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IMPACT OF MUNICIPAL WASTE WATER OF QUETTA CITY ON BIOMASS, PHYSIOLOGY AND YIELD OF CANOLA (*BRASSICA NAPUS* L.)

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Abstract

The present study was carried out in order to investigate the impact of municipal wastewater effluents of Quetta city on the biomass, physiology, and productivity of two canola (*Brassica napus* L.) cultivars viz., Oscar and Rainbow. Plants were grown in pots from seed to maturity during 2005-2006 growth season. Different concentrations of effluents (T1: 20%; T2: 40%; T3: 60%; T4: 80; T5: 100%) were supplied to plants as a soil drench compared to control plants (T0) receiving normal tap water. The wastewater effluents were highly alkaline in nature along with very high Electrical Conductivity, Biological Oxygen Demand; Chemical Oxygen Demand; Sodium Adsorption Ratio, Total Suspended Solids and minerals concentrations have found well above threshold limits set for the usage of municipal wastewater for irrigation purposes. Growth performance of both canola cultivars showed statistically significant effects on some physiological attributes. All treated plants showed reductions in growth and yield parameters, but T5 treated plants were most affected compared to control. There were significantly higher reductions in stomatal conductance (49% in Oscar; 53% in Rainbow), transpiration rate (62% Oscar; 67% in Rainbow), and photosynthetic rate (62% in Oscar; 69% in Rainbow) of T5 treatment plants compared with control. Both pigments of chlorophyll (*a* and *b*) responded efficiently to the applied stress of wastewater effluents showing reductions in chlorophyll *a* and *b* by 68-82% in cv. Oscar and 74-86% in cv. Rainbow. Similarly, fresh and dry biomass also showed reductions in different effluents treated plants (T1 to T5) ranging from 2-78% in both the cultivars of canola. Drastic reductions were recorded in the number of siliqua per plant (70-72%), seeds per plant (84-85%), seed weight per plant (87-90), and in the harvest index (72-74%) in cultivars Oscar and Rainbow, respectively than that of control. The overall result of the municipal wastewater impacts on canola cultivars are alarming, as Pakistan is an agrarian country and the agriculture sector bears the brunt of country's economy. This study urged the vital significance of recycling the liquid wastewater effluents before discharge otherwise these could seriously affect the growth and productivity of plants.

Introduction

Water is undoubtedly is a requirement for all of the living organisms in the biosphere (Singh & Mishra, 1997). Man has used the water systems for numerous purposes such as drinking, irrigation, fisheries, industrial processes, transportation and waste disposal. Environmental contamination of water has become threat to the continued existence of many plants and animals' communities in the ecosystem (Shamsi *et al*., 1983).

Sewage pollutants include pathogenic organisms, oxygen-demanding wastes, plant nutrients, organic and inorganic substances, sediments, radioactive materials, oil and heat (Abedi and Najafi, 2001). The principal impurities in polluted waters are organic materials and plant nutrients, but domestic sewage is also very likely to contain disease-causing microbes (Wahid *et al*., 1999; Kakar *et al*., 2006; Al-Makhdoom, 2006). Heavy metals such as copper, cadmium, chromium, lead, mercury, and selenium get into water from many sources, including industries, automobile exhaust, mines, and even from natural soils (Al-Nakshabandi *et al*., 1997; Faryal *et al.*, 2007; Khan *et al*., 2008). Plants grown in contaminated soils or irrigated with municipal wastewater when consumed by peoples can result in health problems (Papadopoulos & Stylianous, 1991; Wahid *et al*., 2004) like diarrhea, mental retardation, liver and kidney damage (Matsuno *et al*., 2004; Uzair *et al*., 2009).

Pakistan is an agrarian country of Southeast Asia and increased industrialization and urbanization have resulted in discharge of effluents of toxic nature into the waterways, thus polluting and rendering the water bodies unfit for consumption in agriculture sector (Sheikh & Irshad, 1980; Wahid *et al*., 1999, 2000). Plants can accumulate the toxic pollutants in their bodies at very high amounts and through food chain can reach the human beings causing serious threat to their health. The impacts of water pollutants are felt and perceived at much longer distances although these are often ignored hitherto. Quetta being capital of Balochistan province of Pakistan with geographic area of 2653 km^2 and urbanization is in a haphazard manner. Available service mechanism and infrastructure in terms of water supply sanitation, sewerage and waste management is out of proportion to the need of existing population. The municipal waste propelled by the dry and windy climate of the city can be seen scattered on major roads. The untreated wastewater, in addition to creating aesthetic problems, infiltrate in to the ground, polluting the water resource as well (Aina *et al*., 2005; Khan *et al*., 2009).

Present research work was therefore undertaken to analyze the quality of municipal wastewater of Quetta city, their effects on growth performance, physiological attributes and productivity of two varieties of canola (*Brassica napus* L. viz., Oscar and Rainbow).

Materials and Methods

Description of experimental site: Present experiment was carried out in the Department of Botany, University of Balochistan, Quetta during 2005-06. Experimental site was representative of the natural agricultural fields of Quetta region and its texture was sandy loam. Experiment was carried out in the wire-netting enclosures with natural environmental conditions.

Source of seeds: Fresh lot of certified seeds of two varieties of canola (*Brassica napus* L. viz., Oscar and Rainbow) were collected from the Federal Seed Certification Department, Quetta.

Source of wastewater: Wastewater effluents were collected from the 'Habib Nala', in which various wastewater channels of Quetta city are mixed. These effluents were collected only once before the commencement of each growth season in a sufficient quantity, stored in shade and then its known concentrations were supplied to the plants as a soil drench. Fresh dilutions were made before each irrigation.

Wastewater analysis: Wastewater effluents collected from the site were analyzed for various parameters of irrigation water quality analysis from Environment Protection Department, Lahore; Department of Botany, GC University, Lahore; and PCSIR Labs, Lahore.

Experimental design: Earthen pots of 30 cm diameter were used in this study for growing canola crop. Soil was mixed farm-yard manure (FYM), in a 8:1ratio, following local agricultural protocol. Approximately 10 kg soil compost was filled in each pot. There were six effluents treatment viz., T0 (control or normal tap water), T1 (20% polluted water: P.W.), T2 (40% P.W.), T3 (60% P.W.), T4 (80% P.W.), T5 (100% or full strength polluted water) used for growing both cultivars of canola. For each cultivar, there were 8 replicate pots within each treatment leading to a total of 48 pots. The pots were labeled according to their respective treatment, replicate and cultivars, to record the data with accuracy.

Growing of seedlings: Four seeds were sown at two equidistant places in each pot during mid October 2005. After complete germination, the number of seedlings per pot was reduced to two by manual thinning in every pot. Pots were watered with measured quantity of wastewater regularly throughout the season.

Measurements of some physiological parameters: Prior to mid-season harvest (70 days old plants), measurements of growth physiology parameters such as stomatal conductance (g_{s}), transpiration rate (*E*) and net photosynthetic rate (P_N) of randomly selected six leaves within each treatment were taken with an infrared gas analyzer. Measurements were made between 1000-1600 hrs. The photon flux density incident on the cuvette was mentioned in the range of 490±20 µ mol m^{-2} s^{-1}. Readings were recorded on the data logger after the leaf had been enclosed in the chamber for at least 1-2 minutes. Leaf temperature of the plants sampled ranged between 19-21ºC and the air relative humidity in the cuvette between 36-38% (Wahid, 2006 a, b).

Biomass assessment: At the prime of vegetative growth (75 days old plants), randomly selected four pots per treatment (4 x 2 = 8 plants) within each cultivar were taken for first destructive harvest. Plants with their roots intact were carefully removed from the pots and washed under running tap water using sieve. After getting fresh the plants were dried in an electrical oven then weighed the dried plants. Chlorophyll contents (both '*a*' and '*b*') of randomly selected equal-aged leaves within each treatment and cultivar were also determined following Arnon (1949).

Yield assessment: When the plants had completed their reproductive growth period, then a final destructive harvest was taken during second week of March 2006. This harvest included four remaining pots (4 x 2 = 8 plants) per treatment. Plants were carefully cut at the soil level and brought to the laboratory in labeled papers-bags for measurements of various yield parameters as:

- Number of siliqua per plant
- Siliqua length per plant (cm)
- Number of seeds per siliqua
- Number of seeds per plant
- Seeds weight per plant (g)
- 100-seed weight (g)
- Straw weight per plant (g)
- Harvest index

Statistical analysis: In order to reach a definite conclusion, ANOVA was carried out to check the efficacy of treatments while the inter-treatment differences were sorted out using Duncan's multiple range test (Steel & Torrie, 1996).

Results

Quality of wastewater effluents of Quetta city: The pH value of full strength wastewater was highly basic. The pH value decreased as different dilutions were made from the concentrated effluents. Similarly, EC was remarkably high in all effluents treatments. In addition, other remarkable parameters include: Biological Oxygen Demand; Chemical Oxygen Demand; Total Dissolved Solids, Total Suspended Solids, grease & oil, chlorides, MBAS, hardness, and sodium contents were extremely high as compared to control (T0) and NEQS (Table 1).

Effects of wastewater effluents on biomass: Fresh and dry weight of shoots and roots responded similarly to different pollutants concentrations. Control and T1 plants were more or less similar but as the treatment progressed then corresponding reductions in the biomass of canola were ascertained. T4 and T5 treatment plants were most seriously and equally affected in all parameters of biomass. However, per cent reductions in various treatments were significantly higher and different from one another when compared with control. From the Figure, it can be noted that reductions in dry weights of both the cultivars, were much higher and reflective of their corresponding fresh weights during the earlier vegetative growth period. In T5 treatment plants, significantly higher reductions in biomass were recorded, for instance, fresh weight of shoot was reduced by 68% and 78%, while dry weight of shoots was reduced by 67% and 77% in Oscar and Rainbow cultivars, respectively. Least reductions in T1 compared to control were however found in fresh weight of shoot (2% in Oscar; 3% in Rainbow) and dry weight of shoot (1% in Oscar; 3% in Rainbow) of canola (Fig. 1).

Effects of wastewater effluents on crop physiology: As shown in Table 2, stomatal conductance, transpiration rate and net photosynthetic rates were appreciably higher in plants grown in control (T0) compared with other pollution treated plants. Drastic reductions in physiological attributes were observed in full strength (100 % or T5) treatment followed by gradual successive reductions in different treatments viz., T4, T3, and T2 plants compared to counterparts grown in control. T1 treatment plants were more or less similar when compared with T0. There were significantly much higher reductions in stomatal conductance (49% in Oscar; 53% in Rainbow), transpiration rate (62% Oscar; 67% in Rainbow), and photosynthetic rate (62% in Oscar; 69% in Rainbow) of T5 treatment plants compared with control. Physiological parameters in T4, T3, T2 treatments were however slightly less reduced than T5 treated plants while negligible reductions can be seen in T1 plants. Both pigments of chlorophyll (*a* and *b*) responded efficiently to the applied stress of wastewater effluents. Plants grown in control and T1 were almost similar and healthier with higher amounts of chlorophyll *a* and chlorophyll *b* than that of the rest of treatment plants. It can be noted from the data in Table 2 that chlorophyll *a* was reduced in cv. Oscar by 68% and 74% in cv. Rainbow, while chlorophyll *b* was reduced by 82% and 86% in cv. Oscar and Rainbow, respectively than that of counterparts grown in control.

Table 1. Analysis of municipal wastewaters effluents of Quetta city used for growing canola plants.

Sr. No.	Parameters	Treatments (Effluents concentrations)						NEQS*
		T0 (0 %)	T1 (20 %)	T2 (40 %)	T3 (60 %)	T4 (80 %)	T5 (100 %)	
1.	pH	7.5	8.3	8.9	9.7	10.2	10.7	6-9
2.	EC (μ S/L)	0.75	1.9	2.6	3.1	3.8	4.2	1.5
3.	BOD	60	250	450	690	750	880	250
4.	COD	92	250	650	1100	1400	1600	400
5.	TSS	50	350	750	1250	1550	1700	400
6.	TDS	200	600	1200	2700	4100	4600	2500
7.	Grease & Oil	Nil	3.2	6.2	10.5	13.1	16.2	10
8.	Phenols	Nil	0.22	0.75	1.14	1.36	1.52	0.3
9.	Chloride	200	450	950	1500	2150	2500	1000
10.	Fluoride	6	6.8	13.4	22.5	30.8	35	10
11.	Cyanide	Nil	0.02	0.68	1.2	1.4	1.8	1.0
12.	MBAS	2	11.5	24.5	32.6	41.5	45.2	20
13.	Sulphate	150	247	657	1000	1250	1400	1000
14.	Ammonia	8	15.1	28.3	62.5	82.2	89	40
15.	Pesticides	Nil	0.08	0.21	0.35	0.46	0.55	0.15
16.	Cadmium	Nil	0.11	0.19	0.25	0.29	0.35	0.1
17.	Chromium**	Nil	0.34	0.98	1.11	1.45	1.65	1.0
18.	Lead	Nil	0.21	1.06	1.75	2.01	2.3	0.5
19.	Mercury	Nil	0.08	0.24	0.32	0.41	0.50	0.01
20.	Nickle	Nil	0.47	1.05	2.03	2.22	2.5	1.0
21.	TTM	Nil	0.57	2.7	4.8	6.1	6.5	2.0
22.	Zinc	0.08	1.1	2.4	5.2	5.9	6.2	5.0
23.	Barium	Nil	0.12	0.85	1.22	1.69	1.8	1.5
24.	Iron	2.0	3.5	4.9	9.5	13.8	15	8.0
25.	Manganese	0.05	0.07	0.12	0.54	1.8	2	1.5
26.	RSC	2.1	7.5	9.9	13.8	18.9	22.8	2.5
27.	Chlorine	0.05	0.07	1.34	1.75	2.0	2.2	1.0
28.	Calcium	50	98	261	385	590	750	200
29.	Magnesium	25	115	162	374	415	490	150
30.	Hardness	50	105	350	720	1600	1800	500
31.	Sodium	31	37	105	218	325	380	250
32.	Copper	Nil	0.12	0.54	1.01	1.2	1.5	1.0
33.	SAR	9.8	13.2	19.8	25.5	33.5	38.5	10.2
34.	Nitrate	10	13	16	32	47	58	45
35.	Total phosphorous	2	3	7	14	21	29	15

*NEQS source: EPA (2007)

• **NEQS**: National Environmental Quality Standards for Municipal wastewaters of Pakistan (Values in mg/L unless otherwise defined); **: Chromium as both trivalent & hexavalent)

• **MBAS**: Modified Benzene Alkyl Sulphonates; **TTM**: Total Toxic Metals; **BOD**: Biological Oxygen Demand; **COD**: Chemical Oxygen Demand; **EC**: Electrical Conductivity; **TSS**: Total Suspended Solids; **TDS**: Total Dissolved Solids; **RSC**: Residual Sodium Carbonate; **SAR**: Sodium Adsorption Ratio.

Effects of wastewater effluents on yield: Yield parameters responded very well to the applied concentrations of wastewater and shown significant decreases in treated plants. There were found drastic reductions in the number of siliqua per plant (70% in Oscar; 72% in Rainbow), seeds per siliqua (43% in Oscar; 44% in Rainbow), seeds per plant (84% in Oscar; 85% in Rainbow), seed weight per plant (87% in Oscar; 90% in Rainbow), and in the harvest index (72% in Oscar; 74% in Rainbow). It was thus noticed that both canola cultivars were almost equally affected by the wastewater effluents stress, although cultivar Rainbow proved slightly more sensitive to water pollutants than cultivar Oscar (Table 3).

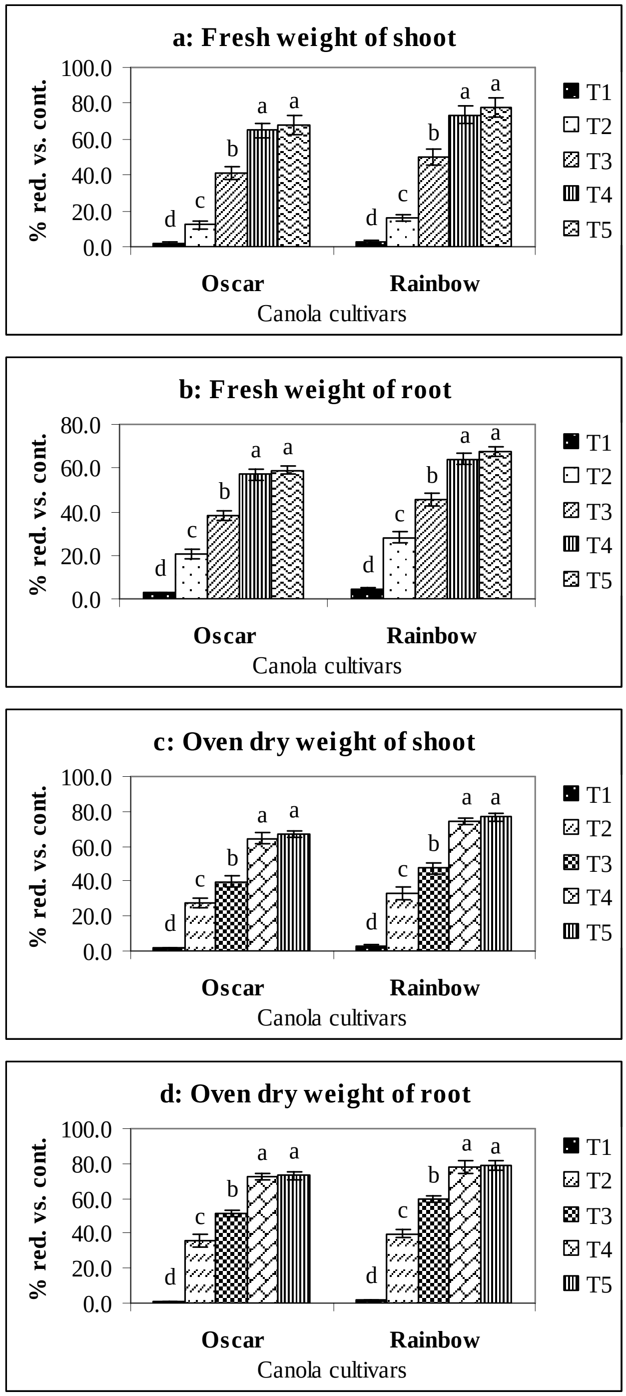

Fig. 1. Effects of wastewaters effluents on the biomass of two cultivars of canola.

Table 2. Effects of wastewater effluents on some physiological parameters and chlorophyll contents of two varieties of canola.

Canola Cultivars	Treatments (% effluents)	Stomatal conductance (millimol/m²/s)	Transpiration rate (millimol/m²/s)	Net photosynthetic rate (µ mol/m²/s)	Chlorophyll *a* (mg/g fresh wt. basis)	Chlorophyll *b* (mg/g fresh wt. basis)
Oscar	T0 (0)	265a ± 5.14	7.2a ± 0.24	13.5a ± 0.51	0.063a ± 0.006	0.028a ± 0.002
	T1 (20)	260a ± 4.69	7.0a ± 0.21	13.2a ± 0.37	0.061a ± 0.008	0.027a ± 0.005
	T2 (40)	235b ± 3.21	4.8b ± 0.17	11.2b ± 0.32	0.054b ± 0.004	0.021b ± 0.001
	T3 (60)	195c ± 2.58	3.5c ± 0.14	9.2c ± 0.28	0.041c ± 0.005	0.016c ± 0.005
	T4 (80)	141d ± 5.41	2.9d ± 0.12	5.5d ± 0.29	0.023d ± 0.003	0.007d ± 0.001
	T5 (100)	135d ± 6.68	2.7d ± 0.13	5.1d ± 0.22	0.021d ± 0.002	0.005d ± 0.001
Rainbow	T0 (0)	258a ± 4.25	6.9a ± 0.18	13.1a ± 0.49	0.055a ± 0.006	0.029a ± 0.005
	T1 (20)	251a ± 3.54	6.7a ± 0.26	12.8a ± 0.38	0.052a ± 0.004	0.028a ± 0.004
	T2 (40)	225b ± 2.31	4.2b ± 0.15	10.2b ± 0.24	0.042b ± 0.004	0.023b ± 0.003
	T3 (60)	185c ± 4.21	3.3c ± 0.18	9.5c ± 0.39	0.032c ± 0.003	0.015c ± 0.003
	T4 (80)	124d ± 7.32	2.4d ± 0.10	4.3d ± 0.32	0.016d ± 0.001	0.006d ± 0.001
	T5 (100)	120d ± 6.87	2.3d ± 0.16	4.1d ± 0.34	0.014d ± 0.001	0.004d ± 0.001

Treatment means followed by different letters in each column within a cultivar are significantly different from one another at P=0.05 according to Duncan's Multiple Range Test.

Discussion

Results of the experiment on canola have established that various concentrations of municipal wastewater have been quite effective to test the effects of water pollution on different parameters of canola biomass, physiology, and yield. Having a look on the results of chemical analysis of municipalwastewater (Tables 1), it is clear that effluents were highly alkaline with very high EC, BOD, COD, SAR, and RSC along with many other toxic wastes in high amounts and simliar results on wastewater analysis have been reported by many workers (Al-Fredan, 2006 ; Nazif *et al*., 2006 ; Mahmood & Maqbool, 2006; Kakar *et al*., 2006).

Crop growth and development showed dramatic effects of municipal wastewater on growth performance of both cultivars of canola. Plants grown in pollution stress remained weak, with less height, and fewer number of leaves that lead to highly pronounced reductions in fresh & dry shoot weights and root weights (Fig. 1). A number of workers have reported adverse effects of wastewater effluents demonstrating reductions in growth performance and fresh weight biomass (Iqbal *et al*., 1991; Jana & Harjee, 1996; Singh & Mishra, 1997; Wahid *et al*., 2000; Farid, 2006), accelerated leaf senescence due to effluents (Sauerbeck, 1991; Singh & Mishra, 1997; Wahid *et al*., 2000; Chen & Chia, 2002; Singh *et al*., 2003) and also reduction in dry biomass production (Singh & Mishra, 1997; Thukral, 1999; Dutta & Boissya, 1999; Kisku *et al*., 2000; Uzair *et al*., 2009).

Response of canola cultivars to some physiological parameters were also highly significant. As it has been described earlier that plants were weak and poorly developed in effluents treatments so their stomatal conductances, transpiration rate and net photosynthesis rate were also lower (Table 2) corresponding to plants grown in control. It was further confirmed that both chlorophyll pigments (*a* and *b*) were also reduced significantly in effluents tretaed plants than control. Many workers have reported that chlorophyl contents are reduced in plants growing under wastewater pollutants stress (Sauerbeck, 1991; Kisku *et al*., 2000; Pandey, 2007; Kang *et al*., 2007) and also showed reduced functioning of physiological parameters (Qadir & Oster, 2004).

Reproductive growth of the plants (Table 3) was clearly a reflection of their vegetative growth performance in the subsequent effleunts treatments and control. All parameters of yeild and yield components were reduced sgnificantly in pollution treatments than that of counterparts in control. For instance, reduction in number of silqua per plant depicted the fewer number of branches in the vegetative growth phase. In addition, silqua length was also reduced in effluents treatments. Seed yield per siliqua and per plant was also reduced leading to lower seed weight per plant and 100-seed weight. Reduction in 100-seed weight is of prime importance as it is indicative of that the seeds in effluents treatments were light in weight than that of heavier weight of seeds found in control plants. Harvest index was also reduced in pollution treatments representing that seed weight was more sensitive to the applied effluents stress than straw weight. Effects of water pollution in reducing the crop yield have been described by some workers (Bazai & Achakzai, 2006; Farid, 2006; Kang *et al*., 2007; Khan *et al*., 2009).

Wahid *et al*. (2000) reported that yield of soybean cultivars were highly reduced due to wastewater effluents of a chemical industry in Lahore that was highly saline with extremely high electrical conductivity. Tamoutsidis *et al*. (2002) reported that increasing doses of municipal wastewater application on vegetables for edible leaves (lettuce, endive and spinach) and roots (radish, carrots and beets), reduced the overall yield of plants. Chen & Chia (2002) working in china, reported municipal wastewater impacts on some

Table 3. Effects of wastewaters effluents on some yield parameters of two varieties of canola.

Canola cultivars	Treatments (% effluents)	Siliqua per plant	Siliqua length per plant (cm)	Seeds per siliqua	Seeds per plant	Seeds weight per plant (g)	100-seed weight (g)	Straw wt. per plant (g)	Harvest index
Oscar	T0 (0)	288a±7.58	7.2a±0.78	17.4a±0.86	5011.2a±213.5	87.98a±3.21	1.76a±0.021	41.5a±1.78	2.12a±0.032
	T1 (20)	275a±9.93	7.1a±0.74	16.9a±0.85	4647.5a±205.8	81.00b±2.04	1.74a±0.008	40.5a±1.54	2.01a±0.021
	T2 (40)	205b±10.06	6.2b±0.32	14.6b±0.47	2993.3b±182.3	50.50c±2.54	1.69b±0.004	37.0b±1.09	1.36b±0.023
	T3 (60)	165c±6.24	5.2c±0.31	12.5c±0.39	2062.5c±91.8	31.68d±1.75	1.54c±0.003	32.0c±1.23	0.99c±0.036
	T4 (80)	85d±9.67	3.1d±0.37	10.2d±0.37	867.1d±98.5	12.33e±1.37	1.42d±0.005	22.0d±1.63	0.56d±0.021
	T5 (100)	81d±5.65	2.9d±0.29	10.0d±0.34	810.4d±88.5	11.42e±1.35	1.41d±0.004	19.0d±1.71	0.60d±0.031
Rainbow	T0 (0)	271a±10.52	6.9a±0.72	17.2a±0.84	4661.2a±219.7	82.49a±2.57	1.77a±0.009	42.0a±2.03	1.96a±0.022
	T1 (20)	261a±10.61	6.7a±0.88	17.1a±0.63	4463.1a±223.2	78.56ab±2.29	1.76a±0.006	40.2a±1.98	1.95a±0.021
	T2 (40)	185b±5.77	5.5b±0.27	14.3b±0.51	2645.5b±175.9	42.00b±2.19	1.59b±0.006	32.0b±1.33	1.31b±0.031
	T3 (60)	152c±5.57	4.8bc±0.25	12.1c±0.32	1839.2c±77.3	29.03c±1.98	1.58b±0.005	27.0c±1.19	1.08c±0.014
	T4 (80)	75d±9.32	2.8c±0.43	9.8d±0.34	735.0d±88.9	9.30d±1.17	1.27c±0.007	18.0d±1.08	0.52d±0.010
	T5 (100)	72d±7.31	2.6c±0.33	9.7d±0.36	698.4d±84.8	8.14d±1.35	1.16d±0.004	16.0d±1.14	0.51d±0.005

Treatment means followed by different letters in each column within a cultivar are significantly different from one another at P=0.05 according to Duncan's Multiple Range Test.

vegetables including cabbage, carrot and sweet peas. According to them, vegetables were more seriously affected by the city water pollution than other crops, and set a critical financial pressure on the growers. Khedkar & Dixit (2003) reported that wastewater of cities have inhibiting effect on seed setting and yield of the crop. Singh *et al*. (2003) reported that economic yield declines corresponding to the higher pollution levels. Kang *et al*. (2007) indicated that irrigation of rice with reclaimed municipal wastewater also caused adverse effects on yield of rice due to high pH and EC.

Given all these supporting evidences, yet it is very difficult to be confident in making comparisons of present results with those obttained by many workers as wastewater of domestic use is often rich in many minerals needed for plant growth but in the present case, municipal wastewater showed high pH, EC, and SAR, and RSC (Table 1) along with many other toxic chemicals that might have produced more synergistic negative effects on the productivity. It is, however, assumed that present study do not overestimate the results in all aspects of plant performance keeping in view the quality of municipal wastewater used for irrigation purposes in this study.

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