Effect of Different Freshwater and Treated Wastewater Levels on Growth and Yield Attributes of Maize (*Zea mays* L.)

Saif A. Al-Khamisi, Saif Al-Busaidi., Nadiya M. Al-Jabri, *Saleem K Nadaf, Abdulaziz. S. Al-Harthy and Hamdan S. Al-Wahaibi

Plant Production Research Center
Directorate General Agriculture & Livestock Research
Ministry of Agriculture & Fisheries; PO Box 50; PC 121Seeb, Sultanate of Oman

**Corresponding Author: Saleem K Nadaf.*

Abstract **- Maize (*Zea mays* L.) is one of the most important crops in irrigated arid and semiarid areas of the world. It is an efficient user of water in terms of total dry matter production and among cereals, it is potentially the highest yielding grain crop. It is one of the most important cereals in Sultanate of Oman for both human and livestock consumption and is grown for grain and forage. Agricultural use of treated wastewater has proved to help preserving scarce water sources, improve plant growth and increase productivity of poor soils fertility. A study was conducted at Agriculture Research Station, Rumais during the winter seasons of 2011/12 and 2012/13 using two water types (Treated Wastewater (TW) and Freshwater (FW)) and four water quantities/ levels (0.6, 0.9, 1.2, and 1.5 ET_o). The results indicated that the effect of year was significant to highly significant in respect of plant height ($p<0.05$), cob weight ($p<0.01$) and WUE ($p<0.01$). The effect of water quantity was significant ($p<0.01$) for only WUE whereas the effect of water type (quality) was significant to highly significant for all the characters except plant height. In respect of two factor interactions, effect of interaction between year and water quantity was significant only for WUE while that between year and water type (quality) was significant for only green and dry matter yields ($p<0.05$) and that between water quantity and water types was significant only for plant height ($p<0.05$). However, three factor interaction between year, water quantity and type was not significant for any characters ($p>0.05$). Plant height and cob yield (t/ha) were significantly ($p<0.05$) superior during summer 2012/13 (172.69 cm and 0.80 t/ha) to that during 2011/12 (164.28 cm and 0.53 t/ha) irrespective of quantity and quality of water. The crop responded significantly or insignificantly better under treated wastewater than under freshwater in respect of all the growth parameters studies viz. plant height ($p>0.05$), cob yield ($p<0.05$), green and dry matter yield ($p<0.05$) and WUE ($p<0.05$). It was cocluded that 1.0 ETo could be considered as desired level as a balance based on significance of interaction effect of water quantity and water types in respect of plant height and significance of main effect of water quantity in respect of WUE.**

Keywords: **Treated wastewater, Freshwater, Irrigation levels, Growth attributes, Forage yield, Maize**

I. INTRODUCTION

Sustained availability of fodder is a pre-requisite for the development of livestock and dairy industries. Maize is one of the important annual cereal forage not only in the world but also in Oman as it meets the demand of fodder in both winter and summer seasons. The use of treated wastewater is progressively increasing world-wide as an alternative water source for irrigation is common today in many regions throughout the world including Oman where water for agriculture is scarce on one hand while available water throughout the coastal lands is becoming saline due to seawater intrusion due to prolonged drought spells. Utilization of treated wastewater as a source for irrigation in the production fields is an environmentally sustainable approach as it is not only known to minimize the disposal to the environment but also offer benefits to the agricultural sectors by reducing demands for fertilizer inputs as a result of the higher concentration of macronutrients (Munir and Ayadi, 2005; Al-Zoubi et al., 2008; Mousavi et al., 2013 and Mausavi and Shahsavari, 2014 in maize and Agunwamba, 2001; Al-Khamisi *et al.*, 2011 and Khan *et al.*, 2012 in other cereal and fodder crops). In Oman, there are as many as 320 Sewage Treatment Plants (STPs) spread throughout governorates of the country. The total amount of treated wastewater produced in Oman during 2013 was 117992 m^3/day, out of it 61% produced in Muscat governorate, 14% in Al-Dhofar governorate and 25% in other governorates. In terms of availability of treated wastewater for use in Oman 78% and 10.25%. is used for landscape along roadside in Muscat governorate and in Salalah respectively In Salalah, however, 89.75% is used for recharging aquifers to prevent seawater intrusion to groundwater. In view of water scarcity in the country and need for effective utilization of available treated wastewater for irrigation, the study was undertaken to determine the effect of different quantities of both fresh and treated wastewater on the growth, yield and water-use efficiency of Hybrid Corn 533, hybrid variety of maize crop at Rumais Agriculture Research Station in South Batinah governorate of Oman.

II. MATERIALS AND METHODS

The experiment was implemented in two consecutive winter seasons of 2011-2012 and 2012-2013 in Split-plot RCBD with types of water (fresh and tertiary treated wastewater) as a main factor and quantity of water (0.8 ET_o, 1.0 ET_o, 1.2 ET_o and 1.4 E ET_o) as sub-factor., and five replications. Seeds of maize hybrid variety Hybrid Corn 533 were planted in October in plots, which consisted of four 3m five-rows at 25 cm between rows and 15 cm between plants in each sub-treatment. The maize was harvested after cob formation in March as the maize variety took 125-135 days to physiological maturity. Drip system was used for irrigation and the plants were irrigated half an hour three times per week and were fertilized at 150:100:50 kg NPK/ha as per national recommendations (Akhtar and Nadaf, 2002). At harvest, the observations were recorded on plant height (cm), cob weight and green matter weight (kg/m^2). The green fodder samples were taken at random for each genotype for determination of dry matter content and dry matter weight (AOAC, 1984). SPAD values of leaf samples were also measured by applying SPAD-502 meter that produce relative SPAD meter values, which are proportional to the amount of chlorophyll present in the leaf chlorophyll content (Ling *et al.*, 2011).

III. RESULTS AND DISCUSSION

Tables 1 to 5 present the means of characters of maize variety, Hybrid corn 533 viz. plant height (cm), cob weight (t/ha), green and dry matter yield (t/ha), and water-use efficiency (WUE- kg/m^3), recorded at four quantities of water viz. 0.8 ET_o, 1.0 ET_o, 1.2 ET_o and 1.4 ET_o in fresh (FW) and treated wastewater (TW) irrigation conditions during winter seasons of 2012 and 2013 along with means over years, respectively. The results indicated that the effect of year was significant to highly significant in respect of plant height ($p<0.05$), cob weight ($p<0.01$) and WUE ($p<0.01$). The effect of water quantity was significant ($p<0.01$) for only WUE whereas the effect of water type (quality) was significant to highly significant for all the characters except plant height. In respect of two factor interactions, effect of interaction between year and water quantity was significant only for WUE while that between year and water type (quality) was significant for only green and dry matter yields ($p<0.05$) and that between water quantity and water types was significant only for plant height ($p<0.05$). However, three factor interaction between year, water quantity and type was not significant for any characters ($p>0.05$).

Plant height (cm):

Plant height was significantly ($p<0.05$) superior during summer 2012/13 (172.69 cm) to that during 2011/12 (164.28 cm) irrespective of quantity and quality of water. However, there were no significant differences between plant heights recorded under treated wastewater and freshwater irrigation. In respect of response of maize to the quantity of water applied, plant height was significantly ($p<0.05$) highest over two years at 1.2 ETo (183. 38 cm) and 1.4 ET0 (173.38 cm) under irrigation of treated wastewater followed by at 1.0 ETo (173.00 cm) under freshwater,

Cob yield (t/ha):

Cob yield was significantly ($p<0.05$) superior during summer 2012/13 (0.80 t/ha) to that during 2011/12 (0.53 t/ha) irrespective of quantity and quality of water. However, there were no significant differences between cob yields recorded under different levels of irrigation. In respect of response of maize to the water type, cob yield was significantly higher over two years under treated wastewater (0.81 t/ha) than under freshwater (0.51 t/ha).

Green and dry matter yields (t/ha):

Both green and dry matter yields were significantly ($p<0.05$) superior over two years under treated wastewater (23.53 t/ha and 6.96 t/ha) to that under freshwater (18.73 t/ha and 6.02 t/ha) irrespective of quantity and years. However, there were no significant differences between green matter yields recorded under different levels of irrigation during different years. In respect of response of maize to the water type during different years, green and dry matter yields were significantly higher under treated wastewater (24.04 t/ha and 7.11 t/ha) than under freshwater (16.80 t/ha and 5.45 t/ha) during 2011/12. However, during 2012/2013 there were no significant differences in both green and dry matter yields under irrigation of two water types.

Water-Use Efficiency (WUE):

WUE was significantly ($p<0.05$) superior during summer 2012/13 (2.13 kg/m^3) to that during 2011/12 (1.44 kg/m^3) irrespective of quantity and quality of water. Besides, WUE was significantly highest at 0.80 ETo (3.09 kg/m^3) as compared that at 1.0 ETo (2.31 kg/m^3) during 2011/2012 followed that at 0.80 ETo (2.03 kg/m^3) during 2012/2013. There were significant differences in WUE between water quantities and water types in terms of response of the crop. The crop had the highest WUE over the years at 0.8 ETo (2.56 kg/m^3) followed that at 1.0 ETo (1.89 kg/m^3), 1.2 ETo (1.42 kg/m^3) and 1.4 ETo (1.27 kg/m^3). The crop had significantly higher WUE under treated wastewater (2.01 kg/m^3) than under freshwater (1.56 kg/m^3).

The results further showed that the crop responded better during 2012/13 than during 2011/13 in respect of all the attributes except WUE (Tables 1 to 4). This is because of higher native salinity in terms of EC values found after the experiment in all the plots irrespective of irrigation water used at the site during 2011/12 (Table 6-A) with lower pH values (Table 6-B) than that in the plots of the experiment at different site during 2012/13. Higher salinity in the experimental site during 2011/13 is also reflected in the higher values of K (Table 6-E), Na (Table 6-F), Cl (Table 6-G), Ca CO_3 (Table 6-H), Ca (Table 6-I) and Mg (Table 6-J) which are associated with salinity directly or indirectly.

It was further observed that the crop responded significantly or insignificantly better under treated wastewater than under freshwater in respect of all the growth parameters studies viz. plant height ($p>0.05$), cob yield ($p<0.05$), green and dry matter yield ($p<0.05$) and WUE ($p<0.05$). Such increase in growth and yield attributes under treated wastewater conditions was also observed previously in maize (Munir and Ayadi, 2005; Al-Zoubi et al., 2008; Mousavi et al., 2013; Mausavi and Shahsavari, 2014)and other cereal fodder crops (Agunwamba, 2001; Al-Khamisi *et al.*, 2011, Khan et al., 2012). The growth and yield attributes are mainly influenced by NPK and organic matter which are adequately available in treated wastewater which improves the plant growth. This is evident from the fact that three major elements viz. N, P and K were found in higher concentrations in soil after harvest of the crop under treated wastewater conditions (N – 0.113 µg/kg; P – 34.469 µg/kg and K – 93.75 µg/kg) than under fresh water irrigation ((N – 0.068 µg/kg; P – 31.063 µg/kg and K – 79.06 µg/kg) in the present experiment (Table 6-C, D and E). This was also supported by Mekki *et al.* (2006) who found his studies that the use of treated wastewater could increase the density of soil microorganisms which helps in nutrient availability of plants.

In the absence of relevant studies in maize on the levels of water through irrigation of treated wastewater and freshwater, it is concluded from the results of present studies that 1.0 ETo could be considered as desired level as a balance based on significance of interaction effect of water quantity and water types in respect of plant height and significance of main effect of water quantity in respect of WUE.

ACKNOWLEDGEMENT

We are grateful to the Director General of Agriculture and Livestock Research for encouragement and International Center for Biosaline Agriculture, Dubai for its collaborative research program in Oman. Thanks are also to Mrs. Majda S.S. Al-Zadjali and Mr. Muneer S.S. Al-Yahyai for plant, soil and water analysis.

REFERENCES

[1]. Agunwamba, J.C., (2001). Analysis of socioeconomic and environmental impacts of waste stabilization and unrestricted wastewater irrigation. Interface with maintenance. *Environmental Management.* 27: 463-476.

[2]. Akhtar, M. and Nadaf, S. K., (2002). Consolidated Results of the Experiments in Field Crops (1971-2000). Directorate General of Agriculture, Ministry of Agriculture and Fisheries. Sultanate of Oman.

[3]. Alkhamisi, S. A., Abdalrahman, H. A., Ahmad, M., and Goosen, M. F. A., 2011. Assessment of Reclaimed Water Irrigation on Growth, Yield and Water-use Efficiency of Forage Crops. Applied Water Science (2011) 1: p 57-65.

[4]. AOAC, (1984). Official methods of analysis. 14th Ed. Association of Official Analytical Chemists. Washington, D.C. USA.

[5]. Al-Zoubi, M.M., Arslan, A., Abdelgawad, G., Pejon, N. Tabba, M. and Jouzdan, O., (2008). The effect of sewage sludge on productivity of crop rotation of wheat, maize and vetch and heavy metal accumulation in soil and plant in Aleppo Governorate. American-Eurasian J. agric. & Env. Sci. 3: 618-625.

[6]. Khan, M.A. Shaukat, S. S., Shahzad, A and Arif, H., (2012). Growth and yield responses of pearl millet (*Pennisetum glaucum* [l.] r.br.) irrigated with treated effluent from waste stabilization ponds. *Pak. J. Bot*., 44(3): 905-910, 2012.

[7]. Ling, Q. Huang, W. and Jarvis P., (2011). Use of a SPAD-502 meter to measure leaf chlorophyll concentration in Arabidopsis thaliana. *Photosynth Res.* 107(2):209-14.

[8]. Mekki, A., Dhoub, A. and Sayadi, S., (2006). Changes in microbial and soil properties following amendment with treated and untreated olive mill wastewater. *Microbiol. Res.*, 16: 93-101.

[9]. Mousavi, S.R., Galavi, M. and Eskandari, H., (2013). Effect of treated municipal treated wastewater on fluctuation trend of leaf area index and quality of maize (*Zea mays*). *Water Sci & Tech.* 67: 797-802.

[10]. Mousavi, S.R. and Shahsavari, M., (2015). Effect of treated municipal wasterwater on growth and yield of maize (*Zea mays*). *Biological Forum-An International J.* 6: 228-233.

[11]. Munir, J.M. and Ayadi, M., (2005). Forage yield and nutrient uptake as influenced by secondary treated wastewater. J. Plant Nutrition. 27: 351-356.

TABLE 1.

MEANS OF PLANT HEIGHT (CM) OF MAIZE UNDER FOUR QUANTITIES OF WATER AND TWO TYPES OF WATER IN TWO SUMMER SEASONS

Water quantity	Winter 2011/2012			Winter 2012/2013			Means of years		
	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean
0.8 ETo	159.50	151.50	155.50	172.50	179.75	176.13	166.00	165.63	165.81
1.0 ETo	150.00	168.00	159.00	158.00	178.00	168.00	154.00	173.00	163.50
1.2 ETo	188.50	162.25	175.38	178.25	170.00	174.13	183.38	166.13	174.75
1.4 ETo	166.00	168.50	167.25	180.75	164.25	172.50	173.38	166.38	169.88
Mean	166.00	162.56	164.28	172.38	173.00	172.69	169.19	167.78	168.48

Sources of variation	df	F-test (5%)	LSD (5%)	C.V. (%)
Replication	3			
Year	1	*	7.79	
Water quantity	3	NS	-	
Water type	1	NS	-	
Year*Water quantity	3	NS	-	9.2
Year*Water type	1	NS	-	
Water quantity*Water type	3	*	15.58	
Year*Water quantity*Water type	3	NS	-	
Error	45			
Total	63			

TABLE 2.

MEANS OF COB WEIGHT (T/HA) OF MAIZE UNDER FOUR QUANTITIES OF WATER AND TWO TYPES OF WATER IN TWO SUMMER SEASONS

Water quantity	Winter 2011/2012			Winter 2012/2013			Means of years		
	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean
0.8 ETo	0.81	0.39	0.60	0.95	0.50	0.72	0.88	0.44	0.66
1.0 ETo	0.55	0.44	0.49	0.86	0.73	0.80	0.71	0.58	0.65
1.2 ETo	0.75	0.39	0.57	0.84	0.44	0.64	0.79	0.42	0.61
1.4 ETo	0.57	0.34	0.45	1.20	0.86	1.03	0.88	0.60	0.74
Mean	0.67	0.39	0.53	0.96	0.63	0.80	0.81	0.51	0.66

Sources of variation	df	F-test (5%)	LSD (5%)	C.V. (%)
Replication	3			
Year	1	**	0.1394	
Water quantity	3	NS	-	
Water type	1	**	0.1394	
Year*Water quantity	3	NS	-	41.7
Year*Water type	1	NS	-	
Water quantity*Water type	3	NS	-	
Year*Water quantity*Water type	3	NS	-	
Error	45			
Total	63			

TABLE 3.
MEANS OF GREEN MATTER YIELD (T/HA) OF MAIZE UNDER FOUR QUANTITIES OF WATER AND TWO TYPES OF WATER IN TWO SUMMER SEASONS

Water quantity	Winter 2011/2012			Winter 2012/2013			Means of years		
	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean
0.8 ETo	24.26	15.47	19.86	23.25	20.83	22.04	23.75	18.15	20.95
1.0 ETo	23.38	16.91	20.14	21.38	21.00	21.19	22.38	18.95	20.66
1.2 ETo	26.18	16.18	21.18	22.12	19.33	20.73	24.15	17.76	20.95
1.4 ETo	22.37	18.63	20.50	25.33	21.50	23.42	23.85	20.06	21.96
Mean	24.04	16.80	20.42	23.02	20.67	21.84	23.53	18.73	21.13

Sources of variation	df	F-test (5%)	LSD (5%)	C.V. (%)
Replication	3			
Year	1	NS	-	
Water quantity	3	NS	-	
Water type	1	**	1.4589	
Year*Water quantity	3	NS	-	13.7
Year*Water type	1	*	2.9179	
Water quantity*Water type	3	NS	-	
Year*Water quantity*Water type	3	NS	-	
Error	45			
Total	63			

TABLE 4.
MEANS OF DRY MATTER YIELD (T/HA) OF MAIZE UNDER FOUR QUANTITIES OF WATER AND TWO TYPES OF WATER IN TWO SUMMER SEASONS

Water quantity	Winter 2011/2012			Winter 2012/2013			Means of years		
	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean
0.8 ETo	6.41	5.15	5.78	6.24	6.80	6.52	6.32	5.97	6.15
1.0 ETo	7.59	5.36	6.47	6.96	6.33	6.64	7.27	5.84	6.56
1.2 ETo	7.79	5.10	6.44	6.51	6.14	6.33	7.15	5.62	6.38
1.4 ETo	6.67	6.21	6.44	7.50	7.08	7.29	7.09	6.65	6.87
Mean	7.11	5.45	6.28	6.80	6.59	6.70	6.96	6.02	6.49

Sources of variation	df	F-test (5%)	LSD (5%)	C.V. (%)
Replication	3			
Year	1	NS	-	
Water quantity	3	NS	-	
Water type	1	*	0.7084	
Year*Water quantity	3	NS	-	21.7
Year*Water type	1	*	1.0018	
Water quantity*Water type	3	NS	-	
Year*Water quantity*Water type	3	NS	-	
Error	45			
Total	63			

TABLE 5.
MEANS OF WATER-USE EFFICIENCY (WUE-KG/M^3) OF MAIZE UNDER FOUR QUANTITIES OF WATER AND TWO TYPES OF WATER IN TWO SUMMER SEASONS

Water quantity	Winter 2011/2012			Winter 2012/2013			Means of years		
	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean	Treated wastewater	Fresh water	Mean
0.8 ETo	3.43	2.76	3.09	2.27	1.78	2.03	2.85	2.27	2.56
1.0 ETo	2.71	1.91	2.31	1.73	1.21	1.47	2.22	1.56	1.89
1.2 ETo	2.09	1.37	1.73	1.26	0.99	1.12	1.67	1.18	1.42
1.4 ETo	1.43	1.33	1.38	1.18	1.12	1.15	1.31	1.23	1.27
Mean	2.41	1.84	2.13	1.61	1.28	1.44	2.01	1.56	1.79

Sources of variation	df	F-test (5%)	LSD (5%)	C.V. (%)
Replication	3			
Year	1	**	0.2145	
Water quantity	3	**	0.3033	
Water type	1	**	0.2145	
Year*Water quantity	3	*	0.429	23.9
Year*Water type	1	NS	-	
Water quantity*Water type	3	NS	-	
Year*Water quantity*Water type	3	NS	-	
Error	45			
Total	63			

TABLE 6-A.
MEANS OF EC VALUES (DS M^{-1}) OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

Water quantity	2011/2012			2012/2013			Mean		
	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	8.740	6.167	7.454	1.350	1.698	1.524	5.045	3.933	4.489
1.0 ETo	6.052	3.530	4.791	1.138	1.055	1.097	3.595	2.293	2.944
1.2 ETo	6.545	2.305	4.425	1.045	1.327	1.186	3.795	1.816	2.806
1.4 ETo	5.985	4.158	5.072	0.882	1.322	1.102	3.434	2.740	3.087
Mean	6.831	4.040	5.435	1.104	1.351	1.227	3.967	2.695	3.331

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	
Year	1	**	1.539	
Water type	1	NS	-	
Water quantity	3	NS	-	91.7
Year*Water type	1	*	2.176	
Year*Water quantity	3	NS	-	
Water type*water quantity	3	NS	-	
Year*Water type*Water quantity	3	NS	-	
Error	45			
Total	63			

TABLE 6-B.

MEANS OF PH VALUES OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

Water quantity	2011/2012			2012/2013			Mean		
	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	7.675	7.825	7.750	8.100	8.200	8.150	7.888	8.013	7.950
1.0 ETo	7.825	8.000	7.913	8.225	8.400	8.313	8.025	8.200	8.113
1.2 ETo	7.800	8.050	7.925	8.225	8.400	8.313	8.013	8.225	8.119
1.4 ETo	7.900	7.900	7.900	8.325	8.300	8.313	8.113	8.100	8.106
Mean	7.800	7.944	7.872	8.219	8.325	8.272	8.009	8.134	8.072

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	
Year	1	**	0.11	
Water type	1	*	0.11	
Water quantity	3	NS	-	
Year*Water type	1	NS	-	2.7
Year*Water quantity	3	NS	-	
Water type*water quantity	3	NS	-	
Year*Water type*Water quantity	3	NS	-	
Error	45			
Total	63			

TABLE 6-C.
MEANS OF N VALUES (%) OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

Water quantity	2011/2012			2012/2013			Mean		
	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	0.258	0.060	0.159	0.088	0.063	0.075	0.173	0.061	0.117
1.0 ETo	0.155	0.048	0.101	0.085	0.070	0.078	0.120	0.059	0.089
1.2 ETo	0.100	0.045	0.073	0.078	0.085	0.081	0.089	0.065	0.077
1.4 ETo	0.100	0.043	0.071	0.045	0.132	0.089	0.073	0.087	0.080
Mean	0.153	0.049	0.101	0.074	0.087	0.081	0.114	0.068	0.091

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	
Year	1	NS	-	
Water type	1	*	0.044	
Water quantity	3	NS	-	
Year*Water type	1	**	0.062	95.5
Year*Water quantity	3	NS	-	
Water type*water quantity	3	NS	-	
Year*Water type*Water quantity	3	NS	-	
Error	45			
Total	63			

TABLE 6-D.

MEANS OF P VALUES (PPM) OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

Water quantity	2011/2012			2012/2013			Mean		
	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	30.000	45.750	37.875	31.750	19.000	25.375	30.875	32.375	31.625
1.0 ETo	55.500	33.750	44.625	28.750	25.500	27.125	42.125	29.625	35.875
1.2 ETo	38.250	28.500	33.375	32.750	18.500	25.625	35.500	23.500	29.500
1.4 ETo	32.000	46.000	39.000	26.750	31.500	29.125	29.375	38.750	34.063
Mean	38.938	38.500	38.719	30.000	23.625	26.813	34.469	31.063	32.766

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	
Year	1	*	7.16	
Water type	1	NS	-	
Water quantity	3	NS	-	
Year*Water type	1	NS	-	43.4
Year*Water quantity	3	NS	-	
Water type*water quantity	3	NS	-	
Year*Water type*Water quantity	3	NS	-	
Error	45			
Total	63			

TABLE 6-E.

MEANS OF K VALUES (PPM) OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

	2011/2012			2012/2013			Mean		
Water quantity	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	127.500	82.500	105.000	72.500	95.000	83.750	100.000	88.750	94.375
1.0 ETo	125.000	75.000	100.000	80.000	95.000	87.500	102.500	85.000	93.750
1.2 ETo	100.000	62.500	81.250	67.500	72.500	70.000	83.750	67.500	75.625
1.4 ETo	102.500	80.000	91.250	75.000	70.000	72.500	88.750	75.000	81.875
Mean	113.750	75.000	94.375	73.750	83.125	78.438	93.750	79.063	86.406

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	
Year	1	NS	-	
Water type	1	NS	-	
Water quantity	3	NS	-	
Year*Water type	1	*	34.306	55.8
Year*Water quantity	3	NS	NS	
Water type*water quantity	3	NS	NS	
Year*Water type*Water quantity	3	NS	NS	
Error	45			
Total	63			

TABLE 6-F.

MEANS OF NA VALUES (PPM) OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

	2011/2012			2012/2013			Mean		
Water quantity	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	859.020	596.590	727.805	133.115	143.458	138.287	496.068	370.024	433.046
1.0 ETo	784.018	490.378	637.198	121.215	113.225	117.220	452.617	301.802	377.209
1.2 ETo	759.015	321.800	540.408	117.940	116.212	117.076	438.478	219.006	328.742
1.4 ETo	612.225	521.642	566.934	106.160	124.665	115.413	359.193	323.154	341.173
Mean	753.570	482.603	618.086	119.608	124.390	121.999	436.589	303.496	370.042

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	
Year	1	**	120.376	
Water type	1	*	120.376	
Water quantity	3	NS	-	
Year*Water type	1	NS	-	64.6
Year*Water quantity	3	NS	-	
Water type*water quantity	3	NS	-	
Year*Water type*Water quantity	3	NS	-	
Error	45			
Total	63			

TABLE 6-G.

MEANS OF CL VALUES (PPM) OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

	2011/2012			2012/2013			Mean		
Water quantity	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	68.332	38.728	53.530	11.788	25.170	18.479	40.060	31.949	36.005
1.0 ETo	62.038	28.892	45.465	17.280	19.140	18.210	39.659	24.016	31.838
1.2 ETo	55.570	17.990	36.780	11.610	15.688	13.649	33.590	16.839	25.215
1.4 ETo	49.718	32.528	41.123	11.345	14.360	12.853	30.532	23.444	26.988
Mean	58.915	29.535	44.225	13.006	18.590	15.798	35.960	24.062	30.011

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	
Year	1	**	15.253	
Water type	1	NS	-	
Water quantity	3	NS	-	
Year*Water type	1	*	21.571	100.9
Year*Water quantity	3	NS	-	
Water type*water quantity	3	NS	-	
Year*Water type*Water quantity	3	NS	-	
Error	45			
Total	63			

TABLE 6-H.

MEANS OF $CACO_3$ VALUES (%) OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

Water quantity	2011/2012			2012/2013			Mean		
	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	30.030	28.270	29.150	30.030	33.495	31.763	30.030	30.883	30.456
1.0 ETo	29.920	27.610	28.765	27.665	40.425	34.045	28.793	34.018	31.405
1.2 ETo	31.130	28.270	29.700	26.290	31.460	28.875	28.710	29.865	29.288
1.4 ETo	30.470	28.050	29.260	30.195	31.460	30.828	30.333	29.755	30.044
Mean	30.388	28.050	29.219	28.545	34.210	31.378	29.466	31.130	30.298

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	
Year	1	NS	-	
Water type	1	NS	-	
Water quantity	3	NS	-	
Year*Water type	1	*	4.426	20.5
Year*Water quantity	3	NS	-	
Water type*water quantity	3	NS	-	
Year*Water type*Water quantity	3	NS	-	
Error	45			
Total	63			

TABLE 6-I.

MEANS OF CA VALUES (PPM) OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

Water quantity	2011/2012			2012/2013			Mean		
	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	371.338	343.285	357.312	20.240	24.248	22.244	195.789	183.767	189.778
1.0 ETo	350.900	185.872	268.386	20.090	17.433	18.762	185.495	101.653	143.574
1.2 ETo	379.960	105.713	242.837	17.535	13.880	15.708	198.748	59.797	129.272
1.4 ETo	328.155	172.645	250.400	14.928	14.530	14.729	171.542	93.588	132.565
Mean	357.588	201.879	279.734	18.198	17.523	17.861	187.893	109.701	148.797

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	
Year	1	*	93.298	
Water type	1	NS	-	
Water quantity	3	NS	-	
Year*Water type	1	NS	-	124.5
Year*Water quantity	3	NS	-	
Water type*water quantity	3	NS	-	
Year*Water type*Water quantity	3	NS	-	
Error	45			
Total	63			

TABLE 6-J.

MEANS OF MG VALUES (PPM) OF THE EXPERIMENTAL SOIL OF THE PLOTS DURING 2011/2012 AND 2012/2013

	2011/2012			2012/2013			Mean		
Water quantity	TW	FW	Mean	TW	FW	Mean	TW	FW	Mean
0.8 ETo	291.723	204.485	248.104	25.513	27.187	26.350	158.618	115.836	137.227
1.0 ETo	96.410	115.000	105.705	23.453	22.995	23.224	59.932	68.998	64.465
1.2 ETo	198.653	242.335	220.494	20.745	31.198	25.972	109.699	136.767	123.233
1.4 ETo	188.083	128.790	158.437	20.320	29.645	24.983	104.202	79.218	91.710
Mean	193.717	172.653	183.185	22.508	27.756	25.132	108.113	100.204	104.158

Statistical parameters

Source or variation	d.f.	F-test (5%)	LSD (5%)	C.V. (%)
Replications	3	-	-	117.5
Year	1	*	61.627	
Water type	1	NS	-	
Water quantity	3	NS	-	
Year*Water type	1	NS	-	
Year*Water quantity	3	NS	-	
Water type*water quantity	3	NS	-	
Year*Water type*Water quantity	3	NS	-	
Error	45			
Total	63			

TABLE 7.

MEAN CHEMICAL CONTENTS OF WATER SAMPLES UNDER TREATED WASTEWATER AND FRESHWATER IRRIGATIONS

Parameter	Unit	Treated wastewater	Fresh water
ECw	*dS/m*	0.88	1.06
pH	-	7.7	7.5
Nitrogen N-NO_3^-(nitrate)	*mg/l*	28.7	0.463
Potassium K^+	*mg/l*	22.93	17.83
Sulfate SO_4^{2-}	*mg/l*	81.17	39.87
Bicarbonate HCO_3^-	*mg/l*	107.99	152.53
Carbonate CO_3^-	*mg/l*	Trace	Trace
Calcium Ca^{2+}	*mg/l*	58.21	38.91
Magnesium Mg^{+2}	*mg/l*	20.29	30.01
Sodium Na^+	*mg/l*	94.07	140.07
Chloride Cl^-	*mg/l*	140.02	276.49
Manganese Mn^{+2}	*mg/l*	0.028	0.018
Cadmium Cd^{+2}	*mg/l*	nd	nd
Copper Cu^+	*mg/l*	nd	nd
Iron Fe	*mg/l*	0.365	0.337
Zinc Zn^{+2}	*mg/l*	nd	nd
Boron B	*mg/l*	nd	nd
Phosphorus P	*mg/l*	nd	nd
Aluminum Al^{+3}	*mg/l*	0.013	0.011
Barium Ba^{+2}	*mg/l*	0.056	0.054
Chromium Cr^{+2}	*mg/l*	0.047	0.044
Cobalt Co^{+2}	*mg/l*	0.062	0.057
Lead Pb^{4+}	*mg/l*	0.211	0.185
Nickel Ni	*mg/l*	nd	nd
Titanium Ti	*mg/l*	0.001	nd

nd- not detected