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Growth and Yield of *Capsicum annum* under Irrigation with Different Levels of Domestic Waste Water

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Abstract

Use of wastewater for a variety of purposes is gaining increased popularity as a means of preserving scarce freshwater resources and nutrient recycling particularly in developing countries. A field experiment was carried out to evaluate the growth and yield of *Capsicum annum* var. Nishat-1 under irrigation with different concentrations of domestic wastewater (grey and black water) in combination with recommended dose of fertilizers (RDF). This field experiment was carried out for two consecutive years Kharief 2012-2013 and involved 6 treatments (T1–T6) with three replications in randomized complete block design. Before being utilized, wastewater was stabilized for 20-25 days in open containers. The highest yield (288.12 q ha^{-1}) was recorded in T1 (Recommended dose of fertilizers =RDF) followed by 283.49 q ha^{-1} in T4 (50% grey water and 50% RDF), 275.92 q ha^{-1} in T5 (50% black water + 50% RDF), 270.03 q ha^{-1} in T2 (100% grey water), 260 q ha^{-1} in T6 (50% black water and 50% grey water) and least of 251.96 q ha^{-1} in T3 (100% black water). The data also reveals that the concentrations of the various physico-chemical parameters (viz., pH, EC, OC, N, P, K, Ca, Mg, Cu, Fe, Mn, Zn, Cd, Ni, Cr, Pb) of waste water and pre and post experiment soil samples were within permissible limits. Quality parameters viz total soluble salts, ascorbic acid, chl-a, chl-b, total-chl, carbohydrates and protein content between various treatments exhibited different trends. This study shows that there is an option for recycling of stabilized waste water in agriculture.

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Keywords

Agriculture,
Capsicum,
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Introduction

Wastewater is generated in bulk quantity from both domestic as well as industrial estates and its crude disposal is posing a tremendous threat to environment. In developing countries including India, wastewater is commonly a choice for irrigating

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agricultural field[1]. Globally, approximately 20% of manufactured nitrogen and phosphorous is contained in domestic wastewater[2] and it has been considered as low price fertilizer because of its high N, P and K content[3]. Waste water being rich in organic matter and also contains appreciable amounts of macro and micro-nutrients[4]. Accordingly nutrients levels of soil are expected to improve considerably using continuous irrigation with waste water[5,6,7,8,9,10,11]. Thus, recycling of wastewater shall pave avenues in agricultural industry in terms of minimizing the use of inorganic fertilizers whose long-term utilization pose negative pressures on natural environment. The main objective of this experiment was to estimate the growth performance, quality parameters and yield responses of *Capsicum annum* var. Nishat-1 when irrigated with domestic wastewater. Moreover, effect of wastewater fertigation on the physicochemical parameters of soil and plant nutrients was studied to investigate the prospects of its safe use.

Materials and Methods

Study Area

The experimental field at FoA Wadura, SKUAST-Kashmir, was used during summer (*Kharif*) 2012 and 2013. The study area falls in 34^0 20/ 55.72"N and 74^0 24/ 6.26"E at an altitude of 1580 m a.s.l. Temperate climatic conditions prevail in the area with mean maximum and minimum temperature as 26.08^{0}C and 11.78^{0}C respectively. The average precipitation recorded during the experimentation was 628.4 mm and 926.2 mm in 2012 and 2013 respectively.

Experimental Design and the Crop

The different concentrations of wastewater were used along with recommended doses of fertilizers to study the growth, yield and quality of *Capsicum annum* var. Nishat-1. The experiment was laid in completely randomized block design and involved six treatments replicated thrice (T1: Recommended dose of fertilizers; T2: 100% Grey water; T3: 100% Black water; T4: 50% Grey water + 50% RDF; T5: 50% black water + 50% RDF; T6: 50% black water + 50% Grey water) along with an untreated control (C) irrigated with fresh water. The fertilizers N, P and K were applied as per package and practice prevailing in the university at the rates of 120, 90 and 40 (kg ha^{-1}), as urea, DAP and MOP respectively. The crop was grown in plots measuring 1.74 × 2.3 m with 45 cm spacing between the plants and 60 cm between the rows. The grey water and black water for irrigation was obtained from the hostels of the university campus and stabilized in open tanks for 20-25 days before being put to use.

Water Analysis

Physicochemical parameters viz; pH and EC were accomplished by following the method of Piper[12]. On the other hand estimation of N, P, K, alkalinity, Ca, Mg, Zn, Cu, Mn, Fe, Cd and Ni of the waste water samples were done by following the methods given by APHA[13].

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[12], total N[14], available P[15], organic carbon[16] and exchangeable Ca, Mg and K using the ammonium acetate method[17]. Zn, Mn, Cu, Fe, Ni and Cd were analysed by using atomic absorption spectrophotometer, after proper standardization. The soils are deep imperfectly drained, calcareous fine silty texture on nearly level slopes with loamy surface and slight flooding, the soils belong to the order of Inceptsols, with aquepts sub order Haplaquepts great group and Typic Haplaquepts sub group.

Crop Yield and Plant Tissue Analysis

Photosynthetic pigments in the foliage were estimated[18] and fruit samples were harvested from each plot, oven dried for 2 days at 70^{0}C, powdered in a grinder and subjected to chemical analysis for the estimation of carbohydrate[19], protein[20] and ascorbic acid contents[21]. Fruit samples were also analyzed for TSS by using Refractometer. Plant nutrients were determined wet oxidation method using 3:1 ratio of HNO_3: $HClO_4$[22]. Total N was determined by Kjeldahl method[14], P by spectrophotometer , K by flame photometer. Ca, Mg, Zn, Fe, Mn, Cu, Cd and Ni were estimated by atomic absorption spectrophotometer. 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}). Pooled data of the two years recorded during the experiment was subjected to ANOVA, followed by least significant difference (CD, $p \leq 0.05$) using R software statistical package[23].

Results and Discussion

Water Chemistry

Data regarding the physicochemical characteristics of black, grey and fresh water 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[24], pH of wastewater should range between 6.5 and 8.5 and EC should not exceed 2.25 dS/m. Our study show that both these parameters of wastewater were within range. Alkalinity, phosphate, Na, Ca, Mg, Zn, Cu, Fe, Mn and Cd were found higher in grey water compared to black and fresh water while as Cl, Fl, SO_4 ,NH_4 and K were found in higher concentration in black water. The concentration of Ni and Pb did not show any significant variation. However, all the parameters were within permissible limits.

Table 1: Physicochemical characteristics of irrigation water

Parameters	Waste/ Fresh Water		
	Black	**Grey**	**Fresh**
pH (1:2.5)	6.80	7.42	7.10
EC (dSm^{-1})	0.85	0.78	0.47
Alkalinity (mg/l)	150.2	180.99	125.13
Nitrate N (mg/l)	49.09	10.0	3.36
Phosphate (PO_4) (mg/l)	3.4	6.21	0.6
Chloride (Cl^-) (mg/l)	524.7	206.99	1.96
Fluoride (F) (mg/l)	0.16	0.14	0.10
Sulphate (mg/l)	1.79	0.84	0.53
Ammonium (mg/l)	169.81	90.22	2.25
Sodium (mg/l)	16.53	17.78	7.31
Potassium (mg/l)	83.92	17.61	0.51
Calcium (mg/l)	47.14	48.31	23.89
Magnesium (mg/l)	10.18	10.44	5.74
Zn (mg/l)	0.99	5.45	0.47
Cu (mg/l)	0.35	0.98	0.23
Fe (mg/l)	0.57	0.88	0.10
Mn (mg/l)	0.17	0.65	0.08
Cd (mg/l)	0.245	0.609	0.020
Cr (mg/l)	0.226	0.226	0.226
Pb (mg/l)	0.001	0.001	0.001
Ni (mg/l)	0.076	0.076	0.076

Physio-chemical Characterization of the Soil

Texture of the soil was loamy and the soil pH of various treatments ranged from 6.70 to 7.56 while EC ranged from 0.20 to 1.10. It is evident form the data that various waste water treatment slightly changed the pH of the soil as also reported earlier[25] (Table-2). Significant increase in EC was also detected in soil after the experiment[26,27,28,29,30] which might be due to the relatively higher EC of waste water and formation of metallic salts-complexes of organic matter and heavy metals[31]. Compared to initial status, the level of N and P exhibited elevated trends in various waste water treatment which can be attributed to the higher concentration of the macronutrients in grey as well as black water. On the other hand lower level of Ca and Mg were observed in waste water compared to initial statues of the soil.

Table 2: Physico- chemical characteristics of the soil of capsicum annum plots after the treatments

Treatment	pH	EC (dS m^{-1})	OC (%)	N	P (kg /ha)	K	Ca	Mg	Cu	Zn (ppm)	Mn	Fe	Pb	Ni	Cd	Cr
Initial status	7.56	0.26	0.75	95.74	8.42	133.8	123.75	30.58	1.18	1.41	7.92	24.14	0.98	1.92	0.012	1.76
Recommended dose of fertilizers	7.12	0.21	1.04	122.64	23.31	131.25	105.65	23.15	1.10	1.69	9.27	31.35	1.04	2.08	0.012	1.81
100% Grey water	7.83	0.55	1.31	123.11	24.23	126.85	107.22	24.20	1.77	1.27	9.40	31.65	1.06	2.31	0.015	2.08
100% Black water	6.70	0.66	1.03	122.84	24.02	126.09	106.16	24.10	1.82	2.01	9.39	31.45	1.10	2.48	0.015	2.07
50% Grey water+ 50%RDF	7.09	0.96	0.96	121.68	24.05	125.00	111.10	20.90	1.25	1.24	9.25	29.31	1.04	2.50	0.179	1.94
50% black water + 50% RDF	6.88	0.54	0.96	123.06	23.63	124.90	107.09	19.79	1.31	1.17	9.37	30.36	1.04	2.32	0.018	1.89
50% black water + 50% RDF	6.93	1.10	1.00	123.22	24.41	132.31	109.04	18.39	1.52	1.06	9.50	33.60	1.09	2.30	0.017	2.05
C.D ($p<0.05$)	0.06	0.13	0.06	1.33	0.65	12.64	1.23	4.65	NS	0.05	NS	1.26	NS	NS	NS	NS

Crop Yield and Fruit Quality

There has been significant effect of treatments on the fresh / dry, root /shoot biomass as well as leaf area of the crop. Compared to other treatments, T1 (RDF), recorded the highest values of these parameters (Table-3) followed by T4. However, in other treatments the differences have been only marginal. The highest yield of capsicum was recorded in T1 (288.12 q ha^{-1}) which might be due to the application of balanced doze of inorganic fertilizers and organic manures to the soil followed by 283.49 q ha^{-1} in T4 (50% grey water and 50%RDF), 275.92 q ha^{-1} in T5(50% black water + 50% RDF), 275.03 q ha^{-1} in T2 (100% grey water), 260 q ha^{-1} (50% black water and 50% grey water) and least of 251.96 q ha^{-1} in T3 (100% black water) (Table -4).

Quality parameters *viz.,* ascorbic acid and Chl-b were higher in T5 while as TSS, Carbohydrates and proteins were higher in T1 and exhibited different trends in different treatments (Table-5). The major nutrients (N, P, and K) were also found highest in T1 and the values for T4 were at par with it. These results reveal that irrigation with black and 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 as also reported earlier[32]. The accumulation of inorganic elements in fruits (Table-6) was not related to the respective accumulation in soil. The level of micronutrients (Zn, Cu, Fe, Mn) showed higher trend in plants irrigated with waste water. However, no significant change was observed in the concentration of heavy metals like Pb, Ni, Cd and Cr. However, all the heavy elemental contents were below toxicity level. These findings are in conformity with other findings[33,34,35]. Thus, regardless of the different concentrations of wastewater treatments alone or in combination or in consonance with recommended fertilizer dose, the concentration of the nutrients varied within the usual levels in plant tissues and did not cause any nutritional problems in the plants[36].

Table 3: Effect of different concentrations of wastewater on growth parameters of *Capsicum annum* (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)
Recommended dose of fertilizers	7.02	25.31	10.01	4.90	172.00	51.35	34.02
100% Grey water	5.40	20.31	8.56	4.30	138.00	21.52	22.09
100% Black water	5.22	20.14	9.56	4.57	109.00	23.85	21.60
50% Grey water+ 50%RDF	7.40	20.15	10.73	3.45	126.00	26.00	26.20
50% black water + 50% RDF	7.20	21.66	14.22	6.64	116.00	23.09	24.70
50% black water + 50% Grey water	5.20	21.00	10.73	4.02	102.00	23.00	18.10
C.D ($p<0.05$)	0.95	1.93	2.34	1.12	25.90	10.50	5.64

Table 4: Effect of different concentrations of waste water on yield parameters of *Capsicum annum* (Nishat -1)

Treatment	FruitNo/ plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Yield / plant (g)	Yield/ plot (kg)	Yield/ ha (q)
Recommended dose of fertilizers	15.14	6.19	6.58	28.97	756.16	12.51	288.12
100% Grey water	14.75	5.01	5.41	27.67	703.00	11.35	270.03
100% Black water	14.08	5.75	5.08	27.62	654.94	10.08	251.96
50% Grey water+ 50%RDF	15.80	6.14	6.80	28.79	738.45	12.06	283.49
50% black water + 50% RDF	14.75	6.14	6.80	28.26	716.00	11.27	275.92
50% black water + 50% Grey water	14.41	5.14	5.75	27.43	676.51	11.21	260.00
C.D ($p<0.05$)	0.93	0.53	0.51	0.65	63.09	0.98	24.26

Table 5: Effect of different concentrations of wastewater on quality parameters of *Capsicum annum* (Nishat -1)

Treatment	TSS (Brix)	Ascorbic acid(mg/	Chlorophyll a (mg/g 100g)	Chlorophyll b (mg/g tissue)	Total Chlorophyll tissue)	Carbohydrate (%) (mg/g tissue)	Protein (%)
Recommended dose of fertilizers	8.38	99.12	2.50	1.43	3.92	5.00	1.42
100% Grey water	9.11	112.13	2.58	1.78	3.75	4.92	1.52
100% Black water	8.52	114.16	2.72	1.92	3.65	4.57	1.32
50% Grey water+ 50%RDF	9.61	112.15	2.63	1.62	3.58	4.00	1.66
50% black water + 50% RDF	9.50	97.47	2.13	1.17	3.11	5.25	1.32
50% black water + 50% Grey water	10.00	97.00	2.30	1.75	3.17	6.03	1.71
C.D ($p<0.05$)	1.13	6.29	0.40	0.55	0.10	0.71	0.15

Table 6: Major nutrient and heavy metals level in fruit of *Capsicum annum*

Treatments	Major Nutrients (%)			Micronutrient Cations (ppm)				Heavy metals (ppm)			
	N	P	K	Zn	Cu	Fe	Mn	Pb	Ni	Cd	Cr
Recommended dose of fertilizers	1. 69	0.86	1.07	19.0	12.5	60.0	15.22	0.82	0.22	0.51	0.86
100% Grey water	1.73	0.44	1.53	21.71	14.8	77.6	16.80	0.88	0.27	0.55	1.40
100% Black water	1.60	0.38	1.50	21.57	14.6	75.9	16.60	0.85	0.25	0.54	1.35
50% Grey water+ 50%RDF	1.89	0.59	1.62	23.52	14.4	73.0	15.8	0.74	0.23	0.52	1.32
50% black water + 50% RDF	1.79	0.49	1.55	22.49	14.2	72.6	15.5	0.71	0.21	0.48	1.27
50% black water + 50% Grey water	1.68	0.43	1.51	21.60	13.3	76.0	16.50	0.83	0.24	0.53	1.37
C.D (p<0.05)	0.35	0.09	0.27	1.03	0.85	4.28	0.98	0.12	0.02	NS	NS

Conclusion

Wastewater effectively increased the yield of *Capsicum annum* crop probably due to high nutrient value of the wastewater. Thus, wastewater can be managed in an ecofriendly way by its exploitation 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 instability in the plants.

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