J. Agric. Sci. Mansoura Univ., 28(5): 4111 - 4119, 2003

IMPACT OF IRRIGATION PRACTICES AND WATER QUALITY ON SOYBEAN AND SUGARBEET CROPS, AND SOIL UNDER LYZIMETER CONDITION

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ABSTRACT

Lyzimeter experiments were conducted at Sakha Agric. Res. Station during the summer season (2000) and winter season (2000/2001) to study the effect of the continuous or alternating low quality water (sewage, well and drainage water) with fresh water under surface and sub- surface irrigation at 25 and 50cm depths on soybean and sugarbeet yield and their components, plant elemental contents, soil salinity and soil elemental contents. The data reveal that the alternative irrigation by low quality water with fresh water achieved the highest yield and yield components for soybean and sugarbeet while the continuous irrigation with low quality water led to significant decrease in the yields of both crops. Also, surface irrigation surpassed sub-surface irrigation in increasing total biomas for both crops. It could be observed from the results that fresh water gave the highest yield followed by sewage water and drainage water, while well water alone or mixed with sewage water gave the lowest values of yield. The irrigation with sewage and drainage water as well as well water directly or belended with sewage water led to an accumulation of elements in plant tissues but they still within the acceptable ranges. On the other hand, the soil salinity contents after harvesting of each crop were clearly increased under all treatments compared to those obtained before planting. On the contrast, SAR values in soil solution after harvesting were lower than the values recorded before planting. The soil contents of available macro, micronutrients and heavy metals were increased by using low quality water for irrigation.

INTRODUCTION

The River Nile water in Egypt is the main water resource ($55.5\times10^9 m^3$) and this supply is not expected to increase in the near future. The annual demand of water for the agriculture and domestic activities is estimated to reach $69.7\times10^9 m^3$. The government has identified various opportunities for increasing the usable supply of water or improving the efficiency of water utilization. Reuse of the agricultural drainage water, sewage water and well water for beneficial purposes in Egypt is an attractive solution which hopefully will help considerably expansion of the irrigated agriculture or saving considerable amounts of fresh water for other sectors. In this regard, applications of low quality water continuously or alternatively with fresh water and sub-surface irrigation at different depths should be considered to alleviate the salinity hazards and reduce the pollution. These findings were stated by several workers, Ayers and Westcot, (1998), Mass *et al.*, (1982a,b) Hoffman *et al.*, (1983).

Soybean is considered one of the most important legumes in Egypt and occupies a substantial area, Day *et al.*, (1979) found that irrigating some field crops with well water mixed with sewage water produced higher yields, compared with those irrigated by well water. However, Oron *et al.* (1990) suggested that saline water can be applied through a sub- surface irrigation system, where water and the nutrients are emerging from the emitters and consumed efficiently by the adjacent roots. Also, sugarbeet plays a prominent role for sugar production in Egypt. Pescod (1992) stated that alternating wastewater with fresh water or well water was superior to blending both sources from the point of view of salinity control. However, an alternating application strategy is required due to the presence conveyance system and the availability of the effluent are dictated by the alternate schedule of application.

The objectives of this work is to study the effect of the continuous irrigation or alternating of low quality water (drainage, sewage or well water) with fresh water in lyzimeters under surface and subsurface irrigation at two depths on soybean and sugarbeet yield and soil salinity.

MATERIALS AND METHODS

Lysimeter experiments were conducted at Sakha Agric. Res. Station, during the summer season (2000) and winter season (2000/2001) to investigate the effect of low quality water (continuous application or alternating with fresh water) under surface or subsurface irrigation at two depths (25 or 50 cm.) on soybean and sugarbeet as well as some soil chemical properties. A split split-plot design with three replicates was used. The concrete lysimeter units with dimension of 70, 80 cm. length and 80-cm. depth were used. The main plots were occupied by methods of water application either continuous or alternative irrigation while, the sub plots were devoted to the methods of irrigation, surface or subsurface irrigation at depths of 25 and 50 cm. and the sub-sub plots were assigned to different water sources (drainage, well, sewage water and sewage water blended with well water at ratio (1:1) or (2:1). Soybean(Giza 21) variety was sown in summer 2000 followed by sugarbeet (*Respoly v.*) in winter season (2000/2001). All the recommended agronomic practices were done. Table (1) shows salinity and the elemental contents (mg/kg) of different water sources. Some physical and chemical properties of the used soil before cultivation are shown in Table (2).

Table (1): Electric conductivity (EC), sodium adsorption rate (SAR) and the elemental contents (mg/kg) of irrigation water used in the experiments.

Water source	EC dS/m	SAR	N	P	K	Zn	Fe	Mn	Cu	Pb	Ni	Co
Fresh (F)	0.45	1.41	2.45	0 33	3.5	0.07	0 23	0.045	0.03	0.03	0.004	0.02
Drainage (D)	1 42	4.35	16.3	0 41	8.4	0.20	0.21	0.032	0 07	0.08	0.003	0.004
Sewage (S)	1.25	4.65	21.8	4.42	6.5	0.90	0 33	0.094	0.12	0.04	0.050	0.016
Well (W)	1.41	4.33	8.30	2.20	7.4	0 27	0 27	0.48	0.12	0.06	0.040	0.01

Chemical analysis of soil and plant were determined according to Cottiene *et al.* (1982) and Lindsay and Norvell (1978). Available heavy metals in soil were extracted by DTPA solution and were determined using Atomic-spectrophotometer. *Soil available* N *was extracted by* $K_2 SO_4$ *solution* 0.5 N and determined using automatic micro-kjeldahl. Soil available P was extracted by $NaHCO_3$, 0.5 N and determined according to Murphy and Riley, (1962). Soil available K was extracted by ammonium acetate I N and determined using the flame-Photometer according to Page (1982). The data was statistically analyzed according to Chocram and Cox, (1960).

Table (2): Some physical and chemical properties of the used soil before experiment.

EC dS/m	SAR	Soil pH 1:2.5	O.M.%	Total carbonate %	Particle size distribution (%)			Macroelement mg/kg.			Microelements mg/kg.						
					Sand	Silt	Clay	N	P	K	Zn	Fe	Mn	Cu	Pb	Ni	Co
3.25	4.95	8.10	1.65	2.25	21.5	31 3	47.2	25.2	4.42	25.6	1.60	20.0	12.24	7.92	1.60	1.42	0.24

RESULTS AND DISCUSSION

A- Soybean:

Data presented in Table (3) show the effect of the continuous irrigation with different low quality water and its alternative with fresh water under two methods of drip irrigation on total biomas, 100-seed weight and protein content of soybean.

Table (3): Potential yield and composition of soybean and sugarbeet crops as affected by water quality and irrigation methods.

	Soybean			Sugarbeet			
	Total biomas gm/m^2	Protein gm/m^2	100-seed weight gm	Total biomas kg/m^2	Weight roots kg/m^2	Sugar yield kg/m^2	Sucrose
Method of application (A)							
Continuous	201.6B	34.8B	15.3	3.96b	0.97b	0.74b	18.9
Alternative	204.8A	36.9A	15.5	4.8A	1.14A	0.89A	18.7
F-Test	*	*	ns	**	*	*	ns
Method of irrigation							
Surface	272.4A	42.49A	15.2A	4.76A	1.12A	0.86A	18.2
Sub-surface at 25 cm.	180.4b	32.47b	15.1A	4.46A	0.97A	0.81A	18.3
Sub-surface at 50 cm.	156 6c	29.12c	14.1b	4.08b	0.96b	0.77b	18.9
F-test	**	*	*	*	*	*	ns
Water sources (S)							
Fresh (control)	270.6A	45.75A	16.67A	4.52 A	1.64 A	0.84 A	18.8 A
Well	185.6c	32.29c	12.4c	4.34c	1.26b	0.78c	18.2b
Drainage	195.8b	31.91c	14.4b	4.48b	1.16b	0.81b	18.1b
Sewage	197.0b	35.26b	16.6 A	4.76 A	1.13b	0.87 A	18.3b
(Sewage: well) 1:1	187.8c	33.99c	13.3c	4.48b	1.02c	0.81b	18.1b
(Sewage :well) 2:1	185.6c	36.74b	14.3b	4.18c	1.01c	0.77c	18.5b
F-test	**	*	**	*	*	*	*
Interaction							
F-Test A:I	*	*	ns	*	ns	*	*
A.S	*	*	ns	ns	ns	*	ns
I.S	*	ns	ns	*	ns	*	ns
A.I.S	*	*	ns	*	ns	ns	ns

The alternative irrigation gave the highest total biomas and protein content. However, the total biomas was decreased with the continuous irrigation by different low quality water sources. Also, the data revealed that the surface irrigation surpassed subsurface irrigation in increasing the total biomas and 100-seed weight. This may be due to the decreasing of salt accumulation in soil and consequently reducing the salinity hazard. These results are similar to that obtained by Oron *et al.* (1990).

It could be observed also from the results that the fresh water gave the highest total biomas, 100-seed weight and protein content followed by sewage water while well water gave the lowest values of these parmeters. This maybe due to the high salt content of drainage water, which raise the salinity of soil solution and consequently increase its osmotic pressure. These results are similar to those obtained by Koriem (1994). The interaction effect between different water sources and irrigation methods was significant on total biomas of soybean. This indicates that each factor is independent.

lmental contents of soybean:

Data in Table (4) show the elemental content in soybean as affected by different treatments. The data revealed that irrigation with sewage, drainage and well water blended or not with sewage water led to accumulation of elements in plant tissues, except K and the accumulation was clear with the microelements.

Table (4): Elemental content of soybean seed as affected by different treatments.

		Water sources	Elements									
			N	k	P	Zn	Fe	Mn	Cu	Pb	Ni	Co
Continuous	Surface	F	11.8	8.7	6.6	18.7	472	22.5	4.2	18.5	4.0	1.7
		S	10.8	9.5	5.5	30.2	695	28.5	7.2	36	6 2	3.5
		D	11.1	6.6	4.4	23.2	553	22.2	4.5	32	5.0	2.7
		W	12.2	8.7	4.5	21.0	511	25.7	4.0	30	4.9	3.0
		S:W 1:1	12.9	11.0	4.6	22.6	600	26.2	6.7	31	5.2	3.1
		S:W 2:1	12.3	10.5	5.5	25.1	620	27.2	7.0	33.3	5.7	3.7
	Sub-surface	F	36	11.1	5.2	43.3	577	45.3	7.8	4.8	3.5	3.8
		S	35	12.8	6.3	42.8	669	56.3	10.0	15.8	4.0	5.0
		D	28	15.4	4.2	48.0	533	58.3	5.5	13.8	5.8	6.3
		W	31.5	12.6	7.5	51.0	515	55.3	8.8	15.3	5.3	5.5
		S:W 1:1	31.8	13.0	6.5	52.0	518	50.0	8.0	15.0	4.5	6.5
		S:W 2:1	32.8	15.4	7.5	51.3	518	55.0	8.3	12.8	5.3	7.3
Alternative	Surface	F	13.6	10.7	4.6	17	270	22	3.7	18	3.9	1.7
		S	12.2	10.5	4.4	27.2	990	28	7.0	35	6.0	3.3
		D	12.9	11.3	3.4	22.5	833	22	4.2	31	4.8	2.5
		W	10.9	7.8	3.2	20.5	715	24	3.7	29	4.7	2.9
		S:W 1:1	11.8	11.7	4.3	20	901	25	6.0	30	5.0	3.0
		S:W 2:1	15.0	14.4	3.5	21.3	920	26	6.5	32	4.5	3.2
	Sub-surface	F	28	11.6	6.0	42.0	577	52.0	6.0	12.6	2.5	2.6
		S	26.9	12.6	5.6	45.2	680	61.0	8.9	14.6	3.0	3.5
		D	24.7	11.3	4.3	51.2	591	50.0	5 5	12.5	3.0	3.0
		W	32.3	10.9	6.2	48.1	59 0	55.0	6.8	15.6	3.0	5.0
		S:W 1:1	31.0	10.1	4.5	42.0	599	51.0	6.0	15.0	3.0	3.0
		S:W 2:1	41.1	12.2	4.5	12.1	601	51.0	7.0	12.0	2.8	3.3

B- Sugarbeet:

The data listed in Table (3) revealed that the growth of sugarbeet plants expressed as total biomas, root weight and sugar yield were significantly increased by the alternative application of water, while sucrose % was not affected. On the other hand, the alternative irrigation surpassed the continuous irrigation in increasing sugarbeet growth. Also, the data showed that surface irrigation was more effective on sugarbeet growth than subsurface irrigation.

Concerning water quality, irrigation by sewage water achieved the highest value of sugar yield while the lowest value was obtained with irrigation by well water. These results may be attributed to that sewage water contain high amounts of nutrients. These results are similar to those obtained by Day *et al.* (1979).

Elemental content of sugarbeet:

The obtained results in Table (5) indicate that water quality marekedly affected the concentration of macro-, micronutrients and heavy metals in sugarbeet roots under surface and subsurface irrigation methods.

Table (5): Elemental content of sugarbeet roots as affected by different treatments.

		Water sources	Elements									
			N	P	K	Zn	Fe	Mn	Cu	Pb	Ni	Co
Continuous	Surface	F	20	1.1	11	36	428	30	2.7	14	2.2	1.3
		S	18	1.2	12	30	433	28	2.6	14	3.2	1.3
		D	21	1.2	13	32	540	34	5.9	21	3.7	2.2
		W	21	1.3	14	32	476	33	4.7	20	3.4	1.7
		S:W 1:1	22	1.4	14	33	468	33	5.3	19	2.9	2.0
		S:W 2:1	22	1.3	13	32	485	23	6.0	19	3.3	2.0
	Sub-surface	F	21	1.1	11	29	453	30	2.8	14	3.0	1.2
		S	18	1.2	12	24	478	27	2.5	13	2.3	1.2
		D	23	1.4	14	31	544	33	8.1	21	2.5	1.6
		W	22	1.2	14	29	438	30	4.3	19	2.8	1.3
		S:W 1:1	21	1.2	14	30	459	32	3.8	18	3.0	1.5
		S:W 2:1	23	1.2	14	29	485	33	4.8	19	2.6	1.3
Alternative	Surface	F	17	1.2	12	30	451	32	2.9	12	3.1	1.3
		S	20	1.4	14	28	523	29	2.8	14	3.2	1.3
		D	21	1.4	18	37	598	33	5.9	18	4.5	1.9
		W	19	1.4	15	33	523	32	3.8	13	3.6	1.6
		S:W 1:1	20	1.3	14	33	519	34	4.3	14	3.9	1.6
		S:W 2:1	20	1.3	15	32	544	33	5.1	15	3.9	1.7
	Sub-surface	F	18	1.1	12	29	468	31	2.8	12	3.0	1.3
		S	18	1.2	13	25	459	28	2.7	14	2.9	1.3
		D	22	1.4	14	34	513	38	4.5	21	4.1	1.7
		W	20	1.2	13	30	438	32	4.3	18	2.3	1.6
		S:W 1:1	20	1.3	14	32	485	33	4.3	19	3.2	1.5
		S:W 2:1	21	1.4	14	30	502	35	4.7	18	3.4	1.7

The concentrations of macro and micronutrients in sugarbeet roots as affected by water sources could be arranged in the following descending order: sewage > sewage: well (2:1) > sewage: well (1:1) > drainage > well water. With regard to the methods of water application, the continuous method tends to increase the contents of elements in sugarbeet roots more than the alternative irrigation.

Also, it could be noticed that surface irrigation increased the accumulation of some elements in sugarbeet roots compared to subirrigation. These finding are agreement with that of Fatma, S. EL-Shafei, and El-Koumey (1994). It is worthy to mention that the concentration of heavy metals in sugarbeet were less than the toxic levels according to Mengel and Kirkby (1977), but the long-term irrigation by the low quality water may lead to a serious problem. Therefore, more efforts are needed on this matter to put a proper management for using low quality water in irrigation.

Soil salinity:

Data listed in Table (6) demonstrat that soil salinity contents after harvesting of each crop were clearly increased under all treatments compared to those obtained before planting. On the contrast, SAR values in soil solution after harvesting were lower than the values recorded before planting. Concerning the irrigation practice, the data showed the superiority of the alternating of low quality water with fresh water since it gave lower values of EC and SAR than those obtained with the continuous use of low quality water for irrigation. Respecting to irrigation methods, the obtained results revealed that the values of ECe and SARe as affected by irrigation methods took the following descending order: subirrigation at 50 cm. depth > surface irrigation > subirrigation at 25 cm. depth. This trend may be attributed to that the amount of irrigation water with subirrigation at 25-cm. depth or with surface irrigation were sufficient to leach salts from soil more than with subirrigation at 50 cm. depth. Finally, it could be observed that the most efficient drainage and aeration of the soil under lysimeter experiment can alleviate the deteriorative effect on soil due to the use of low quality water in irrigation.

Table (6): Mean values of ECe, and SARe of soil as affected by water sources and irrigation methods under buried lysimeter conditions.

Treatments	Soybean		Sugarbeet	
	EC dSm^{-1}	SAR	EC dSm^{-1}	SAR
Fresh (F)	5.32	5.0	3.60	4.83
Drainage water (D)	5.77	6.61	4.45	5.3
Well water (W)	6.28	6.25	4.6	6.23
Sewage water (S)	5.73	5.67	4.93	5.5
S:W (1:1)	5.80	5.93	4.1	5.4
S:W (2:1)	6.26	6.85	4.6	6.0
Surface irrigation	6.03	4.91	4.45	4.89
Sub-irri. at 25 cm.	5.12	4.65	4.3	5.07
Sub-irri. at 50 cm.	6.93	5.18	4.1	4.06
Continuous irri.	6.04	6.01	4.43	5.4
Alternative irri.	5.70	5.92	4.34	5.83
Before planting	3.94	6.63	-	-

Soil elemental content:

Data in Table (7) indicate that irrigation with drainage, sewage, well water increased the soil available NPK, and heavy metals in comparison to fresh water after both two growing season. This increase was pronounced when the soil irrigated with blended water probably due to its high content of these elements. These results were similar to those obtained by El-Wakeel and El-Mowelhi, (1993) who stated that the soil contents of available macro-, micronutrients and heavy metals were increased by using low quality water for irrigation.

Table (7): Soil elemental contents mg/kg^{-1} after soybean and sugarbeet.

		Water sources	Mg/kg^{-1}									
			N	P	K	Zn	Fe	Mn	Cu	Pb	Ni	Co
Continuous	Surface	F	35	2 2	210	5.7	28	14.0	5 5	5.4	1 8	1 1
		S	45	5.7	397	10 5	33	23.0	7.6	4 4	2.9	1.5
		D	45	12.5	494	8 4	33	24.0	9 3	5 8	4.4	2.4
		W	50	9.1	426	11.4	34	21 0	7.6	2.9	2.5	1 3
		S:W 1:1	38	5.0	330	10.0	39	23.0	9.9	5.3	3.0	0.85
		S:W 2:1	35	9.1	431	8 6	37	28.0	6 7	4 2	2.6	0 98
	Sub-surface	F	29	8.0	220	6.0	26.1	18 1	3.5	3.3	1.0	0 21
		S	38	8.2	290	5 5	33 1	21.6	5.0	4.5	2 0	0.28
		D	42	9.5	320	8.0	31.2	20 2	4.5	4.5	2.0	0 31
		W	40	9.0	310	6.1	32.1	22.0	5 1	4.0	2 0	0.32
		S:W 1:1	39	9 0	300	5 5	32.0	20.1	5.0	5.5	2 5	0.31
		S:W 2:1	40	9.2	350	4.5	29.0	22.1	6.0	5.0	1.8	0.30
Alternative	Surface	F	35	2.9	210	9.9	25 0	15.0	5.6	4.7	3 4	0 73
		S	40	6.5	415	9 6	33 0	25.0	6.0	4 0	3.2	0.21
		D	36	3.4	244	13 5	32 0	26 0	9 1	3.7	2 9	0.84
		W	38	4.9	205	12.0	40.0	19.0	6 0	4.5	4 1	0.7
		S:W 1:1	45	4.1	111	15.0	35.0	25.0	6.0	5.8	5 2	0 73
		S:W 2:1	38	7 4	241	13.5	36 0	24.0	6 0	3.9	3.7	0.33
	Sub-surface	F	28.5	8.0	218	6.0	26.1	18.1	3.3	3.5	0 9	0 2
		S	36	7.9	280	5.0	33.0	21.6	5 0	3.6	2.0	0 23
		D	39	9.0	315	7.5	31.2	20.2	4.0	4.2	2.1	0 2
		W	36	8 3	302	5.6	32.1	22.0	5 0	4 5	2.3	0 3
		S:W 1:1	39	8 5	290	4.0	32.0	19.3	5 0	5.0	2.1	0 27
		S:W 2:1	39.5	5.6	291	4 0	29 0	19 2	5 0	5 0	2 0	0 26

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تاثير ممارسات الرى و نوعية المياه على محاصيل فول الصويـــاوبنجر الســكر و على التربة تحت ظروف ليزومترات (الليسيمترات).

رمضان عبد الحميد صابر
معهد بحوث الأراضي و المياه و البيئة-مركز البحوث الزراعية

أقيمت تجارب (ليسيمترات) بمحطة البحوث الزراعية بسخا فى الموسم الصيفـــى عــام ٢٠٠٠ و الموسم الشتوى عام ٢٠٠٠/٢٠٠١ لدراسة تأثير الرى المستمر و التبـــادلى بالميـــاه منخفضة الجودة تحت نظامين من الرى و هو الرى السطحى و الرى تحت السطحى المثبت علـــى أعماق ٢٥ ، ٥٠ سم على محصول فول الصويا و بنجر السكر و مكوناتهم و المحتوى العنصـــرى في النبات و ملوحة التربة و المحتوى العنصرى فى التربة.

و تشير البيانات أن الرى التبادلى بهذه النوعية مع المياه مع الماء العذب أدت إلى تحقيـــق أعلـــى محصول لفول الصويا و بنجر السكر ، بينما الرى المستمر بهذه النوعية من المياه أدي إلى نقــص معنوى فى كلا المحصولين،

أيضا تفوق الرى السطحى على الرى تحت سطحى فى زيادة المحصول الكلـــى لفــول الصويا و بنجر السكر.

كما أوضحت الدراسة أن الرى بهذه النوعية من المياه مباشرة أو تبادلها أو خلطها قـــد زاد المحتوى العنصرى لكلا المحصولين إلا أن هذه التركيزات كانت تقع فى نطاق الحدود المقبولة ولا يوجد خطورة من سمية هذه العناصر.

كما أوضحت الدراسة ارتفاع قيمة ملوحة التربة EC و نســبة ادمصـــاص الصوديــوم SAR بالتربة كنتيجة لاستخدام مياه الصرف الزراعى و مياه الصرف الصحى و ميـــاه الآبـــار و الماء المخلوط لرى المحاصيل.

ازداد محتوى التربة من العناصر الغذائية الكبرى و الصغرى و الثقيلة نتيجة لاســـتخدام هذه النوعية من المياه.