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EFFECT OF SURFACE IRRIGATION METHODS AND LAND LEVELING ON SALT DISTRIBUTION AND MOISTURE UPTAKE BY COTTON PLANT IN SALT AFFECTED SOILS AT NORTH DELTA

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ABSTRACT

Two field trials were conduced at Sakha Agricultural Research Station during the two successive growing seasons 2004 and 2005 to study the impact of three methods of surface irrigation which are: 1- Short Furrows, 2. Long furrows and 3. Border irrigation, and three land leveling practices were used as, traditional land leveling, dead level (precision leveling) and ground surface slope of 10 cm/100 m (0.1%) on salt distribution patterns and moisture extraction under Egyptian cotton variety Giza 86. The experimental design which used in this study was split-plot with four replicates, where the main plots were assigned to surface irrigation methods and the sub plot were devoted to land leveling methods.

Results revealed that, the salt concentration in soil after fifth irrigation was decreased by 17.79, 15.22 and 12.76% under border, long furrows and short furrows. While the decrease in salt concentration after harvesting of cotton were 20.17, 20.12 and 13.71% under border, long furrows and short furrows irrigation. Furthermore, the salt content under 0.1% ground surface slope was decreased as compared to dead level and traditional land leveling. At the same time, more than 70% of water absorbed by cotton roots was obtained from the upper 30 cm soil layer, while less than 30% was extracted from the lower soil layer (30-60 cm).

INTRODUCTION

Management of irrigation water and improving soil productivity in Egypt became necessary in order to face water shortage as well as increasing population.

Irrigation is generally defined as the application of water to soil for the purpose of supplying the essential moisture for plant growth.

The salt content under furrow irrigation system generally increased by increasing distance from the furrow and with the depth, the giving a decrease in salt content with 25.45% of the amount before irrigation. This indicates the effect of applied water in leaching soluble salts deep down the soil profile (Abd El-Razek *et al.,* 1992). It has been noticed that 0.1% ground surface slope treatment achieved the highest production and received less amount of water delivered to the crops. The highest values of both water use and water utilization efficiencies, the highest values of application efficiency and the highest of leaching efficiency of salts, were achieved under 0.1% slope, while the traditional methods recorded the lowest one and used the highest values of irrigation water (El-Mowelhi *et al.,* 1995). Precision land leveling as well was efficient drainage system is the most important factor in soil and water management effect on rate and uniformity of salt leaching (Abo Soliman *et al.,* 1996). The precision land leveling using LASER scraper leached considerable amount of soluble salts from salt affected soil in North Delta compared to traditional leveling (El-Mowelhi *et al.,* 1999). The soil salinity increased by increasing soil depth after irrigation but before the next irrigation, the soil salinity decreased by increasing depth under furrow irrigation system (Helmy *et al.,* 2000). The highest percentage of the moisture uptake by cotton plant roots is occurred in the soil surface 15 cm depth, it ranges between 43.49 and 45.06%. While the less water is extracted from the successive depths (Meleha, 2000). The highest uptake of water by cotton plants was occurred with irrigation of all furrows under precision land leveling for both seasons, while the lowest uptake of water was obtained with alternative furrow irrigation under traditional land leveling (El-Shahawy, 2004).

MATERIALS AND METHODS

Two field experiments were conduced at Sakha Agricultural Research Station during 2004 and 2005 summer seasons using Egyptian cotton (*Gossypium barnadense* L.), variety Giza 86).

The soils of two experimental sites were clayey in texture and saline. Some chemical and hydrological parameters of soils are shown in Table (1). Mechanical analysis was carried out using the pipette method (Dewis and Fertias 1970). Bulk density was determined by using paraffin wax method (Dewis and Fertias, 1970). Soil reaction (pH) was measured in (1: 2.5 soil suspension) using combined electrode pH meter as mentioned by (Richards 1954). Soil salinity was determined by measuring the electrical conductivity in the extract of saturated soil paste in dSm^{-1} as explained by (Jackson (1967). The amounts of water soluble cations (Ca^{++}, M^{g++}, Na^{+} and K^{+}) and anions (CO^{-}_{3}, HCO^{-}_{3}, Cl^{-} and $SO^{=}_{4}$) were determined in the extract of saturated soil paste by the methods described by (Hessse 1971). Field capacity and permanent wilting point were calculated from the soil moisture characteristic curve (PF) according to (Black, 1965) and available water value is the difference between field capacity and permanent wilting point.

The experimental design was split plot with four replicates. The main plots were devoted to three surface irrigation methods. Which are 1- Short furrows irrigation (SF) , 2- Long furrows irrigation (LF) and 3- border irrigation, (B) where the sub plots were assigned to the three land leveling methods; traditional, dead leveling (D) (precision land leveling) and ground surface slope of 10 cms/100 m (0.1% slope) (S).

Parameters studied:

1. Salt distribution patterns in clay soils:

Soil samples from three soil profiles were collected before planting, after fifth irrigation and after harvesting for each treatment at four depths namely (0-20), (20-40), (40-60) and (60-80 cm) along the strip and the distance between profiles 10, 40 and 70 m, to study the salinity distribution through soil profile at different depths along the strip.

Table (1): Soil chemical and physical properties of the experimental site.

Depth cm		pH (1: 2.5)	ECe mmhos cm^{-1} at 25°C	Particle size distribution			Texture class	SAR	ESP	F.C. %	P.W.P. %	Av. water	Bulk density g/cm^3
				Sand %	Silt %	Clay %							
0-20	First season	7.47	6.02	16.44	24.87	58.69	Clayey	10.32	12.25	41.75	20.25	21.50	1.18
20-40		7.85	5.02	17.55	26.75	55.70	Clayey	10.23	12.15	39.47	19.10	20.37	1.21
40-60		8.04	3.96	17.31	23.5	59.19	Clayey	10.6	12.52	37.82	18.62	19.20	1.26
60-80		806	3.83	1705	27.62	55.33	Clayey	9.8	11.65	36.15	17.54	18.61	1.31
Mean		7.86	4.70	17.10	25.68	57.22	Clayey	10.24	12.16	38.79	18.87	19.92	1.24
0-20	Second season	7.78	6.75	15.86	26.46	57.68	Clayey	11.19	13.22	42.1	21.63	20.98	1.15
20-40		7.87	5.68	18.94	25.16	55.90	Clayey	10.93	12.94	40.15	20.51	19.64	1.19
40-60		7.84	4.85	17.52	24.25	58.23	Clayey	10.34	12.22	38.75	20.25	18.5	1.23
60-80		7.97	4.37	15.65	28.17	56.18	Clayey	10.59	12.51	37.50	18.91	18.59	1.26
Mean		7.85	5.41	17.01	26.01	56.98	Clayey	10.74	12.72	39.75	20.32	19.43	1.20

Soil moisture content:

Soil moisture percentage was determined gravemetrically at three selected sites 10, 40 and 70 m along the furrow, before irrigation and 2 days after each irrigation and immediately before harvesting. Soil samples were taken with help of auger from the successive soil layers (0-15), (15-30), (30-45) and (45-60) cms depth.

Soil moisture extraction patterns:

Soil moisture extraction patterns were calculated as follows:

$$\text{S.M.E.P.} = \frac{\text{SME layer}}{\text{Total SME (seasonal)}}$$

Where:

SME layer = Season soil moisture extracted water for specific layer.

SME (seasonal) = seasonal soil moisture extracted for the whole profiles and calculated according to (Israelsen and Hansen, 1962).

Measurement of water table depth:

Water table level fluctuation during both growing seasons was monitored by using 18 observation wells that were installed along different treatments. Each observation well was 2.5 meter length and 5 cm diameter. A metallic sounds fixed in a sealed tapes was used to measure the depth of water table Tables (2 and 3).

Table (2): Average water table level (cm) for the whole season 2004 of cotton crop at different sites along the furrow under different treatments.

Irrigation methods treatments	Land leveling	Site (1) at 30 m from furrow inlet			Δ	Site (2) at 50 m from furrow inlet			Δ
		B	A	Mean		B	A	Mean	
Short furrows	T	104	79	91.50	25	105	86	95.5	19
	D	112	85	98.50	27	117	92	104.5	25
	S	125	98	111.50	27	127	105	116	22
Mean		113.67	87.33	100.50	26.34	116.33	94.33	105.33	22
Long furrows	T	100	77	88.5	23	98	80	89	18
	D	106	80	93.0	26	113	91	102	22
	S	123	95	109	28	125	100	112.5	25
Mean		109.67	84	96.84	25.67	112	90.33	101.16	21.67
Border	T	98	75	86.5	23	95	73	84	22
	D	102	83	92.5	19	109	89	99	20
	S	118	90	104	28	120	96	108	24
Mean		106	82.67	94.33	23.33	108	86	97	22

Δ : Fluctuation range **B: Before irrigation** **A: After irrigation**

Table (3): Average water table level (cm) for the whole season 2005 of cotton crop at different sites along the furrow under different treatments.

Irrigation methods treatments	Land levelling	Site (1) at 30 m from furrow inlet			Δ	Site (2) at 50 m from furrow inlet			Δ
		B	A	Mean		B	A	Mean	
Short furrows	T	102	79	90.5	23	104	80	92	24
	D	116	89	102.5	27	119	91	105	28
	S	129	98	113.5	31	133	101	117	32
Mean		115.67	88.67	102.17	27	118.67	90.67	104.67	28
Long furrows	T	99	75	87	24	101	76	88.5	25
	D	110	84	97	26	113	87	100	26
	S	127	96	11.5	31	130	99	114.5	31
Mean		112	85	98.5	27	114.47	87.33	101	22
Border	T	95	74	84.5	21	97	75	86	22
	D	106	80	93.0	26	109	82	95.5	27
	S	122	93	107.5	29	126	96	111	30
Mean		107.67	83.33	95.0	24.34	110.67	84.33	97.5	26.34

B: Before irrigation **A: After irrigation** **Δ : Fluctuation range**

RESULTS AND DISCUSSION

Effect of surface irrigation methods and land leveling practices on:

1. Salt distribution in soil:

Data presented in Table (4) and Figs. (1-6) clearly show that under all methods of surface irrigation, ECe values were decreased comparing to those obtained before planting. The ECe values after the fifth irrigation were 4.67, 4.78 and 4.25 dSm^{-1} in comparison with before planting which these were 5.25, 5.71 and 5.17 dSm^{-1} under short furrows (SF), long furrows (LF) and border irrigation (B) methods, respectively. As shown in the same table the mean values of ECe were decreased at harvesting of cotton. The results indicate that the decreased in salt content after fifth irrigation were 18.14, 16.33 and 10.98 % under B, LF and SF, respectively. While the decrease in salt content after harvesting of cotton were 21.31, 21.00 and 13.78% under B, LF and SF respectively in the first seasons. For the second season the rate of decrease in salt content after fifth irrigation were 16.96, 14.82 and 10.86% under B, LF and SF, respectively. Moreover, the decrease in salt content after harvesting of cotton were 18.09, 15.63 and 12.67% under B, LF and SF respectively.

It is clear from Table (4) that the mean values of salinity distribution were affected by land leveling practices where the lowest mean values under all methods of surface irrigation were recorded under border irrigation method and dead leveling since it was 3.82 dS/m^{-1} on contrary to this the highest mean value was recorded under long furrow and dead level since the value was 5.17 dS/m^{-1}.

2. Soil moisture extraction patterns by cotton crop as influenced by surface irrigation methods and land leveling:

This parameter might be used as a tool to predict the degree of root distribution within different depths of the effective root zone.

Values of soil moisture extraction patterns with in the root zone of 60 cm as affected by surface irrigation method and land leveling in both seasons are recorded in Table (5).

Table (4): Mean values of ECe before planting, after fifth irrigation, after harvesting of cotton and the rate of change under different surface irrigation methods of the two growing seasons.

Irrigation methods	Land leveling	ECe dSm^{-1}				
		Before planting	After fifth irrigation	Rate of change ± %	After harvesting	Rate of change
		Season 2004				
SF	T	4.98	4.30	-13.65	4.25	-14.66
	D	6.08	5.45	-10.36	5.22	-14.14
	S	4.70	4.28	-8.94	4.11	-12.55
Mean		5.25	4.67	-10.98	4.54	-13.78
LF	T	6.31	5.43	-13.95	5.10	-19.18
	D	5.56	4.52	-18.70	4.18	-24.82
	S	5.26	4.40	-16.35	4.26	-19.01
Mean		5.71	4.78	-16.33	4.51	-21.00
B	T	4.88	3.82	-21.72	3.72	-23.77
	D	4.57	3.71	-18.82	3.58	-21.66
	S	6.05	5.21	-13.88	4.93	-18.51
Mean		5.17	4.25	-18.14	4.08	-21.31
		Season 2005				
SF	T	5.05	4.39	-13.07	4.34	-14.06
	D	5.61	5.08	-9.45	4.920	-12.66
	S	5.76	5.18	-10.07	5.11	-11.28
Mean		5.47	4.88	-10.86	4.78	-12.67
LF	T	4.96	4.30	-13.31	4.26	-14.11
	D	6.17	5.21	-15.56	5.17	-16.20
	S	5.07	4.28	-15.58	46.23	-16.57
Mean		5.40	4.59	-14.82	4.55	-15.63
B	T	5.96	5.02	-15.77	4.96	-16.78
	D	4.66	3.88	-16.67	3.82	-18.03
	S	5.75	4.69	-18.43	4.63	-19.48
Mean		4.46	4.53	-16.96	4.47	-18.09

Table (5): Soil moisture extracted by cotton roots (%) for different layers during the two growing seasons.

Irrigation methods	Land leveling	Season 2004						Season 2005					
		Soil layers (cm)						Soil layers (cm)					
		0-15	15-30	Total	30-45	45-60	Total	0-15	15-30	Total	30-45	45-60	Total
SF	T	4404	29.18	73.22	18.29	8.49	26.78	46.57	27.50	74.07	16.17	9.76	25.93
	D	43.45	25.46	68.91	18.93	12.16	31.09	43.95	25.17	69.12	19.11	11.77	30.88
	S	42.52	26.79	69.31	18.72	11.97	30.69	43.76	24.65	68.41	17.65	13.94	31.59
Mean		43.34	27.14	70.48	18.65	10.87	29.52	44.76	25.77	70.53	17.64	11.82	29.47
LF	T	45.84	26.67	72.51	18.84	8.65	27.49	45.25	28.46	73.74	16.65	9.64	26.29
	D	43.72	27.58	71.30	19.49	9.21	28.70	44.65	24.27	68.92	18.65	12.43	31.08
	S	43.22	28.49	71.71	18.81	9.48	28.29	44.10	27.60	71.70	1.35	10.95	28.30
Mean		44.26	27.58	71.84	19.05	9.11	28.16	44.67	26.78	71.44	17.56	11.00	28.56
B	T	46.29	27.60	73.89	17.33	8.78	26.11	44.85	26.76	71.61	17.50	10.89	28.39
	D	43.32	28.21	71.53	17.69	10.78	28.47	44.15	25.17	69.32	18.50	12.08	30.58
	S	43.11	27.33	70.44	18.27	11.29	29.56	42.65	25.75	68.41	18.83	12.77	31.60
Mean		44.24	27.71	71.95	17.76	10.28	28.05	43.88	25.89	69.77	48.27	11.96	30.23

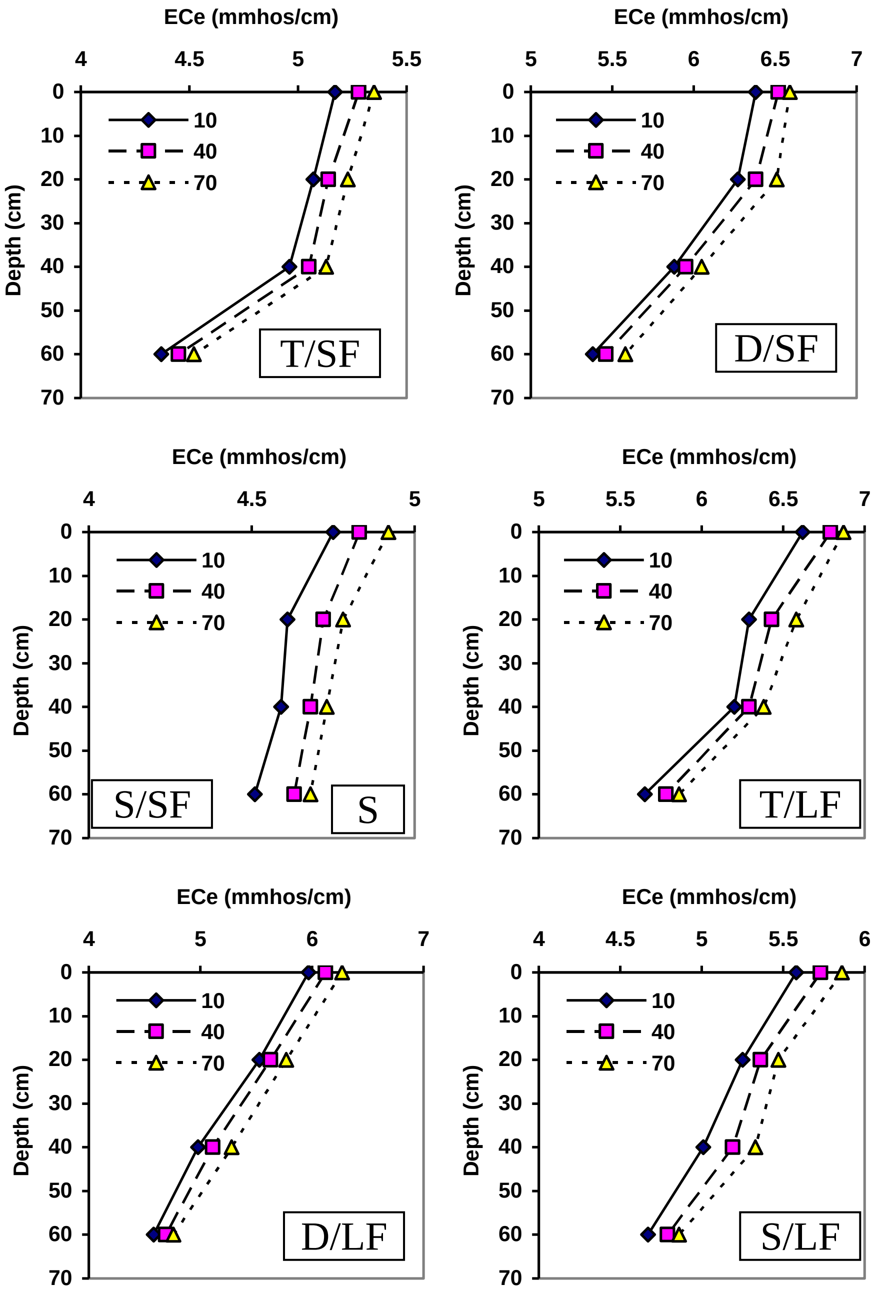


Fig. (1) Salt distribution in soil profile for traditional, dead and slope land leveling under short furrows, long furrows and border irrigation before planting in the first season.

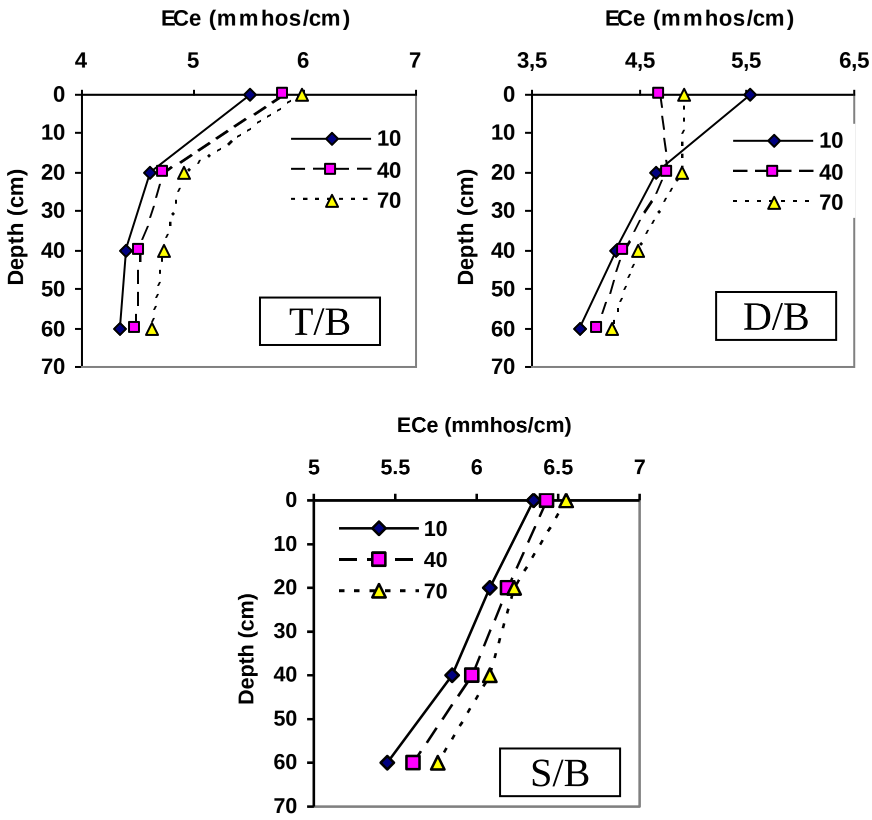


Fig. (1): Cont.

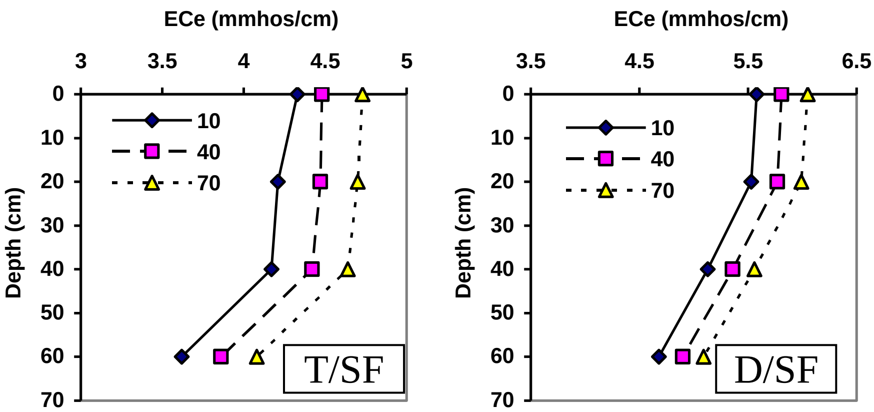
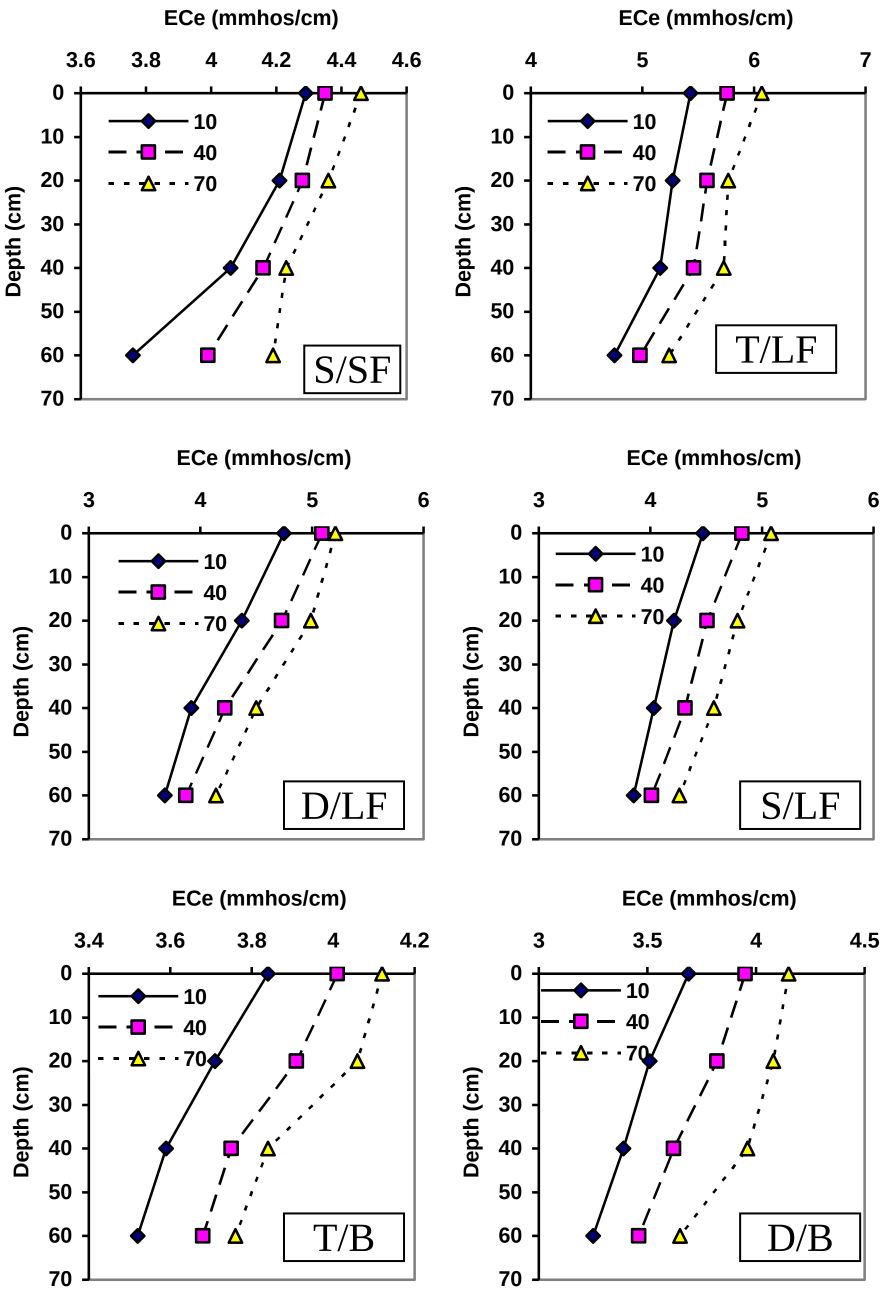


Fig. (2) Salt distribution in soil profile for traditional, dead and slope land leveling under short furrows after fifth irrigation, long furrows and border irrigation before planting in the first season.



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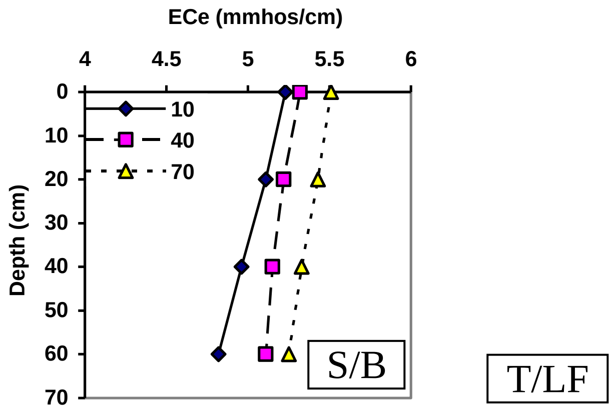

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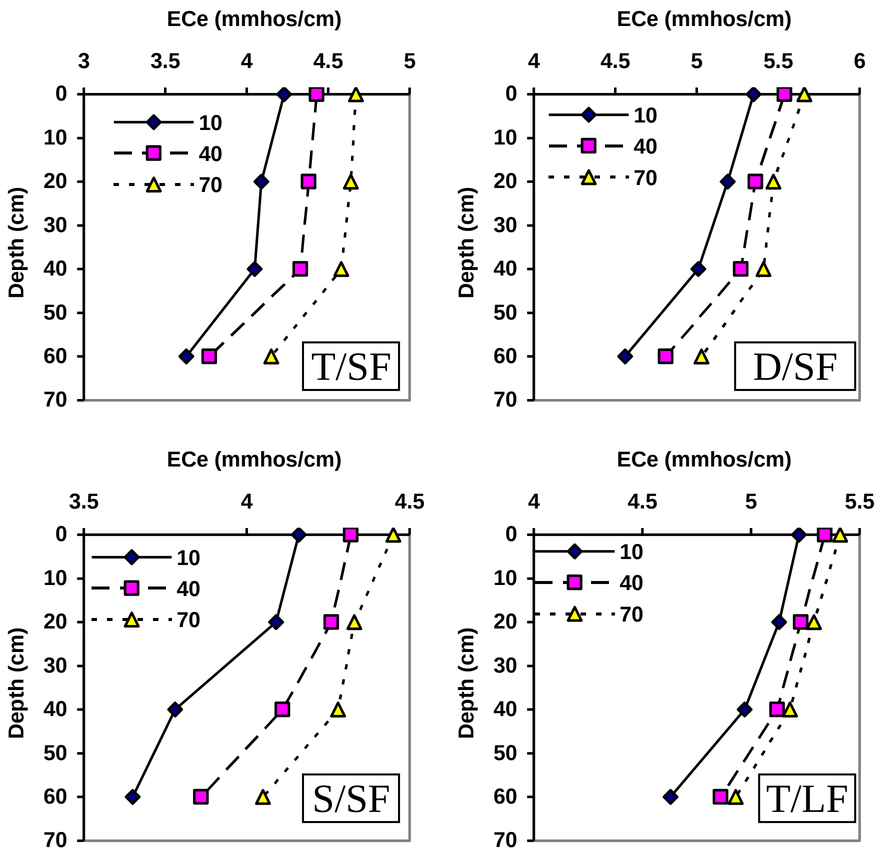
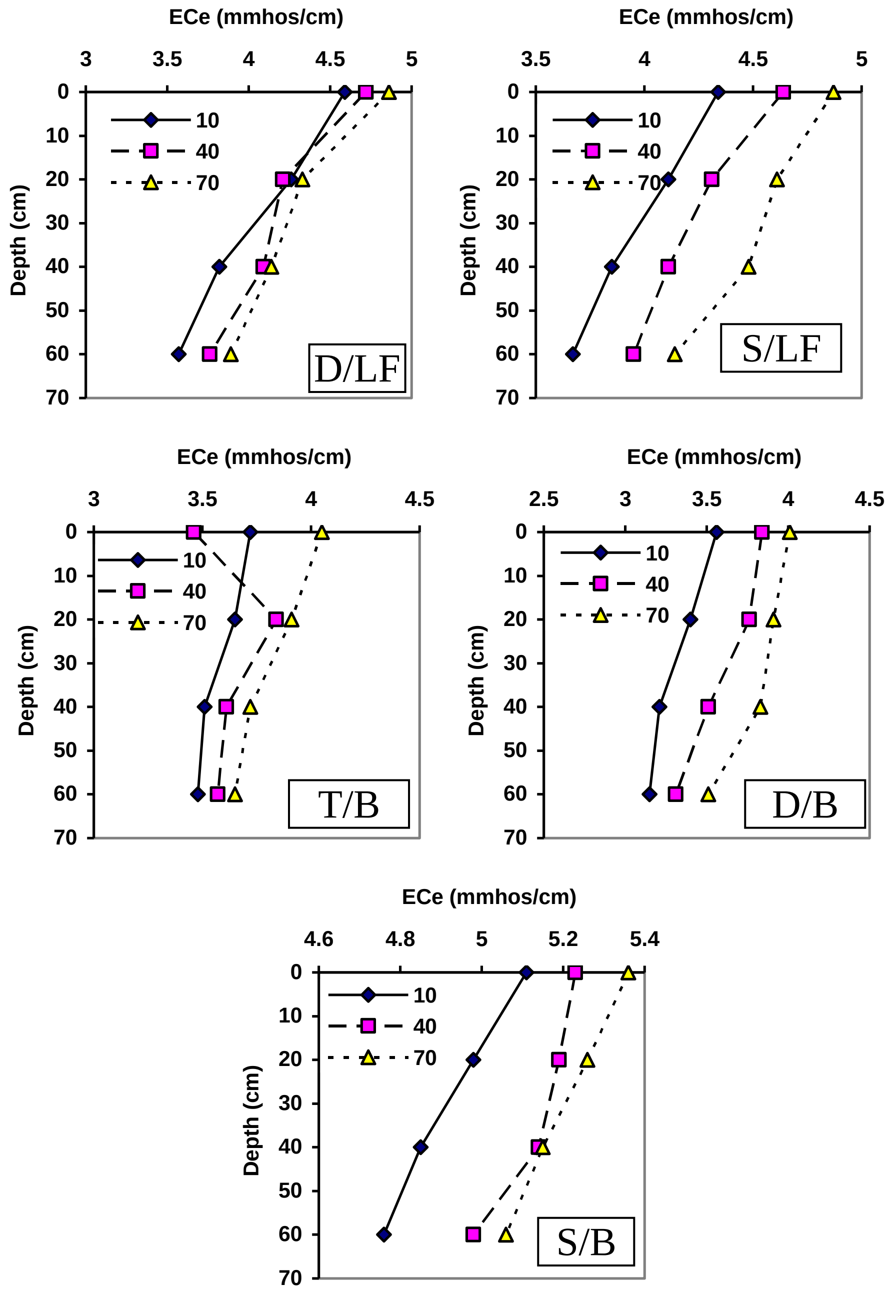


Fig. (3) Salt distribution in soil profile for traditional, dead and slope land leveling under short furrows, long furrows and border irrigation after harvesting of cotton in the first season.



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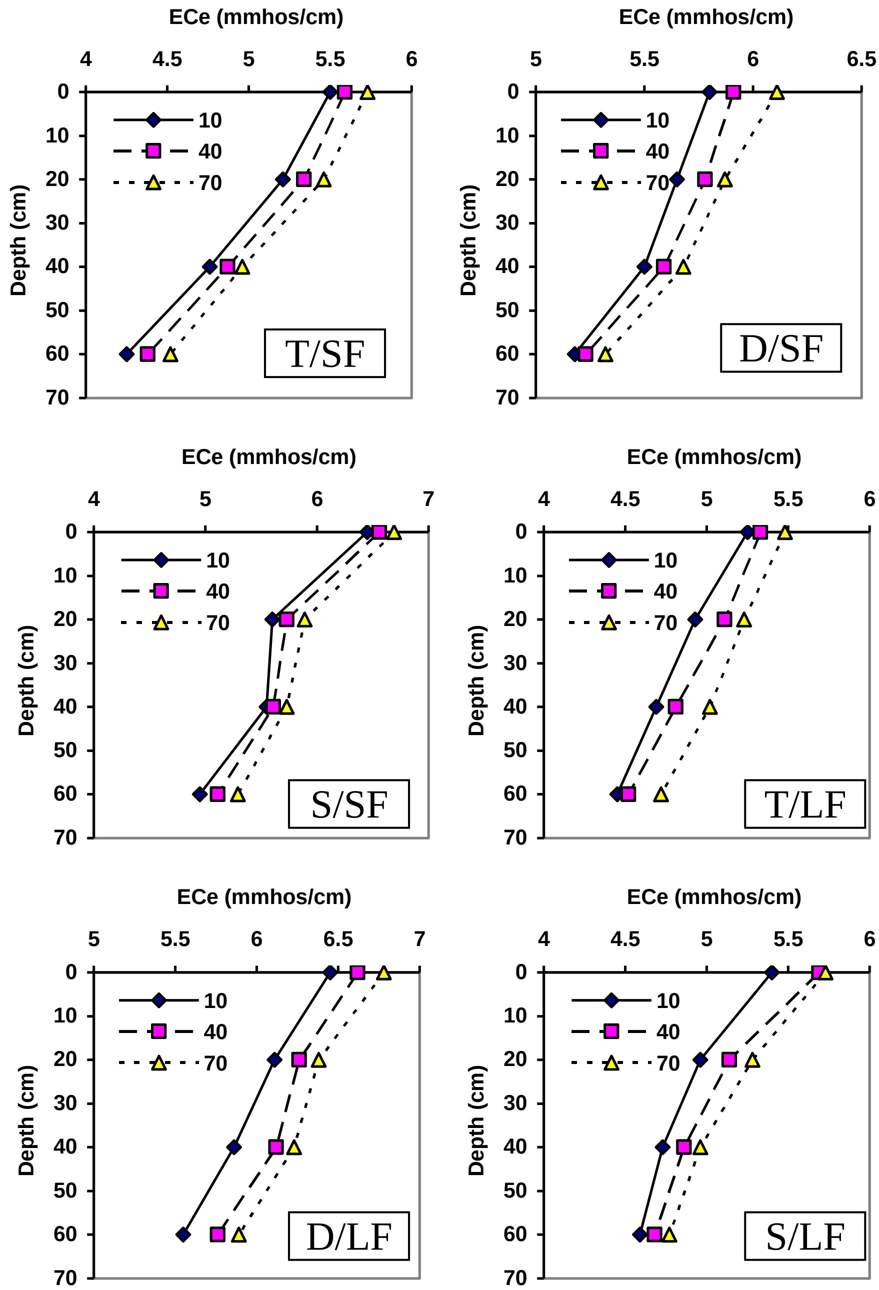
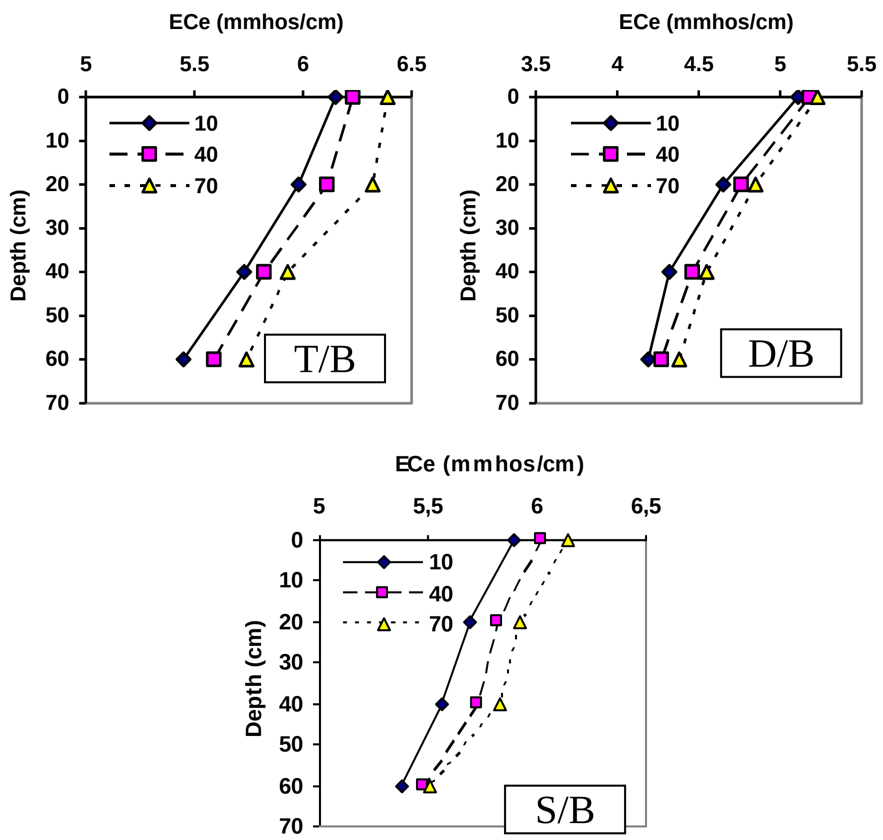


Fig. (4) Salt distribution in soil profile for traditional, dead and slope land leveling under short furrows, long furrows, and border irrigation before planting in the second season.



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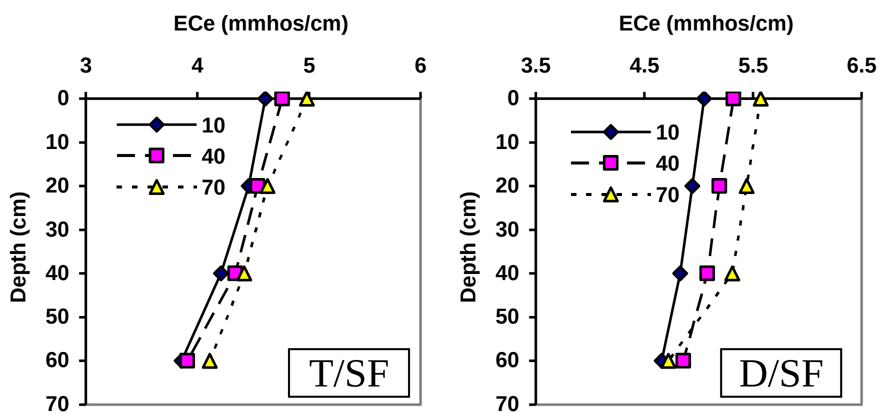
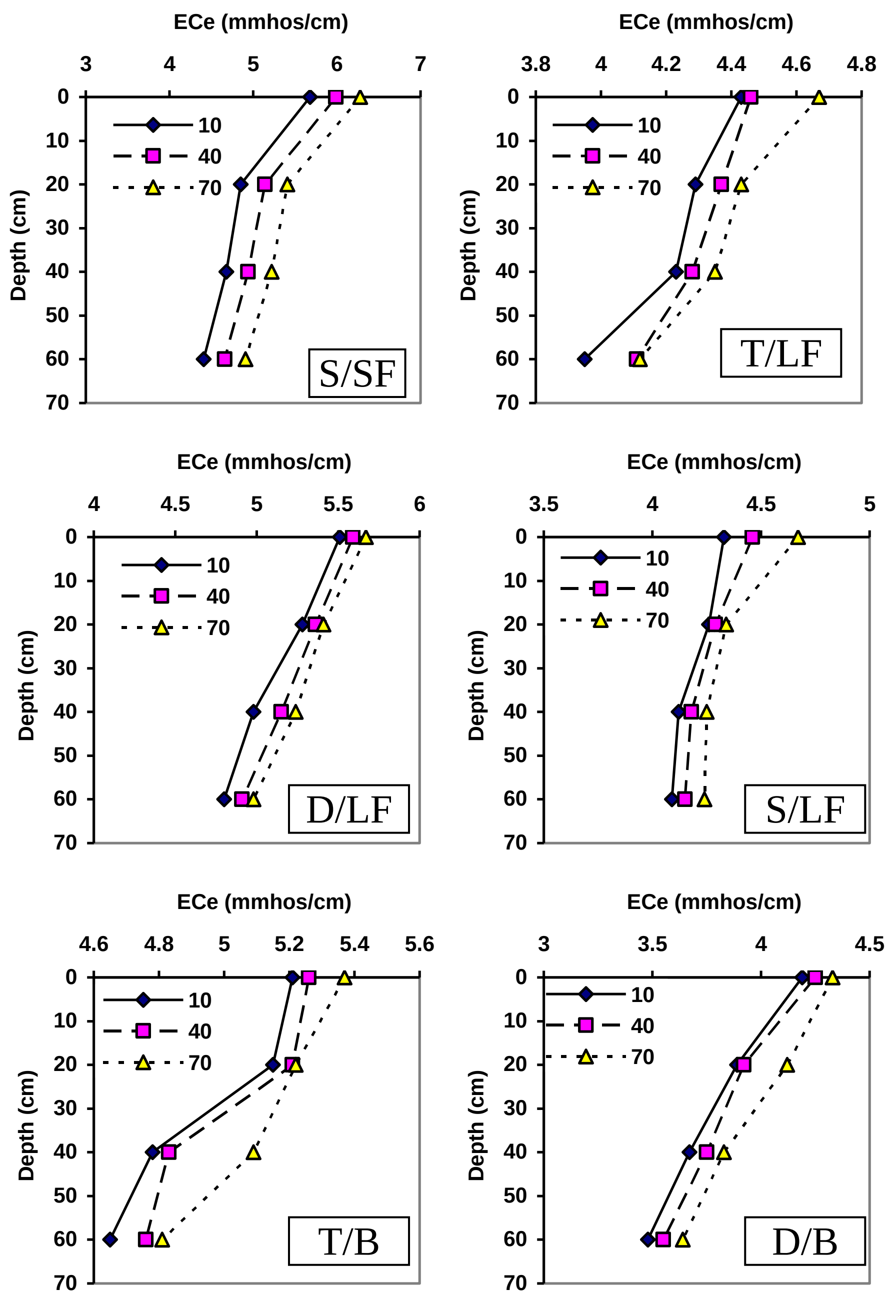


Fig. (5) Salt distribution in soil profile for traditional, dead and slope land leveling under short furrows, long furrows, and border irrigation after fifth irrigation in the second season.



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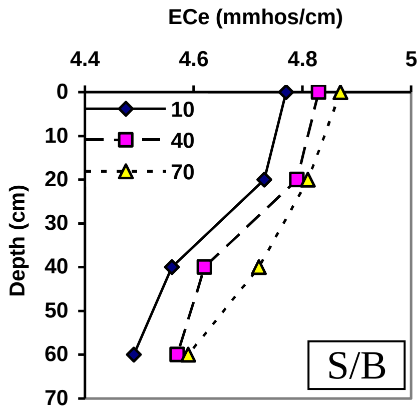

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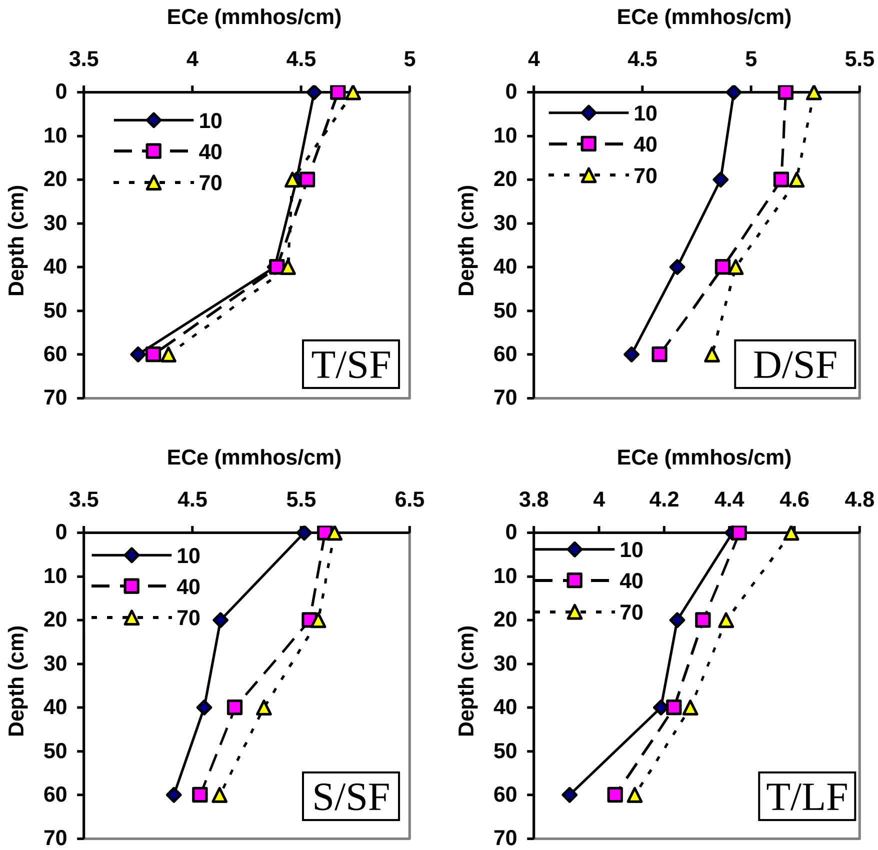

Fig. (6) Salt distribution in soil profile for traditional, dead and slope land leveling under short furrows, long furrows and border irrigation after harvesting of cotton in the second season.

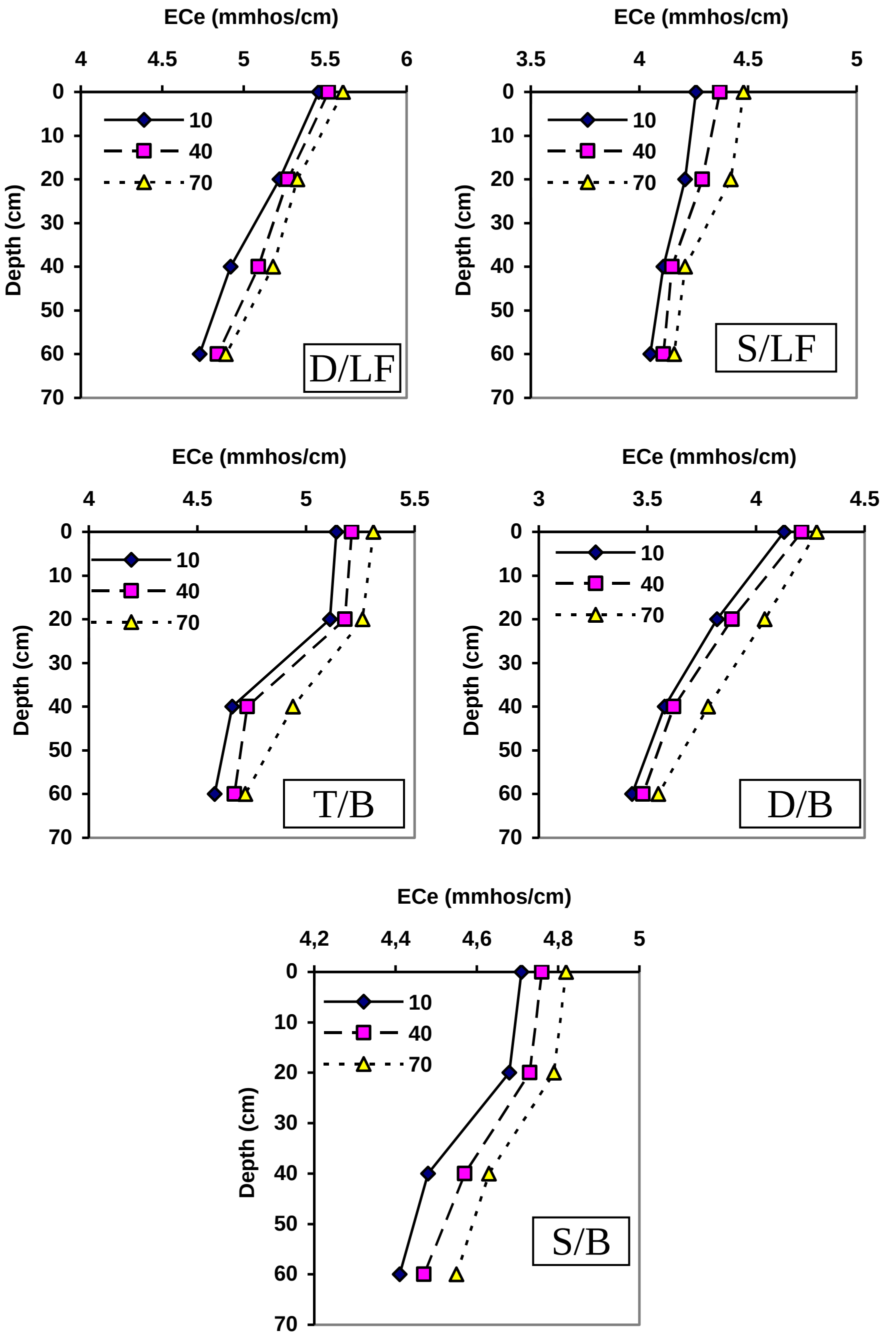
ECe (mmhos/cm)
4
4.5
5
5.5
6
Depth (cm)
0
10
20
30
40
50
60
70
10
40
70
D/LF
ECe (mmhos/cm)
3.5
4
4.5
5
S/LF
ECe (mmhos/cm)
4
4.5
5
5.5
T/B
ECe (mmhos/cm)
3
3.5
4
4.5
D/B
ECe (mmhos/cm)
4,2
4,4
4,6
4,8
5
S/B

Fig. (6): Cont.

In both seasons results clearly indicate that the most of the water consumed by plants was removed from the surface layer (0-15 cm) and (15-30 cm) while less water was extracted from the sequences layers. Average values o soil moisture extraction pattern from the soil layer (0-30 cm) in the first season were 73.22, 68.91 and 69.31% for T, D and S, respectively under SF while the corresponding values under long furrows were 72.51, 71.30 and 71.71%. Also, under border irrigation the values were found to be 73.89, 71.53 and 70.44% for T, D and S, respectively. It was observed that the highest uptake of water by cotton plants was occurred with traditional land leveling under border irrigation method for both seasons. On the other hand, the lowest uptake of water was obtained with 0.1% ground surface slope under short furrows irrigation. It can be concluded that, more than 70% of the water extracted by cotton roots was obtained for the upper 30 cm soil layer and less than 30% form the lower depth (30-60 cm).

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تأثير طرق الرى السطحى والتسوية على توزيع الأملاح والرطوبة الأرضية فى الأراضى المتأثرة بالأملاح فى شمال الدلتا

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أقيمت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بسخا خلال الموسمين الزراعيين 2004 ، 2005م لدراسة ثلاثة طرق للرى السطحى:

1- الرى فى الخطوط القصيرة.
2- الرى فى الخطوط طويلة.
3- الرى فى الشرائح وكذلك تحت ظروف ثلاثة معاملات للتسوية التقليدية والتسوية الدقيقة والتسوية بميول 0.1% لدراسة توزيع الأملاح فى التربة مع طول الخطوط والشرائح الرى ومع العمق والرطوبة المستخلصة بواسطة جذور القطن.

وكان التصميم الإحصائى المستخدم فى هذه التجربة هو القطع المنشقة فى أربع مكررات. وأوضحت النتائج حدوث انخفاض فى توزيع الأملاح فى التربة بعد الرية الخامسة حيث كانت 18.14 ، 16.35 ، 10.98% باستخدام طرق الرى فى الشرائح وفى الخطوط الطويلة وفى الخطوط القصيرة على الترتيب.

بينما كان انخفاض توزيع الأملاح فى التربة أعلى فى حالة استخدام التسوية بميول 0.1% مقارنة بالتسوية الدقيقة والتسوية التقليدية.

وأيضا حدث انخفاض فى المحوى الملحى لقطاع التربة بعد حصاد المحصول كانت 21.13 ، 21.0 ، 13.78% تحت طرق الرى فى الشرائح والخطوط الطويلة والخطوط القصيرة.

وتشير النتائج أن الانخفاض فى المحتوى الملحى تحت معاملات التسوية بميول 0.1% كان معنويا مقارنة بمعاملات التسوية الدقيقة والتقليدية.

وتدل النتائج المتحصل عليها أن استخلاص الرطوبة الأرضية بواسطة جذور القطن يزيد عن 70% من الطبقة السطحية وأقل من 30% من الطبقة تحت السطحية.