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POSSIBILITY OF REUSING THE AGRICULTURAL DRAINAGE WATER AND ITS EFFECT ON GROWTH AND FRUITING OF BALADY LIME TREES

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ABSTRACT

This study was conducted during 2002 and 2003 seasons to evaluate the possibility of reusing the agricultural drainage water for irrigation and to examine the effect of the use of this water on growth, nutrient content, yield and fruit quality of Balady lime trees. The trees were irrigated twentyone times through each season with five water quality treatments namely River Nile water, agricultural drainage water, as well as diluted drainage water at proportions (75 : 25 %), (50: 50%), and (25 : 75%) from drainage water to Nile water.

Results revealed that irrigation with either full or diluted drainage water resulted in a reduction of shoot length, leaf area, percentages of N, P and K in the leaves, yield, fruit weight and dimensions, total soluble solids %, total acidity % and ascorbic acid content while causing an increase in the percentages of Na and Cl in the leaves. Fruit peel thickness did not change with the present treatments. The effect of water quality on the studied parameters was remarkable due to the irrigation with drainage water or with diluted drainage water at 75 % drainage water: 25 % Nile water, while it was less remarkable due to the irrigation with the other diluted drainage waters.

These results suggest that the diluted drainage water; at the ratio of 50% drainage water : 50% River Nile water can safely be used

for irrigation of Balady lime trees grown in silty clay soil without any harmful effects on growth, yield and fruit quality. Concerning the EC, the favorable and safe concentration of irrigating water EC is up to 1300 ppm, so, mixing by 75% from agricultural drainage water leads to a mean of 1248 ppm E. C, according to Table(3). Moreover, mixing by 50% agricultural drainage water leads to a mean EC 966 ppm during 2003 season, that means safe concentration gradients from 2:1 ; 1:1 in the allowance level from irrigated water at Balady lime trees (Aljubri, 1996).

Key words: *e.c electrical-conductivity , drainage water. reuse.*

1.INTRODUCTION

Egypt lies in the arid region of the world. Egypt's share of the River Nile is fixed according to the international agreements at 55.5 billion m^3/year. Egypt's water supply, although sufficient now, will be in deficit in the near future at the presently planned rate of growth for agriculture, industry and urban consumption (El-Quosy, 1989).

The reuse of the agricultural drainage water for irrigation is one of the possibilities for the expansion of the agricultural land in Egypt because it is the most promising, fast and economic means of increasing the water budget of Egypt and improving the efficiency of water use and most important for the possibility of disposing of a major part of the water that would otherwise cause environmental pollution (Morsy, 2000). Blending or diluting the poorer with the better quality water is especially effective for preventing sodium toxicity and many of the secondary problems caused by short term usage of high SAR waters such as surface crusting and sealing (Ayers and Westcot, 1985).

The factors affecting growth and yield of citrus trees are water salinity and composition of the irrigation water. The adverse effects of salinity on citrus trees include the reduction in growth aspects and production (Waldron, 1984; Nijjar, 1985: Biclorai *et al.*1988; Dasberg *et al.*, 1989, Cedra *et al.* 1990; Alva and Syvertsem, 1991; Levy *et al*, 1994; El-Hammady *et al*, 1995; Aljuburi, 1996; El-Desouky and Atawia, 1998, Levy *et al.* 1999 and Morinaga and Sykes , 2001).

The present study was carried out to evaluate the possibility of reusing the agricultural drainage water either alone or diluted with the River Nile water in different proportions for irrigation of Balady lime trees grown in silty clay soil. The effect of the reused agricultural drainage water on growth, nutritional status of the trees, yield and fruit quality was also studied.

2. MATERIALS AND METHODS

This experiment was conducted during 2002 and 2003 seasons on forty-five 12-year old nucellar Balady lime trees grown in a private orchard located at Beni Suef district, Beni Suef Governorate. Tree spacing was 5 x 5 m. The soil of the experimental orchard is well drained silty clay with a water table not less than two meters deep. Physical and chemical analyses of the tested soil at 0.0 – 90.0 cm depth were tested according to Black (1965) and the obtained data are shown in Table (1).

Table (1): Some physical and chemical properties of the tested soil .

Sand	:9.0
Silt	:34.1
Clay	:47.9
Texture grade	:Silty day
pH(1: 2.5)	:8.00
EC (ds/m)	:0.60
O.M. %	:1.00
$CaCO_3$ %	:2.29
Total N %	:0.055
Available P (mg/kg)	:3.2
Available K (meq/kg)	:0.49

2.1.Irrigation water quality treatments

El-Mohcat drain at Beni Suef City was the source of agriculture drainage water in both growing seasons. Three diluted waters were prepared by mixing the drainage water with River Nile water in different proportions. The water quality treatments used for irrigation of Balady lime trees during 2002 and 2003 seasons are described in Table (2).

Before each irrigation (21 irrigations), a water sample from each of the water quality treatments was collected in a clean and dried

Table (2) : Water quality treatments used for irrigation of the Balady lime trees during 2002 and 2003 seasons.

Water quality treatments	Description
Drainage water	100 % agricultural drainage water
Diluted drainage water	75% Agricultural drainage water + 25% River Nile
Diluted drainage water	50% Agricultural drainage + 50 % River Nile water
Diluted drainage water	25% Agricultural drainage + 75 % River Nile water
Nile water	100 % River Nile water

plastic bottle. The water samples were analyzed for electrical conductivity (ds/m) (Table 3). The change of E. C from 2002 with increasing salinity compared with 2003 seasons, was due to two main reasons; high temperature in this year that led to increasing in the vaporization rate from drainage water which helped to concentrate the salts gradually and increase their percentage, and leaching water of reclaimed land which affects the valley land by increasing their contents of salt.

The selected trees received the same amount of N (4.0 kg ammonium sulphate / tree), K (625.0 g potassium sulphate / tree) and P (625.0 g calcium super phosphate, 15.5 P_2O_5). Irrigation with the five water quality treatments was carried out to keep the soil moisture content at the field capacity. Number of irrigations was twenty- one in both growing seasons. Horticultural practices such as hoeing as well as pest and fungi control were done as usual. In both seasons, four one year old branches were chosen on each tree, one toward each direction. Four shoots from the current spring shoots were labeled for measuring shoot length (cm.) and leaf area (cm^2), (late May) (according to Ahmed and Morsy, 1999).

Twenty mature leaves (7 month old) were picked at random from fruiting shoots in the spring growth cycle per each tree (1st week of September). The leaves were oven dried at 70°C and analyzed for their content of N, P, K, Na and Cl (on dry weight basis) using the standard procedures outlined by Wilde *et al.*, (1985).

Fruits were harvested at periods from the last week of July till the mid of October and cumulative yield expressed in weight (kg.) was recorded.

Fifty fruits were taken randomly at the commercial harvesting date for determinations of fruit weight (g.) and dimensions (diameter and height cm.), fruit peel thickness (cm.), percentage of total soluble

solids, percentage of total acidity (expressed as, g citric acid / 100 ml juice) (A.O.A.C., 1985) and ascorbic acid content (as g / 100 ml juice) using 2.6 dichlorophenol endophenol dye (A.O.A.C., 1985).

All obtained data were statistically analysed according to Mead *et al.* (1993) using new L.S.D parameter at 5% for comparing the significant differences among various levels of water quality treatments.

3.RESULTS AND DISCUSSION

3.1.Water quality parameters

Overall, the agriculture drainage water is having a quality that is less than that of the Nile water, as the electrical conductivity value of the drainage water was about 4-5 folds those of the River Nile water. Regarding the seasonal variations in EC of water quality, it is obvious that values were gradually increased during summer months. Regarding the salinity problems, the River Nile water and drainage water diluted up to 50 : 50 % in all dates of irrigation had an electrical conductivity value in the category of non-hazard (< 1.5 ds/m) (according to Chapman, 1968). This is indicated that a salinity problem would not occur, however, the drainage water and diluted drainage water (75 %: 25 %) had an electrical conductivity value in the category of slight to moderate (1.5 to 2.3 ds/m) suggesting that an increasing salinity problem would result from using them. According to Chapman (1968), in the case of citrus, the total salt, level of about 2.3 ds/m in the irrigation water are the upper safe limits under most conditions.

3.2. Effect of water quality on growth characters

Data illustrated in Table (4) clearly show that Balady lime trees irrigated with the Nile water had the highest shoot length and leaf area, while those irrigated with the agricultural drainage water had the lowest values compared to irrigations with the Nile water. Irrigation with either the drainage water or the diluted waters resulted in a reduction in the two growth characters. The decrease in growth parameters was remarkable due to irrigation with the drainage water and irrigation with diluted drainage water at 75% drainage water: 25 % Nile water. Insignificant reduction in shoot length and leaf area was

Table (3): Electrical conductivity (EC, ds/m) of the water quality treatments in the various irrigations of Balady lime trees during 2002 and 2003 seasons.

Water quality treatments	2002																				
	EC (ds/m) in water before irrigation																				
	1	15	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
	Mar.	Ma.	Mar.	Apr.	Apr.	Apr.	May	May	May	June	June	June	July	July	July	Aug.	Aug.	Aug.	Sept.	Sept.	Sept
Drainage water	1.60	1.71	1.62	1.72	1.75	1.77	1.79	1 82	1.90	1.90	1.95	1.99	1.99	2.01	2.02	2.12	2.13	2.13	2.00	2.00	1.46
Diluted drainage water (75 %: 25%)	1.20	1.32	1.33	1.35	1.35	1.36	1.40	1.44	1.46	1.50	1.55	1.56	1.58	1.62	1.63	1.63	1.70	1.70	1.60	1.55	1.56
Diluted drainage water (50 %: 50%)	0.96	1.05	1.07	1.09	1.10	1.10	1.12	1.15	1.16	1.20	1.25	1.25	1.28	1.30	1.36	1.40	1.41	1.40	1.30	1.28	1.27
Diluted drainage water (25 %: 75%)	0.61	0.71	0.73	0.75	0.77	0.08	0.81	0 81	0.82	0.84	0.91	0 92	0.94	0.45	0.97	0.98	1.00	1.00	0.97	0.96	0.94
Nile water (0.0 : 100)	0 36	0.40	0.40	0.41	0.41	0.42	0.42	0.42	0.42	0.43	0.43	0.43	1.44	0.44	0.43	0.43	0.42	0.41	0.40	0.39	0.38
	2003																				
Drainage water	2.27	2.28	2.28	2.28	2.30	2.30	2.31	2.31	2.31	2.53	2.39	2.40	2.41	2.42	2.47	1.48	2.50	2.40	2.36	2.35	2.30
Diluted drainage water (75 %: 25%)	1.78	1.80	1.81	1.82	1.82	1 83	1.87	1.90	1.90	1.94	1.96	1.98	2.00	2.05	2.06	2.10	2.10	2.10	2.05	2.01	2.00
Diluted drainage water (50 %: 50%)	1.35	1.36	1.36	1.37	1.38	1 40	1.41	1.42	1.44	1.49	1.50	1 55	1.55	1.57	1.66	1.70	1.71	1.72	1.60	1.60	1.56
Diluted drainage water (25 %: 75%)	0.84	0.85	0.85	0.86	0.87	0.88	0.90	0.41	0.42	0.94	0.95	0.96	1.01	1.11	1.15	1..6	1.20	1.22	1.20	1.17	1.15
Nile water (0.0 : 100)	0.40	0.40	0.40	0.41	0.41	0.41	0.42	0 42	0.43	0.43	0.34	0.43	0.44	0.45	0.45	0.45	0.45	0.45	0.40	0.40	0.40

obtained with using diluted drainage water containing 25-50% drainage water +75 to50% Nile water compared to irrigation with 100% Nile water. Generally, the above trends were noticed in 2002 and 2003 seasons.

These results are in agreement with those obtained by Waldron (1984); El-Desouky and Atawia (1998), Levy *et al.*, (1999) and Morinaga and Sykes (2001).

3.3. Effect of water quality on nutrient concentrations

It is clear from the data in Table (4) that the percentages of N, P and K in the leaves greatly varied among the five water quality treatments. Balady lime trees irrigated with River Nile water contained the highest percentages of N, P and K , while the trees irrigated with the concentrated drainage water contained the minimum values. Compared to irrigation with the Nile water, irrigation with either the drainage water or with the diluted drainage water at various proportions caused a higher reduction in the percentages of N, P and K in the leaves. Irrigation of the trees with water containing 75 % drainage water + 25 % Nile water as well as with concentrated drainage water significantly decreased percentages of N, P and K compared to irrigation with Nile water and other diluted drainage waters. Irrigation with water containing 25% to 50% agricultural drainage water had a slight reduction in these essential macronutrients compared to irrigation with Nile water. These trends were observed in both seasons. Similar results were obtained by Dasberg *et al.* (1989), Cedra *et al.*(1990) , Alva and Syvertsen (1991) and Levy *et al.* (1994).

3.4. Effect of water quality on sodium and chloride in the leaves

Data presented in Table (5) indicate that Balady lime trees irrigated with concentrated drainage water contained the highest percentage of sodium and chloride, followed by diluted drainage water at 75 % drainage water + 25 % Nile water and therefore, they could be considered as more susceptible to irrigation than the trees irrigated with either the Nile water or the diluted drainage water at 25-50 drainage water + 75- 50% Nile water. On the contrary, Balady lime trees irrigated with the Nile water contained the lowest concentration of sodium and chloride.The same trends were noticed in both seasons.

These results are in harmony with those obtained by El-

Hammady *et al.* (1995); Aljuburi (1996); El-Desouky and Atawia (1998) and Morinaga and Sykes (2001).

3.5. Effect of water quality on the yield

It is apparent from the data in Table (5) that irrigation with concentrated drainage water containing 75 % or completely drainage water significantly reduced the yield compared to irrigation with Nile water or diluted drainage water containing 50 to 75 % Nile water. The reduction on the yield of Balady lime trees was associated with increasing the percentages of agricultural drainage water in the irrigation water. Insignificant reduction in the yield was observed due to raising the percentages of agricultural water in the irrigation water from 25 to 50 %. The maximum yield was recorded in the trees irrigated with Nile water, however no significant reduction was observed between this treatment and the treatments including the irrigation with water containing 25-50 % agricultural drainage water. Therefore, from an economic point of view it is possible to use a diluted drainage water at a proportion of 50% drainage water: 50 % Nile water for irrigation of Balady lime trees for gaining an economical yield. Under such treatment, yield reached 81.0 and 80.5 kg / tree in both seasons, respectively. The minimum yields i.e. 70.0 and 68.0 kg in both seasons, respectively were recorded in the trees irrigated completely with agricultural drainage water . These results were the same in both seasons. These results are in agreement with those obtained by Bielorai *et al.* (1988); Dasberg, *et al.* (1989), Cerda *et al.* (1990); El-Hammady *et al.* (1995) and Morinaga and Sykes (2001).

3.6. Effect of water quality on fruit quality

Data in Tables (5 & 6) show that irrigation of Balady lime trees with agricultural drainage water or with diluted drainage water at 75 % drainage water + 25% Nile water gave significantly unacceptable quality of fruits compared to irrigation with Nile water or diluted drainage water at 25-50 % drainage water + 75- 50 % Nile water. Irrigation with Nile water gave the best results with regard to fruit quality in terms of increasing fruit weight and dimensions, total soluble solids, total acidity, and ascorbic acid content and in decreasing fruit peel thickness.

Table (4): Effect of irrigation water quality on some growth characters and percentages of N, P and K in the leaves of Balady lime trees during 2002 and 2003 seasons.

Water quality treatments (drainage water: Nile water)	Shoot length (cm.)		Leaf area (cm^2)		Leaf N %		Leaf P %		Leaf K %	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Drainage water	8.2	8.3	14.1	15.3	2.20	2.10	0.18	0.16	1.41	1.39
Diluted drainage water(75% : 25%)	9.0	9.1	15.0	16.2	2.31	2.20	0.22	0.20	1.60	1.52
Diluted drainage water(50% : 50%)	10.4	9.7	16.8	17.3	2.51	2.35	0.29	0.26	1.80	1.77
Diluted drainage water(25% : 75%)	10.5	9.8	17.0	17.5	2.52	2.36	0.30	0.27	1.81	1.78
Nile water (0.0% + 100%)	10.9	10.0	17.2	17.6	2.55	2.39	0.31	0.28	1.82	1.80
New L.S. D. at 5 %	0.6	0.4	0.8	0.6	0.09	0.08	0.04	0.03	0.11	0.12

Table (5): Effect of irrigation water quality on percentages of Na and Cl in the leaves, yield per tree as well as weight and diameter of fruits of Balady lime trees during 2002 and 2003 seasons.

Water quality treatments Drainage water: Nile water	Leaf Na		Leaf Cl		Yield / tree (kg.)		Fruit weight (g.)		Fruit diameter (cm.)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Drainage water	0.086	0.090	0.038	0.044	70.0	68.0	20.0	19.6	3.21	3.20
Diluted drainage water(75% : 25%)	0.055	0.065	0.030	0.039	76.0	74.0	22.0	21.3	3.41	3.30
Diluted drainage water(50% : 50%)	0.042	0.053	0.025	0.024	81.0	80.0	25.0	25.1	3.64	3.47
Diluted drainage water(25% : 75%)	0.041	0.052	0.024	0.023	81.0	81.0	25.2	25.3	3.65	3.48
Nile water (0.0 % + 100%)	0.040	0.051	0.023	0.022	81.0	82.0	25.8	25.6	3.66	3.51
New L.S. D. at 5 %	0.005	0.006	0.003	0.004	3.1	2.9	0.8	0.9	0.05	0.05

Table (6): Effect of irrigation water quality on some physical and chemical quality parameters of Balady lime fruits during 2002 and 2003 seasons.

Water quality treatments Drainage water: Nile water	Fruit height (cm.)		Peel thickness (cm.		T.S.S. %		Total acidity %		Ascorbic acid content	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Drainage water	3.60	3.55	0.167	0.178	8.20	8.35	7.62	7.73	22.2	22.0
Diluted drainage water(75% : 25%)	3.71	3.70	0.169	0.178	8.35	8.45	7.77	7.86	25.0	24.1
Diluted drainage water(50% : 50%)	3.88	3.85	0.170	0.178	8.47	8.57	7.88	7.79	28.7	26.3
Diluted drainage water(25% : 75%)	3.92	3.87	0.170	0.180	8.48	8.58	7.89	7.98	29.0	27.0
Nile water (0.0 % + 100%)	3.96	3.90	0.171	0.181	8.51	8.60	7.91	8.00	29.3	27.3
New L.S. D. at 5 %	0.09	0.08	N.S	N.S	0.09	0.08	0.11	0.10	2.1	2.0

Increasing percentages of agricultural drainage water applied with River Nile water from 25 to 50% had a slight adverse effect on fruit quality. However, adverse effects on fruit quality were recorded as the percentages of agricultural drainage water in the irrigation water were higher than 50 %. Irrigation of Balady lime trees with water containing 50 % of agricultural drainage water gave satisfactory promotion on the physical and chemical fruit quality. Similar results were recorded in both seasons. These results are in agreement with those obtained by El-Desouky and Atawia (1998); Levy *et al.* (1999) and Morinaga and Sykes (2001).

The previous adverse effects of salinity on growth, nutrient concentrations and fruiting of Balady lime trees might be due to its retarding effect on cell division and cell elongation, interrupting the activity of meristematic tissues, disturbing normal stomatal opening and closure, reducing photosynthesis and translocation of assimilates and uptake of nutrients, disturbing chloroplast structure, lowering the translocation of water from roots to vegetative organs and reducing xylem tissues and number of xylem and vessels in xylem (Foth, 1980 and Nijjar, 1985).

Results of this study suggest that the diluted agricultural drainage water at the ratio of 50 % drainage water + 50 % Nile water can safely be used for irrigation of Balady lime trees grown in silty clay soil without harmful effects on growth, nutritional status of the trees, yield and fruit quality under the conditions of Beni Suef Governorate.

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إمكانية إعادة استخدام مياه الصرف الزراعى وتأثيرها على نمو واثمار أشجار الليمون البلدى

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ملخص

أجريت هذه التجربة أثناء موسمى ٢٠٠٢ ، ٢٠٠٣ لتقييم إمكانية إعادة استخدام مياه الصرف الزراعى للرى و ذلك من مصرف المحيط الذى يخدم أراضي محافظة بني سويف بالوادى والأراضى الجديدة. وكذلك لدراسة تأثير مياه الصرف الزراعى المعاد استخدامها على النمو، المحتوى العنصرى للأوراق، المحصول وخصائص الجودة لثمار أشجار الليمون البلدى.

وقد تم رى الأشجار واحد وعشرين مرة فى الموسم بخمسة معاملات لنوعية مياه الرى الكامل وهى : مياه نهر النيل ، مياه الصرف الزراعى بالكامل، مياه الصرف الزراعى المخففة بنسبة ٧٥% مياه صرف : ٢٥% مياه نهر النيل، مياه الصرف الزراعى المخففة بنسبة ٥٠% مياه صرف زراعى : ٥٠ % مياه نهر النيل، مياه الصرف الزراعى المخففة بنسبة ٢٥% صرف زراعى : ٧٥% مياه نهر النيل.

وحيث أن التركيز الآمن للاملاح فى ماء الرى لا يتجاوز ١٥٠٠ جزء في المليون لليمون البلدي فأنه عند نسبة الخلط ١:٢ (ماء صرف : ماء نيل) كان متوسط تركيز الأملاح الكلية على مدار العام ٢٠٠٣م هو ١٢٤٨ جزء في المليون. بينما عند الخلط بنسبة ١:١ (صرف زراعى : ماء نيل) خلال نفس العام كان ٩٦٦ جزء في المليون نظرا لزيادة تركيز الأملاح الكلية بسبب أرتفاع الحرارة و غسل أراضى الاستصلاح التى تصب في نفس المصرف.

أظهرت النتائج المتحصل عليها فى هذه الدراسة أن الرى سواء بمياه الصرف الزراعى أو بالمياه المخففة منه أدى الى نقص فى طول النموات، مساحة الورقة، محتوى الورقة من النيتروجين والفوسفور والبوتاسيوم ، المحصول، وزن الثمرة وأبعادها، النسبة المئوية للمواد الصلبة الذائبة الكلية ، النسبة المئوية للحموضة الكلية، محتوى الثمار، من فيتامين ج كما وأدى الى زيادة النسبة المئوية للصوديوم والكلوريد فى الورقة ولم يتغير سمك قشرة الثمرة بجميع المعاملات تحت الدراسة .

كان تأثير نوعية المياه على الصفات تحت الدراسة ملحوظا نتيجة الرى بمياه الصرف الزراعى الخالصة حيث وصل متوسط تركيز الأملاح الكلية خلال عام ٢٠٠٣ / ١٤٨٥ جزء في المليون و هو الحد الحرج، أو ماء الصرف الزراعى المخفف بنسبة ٧٥% مياه صرف زراعى الى ٢٥% مياه نهر النيل بينما كان التأثير غير ملحوظ نتيجة الرى بالمياه المخففة بالنسب الأخرى.

ويتضح من هذه النتائج إمكانية استخدام مياه الصرف الزراعى المخلوطة بنسبة١:٢أو ١:١ مياه صرف زراعى الى مياه نهر النيل تدرجا في التركيز تنازليا لحد الأمان لرى أشجار الليمون البلدى النامية فى تربة طينية سلتية بدون اية تأثيرات ضارة على النمو والمحصول وجودة الثمار.
