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Effect of polluted municipal waste water on growth yield and heavy metal accumulation in wheat plants

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Abstract

ABSTRACT

This research was carried out to study the effects of wastewater on yield attributes andaccumulation of wastewater wheat grains. Pre and post green revolution selected wheat varieties were crossed in diallel mating fashion. F1 crosses along with parents were sown in pots by using three water sources i.e. Ground water, Canal water and wastewater in three replications. Ground water was used as control in the experiment. Under wastewater condition, the traits like plant height, Number of spikes per plant and grain yield per plant showed increasing trend while spike length showed decreasing trend as compared to control. The concentration of heavy metals Cr, Zn and Pb in wheat grains was determined by Flame atomic absorption spectrometer (FAAS).The concentration of Cr was found lowest of three metals while Zn showed highest concentration. The concentration of heavy metals was found higher under wastewater condition than control but it was less than permissible limits under both water conditions.

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Introduction

Wheat is an important cereal crop. It is being grown in large areas over the world. It is staple food in Pakistan and is being irrigated mainly with fresh water. However some farmers use wastewater as source of supplementary irrigation. Wastewater contains nutrients which are beneficial for crop growth and reduces fertilizer requirement of crops (Valipour and Singh, 2016). Wastewater is being used to irrigate most of crops and vegetables grown in the vicinities of city. Untreated wastewater is also being used to irrigate crop plants worldwide (Khan N and Bano A, 2016). Many researchers like (Deshpande and Kaul, 1991 Fonseca *et al*., 2007, Galavi *et al*., 2010) has reported the use of wastewater. In Pakistan, use of untreated wastewater is being practiced around the cities due to high fertility and as a method of wastewater disposal (Matsuno *et al*., 2001). Some textile effluents have beneficial effects on crop growth when applied directly or the same water is diluted (Najam-us-Sahar *et al*., 2019; Rahman *et al*., 2009). Growth and germination of some crop plants i.e. black gram, green gram, rice, groundnut, sunflower and maize increases under diluted wastewater (Elarajan and Bupathi, 2006; Wins and Murgan, 2010). Sewage sludge improves physical, chemical and biological properties of soil (Angın and Yağanoğlu, 2009).

Less nitrogen and phosphorus are required when land is treated with sludge and thus it helps to improve growth and yield of crop plants (Petersen *et al.,* 2003). Growth, biomass and yield of crop plants increases under sludge treated soils (Togay *et al.* 2008).Uptake of heavy metals by plants causes toxicity (McGrath *et al*., 1995).Textile wastewater contains inorganic compounds and pollutants (Siddique *et al*., 2010). More accumulation of heavy metals in edible parts than permissible limits is unsafe for human consumption and has some health issues. Crop growth and productivity is negatively affected by excessive concentration of these heavy metals. (Beghum *et al.,* 2011) reported increased concentration of Lead, Zn, Fe, Mn and Cu contents in rice due to application of wastewater.

It is perceived that wastewater can be used as a substitute for fertilizers and hence there will be decreased need of agriculture inputs (Suciu NA *et al*., 2015). Pakistan is facing water shortage for agriculture crops and at the same time we have ample supply of untreated wastewater from domestic and industrial sources. Wastewater is one of options for farmers to irrigate their crops along with its safe disposal. The present study was conducted to check the effect of wastewater on yield parameters of wheat with ultimate focus on wastewater as alternate supply for irrigation as well as uptake of heavy metals by the edible parts of wheat plant.

Material and methods

Experiment was conducted at College of Agriculture, University of Sargodha. Sargodha is the divisional Headquarter and is situated in the Province of Punjab. The college is situated around 9 km from Main campus. Pot experiment was conducted at research area of College of Agriculture. College of agriculture Sargodha is surrounded by crop fields, Jhelum canal and a small village along with some bamboo processing units.

Climate of Sargodha can be characterized as desert or near desert. Pakistan is amongst most arid countries with an annual rainfall of below 240 mm (Farooq *et al*. 2007). Sargodha is having very hot summer and temperate winter with temperature ranging from highest 50 °C to lowest 6 °C.

Crossing of pre and post green varieties was done in year 2017-2018. Pre green revolution wheat varieties i.e.C518, C250, C271, C273 and post green revolution wheat varieties i.e. Johar16, Ujala16, Galay2013, Faisalabad 2008 were used for crossing. Eight crosses out of 64 were selected with increased yield and less uptake of heavy metals, detail as under.

F1 hybrids of these crosses were sown in 2018 in plastic pots using three replicates. 5 Kg of fertile soil was filled in each pot. Four seeds of each variety were sown in each pot. Wheat hybrids along with parents were grown with following thee treatments.

1. Ground water (Control)
2. Canal water
3. Wastewater

Fertilizer, water requirements and other crop protection measures were taken as per production technology of wheat crop. Plants were harvested at the end of April 2019.

Sample preparation for metals determination

Flour of fine grain was prepared as sample digesting inH_2O_2 and HNO_3 by 2:1 ratio.

The sample was kept on hot plate for one hour. After that 2 ml quantity of H_2O_2 was added to sample. Digestion was continued till clear sample was obtained. 50 ml of distilled was used to dilute filtered sample (Khan *et al.*, 2016a, b). Flame atomic absorption spectrometer was used to determine heavy metal concentration in grain samples.

Results and discussion

Yield attributes

Plant height

All the F1 hybrids of wheat showed increase in plant height under wastewater condition ranging from 0.8% to 2.42% as compared to control (ground water) Table 2&3 (Figure 1). Cross (C518×Johar 16) showed minimum increase in pant height while Cross (Faisalabad 2008× C518) showed maximum plant height. Overall percentage of increase in plant height was recorded as 1.41% in case of all crosses/hybrids.

Table 1. Detail of Pre and Post green genotypes and crosses.

CROSSES	GENOTYES	GENOTYES
H1	C518	JOHAR16
H2	C518	UJALA16
H3	C518	GALAXY 2013
H4	C518	FAISALBAD 2008
H5	JOHAR16	C518
H6	UJALA16	C518
H7	GALAXY 2013	C518
H8	FAISALBAD 2008	C518

Overall increase in height of all crosses shows that wastewater have beneficial impact on wheat growth. Similar results have been reported by the scientists around the globe like (Day *et al.*, 1975, Day *et al.*, 1979) in wheat crop, (Pratibha, 1991) in coriander plant. Also (Kattimani *et al.*, 1989) obtained similar results and he reported improvement in growth attributes of wheat plants when irrigated with wastewater as compared with fresh water.

Improvement in growth attributes also contributed towards increase in yield of wheat plant.

Table 2. Effect of wastewater on yield parameters of wheat.

	Plant Height (cm)			Number of spikes per plant			Spike length (cm)			Grain yield per plant (gms)		
Parents/ Hybrids	Ground Water	Canal Water	Waste Water	Ground Water	Canal Water	Waste Water	Ground Water	Canal Water	Waste Water	Ground Water	Canal Water	Waste Water
C 518	123.510	126.504	121.500	5.950	6.410	6.150	10.910	10.570	10.790	9.526	10.764	10.110
Johar 16	96.830	99.684	88.843	7.260	7.690	6.610	12.220	11.890	12.540	14.569	16.227	12.201
Ujala 16	93.880	96.316	86.139	7.710	8.250	7.100	11.230	10.970	11.480	15.866	17.703	13.539
Galaxy 2013	97.270	100.335	89.576	7.350	7.840	6.740	12.920	12.620	13.200	16.761	18.847	14.342
Faisalabad 2008	99.180	101.939	90.958	6.990	7.510	6.330	11.990	11.710	12.300	14.594	16.415	12.312
C518×Johar 16	101.330	103.743	102.150	6.880	7.290	7.205	11.990	11.710	11.775	12.506	13.809	13.225
C518×Ujala 16	92.565	100.728	92.800	7.995	7.997	7.999	10.775	10.660	10.770	11.751	12.922	12.447
C518×Galaxy 13	102.440	105.252	103.710	6.310	6.590	6.630	12.490	12.210	12.109	14.315	15.659	15.010
C518×Faisalabad 2008	104.250	106.628	106.250	6.570	6.980	6.890	11.440	11.130	11.290	13.168	14.529	13.775
Johar 16× C518	100.940	103.143	102.950	6.542	6.690	6.812	11.625	11.339	11.450	12.174	13.509	12.765
Ujala 16× C518	98.155	100.183	99.405	6.303	6.425	6.515	10.640	10.364	10.590	11.474	12.677	11.967
Galaxy 13× C518	103.355	105.957	104.815	7.283	7.295	7.585	13.430	13.015	13.210	15.281	16.664	15.700
Faisalabad 2008× C518	103.835	105.983	106.355	6.193	6.235	6.560	11.036	10.585	10.845	12.784	14.195	13.555

Number of spikes per plant

All the F1 hybrids of wheat showed increase in number of spikes per plant under wastewater condition ranging from 0.05% to 5.92% as compared to control (ground water) Table 2&3 (Figure 2). Cross (C518×Ujala 16) showed minimum increase in pant height while Cross (Faisalabad 2008× C518) showed maximum number of spikes per plant.

Table 3. Percentage Increase/decrease in yield Parameters under wastewater condition.

Hybrids	Plant Height	No. of Spikes per plant	Spike length	Grain Yield per plant
C518×Johar 16	0.81	4.72	-1.79	5.75
C518×Ujala 16	0.25	0.05	-0.05	5.92
C518×Galaxy 13	1.24	5.07	-3.05	4.85
C518×Faisalabad 2008	1.92	4.87	-1.31	4.61
Johar 16× C518	1.99	4.13	-1.51	4.85
Ujala 16× C518	1.27	3.36	-0.47	4.30
Galaxy 13× C518	1.41	4.15	-1.64	2.74
Faisalabad 2008× C518	2.43	5.93	-1.73	6.03

Overall percentage of increase in number of spikes per plant was recorded as 4.03% in case of all crosses/hybrids. An increase in number of spikes per plant shows that wastewater has contributed towards the increased yield of wheat. Results of day *et al.*, (1975), Day *et al.*, (1979), and Veer and Lata (1987) have been found in conformity with our present findings because they reported increased number of spikes/ears per plant when irrigated with wastewater compared with tube well water. (Day and Tucker, 1977) also had similar kind of results in case barley crop.

Table 4. Concentration of Heavy metals in wheat Grains under three water conditions.

	Ground water (mg kg-1)			Canal water (mg kg-1)			Wastewater (mg kg-1)		
Genotypes	Cr	Zn	Pb	Cr	Zn	Pb	Cr	Zn	Pb
C 518	0.078	12.351	0.115	0.092	15.321	0.153	0.089	12.589	0.295
Johar 16	0.081	12.367	0.172	0.095	15.337	0.230	0.091	12.605	0.415
Ujala 16	0.083	12.356	0.137	0.097	15.326	0.195	0.099	12.594	0.425
Galaxy 2013	0.074	12.347	0.128	0.088	15.317	0.186	0.098	12.585	0.435
Faisalabad 2008	0.113	12.356	0.137	0.127	15.326	0.195	0.138	12.594	0.455
C518×Johar 16	0.079	12.354	0.113	0.093	15.324	0.159	0.102	12.592	0.298
C518×Ujala 16	0.084	12.357	0.109	0.098	15.327	0.162	0.091	12.595	0.291
C518×Galaxy 13	0.069	12.340	0.115	0.083	15.310	0.157	0.079	12.578	0.298
C518×Faisalabad 2008	0.084	12.359	0.107	0.098	15.329	0.155	0.097	12.597	0.293
Johar 16× C518	0.079	12.353	0.103	0.093	15.323	0.161	0.085	12.591	0.294
Ujala 16× C518	0.098	12.357	0.110	0.112	15.327	0.159	0.110	12.595	0.299
Galaxy13× C518	0.081	12.356	0.105	0.095	15.326	0.159	0.102	12.594	0.295
Faisalabad 2008× C518	0.084	12.358	0.106	0.098	15.328	0.161	0.102	12.596	0.299
PML(µg/g)a	50b	100	0.3	50b	100	0.3	50b	100	0.3

a Source: Chiroma *et al.* (2014)

b Source: US-EPA, Environmental Protection Agency, US 1997.

Spike length

Spikes however showed decrease in length ranging from 0.04% to 1.79% when irrigated with wastewater as compared to control Table 2&3 (Figure 3). Cross (C518×Ujala 16) showed minimum decrease in spike length while Cross (C518×Galaxy 13) showed maximum decrease in spike length. Overall spike length in case of all crossed decreased by 1.44%. (Pathak*et al.*, 1999; Robinson *et al.*, 2001) also showed same kind of decrease in growth attributes when treated with 100% sewage water as compared to control.

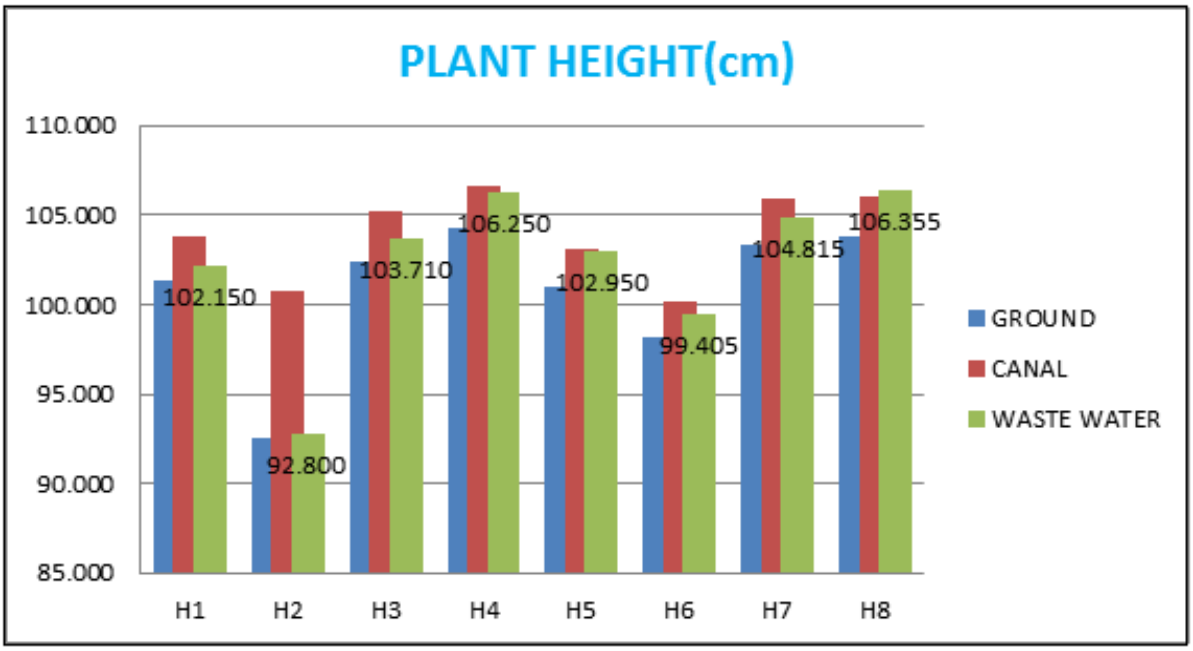

Fig. 1. Graphical presentation of plant height.

Grain yield per plant

Due to application of wastewater, Grain yield of wheat hybrids was increased when irrigated with wastewater as compared to control Table 2&3 (Figure 4). The increase in grain yield was ranging from 2.73% to 6.02% as compared to control (ground water). Cross (Galaxy 13× C518) showed minimum increase in grain yield while Cross (Faisalabad 2008× C518) showed maximum increase in grain yield.

Overall percentage of increase in grain yield was recorded as 4.88% in case of all crosses/hybrid.

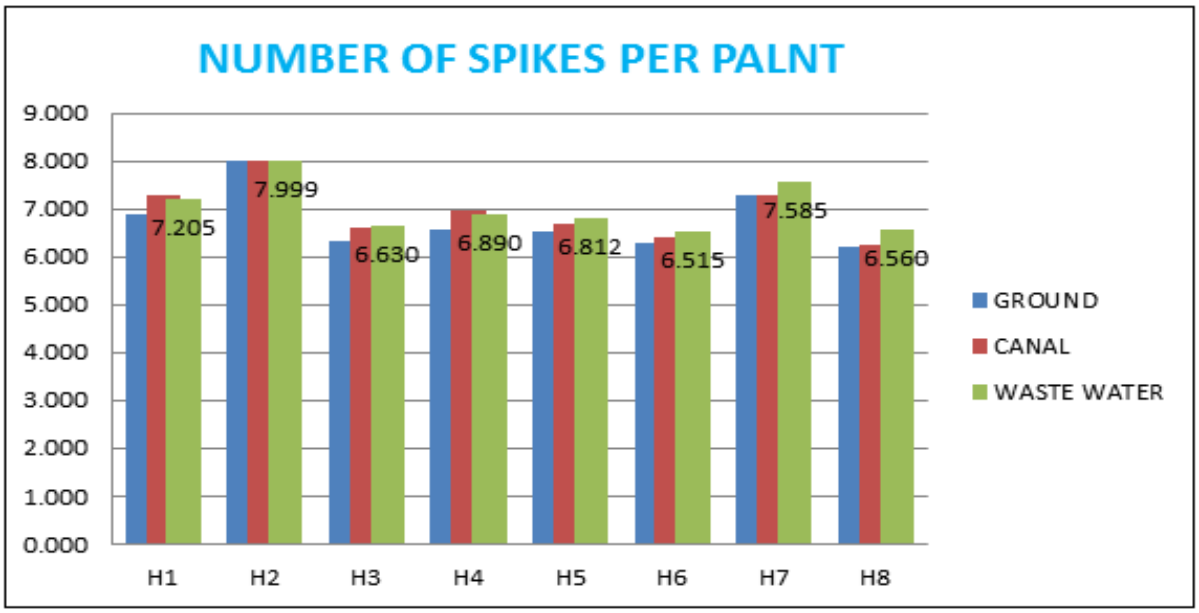

Fig. 2. Graphical presentation of Number of spikes per plant.

Increase in grain yield by the application of wastewater has been reported by many researchers/scientists (Day and Tucker, 1977) in Sorghum and Pratibha (1991) in coriander. However (Day *et al.* 1975, Day *et al.*, 1979, Chakraborti and Chakraborti, 1988) have reported decrease in grain yield of wheat when irrigated with sewage than irrigated with wastewater.

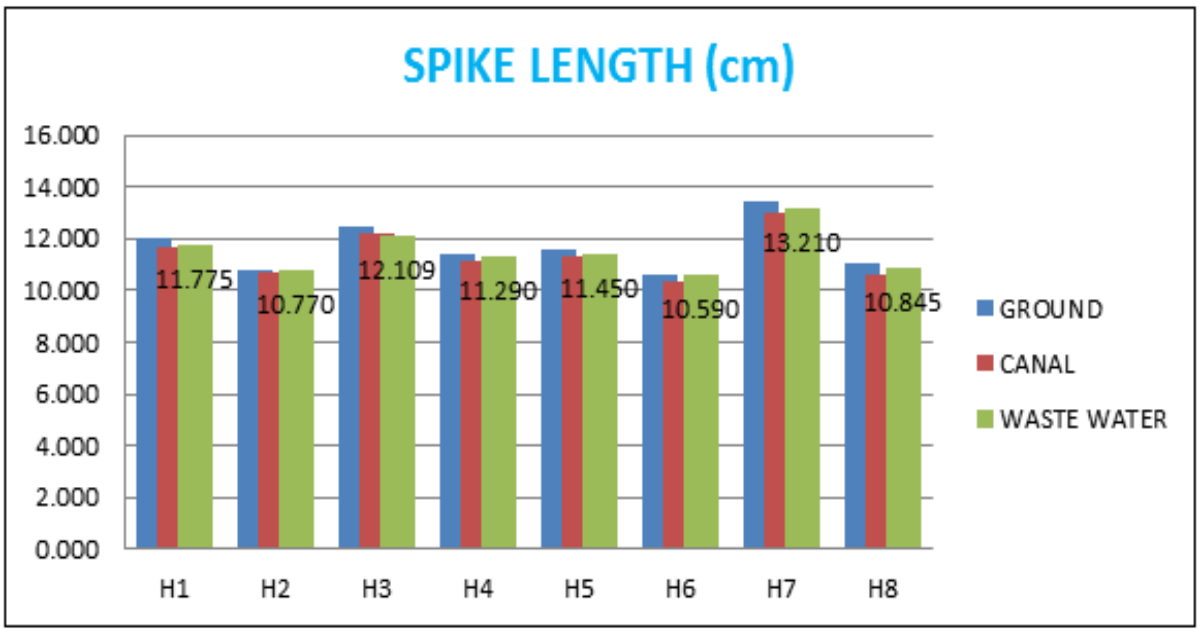

Fig. 3. Graphical presentation of spike length.

Heavy metals in grains

Following three heavy metals were investigated in wheat grains.

1. Cr
2. Zn
3. Pb

According to mean concentration of heavy metals, Cr concentration (mg kg−1) was lowest while that of Zn was highest. Under wastewater condition Cross (C518×Galaxy 13) showed lowest concentration of Cr while Cross (Ujala 16× C518) showed highest concentration. Under the same parameter Cross (C518×Faisalabad 2008) showed lowest concentration of Zn while Cross (Faisalabad 2008× C518) showed highest concentration. In case of Pb under wastewater condition, Cross (C518×Ujala 16) showed lowest concentration while Cross (C518×Faisalabad 2008) &Cross (Faisalabad 2008× C518) showed highest concentration.

In our present study the concentration of Cr in wheat grains is found ranging from 0.079 to 0.112 (mg/kg) (Table 4). These results are similar as reported by Chandra *et al.*, (2009). The concentration of Pb in our study ranged from 0.291 to 0.299 (mg/kg) (Table 4) in line with results reported by Hussain *et al.*, (2011). Similarly Zn concentration in case of our present study ranged from 12.578 to 12.596 (mg/kg) (Table 4) under wastewater condition, these results are similar to the results of Lakhdar *et al.*, (2009). Though Zn concentration was much lower than permissible limit, such low concentration would not cause any health issues.

According to PARC, small amount of Zn is beneficial for human health. (Karatas *et al.*, 2006) reported that wastewater irrigation to wheat produced average amount of Zn i.e. 22.31 mg kg−1 of Zn. Zn level of our study did not match results of Karatas, However lead level of our study were comparable to Karatas. Low level of Zn than Karartas may be due to less uptake of metals by hybrids in our study. Highest level of Zn was obtained in case of (C518×JOHAR 16) CROSS under canal water conditions. Mean concentration of all the metals in wheat grains increased under wastewater condition when compared to control. An overall concentration of all the metals was found higher under wastewater condition but concentration of all these metals remained within permissible.

The order of mean concentration of heavy metals in wheat grains was reported as Cr<Pb<Zn. The lower values of all heavy metals than PML indicate that consumption of wheat grains is safe for human beings.

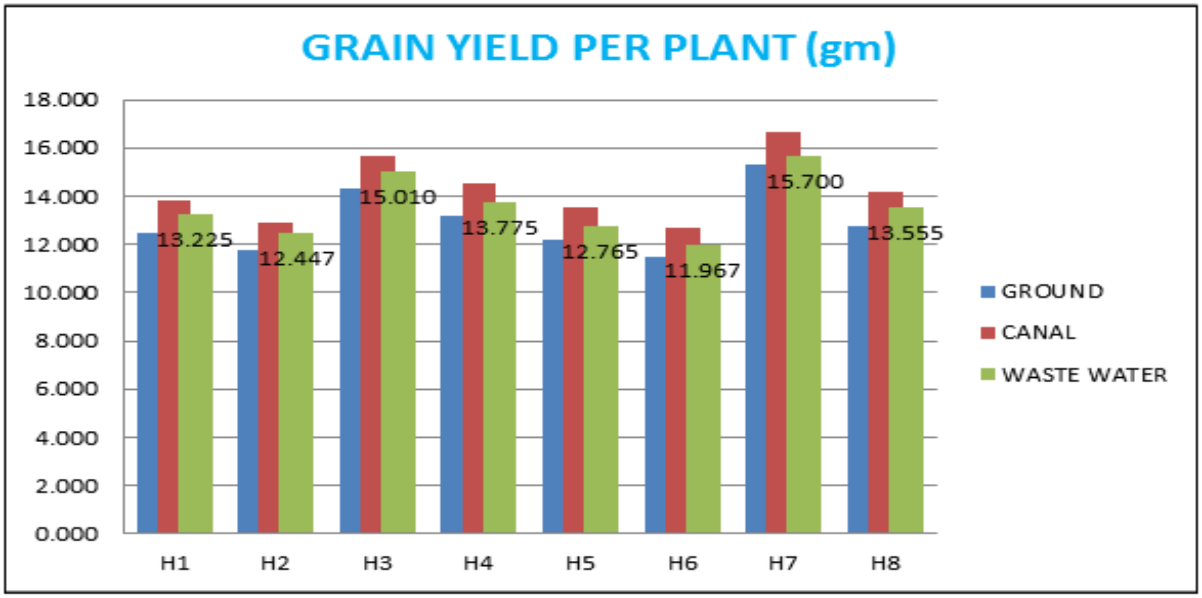

Fig. 4. Graphical presentation of grain yield per plant.

Conclusions

Our present results indicated that wastewater imparted beneficial impact on wheat hybrids. Plant height, Number of spikes per plant and yield per plant was found higher under wastewater conditions as compared to control. However spike length was found to be lower than control under wastewater condition. Also cost of fertilizer was saved due to application of wastewater. Though heavy metals uptake was observed in wheat grains of hybrids crosses, yet concentration of these metals was under PML showing that consumption of these grains is safe for human consumption. We may conclude that our wheat hybrids showed increase in growth and yield attributes. Though uptake of heavy metals was found however heavy metal concentration in all metals remained within PML in case of studied metals. This study also revealed that application of wastewater can be good method of wastewater disposal provided heavy metal concentration is within PML. Furthermore these F1 crossed can be used as parent material within wheat breeding program.

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