1 and T_3 plots also exhibited similar trends in plant morphological parameters (viz, vine length, number of basal branches and internodes, male and female flowers and leaves/plant), yield parameters (length, diameter and weight of fruits), concentration of macro (N, P, K) and micronutrients (Cu, Zn, Mn, Fe). The values of pH, EC, alkalinity, SO_4, NO_3, total N, P and K, Cu, Zn, Mn, Fe, Cd and Ni in the grey water were within the permissible range. This study also shows that irrigation with stabilized grey water did not have any adverse effects on the soil chemistry. It is, therefore, concluded that recycling of wastewater in agriculture offers a great potential and could be promoted in areas facing acute shortage of water.

INTRODUCTION

With the growing population and impacts of climate change, demand for food and freshwater is increasing. The huge quantities of wastewater generated both in domestic and industrial sectors and its indiscriminate disposal are posing a great threat to the environment. Wastewater is commonly used for irrigating agricultural fields in developing countries including India (Pandey et al. 2008, Nath et al. 2009). In addition to being a valuable resource of water, the major objective of wastewater use is the effective utilization of its rich stock of nutrients for agricultural and other purposes. Nutrients found in wastewater are beneficial for the growth and metabolism of the plants. Application of wastewater to the crop fields leads to enrichment of soil with essential plant nutrients (Kanan et al. 2005). Recycling of wastewater in agriculture shall also help in minimizing the use of inorganic fertilizers. The objective of this experiment was to evaluate the physio-morphological and yield responses of bottle gourd (*Lagenaria siceraria* Mollin var. Shalimar improved) under irrigation with different doses of untreated domestic wastewater (grey water). Furthermore, its effect on the composition of the soil and plant tissues was studied in order to explore the possibility of safe use of urban wastewater for irrigation.

MATERIALS AND METHODS

Study area: The experiments were conducted for two consecutive years (2008-09) in the research field of the SKUAST-K campus, Srinagar (J&K), India situated at 1600 M.S.L. Climate of the area is characterized as temperate with mean maximum and minimum temperatures during the growing season (April-October) as 26.08°C and 11.78°C respectively. During the season of the experiments the average rainfall and relative humidity were 89.22 mm and 70.53% respectively.

Experimental design and the crop: The field was prepared for assessing the impact of different concentrations of wastewater and recommended doses of fertilizers on growth, yield and quality of bottle gourd (*Lagenaria siceraria* Mollin var. Shalimar improved), one of the commonly grown summer vegetables of Kashmir valley. The experiment was laid in completely randomized block design and involved five treatments (T_1 = recommended dose of fertilizers and tap water; T_2 = 50% recommended dose of fertilizers and 100% grey water; T_3 = 50% recommended dose of fertilizers and 50% grey water; T_4 = 100% grey water and T_5 = 50% grey water) each with three replications and an untreated control (C) irrigated with tap water. The fertilizers were applied to the plots according to the recommended doses. The plot size for the experiment was 2.4 × 1.8 m with 45 cm spacing between the plants and 60 cm between the rows. The grey water for irrigation was collected from the households located in the vicinity of the university campus and stabilized in open tanks for 20-25 days before being put to use.

Water analysis: Samples of wastewater and tap water were subjected to chemical analysis during both the years of experimentation. pH and EC (Piper 1966), N, P, K, alkalinity, Ca, Mg, Zn, Cu, Mn, Fe, Cd and Ni (APHA 1995) were determined.

Soil analysis: Composite soil samples were collected from each plot at the depth of 0-30 cm before transplantation and after harvest. Samples were oven dried, ground, sieved and analysed for pH, EC (Piper 1966), total N by Kjeldahl method (Jackson 1973), available P (Olsen 1954) and exchangeable Ca, Mg and K using the ammonium acetate method (Hesse 1971). Further Zn, Mn, Cu, Fe, Ni and Cd were analysed by using atomic absorption spectrophotometer.

Crop yield and plant tissue analysis: From each plot fruit samples were collected randomly at harvest, washed, oven dried and ground for chemical analysis. Plant tissue samples were washed with a solution of 0.1 N HCl, rewashed repeatedly (three times) with distilled water, left to drain on filter paper and dried in hot air oven at 70°C for 48 hours. They were then powdered in a grinder and subjected to chemical analysis. Mineral contents of plant tissues were determined by the method of wet oxidation using a mixture of HNO_3 and $HClO_4$ (AOAC 1984). Total N was determined by the Kjeldahl method (Jackson 1973), P by blue phosphomolybdic complex by a spectrophotometer, K by flame photometer and Ca, Mg, Zn, Fe, Mn, Cu, Cd and Ni by atomic absorption spectrophotometer.

Statistical methods: The data were analysed by one way ANOVA (Snedecor & Cochran 1967).

RESULTS AND DISCUSSION

Water chemistry: Data regarding the physico-chemical characteristics of tap water and wastewater are presented in Table 1. The values were in lower levels than those permitted for upper threshold set of irrigation water and safe reuse in agriculture. According to PCB (2003), pH of wastewater should range between 6.5 and 8.5 and EC should not exceed 2.25 dS/m. Our study showed that both these parameters of wastewater were within range. The values of N and other nutrients were higher in grey water than in tap water, but were within the permissible limits set for irrigation water. However, the content of copper in wastewater slightly exceeded the permissible limit set by WHO (2006).

Physico-chemical characterization of the soil: Soil texture was loamy and wastewater treatments did not have any significant effect on the soil pH value as also reported by Shahalam et al. (1998) (Table 2). However, the composition of macroelements (N, P, K) exhibited increased trends in the fertilizer amended treatments under irrigation with grey water (Kizilogu et al. 2008). This might be attributed to the fact that in wastewater, the availability of N, P and K was high and enhanced their content in soil. The contents of micronutrients (Fe, Mn, Cu, Zn) also show that irrigation with different concentrations of wastewater alone and in combination with fertilization significantly increased their concentration compared to irrigation with tap water alone. Such results have also been observed by Baskar et al. (2003) in the soils irrigated with distillery effluents.

Crop yield and fruit quality: Data regarding the morphological growth parameters affected by wastewater treatments alone and in combination with the fertilizers are presented in Table 3. Results indicate that compared to control, T_1 and T_2 exhibited highly significant values than all other treatments in all the morphological parameters (vine length, number of basal branches and internodes, male and female flowers and leaf number/plant). The results of yield (kg/ha) (mean of two years) are presented in Table 4, which indicate that plots irrigated with 50% wastewater and fertigation with half the recommended dose of fertilizers (T_3) effectively increased the yield and was at par with the plots irrigated with tap water and recommended dose of fertilizers (T_1). The yield of the plots irrigated alone with wastewater or tap water was significantly lesser than other treatments. The mean yield of bottle gourd followed the sequence T_1>T_3>T_2>T_4>T_5>C. These results reveal that irrigation with grey water had a positive effect on plant productivity, probably due to additional nutrient content, thereby a lower cultivation cost is expected due to lesser fertilizer utilization. These findings are in agreement with the findings of Al-Zubi and Al-Mohamadi (2008), Chidankumar et al. (2009) and Esmailian et al. (2011). The accumulation of inorganic elements in fruits (Table 5) was not related to the respective accumulation in soil. However, in both fruits and soil, the concentration of inorganic macro and microelements was below any toxicity levels. These findings are in conformity with the findings of Arcadia et al. (1998). Thus, regardless of the different concentrations of wastewater treatments alone or in combination with fertilization, the concentration of the mineral elements varied within the usual levels in plant

Table 1: Chemical characteristics of wastewater and tap water averaged across the two growing seasons.

S. No	Source of water	pH	EC dsm^{-1}	Alkalinity mg/L	N mg/L	PO_4 mg/L	K mg/L	Ca mg/L	Mg mg/L	Zn mg/L	Cu mg/L	Mn mg/L	Fe mg/L	Cd mg/L	Ni mg/L
1.	Waste water	7.4	0.82	138.99	8.0	4.5	9.1	55.7	28.5	0.9	0.9	0.55	0.82	ND	ND
2.	Tap water	7.1	0.45	102.13	3.2	0.5	0.4	40.9	23.1	0.4	0.2	0.05	0.10	ND	ND
	CD	0.07	0.09	8.45	1.4	0.2	0.1	5.5	2.8	0.1	0.1	0.02	0.08		

ND = not detected ; WHO standards: pH (6.5-8.0); EC (3 dS/m); Mn (1.5 mg/L); Cu (0.2 mg/L); Zn (2.0 mg/L); Fe (1.5 mg/L).

Table 2: Mean values of different soil characteristics before and after the experiment.

.	Treat-ments	pH	Ec (dS/m)	N kg/ha	P kg/ha	K kg/ha	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
Before the Expt.	-	7.00	0..36	605	40	290	1.47	12.12	1.59	1.10
After the Expt.	T_1	7.08	0.82	910	51	411	2.86	14.05	2.25	1.18
	T_2	7.07	0.70	901	49	404	3.76	16.68	2.27	1.20
	T_3	7.07	0.64	803	47	328	3.70	16.65	2.23	1.21
	T_4	7.05	0.62	770	45	305	3.68	15.52	2.22	1.19
	T_5	7.03	0.57	741	41	305	3.09	15.13	2.20	1.16
	C	7.03	0.52	613	43	301	2.55	14.68	2.01	1.15
	CD	NS	0.10	9.40	3.38	11.45	0.34	0.52	0.31	0.08

Table 3: Effect of different concentrations of wastewater on various morphological characteristics of bottle gourd (*Lagenaria siceraria* Mollin var. Shalimar improved).

		Treatments						
S.No.	Parameters	T_1	T_2	T_3	T_4	T_5	C	CD
1.	No. of basal branches	4.50	4.17	4.50	4.16	3.94	3.85	0.84
2.	No. of internodes/plant	13.0	13.66	11.6	08.3	09.0	08.3	0.35
3.	No. of male flowers/plant (total of five observations)	140	126	134	108	120	96	5.15
4.	No. of female flowers/plant (total of five observation)	60	43	64	34	40	28	4.95
5.	Male/female flower ratio	2.23	2.70	2.02	2.85	2.75	3.01	0.07
6.	No. of leaves per plant after 2 months plantation	50.00	46.66	47.83	39.00	59.16	47.5	4.04
7.	Average vine length (cm) after 2 months of plantation	382.40	348.6	395.0	329.8	314.9	250.0	23.36

Table 4: Effect of different concentrations of wastewater on yield parameters of bottle gourd (*Lagenaria siceraria* Mollin var. Shalimar improved)

		Treatments						
S. No	Parameters	T_1	T_2	T_3	T_4	T_5	C	CD
1.	No. of fruits per plant	5.95	3.22	5.92	3.5	3.18	2.50	0.64
2.	Length of fruit (cm)	33.3	40.7	46.00	23.87	19.27	12.60	2.05
3.	Diameter of fruit (cm)	14.47	16.40	18.37	11.97	8.65	6.97	1.85
4.	Weight of fruit (g)	0.60	0.70	0.59	0.36	0.27	0.15	0.07
5.	Yield / plant (kg)	3.57	2.25	3.49	1.26	0.85	.48	0.29
6.	Yield / plot (kg)	64.26	40.5	62.87	22.68	15.30	8.64	4.25
7.	Yield / ha (q)	213.98	134.86	208.72	75.52	50.94	30.77	13.15

tissues and did not cause any nutritional problems in the plants (Panoras & Ilias 1999).

CONCLUSION

Wastewater effectively increased the yield of bottle gourd probably due to high nutrient value of the wastewater. Thus, wastewater can be managed in an ecofriendly manner by its utilization in the agro-ecosystems. The results show that the accumulation of toxic and nutritive elements in plant tissues and the soil varied in low levels and did not cause any nutritional problems in the plants.

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Table 5: Effect of different concentrations of waste water on nutrient status of fruit samples of bottle gourd (*Lagenaria siceraria* Mollin var. Shalimar improved).

Nutrient	Treatments						
	T_1	T_2	T_3	T_4	T_5	C	CD
N (%)	3.90	3.80	3.60	3.58	3.50	3.00	NS
P (%)	0.42	0.42	0.47	0.49	0.46	0.40	NS
K (%)	1.38	1.45	1.48	1.55	1.45	1.38	NS
Ca (%)	1.96	1.82	1.50	1.26	1.26	1.20	0.01
Mg (%)	1.08	1.07	1.07	1.06	1.06	1.04	NS
Zn (ppm)	33.70	31.40	31.00	30.60	31.10	28.0	2.22
Fe (ppm)	171.0	166.4	165.9	160.9	159.0	152.6	5.45
Mn (ppm)	38.90	38.70	38.65	38.40	38.20	36.80	NS
Cu (ppm)	19.50	19.30	18.10	15.50	14.40	13.50	0.87

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