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IMPACT OF MUNICIPAL WASTEWATERS OF QUETTA CITY ON SOME OILSEED CROPS OF PAKISTAN: EFFECTS ON BIOMASS, PHYSIOLOGY AND YIELD OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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Abstract

Impact of municipal wastewaters of Quetta city on two cultivars viz., SF-187 and SH-3322 of sunflower (*Helianthus annuus* L.) was assessed during 2005 growth season. Wastewaters effluents were not fit for irrigation purposes due to extremely high mineral contents and heavy metals. In addition, effluents were highly alkaline in nature with much higher EC, BOD, COD, SAR, ESP values. Both cultivars of sunflower were grown in pots and received different effluent concentrations (20%:T1; 40%: T2; 60%: T3; 80%: T2; 100%: T5) for their complete growth period. Control (T1) plants were irrigated with normal tap water. Plants grown in effluents treatments showed stunted growth and development from seedling stage to maturity leading to reduced biomass (50-60%) as compared to the control plants which were lush green with more expanded leaves, fresh and dry weights of shoot and roots. Reduced biomass of treated plants was mainly due to altered physiological process. Stomatal conductance,transpiration rate and photosynthesis rates were reduced by approximately 46%, 58% and 64%, respectively in both the cultivars. Photosynthetic pigments (chlorophyll *a* & *b*) were also appreciably reduced in different pollutant treatments compared with control. Reproductive growth of sunflower cultivars was drastically affected by the application of sewage waters. Number of seeds per plant in T5-treated plants was reduced by 53-58%, while seed weight was reduced by 65-69% compared with control. 100-seed weight and harvest index was also reduced significantly from 50-54%, and 29-33% respectively in cultivars SF-187 and SH-3322. Present research work has reported remarkably high reductions in biomass and yield of sunflower plants primarily due to reduced performance of physiological attributes of treated-plants irrigated with deteriorating quality of wastewaters effluents. The results are undoubtedly alarming as the untreated municipal wastewater is being used for irrigation purposes to crops and fruit gardens of Quetta city which is a matter of serious concern and a hidden threat to the farmers and ultimately to the country's economy.

Introduction

Recently, the subject of 'water pollution' remained high in the public consciousness and is a significant factor on the political agenda of both developed and developing countries (Ahmad, 2002; Kakar *et al*., 2010). Industrialization has its unavoidable effects on pollution of air, water and soil, based on the type of industry, nature of raw materials used and the manufacturing processes involved (Mishra & Sahu, 1983). Industrialization is the index of modernization, which often leads to alteration in the physical, chemical and biological properties of the environment (McGrath *et al*., 1997; Sharma *et al.,* 2007; Khan *et al*., 2008).

Water pollution has been accelerated dramatically since the beginning of the industrial revolution. Heavy metals poured into the waterways have long life and accumulate in tissues of plants and animals, and are toxic at high concentrations (Alonoso *et al*., 2000). The other harmful impact of these effluents is due to their high NaCl contents which induces salinity and sodicity hazard to the subjected soils (Sheikh & Irshad, 1980). Sulphide and sulphate combinations have a variety of potential health and environmental impacts and cause damage to structures. Excessive nitrogen is now known to cause nitrate contamination of ground waters. Several species have been identified in different plant groups that are good hyper accumulators of a number of heavy metals e.g., angiosperms (Misra & Ciedamu, 1989), mosses (Lee & Low, 1987) and algae (Holsan *et al*., 1993). Lahouti and Peterson (1979) reported that cauliflower, carrot, radish, maize and barley can accumulate chromium in threshold amounts in their shoots from polluted soils and when consumed by humans can be seriously carcinogenic.

Cardiet *et al*., (1995) determined plant absorption of heavy metals from various municipal wastewaters treatment. Brown & Davies (1995) reported that higher pH and EC severely inhibited photosynthesis and reduce chlorophyll *a* and chlorophyll *b* concentration. Jana & Harjee (1996) reported that water pollutant can affect the plants at different development stages i.e., germination, vegetative growth, flowering and the onset of fruit. The time of seed germination and seedling emergence is a critical stage in crop production on the soils depending upon the wastewater effluents concentrations for irrigation. Iqbal *et al*., (1991) reported influence of municipal wastewaters toxicity on germination and growth of some common trees. Seedling length of assigned species showed gradual decrease with increase in effluents concentrations. Thukral (1999) suggested that wastewaters discharged from Khetri copper complex, India, have harmful effects on biomass of some crop plants.

The presented study was envisaged to investigate the municipal wastewater quality of Quetta city and its subsequent effect on biomass, stomatal conductance, transpiration rate, net photosynthetic rate and seed yield of two cultivars (SF-187 and SH-3322) of sunflower (*Helianthus annuus* L.).

Materials and Methods

Impact of municipal wastewater effluents on the growth and yield of sunflower was studied in the Botany Department, University of Balochistan, Quetta during 2005 sunflower growth season. Two locally grown cultivars of sunflower (*Helianthus annuus* L.) viz., SF-187 and SH-3322 were studied in this experiment using certified seeds obtained through courtesy of Federal Seed Certification Department, Quetta, Balochistan. Equal sized, healthier seeds of both cultivars were carefully sorted out, from a fresh lot while discarding the infected ones. They were stored in labelled paper bags prior to use in the experiment. Normal soil (sandy loam) collected from the cultivated fertile fields of Botany Department was sieved to remove roots and stones etc. Farm-yard-manure (FYM) and humus were air-dried and also sieved to remove stones or humps, or any decaying twigs etc. Sieved soil, FYM and humus were mixed in 9:1:1 ratio and stored in a shed before use in the pot-experiment. Wastewaters effluents were collected from the

'Habib Nullah', of Quetta city in 100 plastic cans (50 litre capacity) to be used for the irrigation of the sunflower plants for their entire growth season. Wastewaters effluents were analyzed in the Environment Protection Department, Lahore; Department of Botany, GC University, Lahore; and PCSIR Labs., Lahore. Six effluents treatments 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) were employed for growing potted sunflower plants.

Selected clay-pots (30 cm diameter) were thoroughly cleaned, and washed with tap water several times before use in the experiment. The drainage holes at the bottom of the pots were temporarily blocked with pebbles in order to minimize drainage of irrigation water/effluents. Pots were also labelled with permanent-ink marker for the respective sunflower cultivar, effluents treatment, replicate number and filled with equal amount of prepared soils (10 kg soil). Pots were arranged in rows to facilitate sowing and for this purpose, soil in each pot was chopped to a considerable depth and then leveled again, so that seeding bed should have necessary ingredients for germination i.e., sufficient soil moisture and aeration etc. Seeds of sunflower were soaked for 3 hours in water to moisten the seed coat and four seeds per pot were sown at two equidistant points (i.e., two seeds at each point) to avoid any discrepancy in germination and mortality of seedlings. Thus, four seedlings were raised in each pot that was later thinned out manually to two equidistant healthier and equal sized sunflower seedlings that were numbered as 1 and 2 by inserting red and yellow plastic strips (size= 4" x 1") close to plants towards the collar of the pot to maintain accuracy in the growth monitoring. Inter-plant distance of 12-14 cm in each pot was comparable to that in the agricultural fields. Major events in the life cycle of sunflower cultivars are given in Table 1.

Table 1. Summary of major events for sunflower cultivars grown during 2005 growth season.

Major events	Growth season 2005	
	Dates	DAS
Date of sowing	01.03.05	-
Complete germination	07.03.05	06
Thinning of seedlings	16.03.05	15
Start of effluents treatments	20.03.05	19
Start of growth monitoring	26.03.05	25
Mid-season harvest	30.04.05	60
Final destructive harvest	30.06.05	120

DAS: Days after sowing

Sunflower plants were managed throughout the growth period according to local agricultural practices i.e., FYM, and humus was incorporated in the pot soil at the start of the experiment, plants were appropriately irrigated with equal amount of wastewaters effluents or tap water (control) after every 4-6 days interval and any weed appearing in the pots were removed manually. The use of pesticides or herbicides or any commercial fertilizer was avoided throughout.

At the approach of prime of vegetative growth, crop physiology parameters viz., stomatal conductance, transpiration rate, and net photosynthetic rates were determined (by using IRGA as in the case of canola crop) during the first week of May 2005 (70-days-old plants after sowing). Chlorophyll contents were also determined (Arnon., 1949) in 70-days-old plants by selecting at least three appropriate leaves in each effluents treatment, and then a mid-season (75-days-old plants after sowing) destructive harvest was also carried out by randomly selecting three pots (6 plants per treatment) in each treatment to ascertain effects of effluents treatments on the shoot and root, fresh and dry biomass of sunflower cultivars. When plants had completed their reproductive growth, then these were cut at the soil level in the pot and were brought to the laboratory for assessment of yield and yield components as:

- Capitulum diameter per plant (cm)
- Number of cypsela per plant
- Weight of cypsela per plant (g)
- 100- cypsela weight (g)
- Straw weight per plant (g)
- Harvest index

Data obtained for all the parameters during the research work were analyzed statistically to understand the effects of wastewaters effluents on the growth and yield performance of two cultivars of sunflower. For this purpose, mean, standard error, % reductions etc. were calculated in Microsoft Excel while ANOVA and Duncan's Multiple Range Test (Steel & Torrie, 1960) was computed using CoStat (version 3.03) and WinStat (version 2007.1).

Results

Data for municipal wastewaters of Habib Nullah of Quetta city collected during the last week of February 2005 are given in Table 2. Polluted sewage water was of very poor quality for irrigation purpose when examined with reference to the National Environmental Quality Standards. It had nearly all minerals and other constituents in excessive amounts compared with NEQS.

Wastewaters of Quetta city showed highly pronounced effects on the growth and development of sunflower crop with reductions seen in every parameters of vegetative growth and biomass of both cultivars of sunflower i.e., SF-187 and SH-3322 as compared to control counterparts. Control or non-treated plants (T0) of both sunflower cultivars were comparatively healthier and better developed, with lush green, relatively longer and more expanded leaves when compared to their effluents-treated counterparts. In general, plants grown in control showed vigorous growth at a very early stage and growth differences from plants of other treatments (viz., T2, T3, T4, T5) became more and more pronounced with the passage of time. Wastewaters effluents had a significant adverse effect on the development of shoots and roots of both cultivars of sunflower as compared to the counterparts grown in controls (T0) that received normal tap water.

Data for fresh weight of shoots and roots per plants suggested that highest effluents treatments caused severe reduction in the weight of both cultivars of sunflower (Table 3). This trend was maintained in other pollution treatments during the whole period of growth span. Differences between various treatment means for fresh shoot weight were highly significant statistically and ranged from 53-55% for cultivars SF-187 and SH-3322, respectively compared with control. Other effluents treatments also showed significantly higher reductions in fresh shoot weight. Similarly fresh root weight was also reduced corresponding to the gradual increases in the effluents concentrations and ranged from 69% each in both cultivars. Differences between treatment means were statistically highly significant in this parameter and as the treatments progressed, the differences became more and more pronounced. It is noteworthy that control (T0) and T1 plants were more or less similar for both shoot and root fresh weights. Data also suggested that there were non-significant differences between T4 & T5 treatments for both shoot and root fresh weights of sunflower cultivars. It can be noted from the data that roots dry weight was reduced by 86% in cultivar SF-187 than that of 90% in cultivar SH-3322 in T5 treated plants compared with control. Other effluents treatments behaved similarly, reducing the root weight corresponding to the concentrations of effluents applied.

Table 2. Composition of municipal wastewaters effluents of Quetta city during 2005 sunflower growth season.

Sr. No.	Parameters	Treatments (effluents concentrations)						NEQS*
		T0 (0 %)	T1 (20 %)	T2 (40 %)	T3 (60 %)	T4 (80 %)	T5 (100 %)	
1.	pH	7.4	8.1	8.9	9.7	10.1	10.7	6-8.5
2.	EC (μ S/L)	0.75	1.9	2.6	3.0	3.6	3.9	1.5
3.	BOD	60	257	463	697	868	987	250
4.	COD	92	254	667	1114	1523	1842	400
5.	TSS	50	345	737	1245	1563	1745	400
6.	TDS	200	712	1325	2875	4352	4951	2500
7.	Grease & Oil	Nil	3.6	8.7	13.6	16.3	18.1	10
8.	Phenols	Nil	0.3	0.8	1.23	1.41	1.48	0.3
9.	Chloride	200	712	1436	2232	2797	2906	1000
10.	Fluoride	6	7.2	14.3	22.1	30.2	34.4	10
11.	Cyanide	Nil	0.03	0.4	1.3	1.5	1.7	1.0
12.	MBAS	2	12.7	25.9	35.2	44.3	48.4	20
13.	Sulphate	150	312	850	1280	1562	1725	1000
15.	Ammonia	8	17	29	64	84	93	40
16.	Pesticides	Nil	0.04	0.19	0.39	0.42	0.49	0.15
17.	Cadmium	Nil	0.08	0.14	0.29	0.31	0.31	0.1
18.	Chromium**	Nil	0.24	0.75	0.98	1.22	1.41	1.0
19.	Lead	Nil	0.3	0.8	1.66	1.53	1.98	0.5
20.	Mercury	Nil	0.04	0.28	0.35	0.46	0.56	0.01
22.	Nickle	Nil	0.5	0.7	1.5	2.7	2.9	1.0
23.	TTM	Nil	0.18	2.2	2.8	3.2	4.4	2.0
24.	Zinc	0.08	1.2	1.8	2.1	3.3	4.3	5.0
26.	Barium	Nil	0.04	0.66	1.05	1.52	1.9	1.5
27.	Iron	2.0	2.8	5.5	10.4	13.5	14	8.0
28.	Manganese	0.05	0.04	0.4	1.9	2.5	3.1	1.5
	RSC	2.3	8.1	10.5	14.4	19.5	23.6	2.5
30.	Chlorine	0.05	1.2	2.2	3.1	3.5	4.1	1.0
31.	Calcium	50	214	332	450	750	900	200
32.	Magnesium	25	168	285	425	520	625	150
33.	Hardness	50	215	550	985	1758	1924	500
34.	Sodium	37	57	145	278	364	397	250
35.	Copper	Nil	0.3	0.7	1.3	1.5	1.9	1.0
	SAR	9.8	15.2	22.8	31.3	38.8	41.3	10.2
37.	Nitrate	10	14	15	30	42	46	45
38.	Total phosphorous	2	2	5	12	15	18	15

*NEQS source: Anon., (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.

Table 3. Effects of wastewaters effluents on biomass of sunflower cultivars grown in 2005 growth season.

Sunflower cultivars	Treatments (% effluents)	Fresh weight (g)		Oven dry weight (g)	
		Shoot	Root	Shoot	Root
SF-187	T0 (0)	53.4a ± 4.61	11.2a ± 1.61	10.4a ± 0.36	2.23a ± 0.23
	T1 (20)	51.3a ± 4.21	10.9a ± 1.52	10.1a ± 0.18	2.17a ± 0.19
	T2 (40)	42.6b ± 3.26	8.2b ± 0.71	7.7b ± 0.37	1.34b ± 0.24
	T3 (60)	36.2c ± 3.16	6.3c ± 0.23	5.5c ± 0.16	0.71c ± 0.21
	T4 (80)	26.3d ± 3.22	4.2d ± 1.16	3.1d ± 0.19	0.34d ± 0.14
	T5 (100)	25.3d ± 4.25	3.5d ± 0.87	2.8d ± 0.11	0.32d ± 0.11
SH-3322	T0 (0)	49.6a ± 6.21	12.1a ± 1.72	11.2a ± 0.21	2.45a ± 0.24
	T1 (20)	47.6a ± 5.75	11.7a ± 1.66	10.9a ± 0.24	2.23a ± 0.29
	T2 (40)	38.2b ± 2.25	7.3b ± 0.39	6.6b ± 0.19	1.12b ± 0.27
	T3 (60)	29.5c ± 2.01	5.4c ± 0.31	4.9c ± 0.12	0.66c ± 0.25
	T4 (80)	21.6d ± 3.98	3.6d ± 0.46	2.8d ± 0.22	0.31d ± 0.11
	T5 (100)	19.8d ± 4.56	3.2d ± 0.23	2.5d ± 0.18	0.25d ± 0.10

* 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

Table 4.Effects of wastewater effluents on some physiological parameters and chlorophyll contents of sunflower cultivars.

Sunflower Cultivars	Treatments (% effluents)	Stomatal conductance (millimol/m^2/s)	Transpiration rate (millimol/m^2/s)	Net photosynthetic rate (µ mol/m^2/s)	Chlorophyll *a* (mg/g fresh wt. basis)	Chlorophyll *b* (mg/g fresh wt. basis)
SF-187	T0 (0)	213a ± 1.98	8.4a±0.39	13.4a±0.39	0.076a±0.008	0.032a±0.003
	T1 (20)	209a ± 4.65	8.1a±0.22	13.2a±0.61	0.072a±0.006	0.030a±0.004
	T2 (40)	174b ± 2.75	7.0b ± 0.18	10.3b±0.29	0.063b±0.003	0.024b±0.002
	T3 (60)	144c ± 3.11	6.3c ± 0.16	8.8c±0.32	0.055c±0.009	0.019c±0.001
	T4 (80)	122d ± 2.41	4.1d ± 0.19	5.3d±0.54	0.039d±0.003	0.012d±0.003
	T5 (100)	115d ± 2.85	3.8d ± 0.15	5.1d±0.37	0.038d±0.005	0.010d±0.002
SH-3322	T0 (0)	209a ± 2.66	7.6a ± 0.33	13.2a±0.41	0.075a±0.006	0.031a±0.004
	T1 (20)	205a ± 4.89	7.1a ± 0.27	12.9a±0.39	0.071a±0.009	0.029a±0.006
	T2 (40)	167b ± 3.57	5.8b ± 0.18	9.9b±0.25	0.061b±0.005	0.021b±0.003
	T3 (60)	139c ± 4.35	5.1c ± 0.23	8.4c±0.29	0.053c±0.002	0.016c±0.003
	T4 (80)	119d ± 1.65	3.2d ± 0.16	4.6d±0.41	0.034d±0.006	0.011d±0.002
	T5 (100)	112d ± 4.66	2.9d ± 0.14	4.4d±0.38	0.031d±0.005	0.009d±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

Data for physiological attributes are given in Table 4 which shows higher values in control (T0) as well as in T1 treatment plants followed by gradual successive reductions in higher treatment plants. Plants in higher treatments showed poor growth resulting in decline of stomatal conductance (46% in both cultivars). Transpiration rate was reduced by 55-62% in both cultivars. The magnitude of reduction in net photosynthetic rate was 62% in SH-187 & 67% in SH-3322, depicting that cultivar SH-3322 was more sensitive to wastewaters effluents than cultivar SF-187. Generally, physiological parameters showed corresponding decline in response to the application of pollution treatments. Chlorophyll is the pigment of prime importance in sustaining the life of plants and the data for this parameter are given in Table 4. Both chlorophyll pigments i.e., *a* and *b* responded negatively to the applied wastewaters effluents concentrations. 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 (T2, T3, T4 and T5).

Reproductive growth of sunflower cultivars were affected by the application of sewage waters (Table 4). Capitulum diameter was higher in both cultivars in control plants and showed gradual decline with the corresponding increase in effluents treatments. Treatment means were often non-significant between T0 & T1 and also in T4 & T5, but differences in treatment means in T3, and T4 were usually highly significant statistically. The magnitude of reductions in capitulum diameter in T5 for cv. SF-187 remained lower (57%) as compared to cv. SH-3322 (61%) depicting that SH-3322 cultivar is more sensitive. Seeds production remained higher in T0 plants while gradual significant loss in seeds number were observed in the other treatment plants from T1, T2, T3, T4 and T5. The magnitude of reduction in seed numbers of T5-treated plants in cultivar SF-187 was 53% while it was 58% in SH-3322 depicting its more sensitivity to water pollutants.

Average seed weight per plant remained significantly higher in T0 followed by gradual lower values in T1, T2, T3, T4, and T5 and this trend was similar in both the cultivars of sunflower. The magnitude of reduction in seed weight per plant in T5 compared with control was 65% in cultivar SF-187, while it was slightly higher in cultivar SH-3322 (69%) demonstrating drastic impact on seed production and seed weight of both cultivars of sunflower. It was noticed that seeds produced by effluent-treated plants were smaller in size and also light in weight, thus contributing towards greater yield reduction. Extreme reductions in 100-seed weight can be noted in T4, and T5 plants of both cultivars i.e., 50% in cv. SF-187 and 54% in cv. SH-3322, indicating that response of cultivar SH-3322 for this important parameter to applied municipal wastewaters was more severe than other variety of sunflower. Harvest index was higher in plants from control and T1 compared with rest of the effluents treatments. The magnitude of reduction was higher in cv. SH-3322 (33%) as compared to cv. SF-187 (29%).

Discussion

Data given in Table 2 have shown analysis of wastewaters used in the experiment for potted sunflower plants. It can be noted from the data that polluted waters was highly alkaline in nature with EC more than 4 dS/m. It also contained very toxic minerals and other chemicals, and for this reason its BOD, COD, SAR, and RSC were very high. Plants were silent sufferers, so their response was stunted growth, reduced biomass, disturbed attributes of physiology and finally drastic yield depression.

A mixture of municipal and industrial wastewater is used for crop production in some parts of Pakistan (Nazif *et al*., 2006; Khan & Khan, 2007). Many other countries including even some developed one also reuse wastewater in agriculture. The mixture of industrial and domestic wastewaters contained nitrogen, phosphorous, potassium, and trace minerals or metals need for plant growth (Kennish, 1992) but when municipal wastewaters were not recycled before irrigating the crops, then it may have very high pH, EC and other toxic wastes as found in the wastewaters used in this experiment. This type of wastewaters was seriously toxic to plants as well as bears potential danger of accumulation of the toxic heavy metals in the soils (Kakar *et al*., 2006) that can destroy fauna and flora of soil (Wahid *et al*., 1999, 2000). According to Mahmood & Maqbool (2006), wastewaters were a complex resource with both advantages and inconveniences for its use. To the extent that wastewater and its nutrient contents can be used for crop production, it provides significant benefits to the farming communities and society in general (Ghafoor *et al*., 1994). However, wastewater use can also impose negative impacts on agricultural communities as found in this study. The widespread use of wastewaters containing toxic wastes and the lack of adequate finance for treatment is likely to cause an increase in the reduction of crop yield, incidence of wastewater-borne diseases (Cooper, 1991) as well as more rapid degradation of the environment(Faryal *et al*., 2007; Farooq *et al*., 2008).

The extent of growth performance of sunflower in both cultivars was not variable and showed adverse impact of municipal wastewaters concentrations. All the treatments (T2: 40%; T3: 60%; T4: 80% and T5: 100%) proved toxic for the growth of plants except for T1 (20 %), which showed more or less similar response as that of control (Table 3, 4; Fig. 1). Both sunflower cultivars showed highly significant reductions in fresh weight of shoots and roots along with similar pattern observed for dry weights of shoots and roots. Both sunflower cultivars behaved similarly but cultivar SH-3322 proved slightly more sensitive than that of SF-187. Generally, plant growth was luxurious in control when compared to other pollution treatments having extremely less shoot and root biomass in higher pollution treatments. As the plants in various treatment were weak and underdevloped, showing chlorosis and necrotic spots, so their stomatal conductance, transpiration rate and net photosynthetic rates were also very low than control plants.

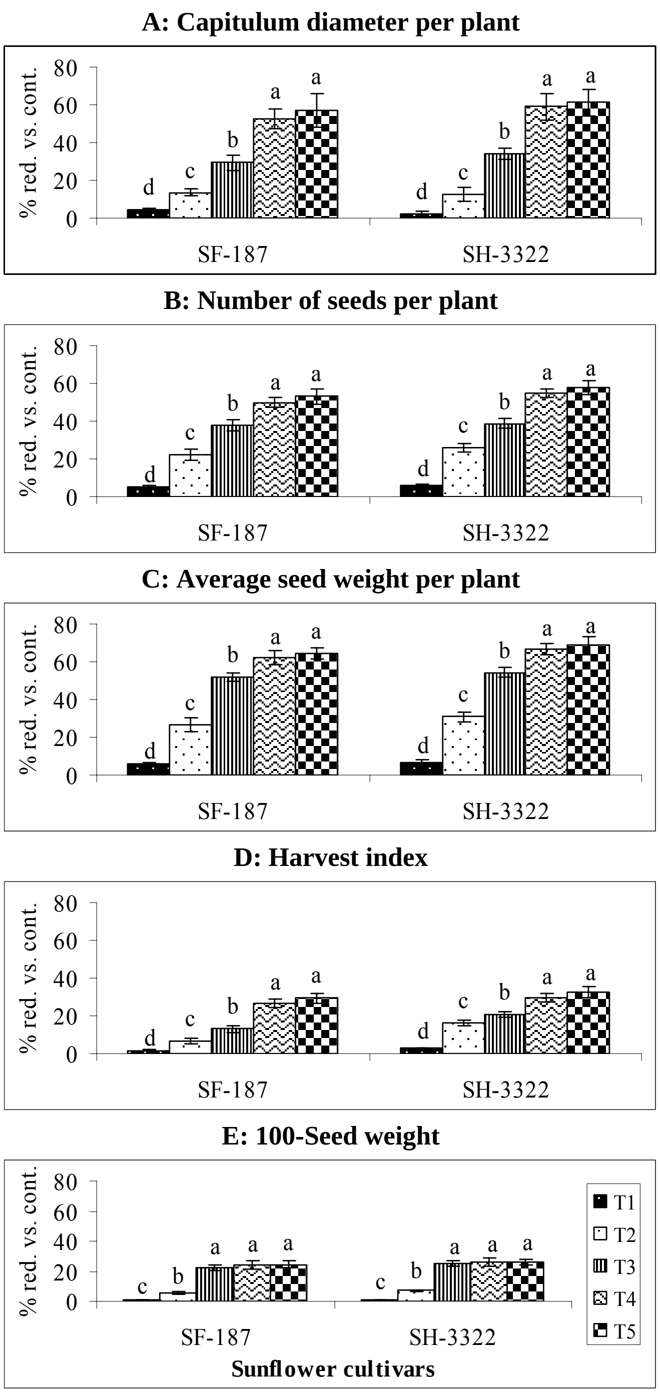

Fig. 1. Impact of wastewater effluents on yield attributes of sunflower cultivars during 2005 growth season.

It is by no means uncertain that plants grown in highly saline environment with excessive amounts of toxic wastes (Tables 4.2 and 4.3) can not establish themselves as healthy plants as in the cleaner environment (Wahid *et al*., 2000). Water pollutants accumulate in the soil to the extent that they interfere with the growth of plants (Mohammad & Ayadi, 2004). Heavy metals such as copper, lead, mercury, chromium, sodium, and selenium, including many other toxic chemicals and compounds also effects the plants (Kilicel & Dag, 2006). The other harmful impact of these effluents is due to their high NaCl contents which induces salinity and sodicity hazard to the subjected soils (Sheikh & Irshad, 1980). Lahouti & Peterson (1979) reported that cauliflower, carrot, radish, maize and barley can accumulate chromium in threshold amounts in their shoots from polluted soils after sewage water treatment can be toxic when consumed. Different species respond differently to water pollution. Response depends upon the kinds of salts, their concentrations and interactions between salts and plants. This effect causes a progressive depression in percentage germination, seedling length and vigor along with reduced fresh and dry weight of plants (Jana & Harjee, 1996). Thukral (1999) suggested that wastewaters discharged from Khetri copper complex, India, have harmful effects on biomass of some crop plants. There was reduction in plant dry weight when irrigated regularly with wastewaters. Singh & Mishra (1997) carried out a study on the effects of fertilizer factory effluents on soil and crop productivity. They reported that the effluents were highly alkaline and contained high amounts of Na, Ca, Cl, CO_3 and HCO_3. Kisku *et al*., 2000 reported that irrigation of vegetables like *Luffa acutangula* and *Lycopersicum esculentum* with municipal wastewaters reduces their fresh and dry biomass.

Wahid *et al*., (2000) also reported that growth and 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. Wastewaters reduced the germination and with poor number of leaves and accelerated rate of leaf senescence (Singh & Iqbal, 2002). Reduction in number of tillers, shoot and root dry weights in some grasses were reported in European countries by some workers recently (Hellawell & Mance, 2002). Effluents hindered the germination to a great extent, and as the plants grew in higher concentrations, their number of tillers and number of leaves decreased when compared to plants treated with normal water (Beg & Farooq, 2002). Richards & Marshall (2002) reported reduced dry weight of soybean and sunflower when grown in different concentrations of municipal wastewaters that have very high pH, EC, and other minerals including chlorides, carbonates, sodium and bicarbonates. Chen & Chia (2002) working in china, reported municipal wastewaters impacts on some 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. Yasir (2003) found that plants treated with dilution series of wastewaters effluents of city were less healthy and have fewer numbers of leaves and earlier onset of aging process. Plants reduced the pollutant concentration in the environment through absorption, adsorption, detoxification, metabolization and accumulation of pollutant compounds in their cells. The pollutants react with the chemical compounds of the cell sap, injure them and eventually get changed to a less toxic state or are destroyed. The epidermis, being the outermost protective layer in all plants may exhibit modifications and abnormalities in form, structure and function with the changes in the surrounding environment and, such modifications van indicate the effects of water pollution (Wahid *et al.,* 2004). The degree of injury to susceptible plants is directly related to the concentration of pollutants to which they are exposed and to the duration of exposure.

Bazai & Achakzai (2006) have reported that seed germination and seedling growth of lettuce (*Lectuca sativa* L.) were adversely affected by irrigation with municipal wastewaters collected from three Cites of Quetta city of Balochistan province of Pakistan. Rusan *et al*., (2007) have also reported increased level of Pb, Cr and Cd in vegetables with wastewaters irrigation. Wastewaters irrigation may increase soil pH and increase soil salinity, K, Fe and Mn levels. Farid (2006) found that irrigation with municipal wastewaters effluents increased soil salinity, sodicity and heavy metals concentrations. Vegetables grown on the land irrigated with municipal effluents caused inhibition of germination, and reduced growth. Pandey (2007) working in India found that untreated wastewaters of city of Bombay has injurious effects on the growth of *Brassica* and *Spinacea oleracea*.

Brown & Davies (1995) reported that higher pH and EC severely inhibited photosynthesis, and reduce chlorophyll *a* and chlorophyll *b* concentrations in susceptible plants. Singh & Mishra (1997) reported that higher concentrations of effluents (10% to 100%) have deleterious effects on photosynthesis, and dry matter production. Kisku *et al*., (2000) reported that irrigation of vegetables with municipal wastewaters reduces the chlorophyll contents and other physiological mechanisms including photosynthetic rate and photosynthesis ratio. According to Qadir & Oster (2004), municipal wastewaters effluents may change the normal behaviour of stomatal rhythm and time of opening and closing of stomata in various plants, thus reducing the transpiration rate which ultimately can reduce the rate of photosynthesis. Singh (2003) working in India reported that wastewaters enhances the rate of senescence of leaves by destroying the chlorophyll pigments leading to stoppage of photosynthesis in severe cases. Pandey (2007) working in India found that loss of chlorophyll and carotenoid pigments significantly reduced the stomatal conductance and reduced transpiration.

Productivity of sunflower cultivars was reduced sgnificantly in response to the effluents treatments, however, plants growing in non-polluted water showed extremely good growth with healthy and expanded capitulum containg more and heavier seeds as compared to effluents treated plants (especially of T4 and T5) of both cultivars with similar effects on yield (Fig. 1) . In general, overall trend in reduction in the life span of both crops may be as follows: $T0 \geq T1 > T2 > T3 > T4 \geq T5$. In both cultivars of sunflowers, highly pronounced reductions in 100-seed weight, and harvest index were also noted that showed the efficacy of treatments. A number of workers have investigated the effects of liquid effluents on the yield of plants. For instance, Tamoutsidis *et al*., (2002) reported that increasing doses of municipal wastewaters application on vegetables for leaves (lettuce, endive and spinach) and roots (radish, carrots and beets), reduced the overall yield of plants. Wahid *et al*., (2000) also 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. Chen & Chia (2002) working in China, reported municipal wastewaters impacts on some 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. Turner (2002) reported that wastewater effluents caused severe growth reductions in crops, particularly in cereals with marked depression in biomass (50-70%) and reduced the quantum yield. Khedkar & Dixit (2003) reported that wastewaters of cities have inhibiting effect on seed setting and yield of the crop. Singh (2003) reported that economic yield declines corresponding to the higher pollution levels. Kang *et al.,* (2007) indicated that irrigation of rice with reclaimed municipal wastewaters also caused adverse effects on yield of rice due to high pH and EC.

Although the impact of municipal wastewaters effluents on the growth performance and productivity of sunflower cultivars have not been studied on an extensive basis in Pakistan, and hence, there is a little relevant data available for other countries of south and south-east Asia, including Europe and USA. In summary, there is a rather inconsistent pattern which emerges when comparing data of sunflower crops with other plants. Also, the crop in present experiment was grown according to local agricultural practices and this, together with the fact that the plants were grown in pots, makes comparisons with studies in other countries very difficult. However, the appearances of the plants in control were very similar to that of crops in the surrounding fields, thus giving confidence that the experimental conditions had not substantially modified the usual pattern of development of crops. Given all the factors considered above, it is still difficult to make direct quantitative comparisons between results of present study and those other published studies.

Future research priorities: It is clear from the discussion that this study has raised a number of issues which urgently need to be addressed in further research aimed at properly evaluating the possible effects of municipal wastewaters effluents of Quetta city as:

1. Municipal wastewaters effluents of Quetta city should be applied to many other vegetable crops and native fruit trees in order to find out the effects on growth and yield performance.
2. Detailed physiological and biochemical responses should be investigated to understand the mechanism of injury or stunted growth in plants grown in wastewaters effluents treated soils.
3. Municipal wastewaters should be recycled or treated before applying its various concentrations to plants to confirm whether its effects are positive or negative.
4. Municipal wastewaters effects should be noted on properties of soils that are currently been supplied with effluents or sludge to understand the status of microbial communities.
5. Heavy metals uptake in the biomass and seeds/fruits of plants should be investigated due to human health concerns.

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