The Effect of Irrigation Water Amounts and Salinity levels on Squash Yield Using Trickle Irrigation

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Dedication

DEDICATED
TO
MY COUNTRY
HADRAMOUT

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Abstract

The Effect of Irrigation Water Amounts and Salinity Levels on Squash Yield Using Trickle Irrigation

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A field experiment was conducted during 1998 growing season at the University of Jordan Agricultural Research Station in the Jordan Valley. The objectives of this experiment were to investigate squash (*Cucurbitae pepo melopepo* L.) response to variations in amounts and salinity of irrigation water using trickle method.

A Split plot in arandomized complete block design was adopted in this experiment with two factors; irrigation water salinity as the main factor comprising five salinity levels :1.4, 2.5, 3.6, 4.7 and 5.8 dS/m, prepared by mixing fresh water with saline water , using 1:0, 1:3, 1:1, 3:1, and 0:1 ratio of fresh to saline water , respectively. While irrigation water amounts were used as sub-main factor. Four different

amount of irrigation water were applied according to the evaporation depth from class A-pan (1/3, 2/3,1, and 1.5 of class A -pan evaporation),and irrigation was scheduled twice a week.

Irrigation scheduled twice a week, increasing irrigation water from 1/3 of class A-pan evaporation (62mm), to 1.5 times of class A-pan evaporation (279mm) significantly increased squash yield from 7.6 to 9.01 ton/ha, respectively. While increasing irrigation water salinity from 1.4 to 5.8 dS/m decreased the squash yield gradually from 10.42 to 5.25 ton/ha, respectively.The threshold values of squash crop were 3.5, 3.5, 3.6 and 3.6 dS/m in 1/3, 2/3, 1, and 1.5 of class A-pan evaporation water treatment, respectively. Plant growth decreased as irrigation water salinity increased , with the adverse effect of the amounts of irrigation water. Soil extracted salinity at the end of the growing season significantly increased from 3.1 to 8.3 dS/m as ECiw increased to 5.82 dS/m, respectively.

Soil salt distribution showed an accumulation of salts at the bottom layer (60 cm), with the high amount of irrigation water and it is tended to accumulate slightly at the restricted wetted area close to the drip irrigation line, with the lower amount of irrigation water. Soil reaction (pH) had a tendency to decrease, as irrigation water salinity increased . Magnesium, Ca , Na and Cl were increased as irrigation water salinity increase, while K, HCO3 and B were slightly affected by saline irrigation water ,whereas sulfate was leached out crop root zone under high amounts of irrigation water. In general, results indicated that using drainage water to irrigate crops is a serious problem, while mixing saline water with fresh water gave good results up to 1:1 ratio, and increasing the depth of water applied leach the salts away from the root zone (30 cm).

1. INTRODUCTION

Water has become the most precious nature resource. The amount of water available to meet the daily needs of plants, animals, and humans is estimated by about one percent of the earth's water (Coosi, 1993). Such a small percentage doesn't sound like enough. And the expansion of the area under irrigation in arid and semi-arid regions has led in many cases to the depletion of high quality water and brought to the forefront the question of the utilization of relatively inferior water of high salinity levels for agriculture.

In the Mediterranean region, many countries are classified as arid to semi-arid regions. In such countries water demand is rising due to the population growth,and agricultural and industrial expansion. Moukhaymer and Hijazi (1996) studied water resources and water demand in a selected number of arab countries and found large gap between them. For example, in Jordan this gap is estimated to reach about 400×10^6 m^3 in the year 2000, and will increase to $2530\times10^6 m^3$ by the year 2075. A similar situation is found in other countries in the region. So water problems are on the top of the national priority agenda. Planners and research centers are forced to consider any source of water, which might be used economically, and effectively to promote further development.

The use and expansion of saline water for irrigation in agriculture might contribute in solving part of the water shortage problem. With such expansion, crop-salt stress is anticipated. The problem is further complicated with the introduction of water-conserving irrigation systems like drip irrigation. Drip irrigation is used to irrigate about 55% of irrigated land in the Jordan Valley. Little, if any, data are available on lateral and vertical salt distribution in the soils under such condition. Therefore, this research was designed to help shed light on the issue of paramount significance to sustainable agricultural management in the Jordan valley.

Squash is one of the most economically important vegetable crops cultivated in Jordan. In 1996, the area cultivated with squash amounted to 1316 ha, which produced about 2830 ton of squash (Department of Statistics, 1996). This crop consumes large amount of water during its very short life cycle, therefore it is suitable to employ cyclic and blending strategies, alternately using saline and none saline water in crop rotation to avoid accumulation of salts in soil profile.

The objective of this study was :

1- Investigate squash (*Cucurbita Pepo Melopepo* L.) response to irrigation water amounts of different salinity levels using trickle irrigation method.

2- Study soil lateral and vertical salt distribution under trickle irrigation.

2. LITERATURE REVIEW

Fresh water resources in many arid and semi-arid regions have been exhausted under the heavy pressure of the increasing demand. The agriculture sector usually uses about 80% of the available water resources for crop production. More water, however, is needed for future demands of food and fiber production. The use of saline water in irrigation has appeared as an important option. Whereas saline water was considered as unusable resource, it has been found that the old standards can be changed and new practices could be adopted (Goldberg, et al. 1971).

2.1 Effect of trickle irrigation on salt distribution

Salt accumulation in the soil depends upon the quantity and the salt concentration of the irrigation water, rainfall, and on the amount of leaching (Bielorai *et al.*, 1978). and its distribution within the soil profile differs markedly depending on the uniformity of water application and the differences in soil texture and root distribution (Fereres, 1981). This is true especially under porous or multi-emitter drip system where horizontal and vertical components of water movement tend to be nonuniform.

The concentration of salts increased with distance from the emitters with high salt concentration at the soil surface short distance from the emitters (Shatanawi, 1987; Abdualziz, 1980; Al-Shater and Al-Kusaybi, 1995). Abu-Awwad and Hill (1991) studied soil salt distribution under line-source trickle irrigation.They reported that soil water salinity increased with both vertical and horizontal distance from trickle lines and reached a maximum at the bottom of the wetted area, and between trickle lines, thy concluded also that soil salt accumulation and distribution varied according to the initial crop rootzone salinity , water salinity, soil water extraction , irrigation frequency , irrigation method, physical and chemical soil characteristics, and irrigationm amounts. Moolman (1989) studied the effect of spatial variability on the estimation of the soluble salt content in a drip irrigated saline loam soil. He mentioned that, salt content increased exponentially with distance from the emitter. At equal distances from the emitter, significantly higher values were observed out side, compared to within the row. Out side the row, the salt content decreased significantly with depth, but within the row it was constant down to 1m depth.

In other study, in flood and sprinkler irrigation, most of the salts moved and accumulated at the lower root zone. Under furrow irrigation, salts tend to accumulate with depth in the soil similar to flood irrigation, (Ayers and Westcot, 1985). Increasing water applicate rate, changed the shape of salinity distribution profile. In an experiment conducted to study the effect of different water quantities on salt distribution in the soil profile, water was applied at rate of 50%, 100%, and 150% , of crop evapotranspiration (ETc) requirement. When 50% of the ETc (14.0m^3/tree) applied during the irrigation season, the highest accumulation of soil salinity (5.7dS/m) was found beneath the trickle line, while soil salinity decreased to 1.56 dS/m at 1.6 m from the trickle line. Increasing amounts of water to 100% of the ETc treatment (26.9m ^{3}/tree), decreased soil salinity to 4.74dS/m under the trickle line, and the zone of highest EC_e (4.98dS/m), in 100% treatment, moved out to 0.8 m from the trickle line, and decreased to 3.93dS/m at 1.6 m. Applying water at 150% of the ETc (40.3m^3/tree) resulted in less salinity (3.35 dS/m) beneath the trickle line, while the EC_e at 1.6 m from the trickle line was increased to 3.84dS/m (Nightingale *et al.*, 1991). Judah (1985) studied salt accumulation as influenced by different water management treatments, crop was irrigated each 2, 4, and 7 days with three application rates 2,4 and 6 lh^{-1}). He indicated that soil salinity had not changed below 10 cm depth up to 40 cm depth for all treatments. The highest salinity for the 2, 4, and 7 days frequencies was at 45, 25 and 25 cm distance from emitters, respectively. Also the highest salinity at the same depth for all irrigation rates was at 25 cm form the emitters.

Judah, *et al.*, (1987) studied salt distribution and accumulation as affected by drip irrigation treatment for tomato grown inside plastic house. Irrigation frequencies were 4 and 7 days and water application rates were 2, 4 and 6 lh^{-1}. They stated that salt accumulation increased at the soil surface (10cm depth) for all treatments as distance from the dripper increased. The following pattern can be advanced by analyzing the horizontal and vertical distribution of salt content:

1- Regardless of the treatment, salt accumulation would occur most significantly in the upper 10-15 cm. And the lowest salt conentration was immediately around the dripper.

2- Higher rate of water application was more effective in reducing the salt content around the plant, and salt started to accumulate at deeper layers.

3- Higher water frequency would be more effective in reducing the salt content in the root zone.

2.2 Effect of irrigation water salinity on plant parameters

Excessive salinity reduces plant growth primarily because it increases the energy that must be expended to acquire water from the soil of the root zone and to make the biochemical adjustment necessary to survive under stress. This energy is diverted from the processes, which lead to growth and yield. (Rhoades, et al. 1992).

Al-Shater and AL-Kusaybi (1995) mentioned that, the salt tolerance of any plant is depending on root distribution and concentration of salts in certain layer. If the roots elongated to the low salt concentration layer, like layers adjacent irrigation canals, plant could grow normally and absorbs the and duration of exposure to salinity. Fruit yield per plant was reduced in the same pattern as vegetative growth. Also the results showed a greater effect of high salinity during the day than during the night, which indicates clearly that salinity acts through its effect on water uptake by the plant.

Al-Harbi (1995) stated that increasing salinity decreased the fresh and dry weight of cucumber and tomato seedlings. Both crops are classified as moderately sensitive to salinity. Cucumber dry weight responded positively to reduced Na/Cl ratio under the low level of salinity.

Chartzoulkis (1992) studied the effect of salinity on germination, growth and yield of the greenhouse cucumber hybrid pepinex. Saline treatments were imposed by irrigation with water containing NaCl and having different levels of the EC. Salinity delayed germination but did not significantly reduced final germination percentage even at high salinity levels. Seedling and plant growth were reduced significantly with salinity higher than 1.2 dSm^{-1}. Relative yield of cucumber fruits was reduced by 15.9% for each unit increase in the EC of the irrigation water above 1.3 dSm^{-1}. Fruit number per plant rather than fruit size, was more affected by salinity, so the cucumber hybrid pepinex proved to be more salt tolerant during germination than during vegetative growth of fruiting. Abu-Sharar,(1988) stated that response to salinity/sodicity stress may vary according to the nature of the responsive parameter (germination or development of coleoptile or shoot).

Mendlinger and Pasternak (1992) studied the effect of time of salinization on flowering, yield and fruit quality factors in melon using three salinity treatments (Fresh water, saline water EC = 6.5 dSm^{-1} for all growth stages, and fresh water for germination and then saline water for subsequent growth stages). They reported that, salinity did not affect the percent emergence of the number of hermaphrodite flowers in any of the cultivars. Salinity also reduced both initial and total vegetative growth in all cultivars, and mean fruit weight, although it did not affect the number of fruit produced. Fruit constituent factors were of the most part unaffected by salinity. Feigin (1990) studied the response of melon plants (Cucumis melo L.) to different ratio of NH_4/NO_3 in saline (9 dSm^{-1}) and nonsaline (1.5 dSm^{-1}) nutrient solution using an aerohydroponic system in a greenhouse. He mentioned that, dry matter production was greatly affected by salinity, and insignificantly by the NH_4/No_3 ratio. The yield of dry matter produced by melon plants grown under nonsaline conditions tended to increase, where a low level of NH_4 was combined with adequate NO_3, while the presence of NH_4 tended to reduce yields under saline conditions.

Plants of Zucchini squash isota cultivar were grown in 157 liter containers of soil and irrigated with water containing NaCl at concentration from 0 to 9 g/Liter, in order to estimate saline-sodic conditions on yield, growth, and element content of squash. Graifenberg *et al.*, 1996 stated that Zucchini squash was moderately tolerant to salinity. The threshold values, expressed as electrical conductivity of irrigation water (ECi) and saturated soil extract (EC_e), for marketable yield were 2.8 and 5.1 dSm^{-1}, respectively. and the slopes of marketable yield against EC were 12.8% for ECi and 11.665% for EC_e.

2.3 Effect of salinity on soil chemical properties

Salinization of a soil alters its chemical characteristics according to the concentration and composition of the saline solution applied. Batchelder *et al.*, (1963) used 5 salinity levels consisted of dilutions of synthetic sea water having electrical conductivity (EC) vlaues of 5, 10, 20 and 30 dS/m for medium salt tolerant crops (Tomato, Broccoli, Onion and peppers), and EC values of 10, 25, 40 and 50 dS/m for high slat tolerant crops (beets and spinach). They reported that increasing soil salinity resulted in a corresponding decrease in soil pH. Exchangeable Ca decreased markedly with increasing salinity, whereas exchangeable Mg decreased only slightly. Exchangeable Na increased markedly with increasing salinity, whereas exchangeable K increased to a Lesser degree, with tendency for divalent cations to decrease and monovalent cations to increase with increasing salinity.

Boron often accumulates in micro quantities, in saline soils. The long term use of saline water by drip irrigation, caused boron to exhibit a progressive build up in the profile which will continue until an equilibrium condition is reached between the B concentration of the applied water and the adsorbed phase. At that time, the B concentration in the soil solution will be controlled by B concentration of the irrigation water (Ayars *et al.*, 1993).

The distribution of the chloride concentration with depth showed that the chloride concentration at the end of the first year increased only slightly with depth, because during the first year, salinity developed from a non-saline start. After the first water application at the start of the second year, the increase with depth became quite pronounced (Van Hoorn et al. 1993).

BieLorai, *et al.*, (1978) used saline irrigation water to determine its effect on grapefruit yield. Treatments consisted of chloride concentration in the irrigation water of 7.1, 11.4, 17.1 meq/l added as $NaCl + CaCl_2$. They found that the Na concentration increased from 6.2 meq/l in the control treatment to 9.4 meq/l in the most saline treatment.

Hassan *et al.*, (1970) studied the influence of soil salinity on the production of dry matter and uptake and distribution of nutrient in barely in green house. They reported that, during the growth period of 98 days, increasing soil salinity increased sulfate-S and chloride in the saturation extract and lowered soil pH. Exchangeable Na, Mg, and Ca increased markedly while exchangeable K and available P increased only slightly. Acid-extractable Mn increased, but there was little or no effect on acid-extractable Zn, Fe, and Cu. Also, they found the same result for corn in another experiment during the growth period of 93 days except that increasing salinity had little or no effect on Mn.

2.4 Effect of soil salinity on evapotranspiration

Increasing salt concentration in soil water solution reduces evapotranspiration by reducing soil water availability for plant root extraction. The presence of salts in the soil water solution reduces the osmotic potential energy of the soil water solution.

By maintaining high soil water content at the crop root zone , the crop will be able to extract sufficient water from the salty-soil solution and evapotranspiration will not be reduced due to mass flow of water to plant cells. Also, by adding more water than that depleted, water-soluble salts can be leached out from the root zone and the salinity problem can be controlled.

On the other hand, the effect of soil salinity on crop yield is due to the reduction in soil water availability (Allen *et al.*, 1998). Forage crops are best suited for using saline water due to the high evapotranspiration. (Malek *et al.*, 1992).

Hanks *et al.*, (1978) studied the production of corn as influenced by irrigation and salinity. They mentioned that, presalinization of the soil decreased yield in proportion to the salinity imposed, the decrease being associated with reduction in evapotranspiration caused by reduced soil water depletion as compared to the nonsalinized treatments. The frequency of irrigation, also, affects directly evapotranspiration.

Duplessis (1985) found that, evapotranspiration of citrus decreases linearly with decreasing soil water potential for both high and low frequency irrigation. But the larger evapotranspiration experienced under the frequent irrigation compared to less frequent irrigation treatment.

Abu-Awwad (1994) stated that under irrigation, where the total water applied is less than crop evapotranspiration, seasonal evapotranspiration, decreased as irrigation water salinity increased. However, increasing total water applied increased soil water contribution to seasonal evapotranspiration.

Deju and Jingwen (1993) indicated that a strong linear relationship was found between the dry biomass (above ground) and evapotranspiration for winter wheat and maize. A similar result was obtained for the grain yield of winter wheat. The harvest index of winter wheat decreases at increasing evapotranspiration.

3. MATERIALS AND METHODS

3.1 Location of the study

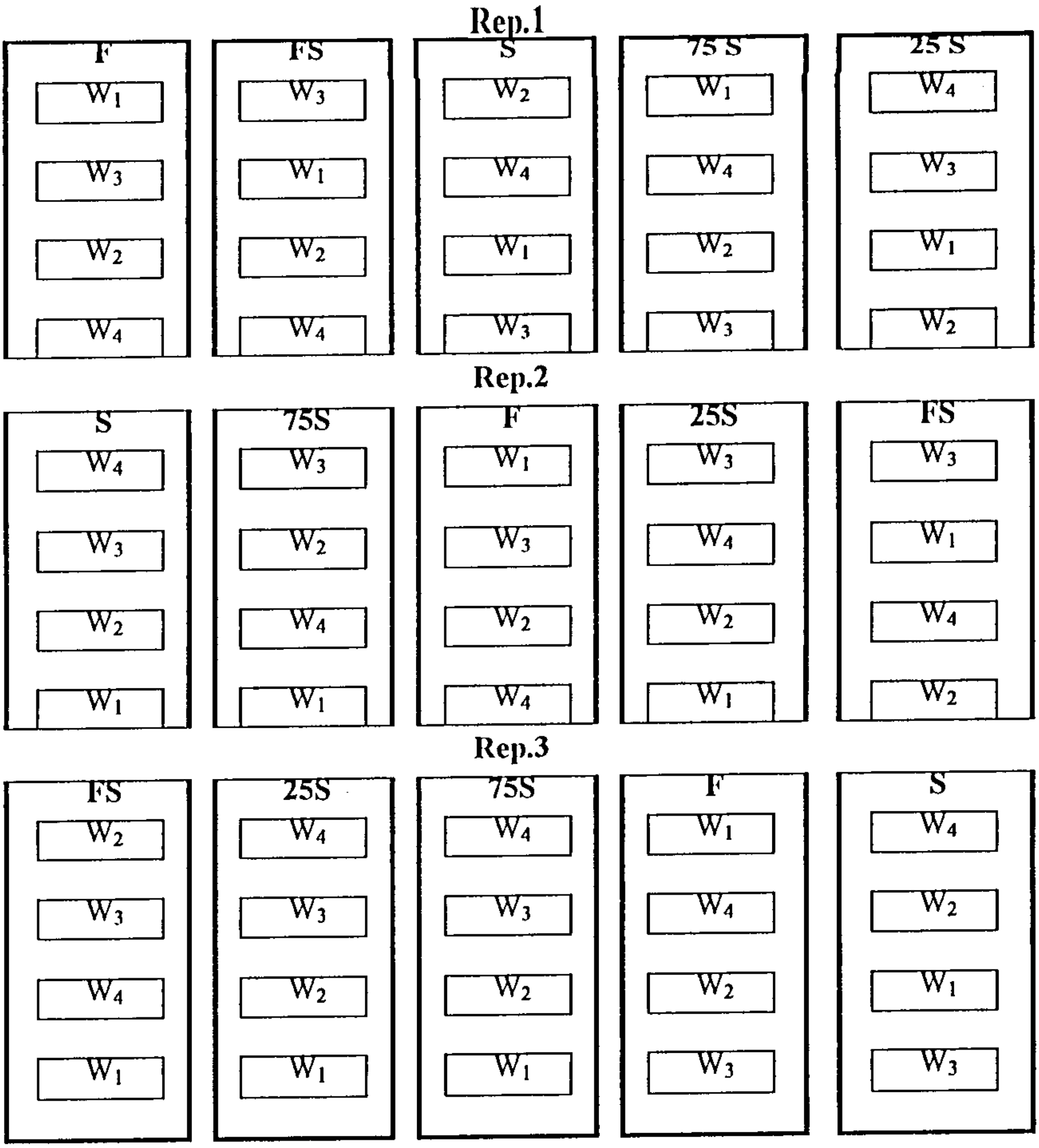
The experiment was conducted at the University of Jordan Agricultural Research Station in the Jordan Valley throughout April to June of 1998. The station lies at 32°N latitude, 35°: 30′ longitude, and 300 m below the sea level. The experiment was carried out in an open field of 43 × 20 m^2.

3.2 Land preparation and plantation:

The experimental area was prepared by plowing, rotating the soil, and the beds were raised, then divided into five main plots representing the five water quality treatments, while the four different amounts of irrigation water qualities were adopted as subplots of 3×3 m^2, (Figure 1).

Squash (*Cucrbita pepo melopepo* L.) of (Anita) cultivar was planted in four rows for each subplot of each replicate in 23^{ed} of April. Three seeds in each hole at nearly 3cm depth were placed. The distance between rows was 0.8m with 0.4m between plants in the row. Plants were thinned out after germination and 112 plants were kept in each treatment.

Black polyethylene mulch (40 micron) was used. All plots received the same fertilizers: 60 kg/ha ammonium sulfate (21% N) one week after emergence, and 85 kg/ha triple superphosphate (46% P_2O_5) was incorporated with the top soil before planting.



F :Fresh water only
25S: Mixed saline water (25%) with fresh water (75%)
FS : Mixed saline water and fresh water (50:50%)
75S: Mixed saline water (75%) and fresh water (25%)
S :Saline water only
W_1 : Water depth equals to 1/3 times evaporation from class A pan
W_2: water depth equals to 2/3 time evaporation from class A pan
W_3: water depth equals to evaporation from class A pan
W_4: water depth equals 1.5 time evaporation from class A pan

Figure 1: The experimental layout.

Also 30 kg/ha of N.P.K (20-20-20) was added every two weeks, by fertiirrigation method, micronutrient were foliar applied two times during the first month of the growing season. Protection against diseases was carried out by applying insecticide (Evisect S) and fungicide (Dithane M45) whenever needed. Weeds were controlled by hands.

3.3 Soil properties

For five soil depth (0-20, 20-40, 40-60, 60-80, and 80-100 cm), three replicates of undisturbed soil samples were taken. These soil samples were used to determine soil bulk density by core method as described by Blake (1965).

To determine soil water content at field capacity, three sites were selected randomly in the field. Aplots of 1m^2 was irrigated several times and covered with a black plastic mulch. After 24 hrs, three soil samples from each layer mentioned above were taken for soil field capacity moisture content determination .Table 1 showed that field capacity was nearly 1.5 (PV%) at the root zone depth.

Another five composite soil samples were collected at the same depths to determine some soil chemical and physical properties. These soil samples were air dried, gently grounded to pass through 40 mesh sieve. Pipette method as described by Gee and Bauder (1986) was used to determine particle size distribution for the different soil depths. Table 2 showed that sandy clay loam class predominates the profile.

Table 1. Some physical soil properties.

Soil depth (cm)	Field capacity (Pv %)	Permanent wilting point (Pv%)	Bulk density (g/cm^3)
0-20	28.0	14.0	1.49
20-40	26.5	11.0	1.53
40-60	27.4	10.5	1.57
60-80	25.4	10.4	1.58
80-100	26.0	11.5	1.56

Table 2. Particle size distribution and texture class of the five soil depth increments.

Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture class description
0-20	56.8	9.6	33.6	Sandy clay loam
20-40	57.1	14.3	28.6	Sandy clay loam
40-60	42.1	21.7	36.2	Clay loam
60-80	46.4	23.8	29.8	Sandy clay loam
80-100	67.8	13.8	18.4	Sandy loam

Soil reaction (pH) was determined by electrode methods. Bicarbonate were determined using titration method

(Eaton *et al.*, 1995). Chloride was determined by titration with $AgNO_3$ (Ryan *et al.*, 1996). Boron using the curcumin colorimetric determination (Eaton *et al.*, 1995). Sulfur using turbidimetric method using $BaCl_2$ precipitation (Eaton *et al.*, 1995) . Calcium and Mg using EDTA titrimetric method (Eaton *et al.*, 1995), and Na and K using flame emission photometry.

Soil salinity was determined in soil water extract (Bower; and Wilcox, 1965).

The same soil chemical properties were determined at the end of the growing season and samples were collected according to the grid system shown in Figure 2.

3.4 Irrigation system

One emitter trickle line was used per row. The water quantities were controlled by a flow meter installed on the main line. Control valves was installed at the beginning of each main plot. Also, water quantities were controlled by the number of emitters in each subplot.

Class A pan evaporation was used to quantify the required amount of irrigation water that added to each treatment. Table 3 shows the dates and amounts of irrigation water applied during the growing season.

Electrical conductivity of irrigation water was measured for each water quality treatment every irrigation event (Table 4).

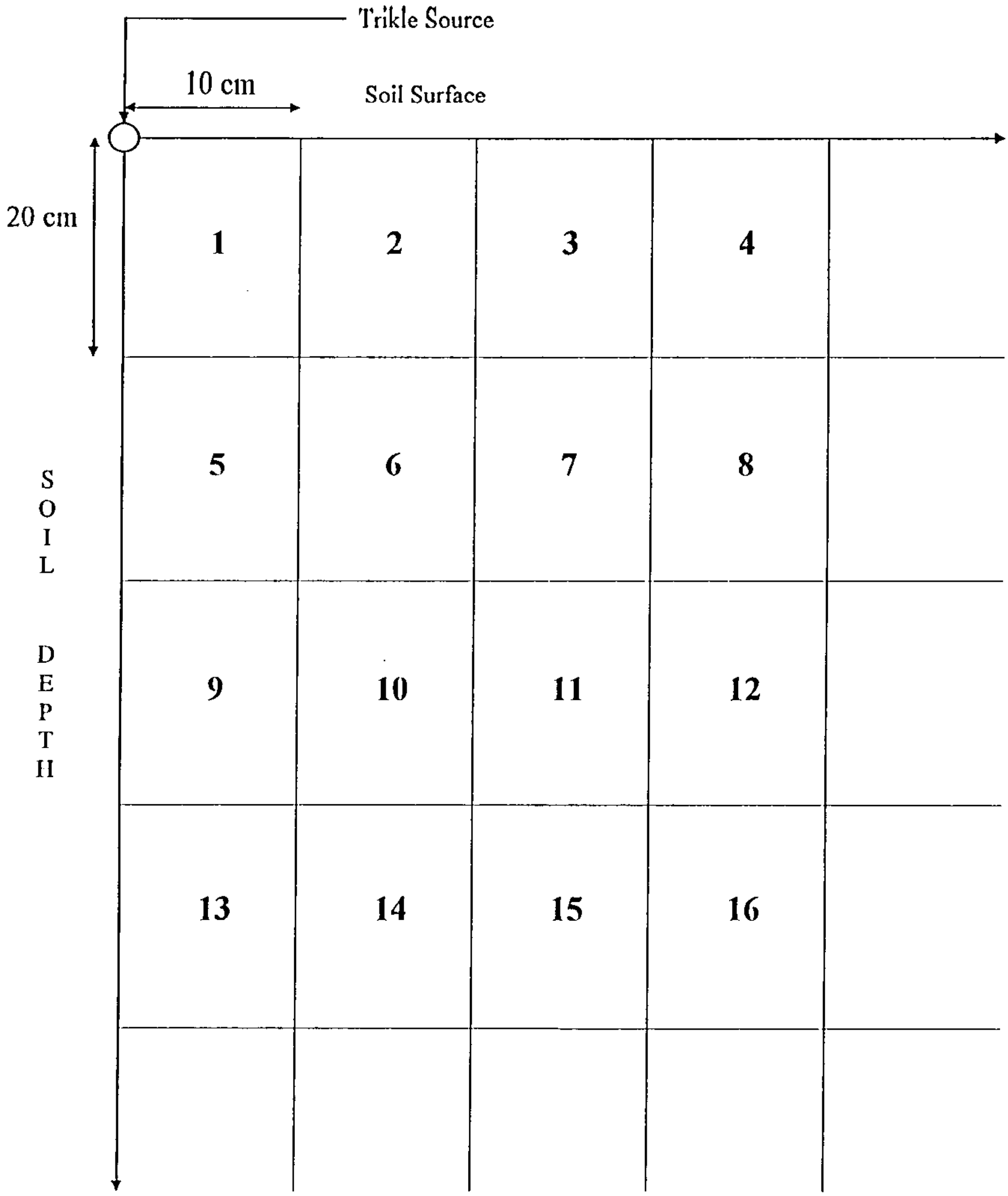


Figure 2. Soil sampling grid.

Table (3): Depths of applied irrigation water during the growing season (mm).

Date	W_1	W_2	W_3*	W_4
17/5/98	3.8	7.5	11.4	17.1
21/5/98	10.0	19.7	29.9	44.8
24/5/98	3.5	6.9	10.5	15.7
26/5/98	3.0	5.9	9.0	13.5
28/5/98	3.6	7.2	10.8	16.2
31/5/98	4.0	8.0	12.12	18.3
4/6/98	8.3	16.5	25.05	37.5
7/6/98	4.8	9.5	14.4	21.7
9/6/98	6.1	12.1	18.3	27.5
11/6/98	4.4	8.7	13.1	19.6
16/6/98	10.5	20.8	31.6	47.4
Total	62	123	186	279

*W_3= Evaporation from class A pan.

Table 4. Electrical conductivity of irrigation water (dS/m)

Date	F	25S	FS	75S	S
17/5/98	1.28	2.36	3.44	4.52	5.60
21/5/98	1.28	2.37	3.46	4.55	5.65
24/5/98	1.28	2.41	3.54	4.67	5.82
26/5/98	1.8	2.79	3.79	4.78	5.78
28/5/98	1.4	2.37	3.34	4.31	5.28
31/5/98	1.4	2.46	3.52	4.58	5.64
4/6/98	1.4	2.50	3.60	4.70	5.80
7/6/98	1.4	2.51	3.61	4.75	5.87
9/6/98	1.34	2.68	4.10	5.36	6.7
11/6/98	1.34	2.68	4.1	5.36	6.7
16/6/98	1.64	2.8	3.97	5.13	6.3
Average	1.40	2.5	3.60	4.7	5.8

A neutron probe access tube was installed in each subplot treatment to 1m depth. Soil water content was measured just before each irrigation event at 0-20, 20-40cm depths using neutron probe. The neutron probe was field calibrated for each layer mentioned above according to Reichard, (1993); (Appendix A). Soil water depletion (crop water use) for the period between irrigation was determined from soil water content measurement using the calibrated neutron probe.

Drainage water was estimated as:

$Dd = d_{fc} - d_{Etc} + d_{IR}$

where;

Dd: Drainage water depth

d_{fc}: The equivalent depth of water in the root zone at the field capacity, d_{Etc}: Measured soil-water deplition depth, and d_{IR} is the irrigation water depth.

Seasonal crop water use was estimated as:

S_{ET} = Irigation + Rain-Drainage $\pm \Delta S_{Wc}$

Where S_{ET} is the seasonal evapotranspiration and ΔS_{Wc} is the seasonal change in the soil water content.

3.5 Treatments and experimental design

Water quality was the main experiment factor comprising five treatments as follow:

F: Fresh water only

25 S: Mixed saline water (25%) and fresh water (75%)

FS: Mixed saline and fresh water (50:50%).

75 S: Mixed saline water (75%) and fresh water (25%).

S: Saline water only

and the four different amounts of water, adopted as subplot, are:

W_1 = 1/3 times evaporation from class A pan.

W_2 = 2/3 times evaporation from class A pan

W_3 = 1.0 times evaporation from class A pan.

W_4 = 1.5 times evaporation class A pan.

The experimental design was a split plot in randomized complete block design with three replications.

3.6 Yield

At the 21st of may ,and through out the growing season, fruits were picked for each plot twice a week. The number and weight of each fruit harvest were recorded. At the end of the growing season (29/6/1998) shoot fresh and dry weight was determined.

4. RESULTS AND DISCUSSION

4.1 Amounts and quality of irrigation water applied

Seasonal amounts of water applied in W_1, W_2, W_3 and W_4 treatments were 62, 123, 186 and 279 mm, respectively (Table 3). The depth of irrigation water applied for each treatment was strongly dependent on the meteorological conditions. The temperature has increased progressively along the season, therefore, the evaporation rate from class A pan has increased and cause increasing the depth of irrigation water.

. The average electrical conductivity of irrigation water (EC_{iw}) applied ranged from 1.40 to 5.8 dS/m, respectively, for F (fresh water) and S (saline water) treatments. The EC values of the fresh and the saline irrigation water have varied during the growing season from 1.3 to 1.6 and from 5.6 to 6.7 dS/m, respectively. The same result was obtained by Abu-Awwad (1995), where the EC values for fresh and drainage water were varied from 0.9 to 2.4 and from 3.7 to 7.4 dS/m, respectively, during the year of 1991.

Chemical analysis for both fresh and saline water (Table 5) shows that pH value was within the normal range (Shatanawi,*et al.*, 1994).

Sodium hazard as describe by SAR value was at the safe range according to Ayers (1977).All cations and anions are at the normal range in fresh water .

In saline water Mg and Ca were at high content ,and the content of SO_4 was slightly high, while HCO_3 , K and Cl were in low quantities (Ayers and Westcot,1985).

4.2 Effect of different water amounts and salinity levels on squash yield

4.2.1 Effect of the different amounts of irrigation water on squash yield

Averaged over salinity levels, squash yield as influenced by amounts of irrigation water is presented in Table 6. Increasing water amounts from W_1 (62 mm) to W_2 (123 mm) significantly increased squash yield from 7.60 to 8.20 ton/ha, respectively, whereas increasing the irrigation water amount from W_2 (123 m) to W_3 (186 mm) was not add any significant increment in the squash yield. The highest yield (9.01 ton/ha) was obtained under W_4 (279 mm), which was significantly higher than yield obtained in W_1, W_2 and W_3.

4.2.2 Effect of irrigation water salinity on squash yield

Figure 3 presents the effect of irrigation water salinity on squash yield. The highest yield (10.42 ton/ha) was obtained in treatment F, which was significantly the highest among yields obtained in all other treatments.

As the salinity of the irrigation water increased from 1.4 dS/m in F treatment to 2.5 dS/m in 25S or to 3.6 dS/m in FS treatments, yields were significantly decreased by 12% and 16%, respectively, with no significant difference in yield between 25S and FS treatments. The increase in

Table 6: Effect of different amounts of irrigation water on squash yield .

Treatment	Total depth of water applied (mm)	Total yield* (ton/ha)
W_1	62	7.60 c
W_2	123	8.20 b
W_3	186	8.56 b
W_4	279	9.01 a

*Values followed by the same letter are not significantly different.

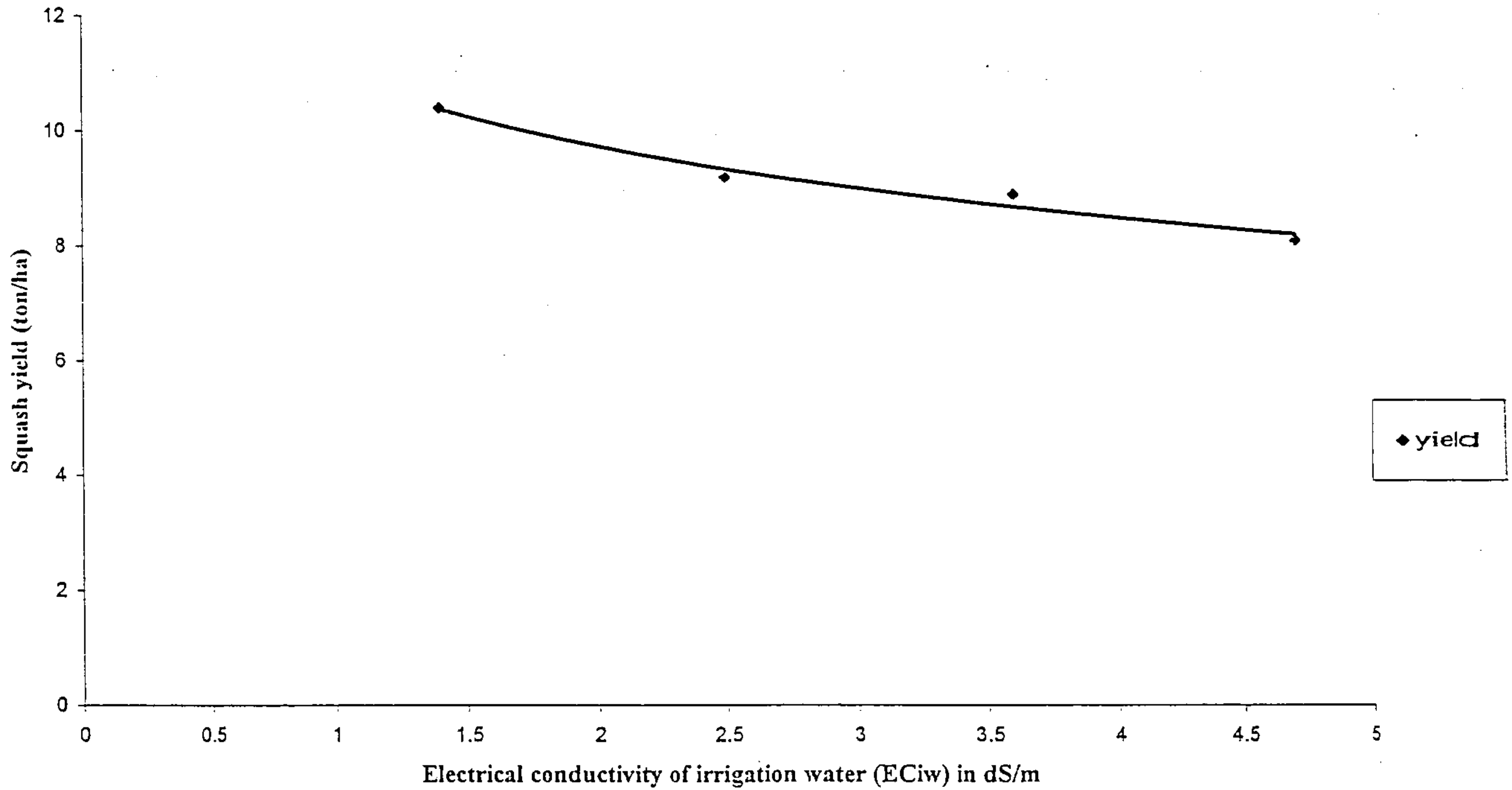


Figure 3: Effect of irrigation water salinity on squash yield

irrigation water salinity for 75S and S treatment, caused significant reduction in squash yield by 22% and 49%, respectively.

Yield obtained in 75S treatment was significantly lower than yield obtained in FS treatment, and at the same time, significantly higher than yield obtained in S treatment. Thus, increasing irrigation water salinity significantly reduced squash yield. This was expected because as irrigation water salinity increases, soil water potential increased and plant must applied more energy to absorb the same amount of water, also from other point view, increasing salinity has a harmful effect on plant growth, Thus plant photosynthesis process will be reduced. Haung et al (1995) indicated that squash shoot dry weight was reduced by 46% for salinized plants.

4.2.3 Effect of amounts of irrigation water on the maximum allowable EC in irrigation water

Figure 4 shows the interactive effect of amounts of irrigation water and salinity levels on squash yield. Regardless of the water salinity treatments, the highest yield was obtained in the higher irrigation water treatment at the same irrigation water salinity. Increasing applied irrigation water from W_1 (62 mm) to W_4 (279.3 mm) for the F, 25S, FS, 75S and S treatments, significantly increased squash yield from 9.80, 8.55, 7.9, 7.22 and 4.57 to 10.80, 10.03, 9.51, 9.17 and 5.57 ton/ha, respectively. However, increasing amount of applied irrigation water

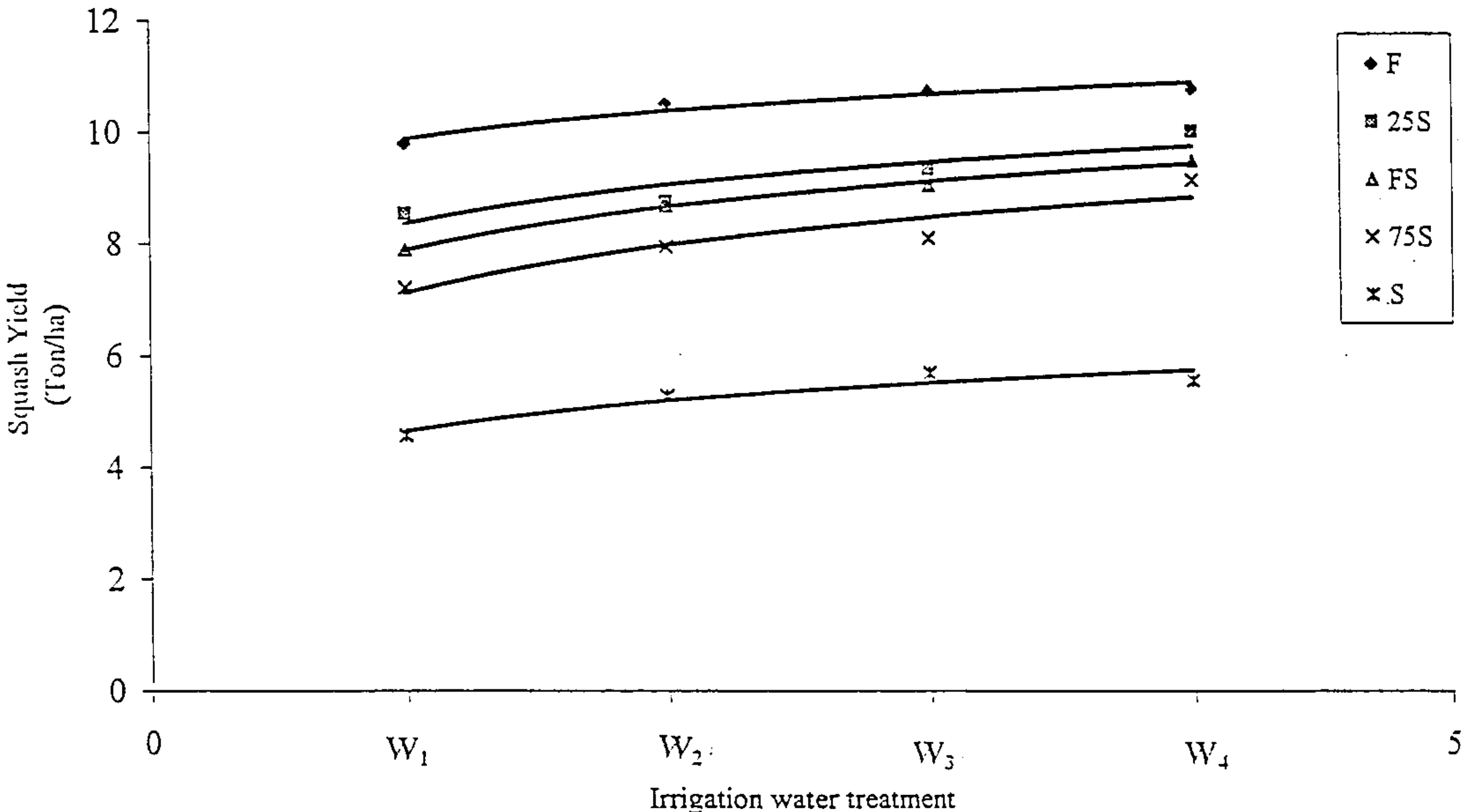


Figure4: Interactive effects of irrigation water amounts and salinity levels on squash yield (ton/ha) grown in Jordan Valley during the growing season 1998.

from W_2 (123mm) or W_3 (186mm) to W_4 (279mm) did not increase squash yield significantly at F and FS salinity treatments. While at the 25S and 75S salinity treatments, squash yield increased significantly from 9.35 and 8.12 to 10.03 and 9.17 ton/ha as irrigation water amount increased from W_3 (186 mm) to W_4 (279mm), but it was not significantly different, when the irrigation water amounts increased from W_1or W_2 to W_3 .

At S salinity treatment, increasing applied irrigation water from W_1 to W_2, significantly increased squash yield from 4.75 to 5.28 ton/ha, while comparing the yield obtained in W_2, W_3 and W_4 irrigation water applied, shows no significant increase in squash yield.

At the same irrigation water treatment, squash yield decreased as irrigation water salinity has increased. The highest yields were obtained in fresh irrigation water treatments, for the all irrigation water treatments. Increasing irrigation water salinity using 25% saline water with the applied irrigation water (25S treatment), decreased squash yield about 12, 16.7, 11.5, and 1.7% for W_1, W_2, W_3 and W_4 irrigation water treatments, respectively.

Another increment increase (25%) in irrigation water salinity has decreased the squash yield by 19, 17.5, 14, and 12 for W_1, W_2, W_3, and W_4 irrigation water treatments, respectively. The further increase in irrigation water salinity (another 25%), caused squash yield to decrease by 26, 24, 23, and 15 for W_1, W_2, W_3, and W_4 irrigation water treatments, respectively.

With W_3, squash yield in 75S treatment was significantly lower than that in FS treatment, due to the increase in irrigation water salinity (from 3.65 to 4.7dS/m for the FS and 75S treatments, respectively). Since the amount of irrigation water applied has increased by 50% (from W_3 to W_4), squash yield for the 75S and W_4 treatment was not significantly different from that of FS and W_3 treatment. This indicates that the increase in the irrigation water amount might compensate for the negative effect of irrigation water salinity on squash yield.

The positive effect of increasing irrigation water amount on salinity could be clearly noticed when FW_1, FW_2, and FW_3 treatments compared with $25SW_1$, $25SW_2$, and $25SW_3$ treatments. Squash yield for the 25S W_1 and $25SW_2$ were significantly lower than those of F W_1, FW_2 and FW_3 due to the increase in irrigation water salinity from 1.4 (F) to 2.5 dS/m (25S). But despite of the increase in irrigation water salinity (from 1.4 dS/m to 3.6 and 4.7 dS/m), squash yield obtained with the higher amounts of irrigation water ($75SW_4$, FSW_3, and FSW_4) were not significantly different from that in FW_1 (Fresh water) treatment. Increasing irrigation water amounts has minimized the adverse effect of irrigation water salinity on squash yield, through all irrigation water salinity treatments, till the 75S treatment, beyond this salinity treatment, increasing amount of irrigation water from W_2 to W_4 did not compensate for the negative effect of salinity, due to the increase in salt accumulation in the soil profile.

Regression relationship for squash yield as affected by (EC_e)

saturation past extract salinity was used to determine the closer fit toMass and Hoffman (1977). In this model squash relative yield (Y) is expressed as:

$$Y = 100 - b\,(EC_e - a) \quad \text{.......} \quad (1)$$

Where a is the threshold value of EC_e beyond which yield begin to decline as root zone salinity increases.

b is the rate (%) yield decline per unit increase in root zone salinity above the threshold value.

The maximum squash yield and the derived empirical coefficient a and b for equation (1) for the different water levels are presented in Table 7. The tolerance thresholds (maximum allowable EC_e without a decline in squash yield) were 3.5, 3.5, 3.6 and 3.6 dS/m in W_1, W_2, W_3 and W_4 treatments, respectively. The yield reduction for each unit increase in salinity above the threshold were 11.7, 3.6, 9.6, and 10.5% in W_1, W_2, W_3, and W_4 treatments, respectively (Figure 5).

Table 7: Maximum squash yield (Y_{max}) and the derived coefficient of Mass and Hoffman equation for the different irrigation water levels.

Water level	Y_{max} (ton/ha)	a(dS/m)	b (%)
W_1	9.7	3.5	11.7
W_2	10.5	3.5	3.6
W_3	10.6	3.6	9.6
W_4	10.8	3.6	10.5

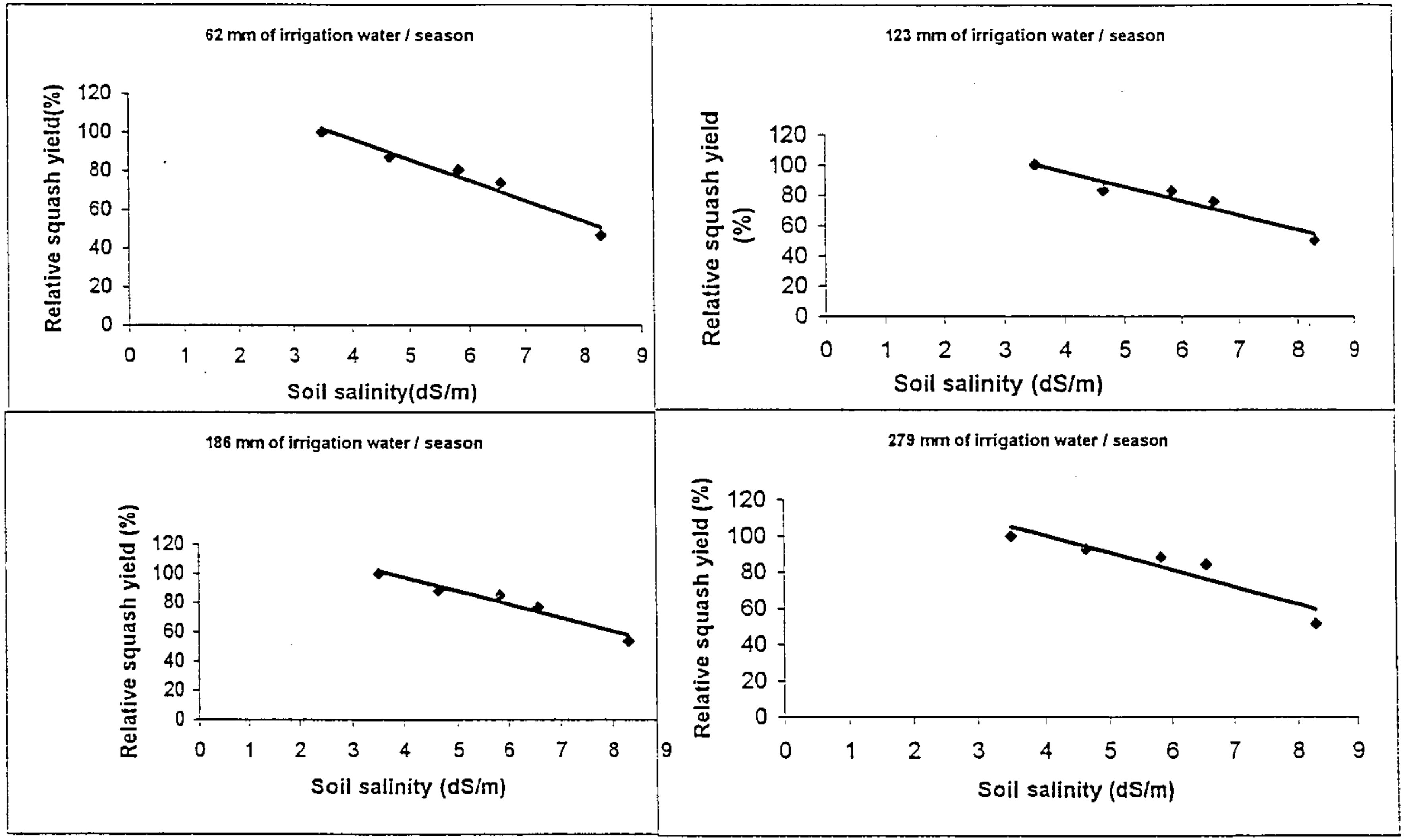


Figure 5. Relative squash yield as influenced by average crop root zone salinity and four different amounts of irrigation water at the end of growing season.

4.3 Effect of the different water amounts and salinity on soil salt distribution

It is expected that using saline water as a source of water for irrigation will be associated with salt accumulation in the crop root zone (Ayers and Westcot,19985). But this accumulation will depend upon the type of the irrigation system and the irrigation management. The initial crop root zone salinity at 20, 40, 60 and 80 cm depth were 1.1, 0.7, 0.75 and0.75dS/m, respectively (Table 8).

Table 9 shows that increasing irrigation water salinity resulted in a varied increase in the average crop root zone saturation paste extract salinity (EC_e) at the end of the growing season. Crop root zone salinity increased from 3.4, 3.1, 3.6 and 3.8 to 8.2, 8.4, 8.4 and 8.4 dS/m as irrigation water salinity increased from 1.4 (Fresh water) to 5.8 dS/m (saline water) at water levels W_1, W_2, W_3, and W_4 treatments, respectively, and from 3.4, 3.1, 3.6 and 3.8 to 4.6, 4.3, 4.7 and 4.9 dS/m as irrigation water salinity increased from 1.4 to 2.5 dS/m for the same respective water levels. Saturation paste extract salinity was increased, as irrigation water salinity increased, but increasing irrigation water amount from W_3 (186 mm) to W_4 (279 mm), decreased average crop root zone salinity from 7.2 to 6.3 dS/m, respectively, in the 75S irrigation salinity treatment, but EC_e remains constant in S irrigation salinity treatment for the same respective increment of water level. Increasing amounts of

Table 8: Initial crop root zone salinity in the location of the study

Soil depth (cm)	Soil saturation paste extract salinity in (dS/m)
0-20	1.10
20-40	0.70
40-60	0.75
60-80	0.75
Average	0.83

Table 9: Saturation soil paste extract salinity at crop root zone (EC_e in dS/m) as influenced by four water amounts and five irrigation water salinity levels at the end of the growing season.

Treatment	F	25S	FS	75S	S
W_1	3.4	4.6	5.5	5.8	8.2
W_2	3.1	4.3	6.1	6.9	8.4
W_3	3.6	4.7	5.5	7.2	8.4
W_4	3.8	4.9	6.1	6.3	8.4

applied saline water from W_1 to W_4 increased crop root zone salinity. In general, increasing the electrical conductivity of the irrigation water increased EC_e in the crop root zone, and increasing amount of saline water applied increased salt accumulation in the soil profile. Results indicated that irrigation water salinity was the most significant factor affecting soil salt accumulation in the crop root zone for this study conditions.

Figure 6-10 show the horizontal and vertical spatial salt distribution. It is obvious that substantial variation in the salt content has occurred depending on the irrigation treatments.

Under low amounts of irrigation water salt tended to accumulate slightly at the restricted wetted area close to the drip line , and has higher concentration values in soil profile as its concentration in irrigation water increase .With fresh irrigation water treatments (F), in the limited irrigation water amounts (W_1 and W_2), salts tended to accumulate in the vicinity of the crop root zone (Figure 6, a and b), while increased amounts of application water tended to leach salts out of the root zone (Figure 6 ,c and d). At 25S irrigation water salinity treatments, increasing irrigation water amounts from W_2 to W_3, increased salts accumulation with distance and depth, with sharp salt accumulation at the edges of the root zone (Figure 7 ,c). Also increasing irrigation water salinity to 3.65 dS/m (FS), salts tended to accumulate close to the surface and away from the emission points(Figure 8, a and b) with the same trend as in the fresh (F) salinity treatment. While for the 75S irrigation salinity treatments, sharp accumulation of salts has occurred toward the line source of trickle irrigation in W_2 treatment due to the increase in irrigation water salinity (Figure 9, b). In W_3 treatment, gradual accumulation of salts occurred at the bottom layer of the profile and away from the emission point (Figure 9, c). While In W_4 treatment, salt tended to accumulate gradually at the upper layer of the profile and away from the source lines of trickle irrigation (Figure 9, d), different from that in F, 25S and FS treatments. Due to high concentration of salts in this treatment (75S).

Under the low irrigation amounts (W_1 and W_2), in saline irrigation treatment (s) the salt tended to accumulate at the upper layer close to emitter (Figure 10 a and b). While increasing irrigation water amounts from W_1 to W_3 and to W_4, force salts to accumulate at the far side from the dripper in both vertical and horizontal directions. (Figure 10 c and d).

Fig 6 (a-d): Vertical and horizontal soil salt distribution in F salinity treatment under four different amounts of water.

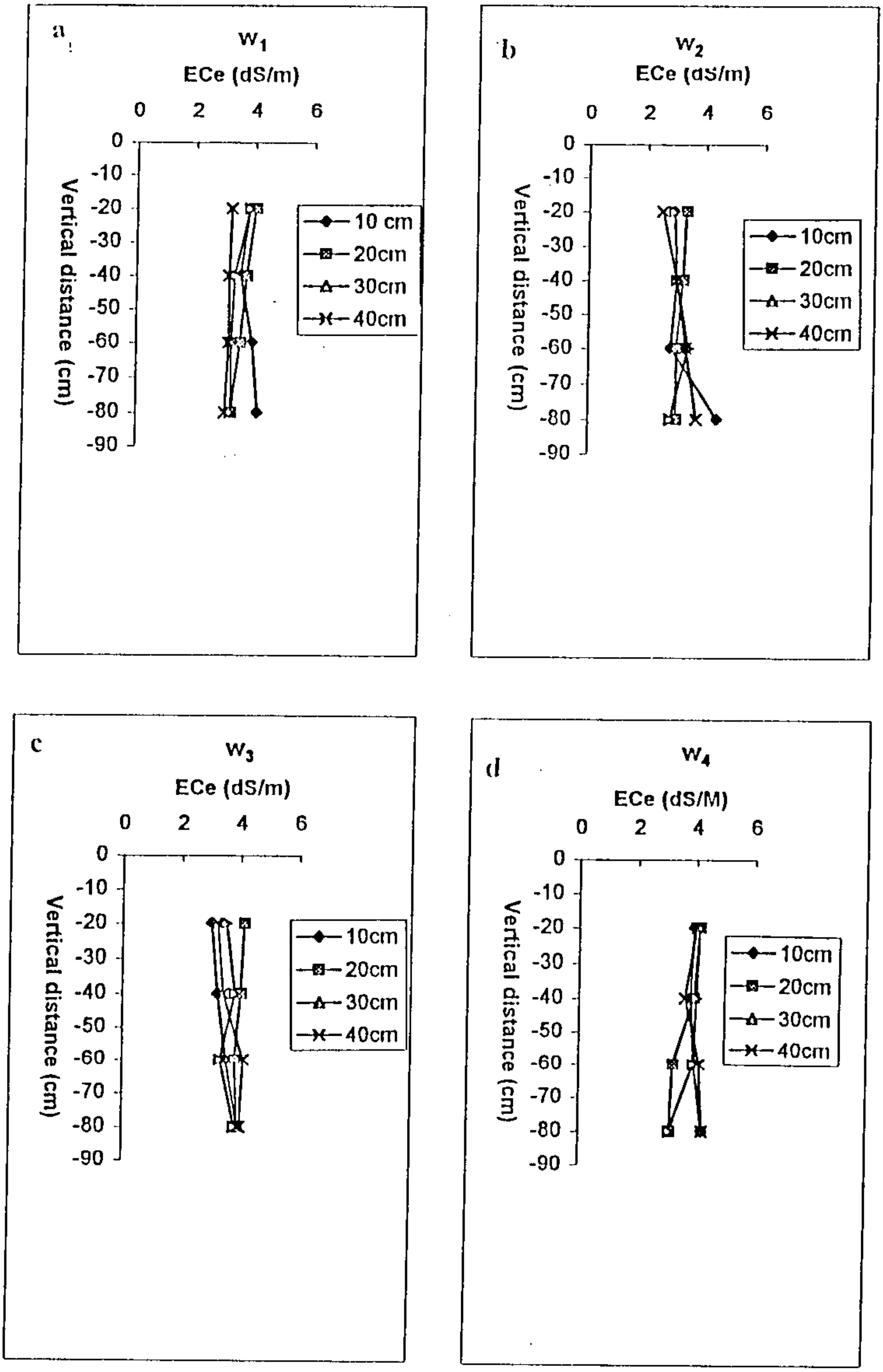


Fig 7 (a-d): Vertical and horizontal soil salt distribution in 25S salinity treatment under four different amounts of water.

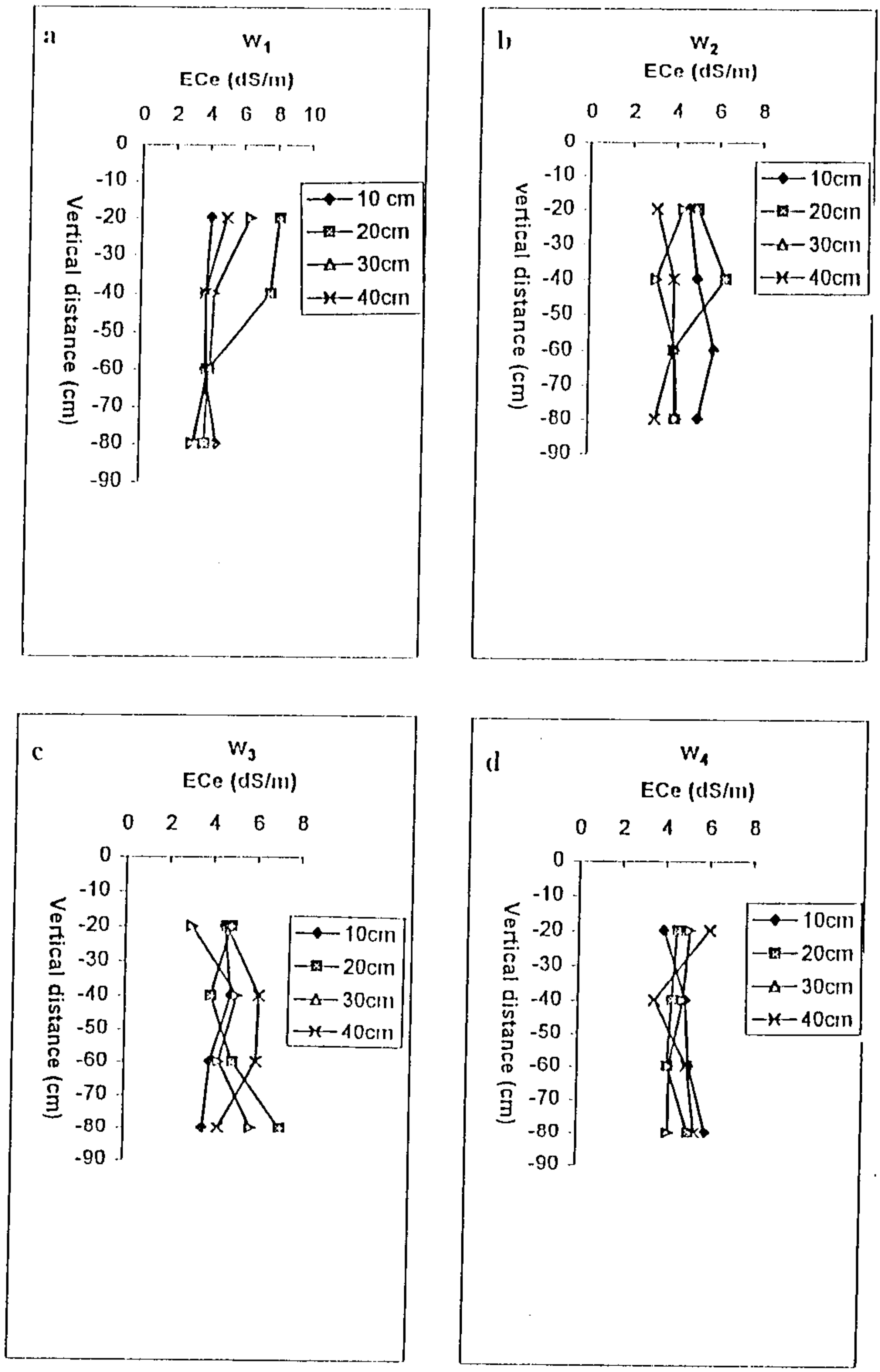


Fig 8 (a-d): Vertical and horizontal soil salt distribution in FS salinity treatment under four different amounts of water.

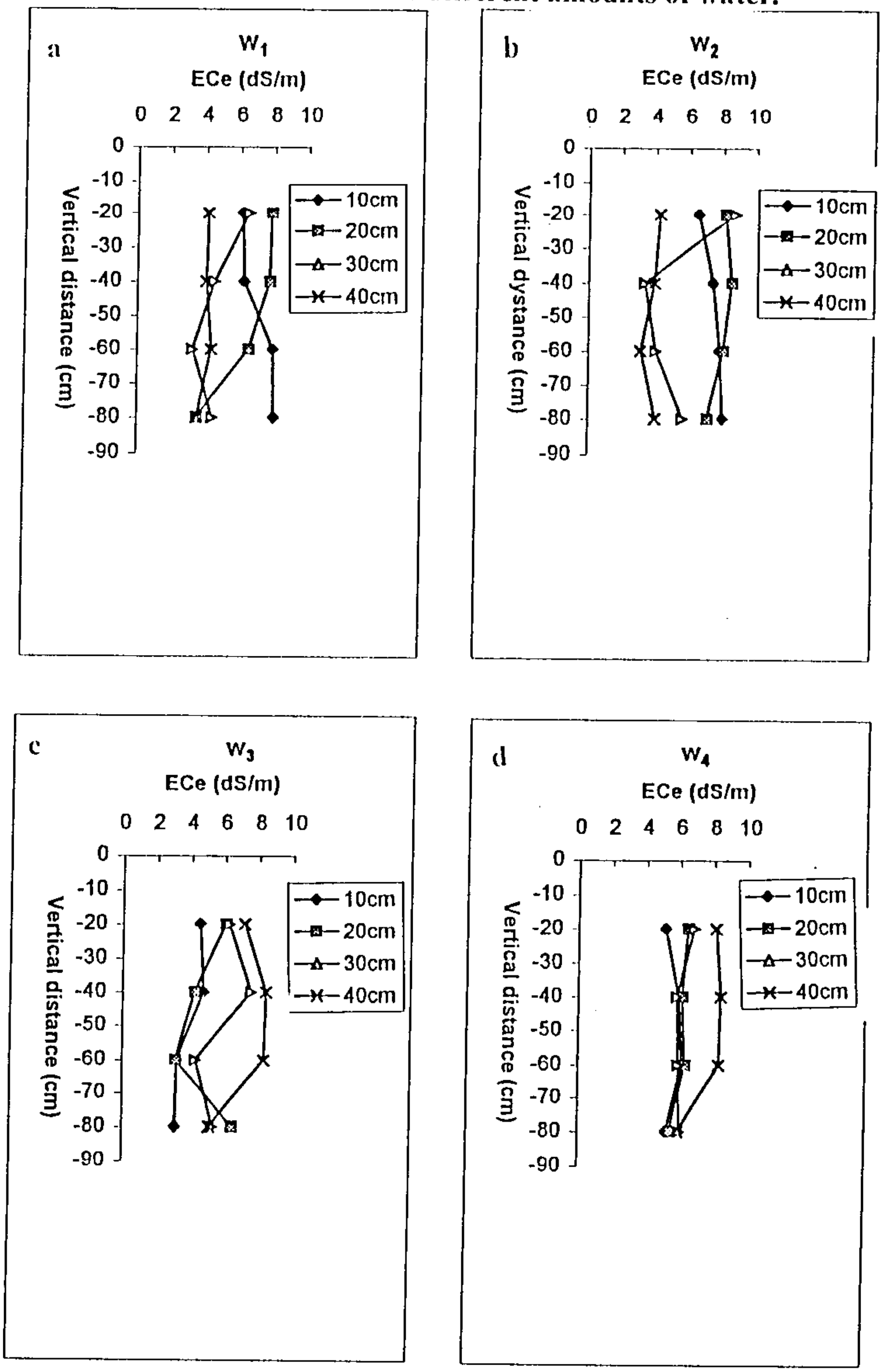


Fig 9 (a-d): Vertical and horizontal soil salt distribution in 75S salinity treatment under four different amounts of water.

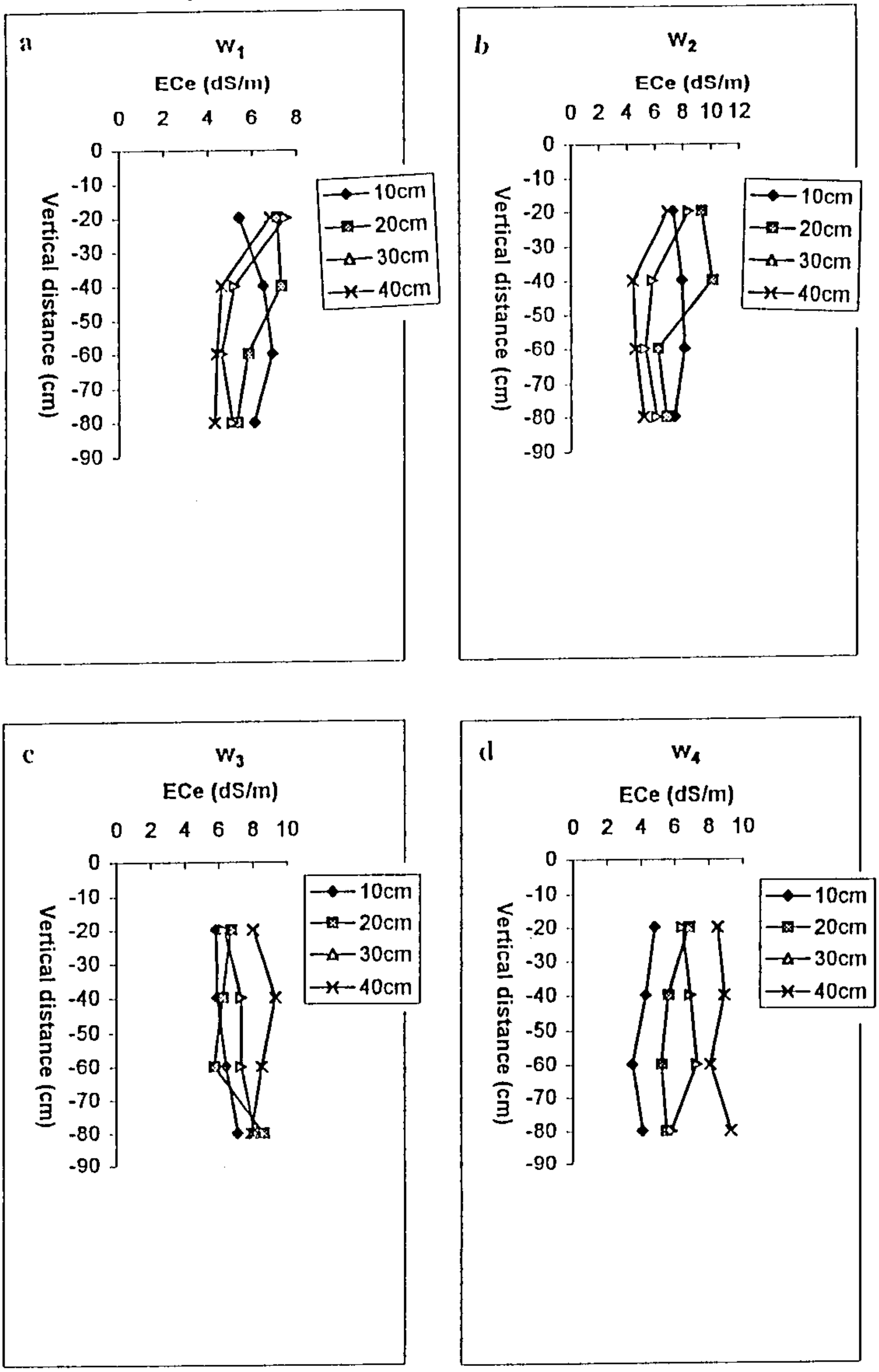
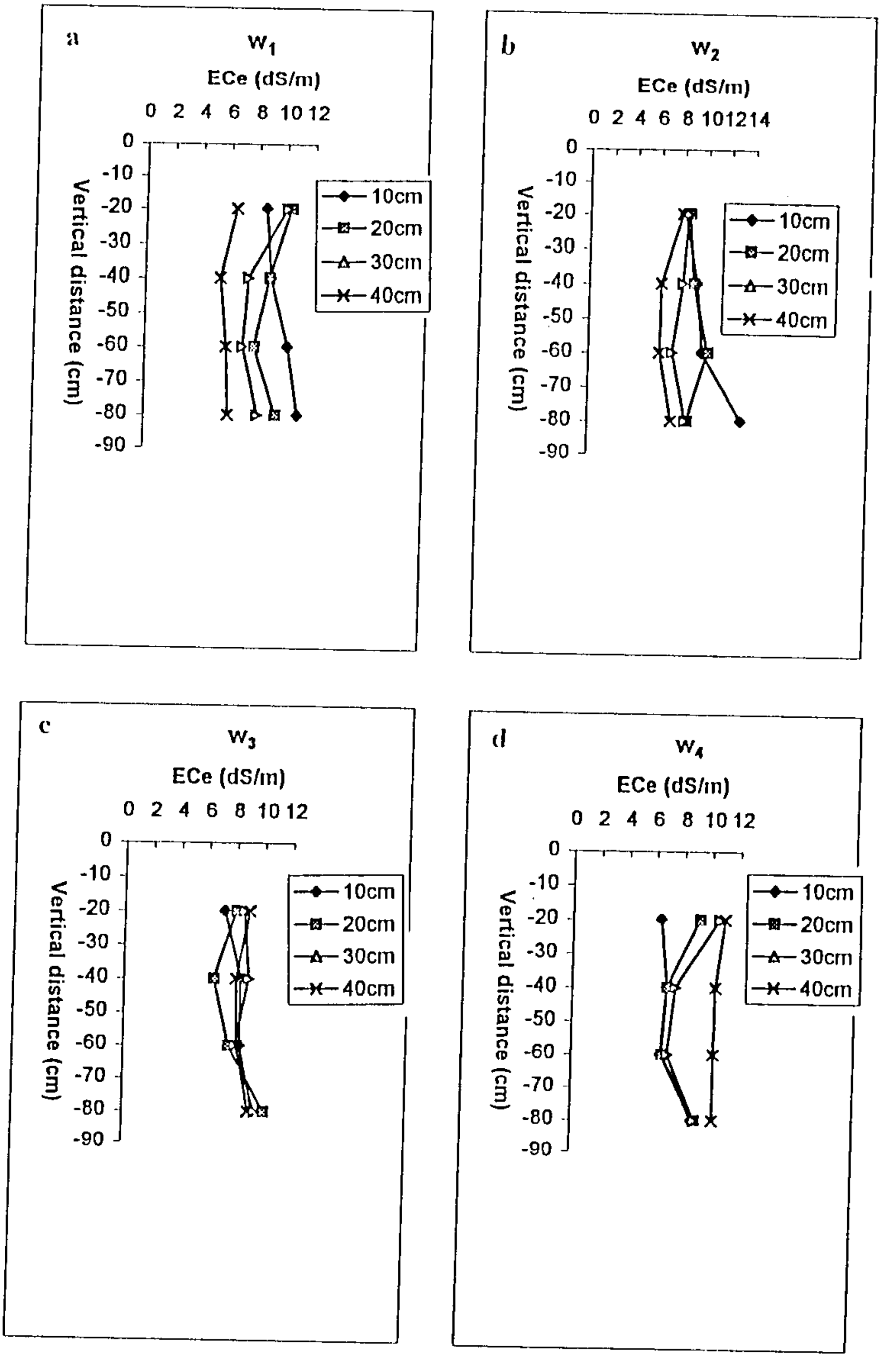


Fig 10 (a-d): Vertical and horizontal soil salt distribution in S salinity treatment under four different amounts of water.



4.4. Effect of the different water amounts and salinity levels on squash shoot dry weight

Statistical analysis indicated that squash shoot dry weight was significantly affected by the interaction of the different water amounts and salinity levels, (Appendix B).

Table 10 shows that fresh water (F) in the highest water amount (W_4), produced significantly higher squash shoot dry weight as compared with squash shoot dry weight in all other treatments.

Squash shoot dry weight produced at the second salinity level (25 S) with high amount of water (W_4) is significantly higher than that produced using fresh water with the lower levels of water amounts (W_3). In general, squash shoot dry weight, produced at the high level of irrigation water salinity treatment (S,75S) associated with the high level of irrigation water amounts (W_4), was not significantly different as compared with squash shoot dry weight produced in the treatments with the low irrigation water salinity levels associated with low level of irrigation water amounts (F and W_1 and FS and W_2).

Shalhevet and Hsiao (1986) indicated that plant has a similar response to water salinity and drought.

The lowest squash shoot dry weight (Table 10) produced in S and W_1 treatment, which has the highest irrigation water salinity (5.8 dS/m) and the lowest irrigation water amount (62mm). It was significantly lower than all other treatment.

Table 10: Squash shoot dry weight as influenced by amounts and salinity of irrigation water.

Water amount treatment	Water salinity	Shoot dry weight ton/ha
W_1	F	1.94 cde
W_1	25S	1.53 h
W_1	FS	1.70 efgh
W_1	75S	1.52 h
W_1	S	1.19 i
W_2	F	1.79 defg
W_2	25S	1.79 defg
W_2	FSS	1.83 cdefg
W_2	75S	1.65 fgh
W_2	S	1.70 efgh
W_3	F	1.96 cd
W_3	25S	2.07 bc
W_3	FS	1.89 cdefg
W_3	75S	1.90 cdef
W_3	S	1.64 gh
W_4	F	2.72 a
W_4	25S	2.30 b
W_4	FS	2.03 cd
W_4	75S	1.98 cd
W_4	S	1.84 cdefg

4.5 Effect of the different water amounts and salinity levels on the number of squash fruits.

Number of fruits per hectare as affected by the different water amounts and salinity levels are presented in Table 11. The highest number of fruits per hectare (205860) was obtained in F and W_3 treatment, while the lowest number of fruits per hectare (13186) was occurred in S and W_4 treatment, increasing irrigation water salinity decreased the number of fruits per hectare. Similar results were also reported by Francois (1985) who showed that the number of fruits per plant of two squash cultivares Scallop and Zucchini were significantly decreased from 10.3 and 8.3 to 1.5 and 6 no/plant as root zone soil salinity increased from 1.8 to 8.9 dS/m, for the two cultivares , respectively. While increasing the amount of irrigation water to W_3 significantly increased the number of fruits per hectare. However increasing irrigation water amount more than W_3 to W_4 treatment significantly decreased the number of fruits per hectare, with all salinity levels, but not with the 75S treatment. That might be due to the physiological effect of the excess amount of water.

Table 11: Number of fruits as influenced by different water amounts and salinity levels.

Treatment	F	25S	FS	75S	S
W_1	58518 de	57262 de	62227 d	27718 h	25408 hi
W_2	62720 d	66823 cd	48422 ef	40775 fg	23164 hi
W_3	205860 a	123497 b	66521 cd	26016 h	32525 gh
W_4	62340 d	76629 c	42716 fg	23246 hi	13186 j

4.6 Effect of the different water amounts and salinity levels on crop seasonal evapotranspiration

4.6.1 Effect of the different amounts of irrigation water on crop evapotranspiration

Statistical analysis (Appendix B) indicated that seasonal crop evapotranspiration was significantly affected by the different irrigation water amounts.

Figure 11 shows that the highest seasonal crop evapotranspiration (162.9 mm) was in the W_4 treatment, which is significantly higher than that in W_3 (136.5), W_2 (97.2) and W_1 (55.5) treatments. Seasonal crop evapotranspiration in W_3 irrigation water treatment was significantly higher than that in W_2 and W_1 treatments. The lowest seasonal crop evapotranspiration (55.5 mm) was in the W_1 treatment, which is significantly lower than that in W_2 (97.2 mm) treatment. It is clearly that any increment in irrigation water amount was significantly contributed in the seasonal crop evapotranspiration , thus indicates that salts caused water stress, which is partialy reduced by increasing water applied.

Abu-Awwad 1994 indicated that increasing total water applied decreased soil water contribution to seasonal crop evapotranspiration.

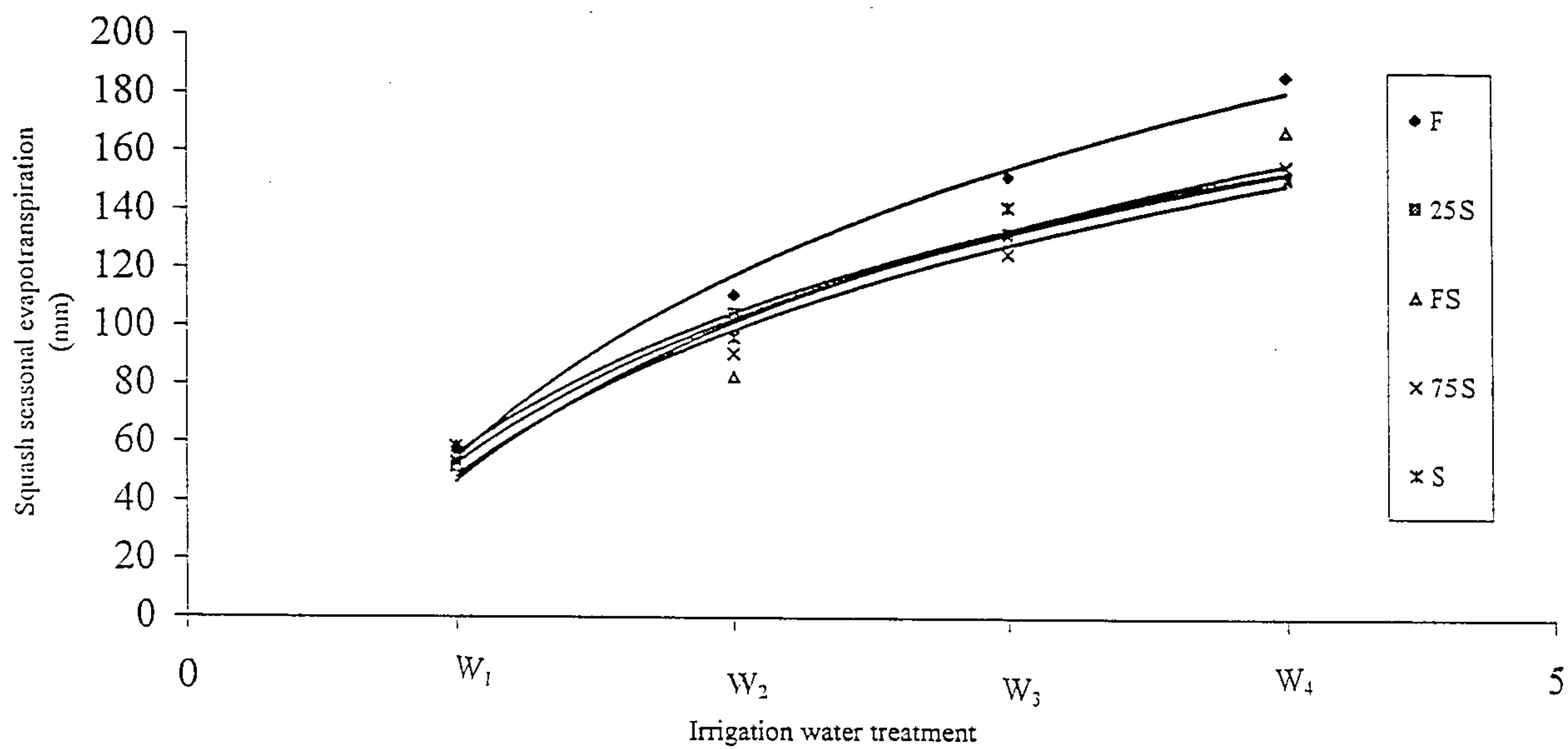


Figure11: Interactive effects of irrigation water amounts and salinity levels on squash evapotranspiration (mm) in Jordan Valley during the growing season 1998.

4.6.2 Effect of irrigation water salinity on crop seasonal evapotranspiration

Statistical analysis showed that seasonal crop evapotranspiration was significantly affected by irrigation water salinity levels (Appendix B). Table 12 shows that with fresh irrigation water (F), crop evapotranspiration was significantly the highest as compared with crop evapotranspiration at 25S, FS, 75S and S treatments. Increasing irrigation water salinity from 1.4 (F treatment) to 2.5 dS/m (25S treatment) significantly decreased crop evapotranspiration by 13.8%. Whereas, there was no significant reduction in crop evapotranspiration, as irrigation water salinity has increased from 2.5 dS/m to 5.8 dS/m, in FS, 75 S and S treatments. This is might be due to the partial compensation for the adverse effect of irrigation water salinity, occurred by increasing water applied (Abu-Awwad 1994).

Table 12: Effect of irrigation water salinity on squash seasonal evapotranspiration.

Treatment	ET (mm)*
F	127.1 a
25S	109.5 b
FS	112 b
75 S	106.3 b
S	110.2 b

*Values followed by the same letter are not significantly different.

4.7 Effect of the different irrigation treatments and the salinity levels on seasonal water-budget.

Seasonal water-budget components as influenced by the four water quantities (W_1, W_2, W_3, and W_4) and five irrigation water salinity treatment (F, 25S, FS, 75S, and S) are presented in Table 13. Soil water content at the beginning of the season was about 68 mm, which was nearly close to the field capacity. Increasing water amounts from W_1 to W_2 and to W_3 increased final soil water content by 11.5 and 7.5%, at F irrigation water salinity treatment. while increasing water amounts from W_1 to $W_2$and W_3 decreased final soil water content by 0.73 and 0.23 % at 25S salinity treatment, respectively.

Regardless of irrigation water salinity treatment, increased water amounts from W_1 to W_2 increased the final soil water content at all treatments.

Increasing irrigation water amounts from W_3 to W_4, increased final soil water content by 11.9 ,21.9 ,3.8 and 25.8% in the 25S, 75S, FS and S salinity treatment, respectively.

Black plastic mulch helps in maintaining soil moisture in the soil profile homogeneous. Increasing irrigation water amounts from W_1 to W_2, W_3, and W_4, increased the total drainage water at all irrigation water salinity treatment, with the highest drainage (128 mm) occurred in W_4 water level and 25S irrigation water salinity treatment.

Table 13: Seasonal Water-budget component as influenced by salinity and quantity of irrigation water.

Treatment	FW_1	FW_2	FW_3	FW_4	$25SW_1$	$25SW_2$	$25SW_3$	$25SW_4$	FSW_1	FSW_2	FSW_3	FSW_4	$75SW_1$	$75SW_2$	$75SW_3$	$75SW_4$	SW_1	SW_2	SW_3	SW_4
Irrigation depth(mm)	62	123	186	279	62	123	186	279	62	123	186	279	62	123	186	279	62	123	186	279
Beginning soil water (mm)	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
Final soil water (mm)	55.6	62	66.6	61.2	68.4	67.9	59.7	66.8	59	76.1	44.3	54	67	75.1	70.5	73.2	61.5	74.7	56.4	71
Drainage depth(mm)	16.2	17.8	35	99	10	18.4	63	128	14.5	32	79	125	10	25	58	118	10	20	56	124
Saesonal water use(mm)	58.17	111.17	152.4	186.8	51.6	104.7	131.3	152.2	56.5	82.9	130.7	168	53	90.9	125.5	155.8	58.5	96.3	141.6	151.9

4.8 Effect of the different water amounts and salinity levels on water use efficiency

Water use efficiency (WUE), defined as the total yield obtained (ton/ha) divided by the total depth of evapotranspiration (mm).

Statistical analysis indicated that water use efficiency was significantly affected by the different irrigation water amounts and salinity levels, (Appendix B).

Table 14 shows that water use efficiency increased as the amount of irrigation water applied decreased from W_4 to W_1, with the maximum WUE occurred in W_1 treatment, while increasing irrigation water salinity decreased WUE with the minimum WUE occurred in S treatment.

The highest WUE occurred in F and W_1, and 25S and W_2 treatments (0.17 ton/ha.mm).

In general, increasing irrigation water salinity slightly affectd WUE. This is might be due to the reduction in the squash yield, which occurred at the high irrigation water salinity treatments. Sharma, et al. 1991 stated that application of saline drainage water with increasing salinity levels decreased the water use efficiency.

Table 14: Water use efficiency (Kgm^{-3}) as influenced by four water levels and five irrigation water salinity.

Treatment	F	25S	FS	75S	S*
W_1	17 a	17 a	14 b	14 b	8 ef
W_2	10 cd	8 ef	11 c	9 de	6 g
W_3	7 fg	7 fg	7 fg	6 g	4 h
W_4	6 g	6 g	6 g	6 g	4 h

* Values followed by the same letter are not significantly different.

4.9 Effect of the different irrigation water amounts and salinity levels on soil chemical properties

Some soil chemical properties were determined before the initiation of the study (Table 15). The soil was characterized as sandy clay loam with alkaline pH (8.5-8.8). Analysis indicated that all soil extractable cations and anions were within the normal concentration ranges, of the local agricultural soils, while it has low amounts of total dissolved solids. Sodium adsorption ratio ranged from 5.1 to 5.5 through the soil profile.

Irrigation with saline water is expected to increase concentration of some soluble salts in the soil. Table 16 shows some soil chemical properties at the end of the growing season.

The minimum value (7.1) of soil reaction (pH) was recorded at $25SW_4$ and at maximum (8.7) at FW_3 treatments, This agrees with results obtained by Batchelder et al. (1963) who found that increasing soil salinity resulted in a corresponding decrease in soil pH. Sodium, Ca and Cl were greatly increased, while K, HCO_3 and B were nearly not affected by saline irrigation water.

Table 15: Some pregrowing soil chemical properties.

Soil depth (cm)	EC_e	pH	Mg	Na	K	Ca	Cl	HCO_3	SO_4	B	SAR
	dS/m		me/l	me/l	me/l	me/l	Me/l	me/l	me/l	mg/l	
0-20	1.1	8.75	0.80	7.2	0.9	3.0	1.30	8.0	1.5	0.17	5.22
20-40	0.7	8.79	0.55	5.0	0.7	1.2	1.57	5.0	2.6	0.18	5.34
40-60	0.8	8.50	0.51	5.1	0.7	1.2	1.25	4.5	2.5	0.15	5.5
60-80	0.8	8.65	0.32	4.6	0.6	1.3	1.50	3.8	2.4	0.14	5.4
80-100	0.7	8.70	0.38	5.2	0.9	1.4	0.98	4.8	2.7	0.17	5.51

Table 16: Some postharvest soil chemical properties

Treatment	EC_e	pH	Mg	Na	K	Ca	Cl	HCO_3	SO_4	B	SAR
	dS/m		me/l	me/l	me/l	me/l	me/l	me/l	me/l	mg/l	
FW_1	3.4	7.5	5.3	19.0	1.25	20.5	20.6	7.0	4.34	0.64	5.29
FW_2	3.1	8.0	4.5	20.1	1.44	16.3	21.8	6.0	6.14	0.17	6.23
FW_3	3.6	8.7	4.1	21.5	1.25	16.5	27.2	4.5	4.34	0.24	6.69
FW_4	3.8	7.8	4.0	18.6	1.30	15.5	25.5	4.0	4.94	0.37	5.95
$25SW_1$	4.6	8.0	5.3	18.2	1.47	20.3	23.7	5.1	6.14	0.70	5
$25SW_2$	4.3	8.2	5.0	16.4	1.77	15.5	27.2	5.5	6.94	0.35	5.1
$25SW_3$	4.7	8.4	5.1	19.4	1.28	19.5	19.5	5.0	4.94	0.10	5.53
$25SW_4$	6.3	7.1	6.5	23.4	0.57	20.0	26.5	7.0	8.94	0.07	6.42
FSW_1	5.5	7.5	7.1	21.1	1.37	25.5	24.5	17.5	6.94	0.19	5.22
FSW_2	6.0	8.3	6.5	20.2	1.47	21.0	22.4	11.0	10.94	0.44	5.44
FSW_3	5.5	8.3	7.4	21.0	1.38	24.0	25.5	17.5	8.94	0.17	5.3
FSW_4	6.1	8.4	6.0	26.6	1.37	17.0	29.2	9.5	11.34	0.10	7.8
$75SW_1$	5.8	8.3	8.5	22.2	1.57	19.0	29.2	12.0	8.14	0.14	5.98
$75SW_2$	6.9	8.3	3.8	22.6	1.21	17.5	25.8	6.5	8.94	0.03	6.92
$75SW_3$	7.2	8.4	9.0	27.2	1.49	28.0	28.4	5.5	7.94	0.92	6.32
$75SW_4$	6.3	7.2	5.6	26.6	1.21	20.4	25.6	7.0	7.14	0.57	7.3
SW_1	8.2	8.3	7.0	23.5	1.29	23.0	28.4	7.0	3.94	0.17	6
SW_2	8.4	8.0	6.4	23.3	1.44	21.5	28.2	8.0	8.94	0.17	6.2
SW_3	8.2	7.5	7.8	28.8	1.80	23.5	29.6	6.2	1.36	0.77	7.28
SW_4	8.4	7.5	6.3	26.2	1.57	22.0	28.9	6.0	12.74	0.71	6.96

The concentration of Mg in the soil solution has a slight increase, depending on the increase in irrigation water salinity, the high value (7.8 me/l) was found at S and W_3 treatment.

The slight increase in Mg concentration could be attributed to some Mg precipitation as $MgCO_3$ and $MgSO_4$ At fresh (F)and 25S salinity treatment, the high concentration of sulfur occurred in W_2 (123 mm) treatment, and decreased as the amount of water increased. This is might be due to the leaching by excess water. Increasing of irrigation water salinity, either increased or did not affect the soil solution Ca. Jury et al. (1978) showed that the rate of Ca precipitation as $CaCO_3$ and $CaSO_4$ was enhanced by the release of Ca ions into soil solution from exchange complex.

Sodium and Cl contents, were increased in soil solution as irrigation water salinity increased. The Na content increased from 16.4 me/l in 25S and W_2 to 28.8 me/l in S and W_3 treatments.

Soil solution Cl was higher than Na and ranged from 19.5 me/l at 25S and W_3 to 29.6 me/l in S and W_3 treatments. Due to the high mobility and solubility of chloride, the higher Cl concentration gives a clear indication of soil salinization.

Specific toxicity of Na was evaluated by calculating sodium adsorption ratio (SAR) of soil solution. The SAR values were greatly affected by salinity treatments. The highest value of SAR (6.96) was obtained in saline water treatment S (5.8 dS/m) at W_4 water amount treatment (279 mm), while the lowest one (5) was occurred in 25S (2.4 dS/m) at W_1 water amount treatment (62 mm). It is obvious that increasing of irrigation water salinity increased SAR values gradually.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

1. The highest yield was at the fresh irrigation water treatment, and increasing irrigation water salinity decreased crop yield.
2. Using saline water could cause a serious problem, if not mixed or diluted with fresh water.
3. Increasing the amounts of irrigation water relief some of the negative effects of the salinity.
4. Salt distribution tended to accumulate at the restricted wetted area close to the drip line, under low irrigation water amount treatments.
5. Increasing irrigation water amount leached salts to a deep distance from the emission point.
6. Evapotranspiration rate was increased, as irrigation water amount increase, and decreased as irrigation water salinity increases.

5.2 Recommendations

1. Mixing fresh water with saline water up to 1:1 ratio, is a good method to conserve water under high efficiency system and optimum management.
2. It is recommended to increase the amount of water applied with low water quality for agriculture.

6. REFERENCES

- Abdualziz, M. H. 1980. Principles of irrigation and drainage engineering. 1st edition King Saud University, Riyadh.pp139-143.
- Abu-Awwad, A. M. 1994. Water use and production functions of sweet corn irrigated with saline Drainage water. *Dirasat,* vol. 21 B, No. **4**:99-114.
- Abu-Awwad, A. M. 1995. Salt distribution and soil water management for line source trickle irrigation sweet corn. *Dirasat* (pure applied science). Volume 22B, No. **1**:7-24.
- Abu-Awwad, A., and Hill, R., 1991. Tomato production and soil salt distributions under line-source trickle irrigation. *Journal of Agronomy and crop science* **167**: 188-195.
- Abu-Sharar, T. M. 1988. Response of four barley cultivars to salinity/ sodicity stress. *Dirasat.* **10**: 56-66.
- Al-Harbi, A. R. 1994. Effect of Manipulating Nutrient Solution Salinity on the Growth of Cucumber cucumis sativas L. Grown in NFT. *ACTA Horticulture*, International symposium on new cultivation system in green house. No. **361**: 267-273.

- Al-Harbi, A. R. 1995. Growth and Nutrient composition of Tomato and Cucumber Seedlings as affected by sodium chloride salinity and supplemental calcium. *Journal of plant Nutrition*, 18(7), 1403 – 1416.
- Allen, R. G., Peteira, L. S., Raes, D., and Smith, M. 1998. Crop Evapotranspiration (guidelines for computing crop water requirements). FAO irrigation and drainage paper, No. XXX. ROME last draft version to be published Nov. 1998.pp152-156.
- Al-Shater, M. S., and Al-Kusaybi, A. M. 1995. Salt affected soils, 1st edition. King Faisal University. AL-HESSA.pp86.
- Ayars, J. E., Hutmacher, R. B., Schoneman, R. A., Vail, S.S., and Pflaum, T. 1993. Long term use of saline water for irrigation, *irrigation science*, **14**: 27-34.
- Ayers, R. s., and westcot, D. W.,1985. Water quality for agriculture. FAO irrigation and drainage paper, No. 29. ROME.pp47.
- Ayrers, R.S. 1977.Quality of water for irrigation. *journal of the irrigation and drainage division* .ASCE, vol 103,no **IR2**:135-154.
- Batchelder, A. R., Lunin, J., and Gallatin, M. H. 1963. Saline irrigation of several vegetables crops at various growth stages. II. Effect on cation composition of crops and soils. *Agronomy Journal*, volume: 55 Mar.-Apr. No. **2**:111-114.

- Bielorai, H., Shalhevet, T., and Levy, Y. 1978 Grapefruit response to variable salinity in irrigation water and soil. *Irrigation science* **1**, 61-70.

- Blake, G. R. 1965. Bulk density in CA Black (ed.) methods of soil analysis part1. Agronomy. 9: 374-390. American. Agron. Madison. Wis.

- Bower, C. A., and Wilcox, L. V. 1965. Soluble Salts in C. A. Black (ed.) methods of soil analysis. Part 2. Chemical and microbiological properties. Agron. Amer. Soc. Madison. Wisconsin. pp. 935-937.

- Chartzoulkis, K. S. 1992. Effects of NaCl salinity on germination, growth and yield of greenhouse cucumber. *Journal of Horticultural science* 67(**1**): 115-119.

- Cossi, OL. GA. 1993 water wars: the fight to control and conserve nature's most precious resource, 1st edition, Macmillan publishing company, New york. pp 10-12.

- Deju, Z, and Jingwen, L. 1993. The water-use efficiency of winter wheat and maize on a salt effected soil in the Hung Hauai Hai river plain of china. *Agriculture Water Management*, **23**: 67-82.

- Department of Statistics. 1996. Statistical Year Book, Jordan, Amman, Number 47.

- Duplessis, H. M. 1985. Evapotranspiration of Citrus as Affected by Soil Water Deficit and Soil Salinity. *Irrigation Science* **6**: 51-61.

- Eaton, A.D., Cleseri, L.S., and Greenberg, A.E. Standard Methods for the Examination of Water and Waste Water. 19th edition. American Public Health Association, Washington, DC.pp2-26:4-137.

- Feigin, A. 1990. Interactive effects of salinity and Ammonium/Nitrate Ratio on growth and Chemical Composition of melon plants. *Journal of plant nutrition*, 13 (10), 1257-1269.

- Fereres, E. (editor) 1981. Drip-irrigation management. Leaflet 2125, University of California, 39 pp.

- Francois, L. 1985. Salinity Effects on Germination, growth and yield of two squash cultivars. *Hort science* 20 (6): 1102-1104.

- Gee, G. W., and Bauder, G. W. 1986. Particle Size Analysis in Methods Soil Analysis. Part 1, 2nd ed. American Society of Agronomy and Soil Science Society of American. Madison Wisconson, USA, pp. 399-404.

- Goldberg, D., Gornat, B., Shmueli, M., Ben-Asher, I., and Rinot, M. 1971. Increasing the Agricultural use of saline water by means of Trickle irrigation. *Water resources bulletin*, Vol. 7, No. 4: 802-809.

- Graifenberg, A., Botrini, L., Giustiniani, L., and Lipucci, M. 1996. Yield, grown and element content of zucchini squash under saline-sodic conditions. *Journal of Horticultural science*, 71:(2). 305 – 311.

- Hanks, R. J., Ashcroft, G. L., Rasmussen, V. P., and Wilson, G. D. 1978. Corn Production as Influenced by Irrigation and salinity – utah studies. *Irrigation Science* 1,47-59.

- Hassan, N. A.K., Drew, J. V., Knudsen, D., and Olson, R. A. 1970.

Influence of soil salinity on production of Dry matter uptake and distribution of nutrients in Barley and Cron. II (Corn (Zea mays L.) *agronomy journal, volume* 62. Jan.-Feb. : 46-49.

- Hassan, N. A.K.,Drew, J. V., Knudsen, D., and Olson, R. A. 1970. Influence of soil salinity on production of Dry matter uptake and distribution of nutrients in Barley and Cron. I. Barly (Hordeum Vulgare L.). *Agronomy journal, volume* 62. Jan.-Feb. : 43-45.
- Huang, B., Nesmith, D. S., Bridges, D. S., and Jerry W. Johnson. 1995. Responses of squash to salinity, waterlogging, and subsequent Drainage: II. Root and shoot Growth. *J-plant nutrition*, V 18(1): 141-152.
- Judah, O. M. 1985. Salt Accumulation under various Drip irrigation treatment. *Dirasat*, volume xii, No. 4:61-76.
- Judah, O. M., Taimeh, A., and Suwwan, M. A. 1987. Salt distribution and accumulation as affected by drip irrigation treatment for tomato grown inside plastic houses. *Dirasat* volume xiv No. **11**. 113-125.
- Jury,W.A.F., Frenkel,H., Devilt,D., and Stolez, L.H.1978.Transient changes in the soil-water system from irrigation with saline water :II.Anzlysis of experimental data. *Soil sci. soc.am. j.* **42**: 585-590

- Maas, E. V., and Hoffman, G. J. 1977. Crop salt tolerance current assessment. *Journal of the Irrigation and Drainage Difission*. ASCE, Vol. 103, No. **1R2**: 115-134.

- Malek, E., Bingham, G. E., Maccurdy, G. D., and hanks, R. J. 1992. Determination of evapotranspiration from an alfalfa crop irrigated with saline waste water from an electrical power plant. *Irrigation Science*. **13**: 73-80.

- Mendlinger, S., and Pasternak, D. 1992. Effect of time of salinization on flowering, yield and fruit quality factors in melon, cucumis melon L. *Journal of Horticulture science*. 67(4): 529-534.

- Moolman, J. H. 1989. Effect of spatial variability on the estimation of the soluble salt content in a Drip-irrigation saline loam soil. *Agricultural water management*, **15**: 361-376.

- Moukhaymer, S., and Hijazi, K. 1996. Water shortage in the Arab regions, facts and possible alternatives. Alam Al Ma'rifa, Kuwait, pp. 32-36.

- Nightingale, H. I., Hoffman, G. J. Rolston, D. E., and Biggar, J. w. 1991. Trickle irrigation rates and soil salinity distribution in an almond (prunus amygdlus) orchard. *Agriculture water management*. **19**: 271-283.

- Reichard, K. 1993. Neutron probes and their use in Agronomy, International atomic energy agency. United Nations Education, scientific and Cultural Organizations, ICFTP September.

- Rhoades, J. D., Kandiah, A., and Mashali A. M. 1992. The use of Saline waters for crop production. FAO, Irrigation and drainage paper No. 48.pp.26-46.

- Ryan, J., Garabet, S. H., Harmsen, K., and AbdeulRashid, 1996. Soil and Plant Analysis Manual Adopted for the West Asia and North Africa Region. ICARDA. pp. 80.

- Shalhevet, J., and Hsaio, C. 1986. Salinity and drought. *Irrigation Science*. 7: 249-264.

- Sharma, D. P., Sungk, K. N., Roa, K. V., and Kumbhare, P. S. 1991. Irrigation of wheat with saline drainage water in sandy loam soil *agricultural water management*, **19**: 223-233.

- Shatanawi , M., Nakashabandi. , G., and Abu-Sharar. T.1994. Indication of irrigation water quality.WERSC.U.J. Amman

- Shatanawi, M. R. 1987. Trickle irrigation and its effect on squash yield, root development and soil salinity. *Dirasat*. Vol. XIV. No. **2**: 107-118.

- Van Hoorn, J. W., Keterje, N., Hamdy, A., and Mastrorilli, M. 1993. Effect of saline water on soil salinity and on water stress, growth, and yield of wheat and potatoes. *Agriculture water management*, **23**: 247-265.

7. APPENDICES

Appendix A:

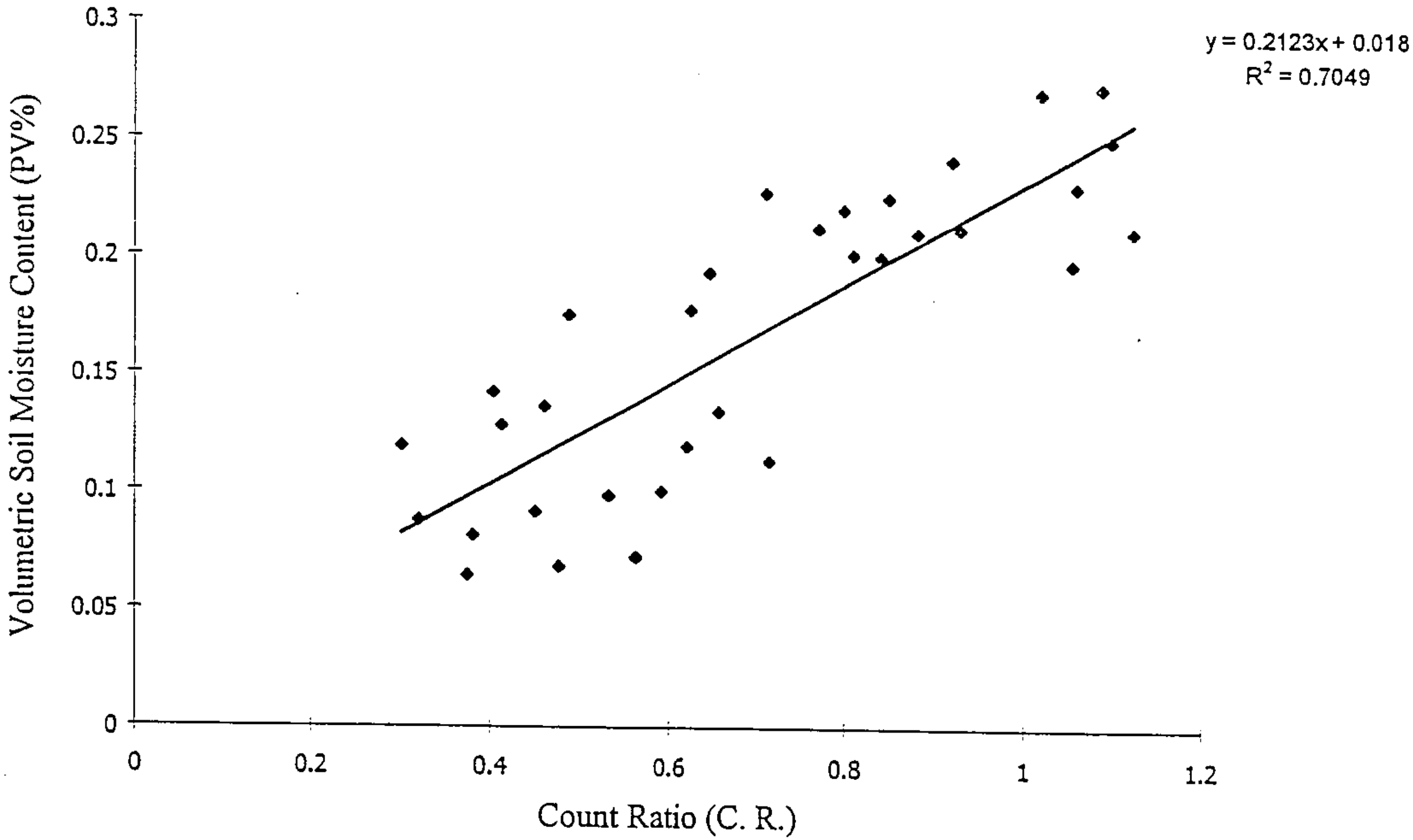


Figure (1): Neutron probe calibration curve for the soil soil depth of 15 cm.

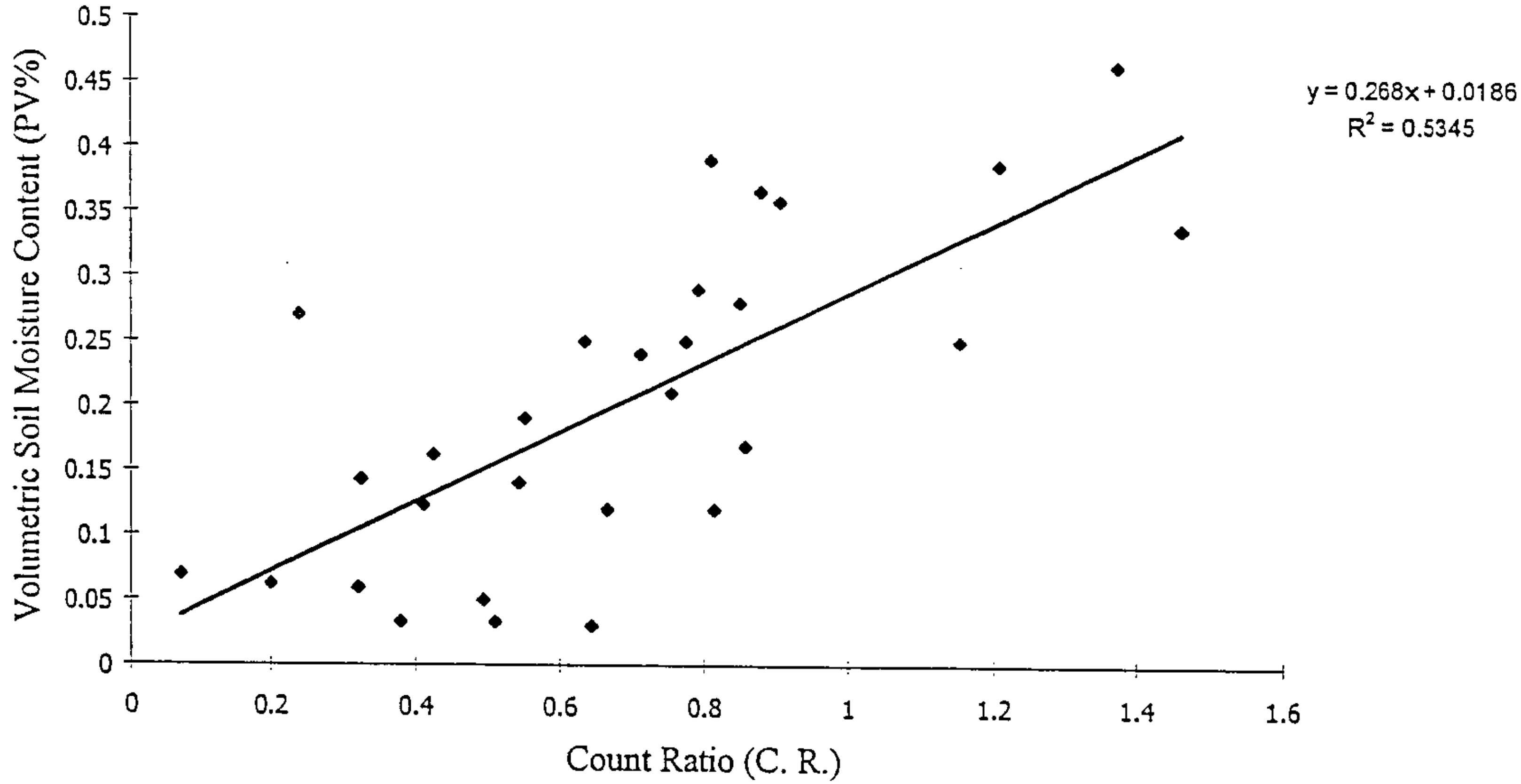


Figure (2): Neutron probe calibration curve for the soil depth of 30 cm.

Appendix: B

Analysis of variance (ANOVA) for;

Table (1): Squash yield (ton/ha) as affected by the different irrigation water salinity and amounts.

Source		DF	MS
Total		59	
Model	Replicate	2	0.69
	Water salinity (Trt)	4	43.93**
	Water amount (W)	3	5.25 **
	TRT*W	12	0.18 NS
	Error a	8	0.4
	Error b	30	0.32

Table (2): Squash shoot dry weight (ton/ha) as affected by the different irrigation water salinity and amounts.

Source		DF	MS
Total		59	
Model	Replicate	2	0.3
	Water salinity (Trt)	4	0.41**
	Water amount (W)	3	1**
	TRT*W	12	0.08*
	Error a	8	0.03
	Error b	30	0.023

Table (3): Crop seasonal evapotranspiration as affected by the different irrigation water salinity and amounts.

Source		DF	MS
Total		59	
Model	Replicate	2	649.8
	Water salinity (Trt)	4	795.7*
	Water amount (W)	3	32989.1**
	TRT*W	12	202 NS
	Error a	8	301.2
	Error b	30	184.7

Table (4). Water use efficiency as affected by the different irrigation water salinity and amounts.

Source		DF	MS
Total		59	
Model	Replicate	2	0.0001
	Water salinity (Trt)	4	0.004*
	Water amount (W)	3	0.02**
	TRT*W	12	0.0005**
	Error a	8	0.008
	Error b	30	0.0009

*DF: Degree of freedom

*MS: Mean squares

Appendix: C

Table 1: Squash yield as influenced by the different amounts of irrigation water and salinity levels.

Level of irrigation water amount	Level of irrigation water salinity				
	F	25S	FS	75S	S
W_1	9.80 bcd	8.55 fg	7.90 gh	7.22 h	4.57 j
W_2	10.53 ab	8.77 efg	8.69 efg	7.96 gh	5.28 ij
W_3	10.75 ab	9.35 cdef	9.07 def	8.12 gh	5.70 I
W_4	10.80 a	10.03 abc	9.51 cde	9.17 cdef	5.57 I

Table (2): Vertical and horizontal soils salt distribution (dS/m) for:

a. FW_1 treatment

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	3.8	4.0	3.8	3.2
Depth	40	3.5	3.7	3.3	3.1
(cm)	60	3.9	3.5	3.2	3.1
	80	4.1	3.2	3.2	3.0

b. FW_2 treatment

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	2.9	3.3	2.9	2.5
Depth	40	3.0	3.2	3.0	3.0
(cm)	60	2.8	3.0	3.4	3.3
	80	4.4	3.0	2.8	3.7

c. FW_3 treatment

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	3.0	4.1	3.5	3.2
Depth	40	3.2	4.0	3.8	3.4
(cm)	60	3.5	3.8	3.3	4.1
	80	3.9	3.9	3.8	4.0

d. FW_4 treatment

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	3.9	4.1	4.1	4.0
Depth	40	3.8	3.9	4.0	3.6
(cm)	60	3.9	3.2	3.9	4.1
	80	4.2	3.1	3.1	4.2

e. $25SW_1$ treatment

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	4.1	8.1	6.4	5.0
Depth	40	3.8	7.6	4.3	3.8
(cm)	60	3.8	4.0	4.1	3.9
	80	4.5	3.8	3.1	3.2

f. $25SW_2$ treatment

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	4.6	5.0	4.3	3.1
Depth	40	5.0	6.3	3.1	3.9
(cm)	60	5.8	3.9	4.0	3.9
	80	5.1	4.0	4.1	3.1

g. 25S W_3 treatment

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	4.5	4.8	3.0	4.6
Depth	40	4.8	3.9	5.1	6.1
(cm)	60	3.9	4.1	4.3	6.0
	80	3.6	7.1	5.8	4.3

h. 25SW_4

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	3.9	4.5	5.1	6.0
Depth	40	4.9	4.3	4.8	5.5
(cm)	60	5.1	4.1	4.2	5.0
	80	5.9	5.1	4.2	5.4

i. FSW_1 treatment

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	6.1	7.8	6.5	4.1
Depth	40	6.2	7.7	4.5	4.0
(cm)	60	7.9	6.5	3.2	4.3
	80	8.0	3.5	4.4	3.5

j. FSW_2 treatment

	Distance from trickle line (cm)				
	0	10	20	30	40
Soil	20	6.5	8.1	8.7	4.2
Depth	40	7.4	8.5	3.3	3.9
(cm)	60	7.8	8.0	4.0	3.1
	80	8.0	7.1	5.6	4.0

k. FSW_3 treatment

	Distance from trickle line (cm)				
	0	10	20	30	40
Soil	20	4.5	6.0	6.2	7.1
Depth	40	4.7	4.2	7.5	8.4
(cm)	60	3.2	3.1	4.3	8.3
	80	3.1	6.4	5.3	5.1

l. FSW_4 treatment

	Distance from trickle line (cm)				
	0	10	20	30	40
Soil	20	5.1	6.4	6.8	8.1
Depth	40	5.9	6.1	5.8	8.4
(cm)	60	6.1	6.3	5.9	5.3
	80	5.2	5.4	6.0	5.9

m. $75SW_1$ treatment

Soil Depth (cm)	Distance from trickle line (cm): 0	10	20	30	40
	20	5.4	7.1	7.5	6.8
	40	6.5	7.3	5.2	4.6
	60	6.9	5.8	4.6	4.4
	80	6.1	5.3	5.1	4.3

n. $75SW_2$ treatment.

Soil Depth (cm)	Distance from trickle line (cm): 0	10	20	30	40
	20	7.3	9.3	8.4	6.9
	40	7.9	10.1	5.8	5.4
	60	8.1	6.2	5.3	4.6
	80	7.4	6.8	6.1	5.2

o. $75SW_3$ treatment.

Soil Depth (cm)	Distance from trickle line (cm): 0	10	20	30	40
	20	5.8	6.7	6.3	8.0
	40	5.9	6.2	7.3	9.3
	60	6.4	5.7	7.3	8.5
	80	7.1	8.6	8.1	7.9

p. 75SW$_4$ treatment

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	4.8	6.8	6.4	8.5
Depth	40	4.3	5.6	6.9	8.9
(cm)	60	3.5	5.2	7.3	8.1
	80	4.1	5.5	5.8	9.3

q. S W$_1$ treatment.

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	8.5	10.3	10.0	6.4
Depth	40	8.9	8.8	7.3	5.3
(cm)	60	10.2	7.8	7.0	5.8
	80	11.0	9.4	8.1	6.0

r. S W$_2$ treatment.

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	8.0	8.4	8.3	7.8
Depth	40	9.1	8.8	7.9	6.1
(cm)	60	9.6	10.1	7.1	6.0
	80	13.0	8.4	8.3	7.1

s. SW_3 treatment.

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	7.1	7.9	8.5	8.9
Depth	40	8.3	6.4	8.9	8.0
(cm)	60	8.3	7.5	8.0	8.1
	80	9.3	10.1	9.5	9

t. S W_4 treatment.

		Distance from trickle line (cm)			
	0	10	20	30	40
Soil	20	6.3	9.1	10.5	10.9
Depth	40	6.8	6.8	7.4	10.3
(cm)	60	6.4	6.5	6.9	10.2
	80	8.7	8.9	8.9	10.2

Table3: Effect of irrigation water amounts on squash seasonal evapotranspiration.

Water treatment	Seasonal ET (mm)*
W_1	55.5 d
W_2	97.2 c
W_3	136.5 b
W_4	162.9 a

* Values followed by the same letter are not significantly different.

Table 4. Effect of irrigation water salinity on squash yield

Salinity treatment level	Average irrigation water salinity (dS/m)	Yield* (ton/ha)
F	1.4	10.4 a
25 S	2.5	9.2 b
FS	3.6	8.9 b
75 S	4.7	8.1 c
S	5.8	5.3 d

*Values followed by the same letter are not significantly different.

الملخـــص

تأثير مستويات مختلفة من كميات وملوحة مياه الري على إنتاج الكوسا باستخدام نظام الري بالتنقيط

إعداد

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المشرف المشارك

أ. د. طالب أبو شرار

نتيجة للتوسع في استصلاح الأراضي الزراعية في المناطق الجافة وشـبه الجافـة، أدى ذلك إلى استنزاف الموارد الجوفية والسطحية للمياه العذبة. وأصبح المصدر المتاح لمواكبة هـذا التوسع في الأراضي هو استخدام المياه المالحة.

هذه المياه المالحة مثلت في تجربة حقلية أجريت في محطة الأبحاث الزراعية فـي وادي الأردن خلال موسم ١٩٩٨، وكان الهدف من هذه التجربة دراسة كل من:

١. مدى استجابة محصول الكوسا لمستويات مختلفة من ملوحة وكميات مياه الري.

٢. دراسة انتشار الأملاح داخل قطاع التربة تحت نظام الري بالتنقيط.

وقد تم استخدام تصميم الألواح المنشقة وفق تصميم القطاعات العشوائية الكاملة.

تم تطبيق مستويات الملوحة المختلفة كعامل أساسي بخمسة معاملات هـي: ١,٤-٢,٥-٣,٦ – ٤,٧ و ٥,٨ ديسمنز/م أعدت عن طريق خلط المياه العذبة بالمالحة باستخدام نسب الخلـط التالية: ١ : ٠ – ١ : ٣ – ١ : ١ – ٣ : ١ و ٠ : ١ مياه عذبة إلى المياه المالحة.

بينما طبقت كمياه مياه الري كعامل ثانوي من خلال أربعة معاملات هـي ٣/١ و ٣/٢ و ٥/١ من حوض ٨ للتبخر، أظهرت الدراسة أنه بزيادة كمية مياه الري من ٣/١ إلى ٥/١ من حول التبخر أدت إلى زيادة معنوية في الإنتاج من ٧,٦ إلى ٩,٠١ طن/هـ على التوالي. بينما أدى زيادة تركيز الأملاح في مياه الري من ١.٤ إلى ٥,٨ ديسمنز/م أدى تناقص في الإنتاج معنوي من ١٠,٤٢ إلى ٥,٢٥ طن / هـ.

كذلك تأثر نمو النبات تأثير معنوي بزيادة تركيز أملاح مياه الري، إلا أنه بزيادة كمية مياه الري أدى إلى التخفيف من التأثير السلبي للأملاح، أظهرت كذلك النتائج زيادة في تركيز مستخلص التربة بزيادة تركيز أملاح ماء الري في نهاية الموسم، بينما أظهر توزيع الأملاح داخل قطاع التربة، بأن الأملاح تراكمت في الطبقة السفلية من القطاع تحت معاملات كميات الماء العالية، بينما اتجهت الأملاح لأن تتجمع في منطقة المحصورة بالقرب من المنقطات عند كميات مياه الري المنخفضة.

أظهرت نتائج التحليل الكيميائي للتربة في نهاية الموسم بأن رقم حموضة التربة (pH) ينخفض بزيادة تركيز الأملاح فيها.

تركيز كل من المجنيزيوم، الكالسيوم، الصوديوم والكلور زاد بزيادة تركيز ملوحة مياه الري، بينما محتوى التربة من البوتاسيوم، البيكربونات والبورون تأثر تأثيراً بسيطاً جداً، بينما حدثت عملية الغسيل للكبريت خارج منطقة الجذور.

بالنتيجة لهذه التجربة فإن استخدام مياه ذات ملوحة عالية للري من دون خلطها مع كميات مياه عذبة يسبب مشكلة خطيرة لصفات التربة، بينما أدت عملية الخلط إلى نتائج طيبة حتى نسبة ١:١ مياه مالحة إلى مياه عذبة، كذلك زيادة كمية مياه الري أدى لغسيل الأملاح إلى خارج منطقة الجذور.