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WATER DISTRIBUTION AND SALTS ACCUMULATION IN SOIL PROFILE UNDER SUBSURFACE DRIP IRRIGATION SYSTEM FOR MAIZE CROP

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ABSTRACT: Field experiments were concerned with studying the performance of a subsurface drip irrigation system in maize in heavy clay soil. Moisture and salinity distribution should be well understood for developing optimum management strategies. The main objective of this study was to determine the optimum depth of the lateral irrigation line beneath the soil surface of the subsurface drip irrigation system for row crops. Three levels of water application rate were considered, which were 60 -70 and 80 % of reference evapotranspiration (ETp). The study also aimed to determine the water use efficiency (WUE) of maize (High tech 2031) in the case of applying subsurface drip irrigation (SSDI). The contour maps of soil moisture content distribution showed that it reached about 90.4 % of its filed capacity at 25 cm of lateral line depth with polymer addition (PAM) case at 80 % ETp. The higher values of electrical conductivity (Ec) were 3.3 ds/m and 3.7 ds/m recorded at 15 cm of lateral line depth in case of without polymer addition (N.PAM) and irrigation with polymer addition (PAM), respectively at 60 % ETp. The higher value of total root weight was 6.3 g per plant, occurred at 80 % ETp and increased by about 4.9 %, at 25 cm of lateral line depth with polymer addition. The higher value of water use efficiency (WUE) was 2.1 kg/m3 and observed at a lateral depth of 25 cm in the case of polymer addition (PAM) with 80% ETp of water application rate.

Key words: Subsurface drip irrigation- polyacrylamide polymer- water application rate -moisture and salt distribution -maize &depth of lateral line.

INTRODUCTION

Subsurface drip irrigation (SSDI) has many advantages, compared with surface irrigation, The main advantages of SSDI are related to water savings because water applied directly to the crop's root zone not only reduces soil water evaporation losses (Jordan et al., 2014). In designing subsurface drip irrigation systems (SSDI) for row crops, the dimensions of the wetted volume and the distribution of soil moisture within this volume are two of the main factors in determining installation depth and spacing between emitters to obtain an optimum distribution of moisture in the crop root zone. Since the source of water is at a certain depth when SSDI is used, the soil surface usually remains drier than for the surface drip irrigation. This leads to reduction in evaporation from the soil surface, and consequently, an increase in transpiration and overall water use efficiency (Romero et al., 2004). Subsurface drip irrigation (SSDI), which delivers the water below the soil surface, can potentially reduce those issues and has shown promise for grape yield and water use efficiency (Ma et al., 2019). Polyacrylamide (PAM) is one of the most common aqueous polymeric additives in soil stabilization, which is a non-toxic, environmentally friendly material (Sojka et al., 2007). Santos and Serralheiro (2000) showed that the 10 g m^{-3} application rate of PAM increased the saturated hydraulic conductivity in a furrow experiment of a Mediterranean, loamy sand soil by 168 %. In a field study.

Bryla *et al*., (2003) illustrated that sub-surface irrigation had improved the yield and increased water use efficiency at depths of 0.30 and 0.40 m, but decreased at the depth of 0.60 m. For more than 40 years organic polymers such as polyvinyl alcohols (PVAs) and polyacrylamides (PAMs) have been used as soil amendments to improve soil quality, including soil physical and chemical properties (Abu-Hamdeh et al., 2018). Polyacrylamide is a synthetic water-soluble

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polymer with a different molecular weight (MW), formed from acrylamide subunits (Moran, 2007). Polyacrylamides have the general chemical formula (−CH2CHCONH2−)n. They can be synthesized commercially in linear or cross-linked structures with MWs ranging from thousands to millions of Daltons. It is used in numerous applications, such as the food industry, well drilling, and wastewater treatment as a flocculation agent. Although PAM degradation could release acrylamide subunits, most of the applied PAM would remain in the soil. Also, PAM molecules are too large, due to their molecular weight, to penetrate any cell membranes (Xiong et al., 2018). Aly and Aboamera,(2000) showed that polymer PAM applied separately or mixed with fertilization significantly increased cabbage yield over control (36 and 42%) for mixed and separate treatments. Water use efficiency (WUE) increased with a decreasing amount of water for all treatments. Polymer application significantly improved (WUE) over the control (no-polymer).The highest (WUE) of 37.98 kg/m^3 was observed with 50% fertilizer application rate for separate polymer application, while the lowest was 17.39 kg/m^3 with a 100% fertilizer application rate for no-polymer treatment. Soil amendments, including polyacrylamides, improve soil aggregate formation by the cohesion of adjacent particles, Albalasmeh and Ghezzehei, (2014). The water use efficiency of corn under different conditions of irrigation treatments, fertilizers rates and crop populations has been investigated by researchers over the world. But an investigation of WUE under different conditions for actual evapotranspiration in a semi-arid environment was not accomplished. In a three years study on broad beans (Katerji et al., 2013). Wang et al., (2014) installed a drip irrigation system for growing maize in the Loess Plateau and observed a peak in irrigation water use efficiency (*IWUE*) with an acceptable yield for a dripper discharge of 3 L/h, a 6-day irrigation frequency and 80% evaporation. (Yang et al., 2021) said that soil moisture deficiency is a major factor in determining crop yields in water-limited agricultural production regions. Evapotranspiration (ET), which consists of crop water use through transpiration and water loss through direct soil evaporation, is a good indicator of soil moisture availability and vegetation health. Therefore, ET has been an integral part of many yield estimation efforts. The Evaporative Stress Index (ESI) is an ET-based crop stress indicator that describes temporal anomalies in a normalized evapotranspiration metric as derived from satellite remote sensing. ESI has demonstrated the capacity to explain regional yield variability in water-limited regions. Until recently, spatially explicit maps of ET and *fRET* have not been extensively used for crop stress monitoring and crop yield estimation. Advances in remote sensing retrieval techniques over a range of spatial scales have produced ET-based metrics that have been identified as valuable indicators of crop water stress (Moran ,2004). Lamm and Trooien (2003) found that corn yield was the highest under SSDI at an irrigation level of 75% crop evapotranspiration.

The main objectives of this study were to apply subsurface drip irrigation to irrigate the maize crop in heavy clay soil, determine water use efficiency (WUE) for the maize crop and study the polymer effect on maize yield. Besides these objectives, a comparative study will be conducted between the two cases (polymer addition and without polymer addition) from the point of view of maize yield and the distribution of roots in the soil profile that reflects how much water was saved.

MATERIALS AND METHODS

Experimental subsurface drip irrigation layout

Fig. (1) shows a schematic diagram of the field experimental subsurface drip irrigation system and its fittings and control devices with all the studied treatments. The experimental area was divided into two experimental main plots (24 m x 7 m). To avoid water diffusion between treatments, a one-meter distance was lifted each main plot, the two main plots were, the first main plot contained all the treatments that were irrigated without adding soil conditioner, while the second contained all those with soil conditioner (polyacrylamide polymer (PAM) was diluted to 25 mg/l with irrigation water). Each main plot was divided into three experimental plots (24 m x 1.5 m). The main line was connected to twelve laterals through six manifolds. Each manifold contained two laterals and the flow rates were measured using a flow meter fitted to the manifold line. The experiment contained twelve treatments, each represented by an experimental plot that includes two plant rows and one lateral line located in the middle between the two plant rows and buried beneath the soil surface. Water source was a large tank with a one cubic meter volume. A centrifugal pump of 0.75kW was attached to the tank. At each irrigation event, for all treatments, the water application rate was adjusted according to the recorded potential evapotranspiration at the experiment site. Water application rate was changed to three levels which, were 60,70 and 80% of reference evapotranspiration (ETp).

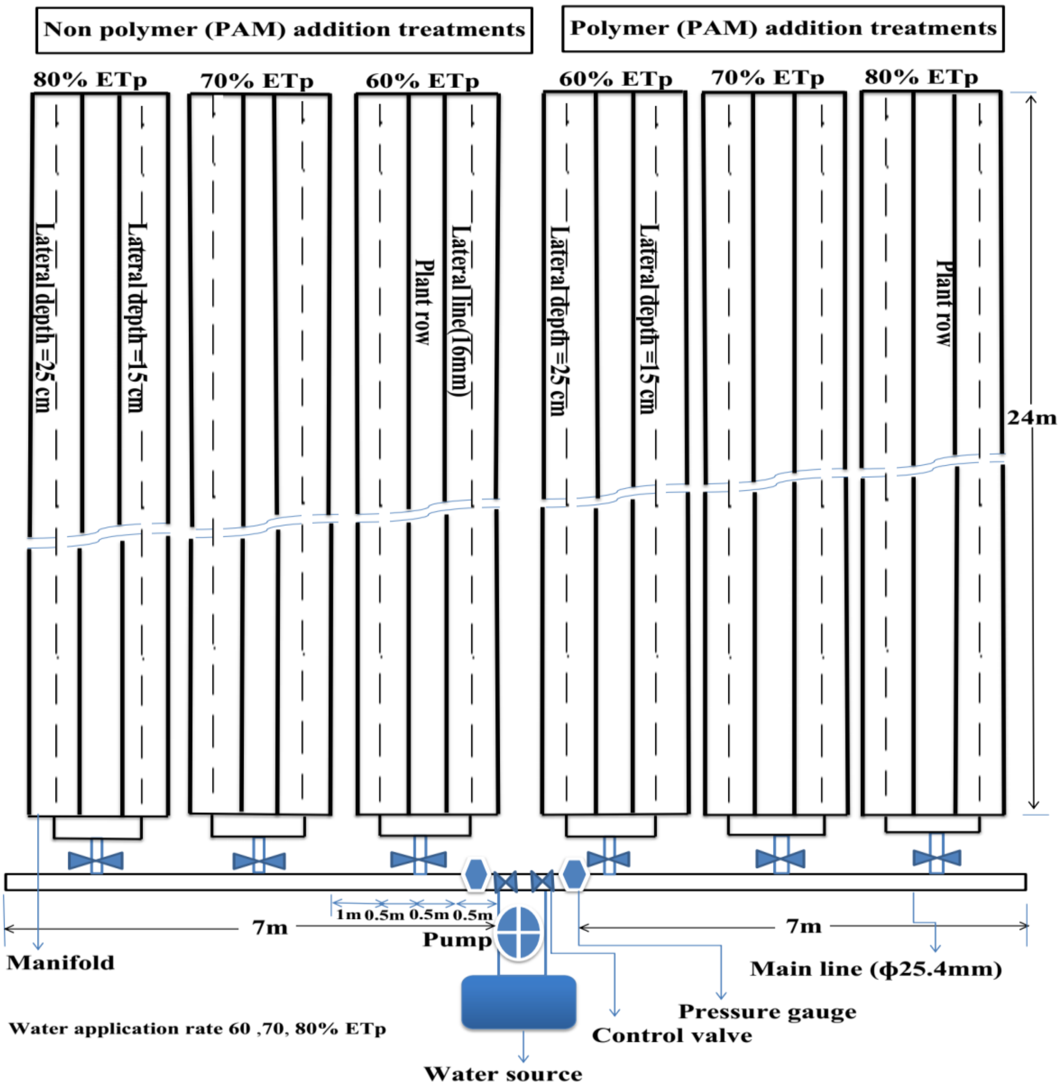

Fig. (1): Schematic diagram of the subsurface experimental irrigation system with the studied treatments.

Moisture distribution in the soil profile

In order to determine soil moisture distribution around and beneath the plant in the soil profile for each treatment, soil samples were taken from 8 spots. All the spots are located around the plant at an equal distance of 25 cm in all directions between each spot at 2 layers of depth (0-20 and 20-40 cm) using the screw auger. Hence, 16 data points were obtained around each plant to form a grid of moisture content values at an equal distance of 25 cm. The plant located at position 0,0 only eight points were measured in the northeast direction. Assuming that the soil is homogenous around the plant in a circle of (25 cm) radius, the data points were mirrored in other locations to obtain the 24 data points that formed the grid. For each location auger holes were dug at three depths (0-20 and 20- 40 cm) for gravitational moisture content determinations. The data points of moisture content were used to prepare contour map for the different depths and in the direction perpendicular to the buried lateral irrigation line. Using the commercial computer program WINSURF, areas between contour lines were calculated for each treatment to reflect the amount of water present at the different percentages of reference evapotranspiration (ET_P).

Salt accumulation in soil profile

To study the movement of salts around the cultivated plant for each treatment, eight spots were considered in all directions. Therefore, 16 data points were obtained around the individual plant to form a grid of electrical conductivity (EC) values at an equal distance of (25 cm). The values of (EC) were obtained for each data point from the soil samples that were taken for soil moisture content measurements in the soil profile, using an electrical conductivity meter. Also, the data points were mirrored in other locations to obtain the 16 data points from the grid. As mentioned before the soil samples were taken at three depths, which were 0-20 and 20-40 cm. These data points were used to prepare contour maps of salt accumulation for the different depths and in the direction perpendicular to the buried lateral irrigation line, using the same computer program WINSURF. Contour maps of electrical conductivity (EC) will be used for differentiation between treatments. Because of the accumulation of salts in the soil profile, which is considered a remarkable problem, the lower values of contour lines reflect the best uniform distribution of salts.

Root system distribution

The distribution of maize roots in the soil profile is considered a practical parameter used in differentiation between treatments. Soil profile was divided into three layers, which were (0-20 and 20-40 cm). At each layer, the spread roots were weighed and the total weight of roots for each treatment can be recorded. This procedure was conducted at the end of the growing season for each treatment. Hence, a schematic diagram of root weight system distribution can be done and the percent of root weight in each layer can be calculated. The relationship between the percent of root weight and the water application rate can be derived. This will be used to compare the three tested levels of water application rate which were 60 ,70 and 80% of potential evapotranspiration. Root system distribution will also reflex the effect of adding polyacrylamide polymer (PAM) to the irrigation water.

Crop evapotranspiration

Water application rate was computed for each irrigation event based on the recorded parameters of the climatic conditions in the experimental site. Crop evapotranspiration (ETc) was calculated according to both the value of daily reference evapotranspiration (ETp) and the value of the Bazzle crop coefficient (kc) of maize throughout the growing season. Daily potential evapotranspiration (ETp) was recoded with the help of a metrological station located close to the experimental site (Wadi AlNatrun city, El-Behera Governorate), which is quite near to the experimental site. The Bazzle crop cofficient (kc) was taken from literature as published by (FAO-56) for each growing stage of the maize crop. According to this measurement information, water application rate for each irrigation event for each treatment can be computed by multiplying the value of ETp (mm/day) by the value of crop coefficient (kc) according to the growing stage of the maize crop where, the crop evapotranspiration was estimated using the following equation (FAO,1998).

$$ET_C = ET_P \times KC \quad (1)$$

Where ;
ET_C= Crop evapotranspiration (mm/day)
ET_p= reference evapotranspiration (mm/day)
Kc= Bazzle crop coefficient (%)

Water use efficiency

Water use efficiency (WUE) in (kg/m^3) which considered as an indicator of the effective use of irrigation water usually uses in comparing between the studied treatments. Water use efficiency (WUE) of maize was calculated using the following equation:

$$WUE = \frac{\text{Total maize yield (kg/fed)}}{\text{Seasonal water application (m}^3\text{/fed)}} \quad (2)$$

Water use efficiency (WUE) as an effective economic parameter will be used generally in driving the effect of applying each level of water application, either separate or mixed with polyacrylamide polymer (PAM). The difference between the amount of water used to produce a certain amount of yield will be used in comparing the different treatments.

RESULTS AND DESCUTION

Moisture distribution as affected by lateral line depth and polymer addition

The distribution of soil moisture content with soil depth in the soil profile for each treatment reflects the status of water around the root zone. The contour maps were conducted for the three tested levels of water application. Figs (2) and (3) represent the contour maps of soil moisture content either with or without polymer addition at 15 and 25 cm of lateral depth during the growing season at 60,70 and 80% of (ETp) of water application rate, respectively. The average value of soil moisture content increased by about 10.5% for polymer addition treatment compared with irrigation without polymer addition at 15 cm of lateral depth and was about 9.5% for polymer addition treatment compared with irrigation without polymer addition (N.PAM) at 25 cm of lateral depth, at 60% of (ETp). The average value of soil moisture content increased by about 9% for polymer addition treatment compared with irrigation without polymer addition at 15 cm of lateral depth and was about 12% for polymer addition (PAM) treatment compared with irrigation without polymer addition at 25 cm of lateral depth, at 70% of (ETp). The average value of soil moisture content increased by about 10.7% for polymer addition treatment compared with irrigation without polymer addition at 15 cm of lateral depth and was about 15.2% for polymer addition treatment compared with irrigation without polymer addition at 25 cm of lateral depth, at 80% of (ETp).

The used polymer condition, in which so called polyacrylamide polymer plays an effective role in maintaining the value of soil moisture content is higher. Therefore, mixing polymer substance with irrigation water might be recommended especially in the case of using a subsurface drip system. This can be strongly recommended, especially in heavy clay soil cultivated with row crops at a water application level of 80% of evapotranspiration (ETp). The highest value of the water application rate normally gives a higher percent of soil moisture content in soil profile. It is clear that, the effective surface layer of soil (20 cm from the soil surface) kept a higher value of soil moisture content which was about 90.4% at field capacity in the lateral depth of 25 cm in the case of polymer addition (PAM), at the water application level of 80% of evapotranspiration (ETp).

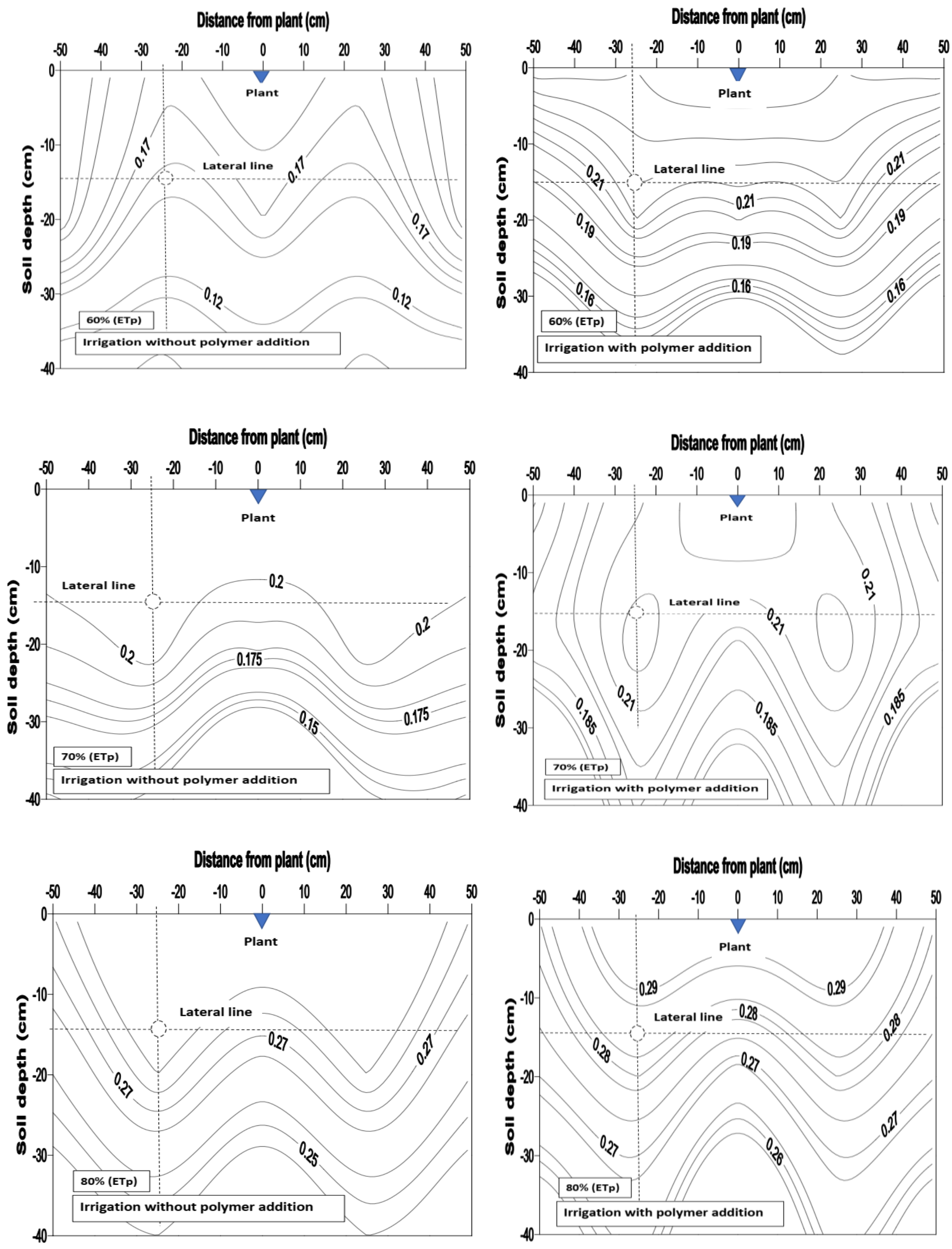

Fig. 2: Contour maps of soil moisture content under different values of water application rate (60,70 and 80% of ETp), at 15 cm of lateral depth .

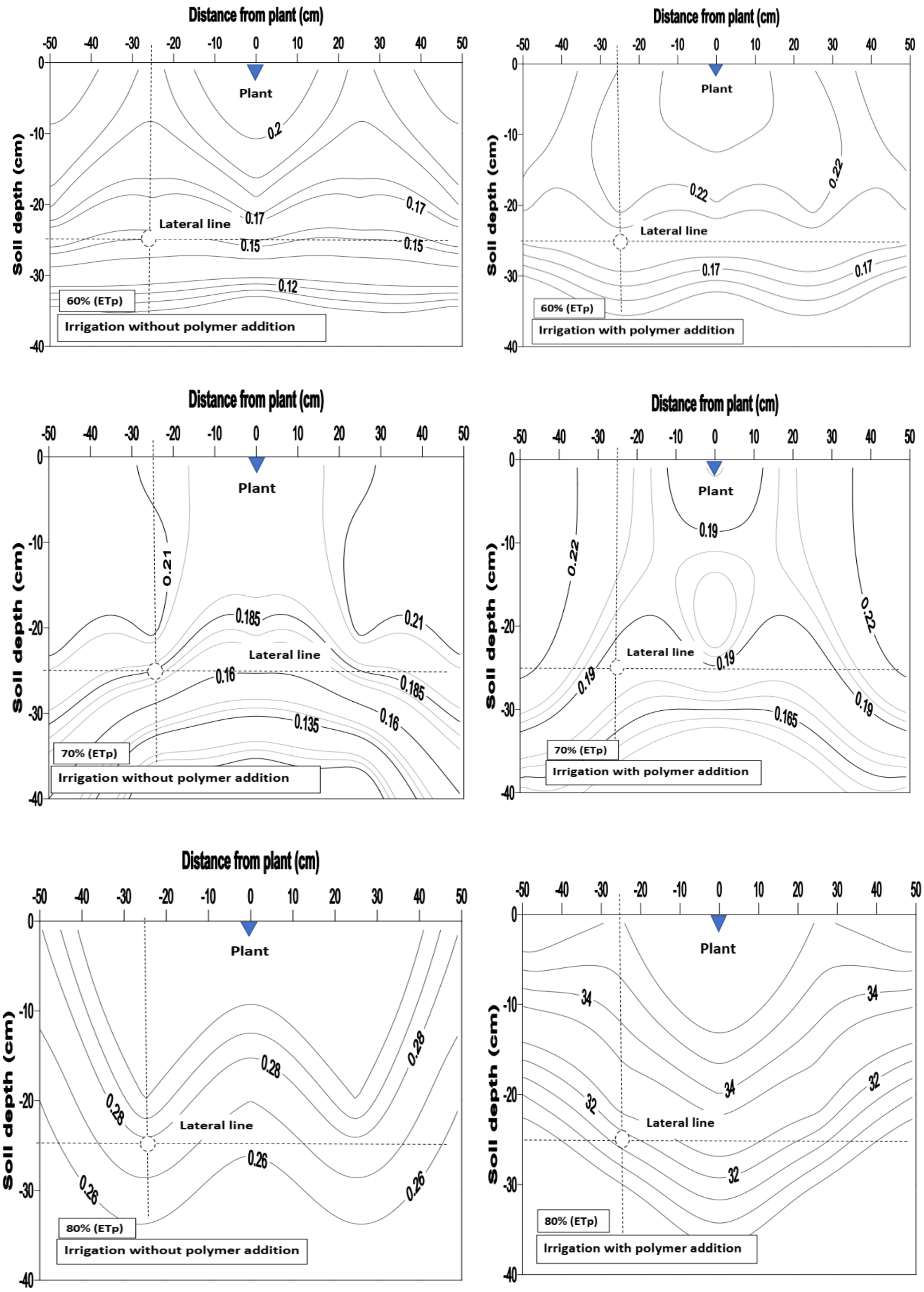

Fig. 3: Contour maps of soil moisture content under different values of water application rate (60,70 and 80% of ETp), at 25 cm of lateral depth .

Salt accumulation as affected by lateral line depth and polymer addition

Figs. (4) and (5) represent the contour maps of salt accumulation in the soil profile expressed in terms of ds/m during the growing season at 60,70 and 80% of ETp of water application rate with two levels of lateral depth of 15 cm and 25 cm. It showed the variation of soil EC for irrigation with polymer addition (PAM) and irrigation without polymer addition. At a depth of 20 cm in the soil profile the average value of (EC) was 3.3 ds/m and 3.7 ds/m at 15 cm of lateral depth with irrigation without polymer addition (N.PAM) and irrigation with polymer addition (PAM), respectively. The average value of (EC) was 2.9 ds/m and 3.1 ds/m at 25 cm of lateral depth with irrigation without polymer addition (N.PAM) and irrigation for polymer addition (PAM), respectively at 60% of ETp of water application rate. The average value of (EC) was 2.9 ds/m and 2.75 ds/m at 15 cm lateral depth with irrigation without polymer addition (N.PAM) and irrigation with polymer addition (PAM). The average value of EC was 2.85 ds/m and 3.1 ds/m at lateral depth 25 cm with irrigation without polymer addition (N.PAM) and irrigation with polymer addition (PAM) at 70% of ETp of water application. The average value of (EC) was 2.25ds/m and 2.35 ds/m at 15cm of lateral depth with irrigation without polymer addition (N.PAM) and irrigation with polymer addition (PAM), the average value of (EC) was 1.6 ds/m and 2.0 ds/m at 25 cm of lateral depth with irrigation without polymer addition (N.PAM) and irrigation with polymer addition (PAM) at 80% of ETp of water application. The value of (EC) which observed at 15 cm of lateral with irrigation with polymer addition (PAM) was higher than irrigation with polymer addition (N.PAM), and at 25 cm lateral depth with irrigation with polymer addition (PAM) was higher than irrigation without polymer addition (N.PAM). But in the two cases the value of (EC) for irrigation with polymer addition (PAM) was the highest compared with irrigation without polymer addition (N.PAM).

The higher value of the water application rate, the lower the value of electrical conductivity (EC). Therefore, from the point of view of salt accumulation, the obtained results concluded the higher value of (EC) at an application rate of (60 % ETp), polymer addition (PAM) and lateral depth 15 cm and the lower value of (EC) at an application rate of (80 % ETp), no polymer addition (N.PAM) and a lateral depth of 25 cm. Adding polymer to the soil to increase concentrations, but only in a very small percentage.

Root system distribution affected lateral line depth and polymer addition.

Root system distribution in the soil profile, is normally affected by both water application rates and the depth of lateral beneath the soil surface and the amount of polymer addition. Tables (1) and (2) represent the distribution of root weight and percent of root weight at three layers of soil depth, which are (0-10, 10-20 and 20-30 cm) with irrigation without polymer addition (N.PAM) and irrigation with polymer addition (PAM) at 15 cm and 25 cm of lateral depth, respectively in the end of season. The results listed in these tables showed that, for all treatments, the higher percent of roots was located at the effective soil layer (up to 25 cm) and it varied from one treatment to another according to water application rate, depth of lateral and amount of polymer addition.

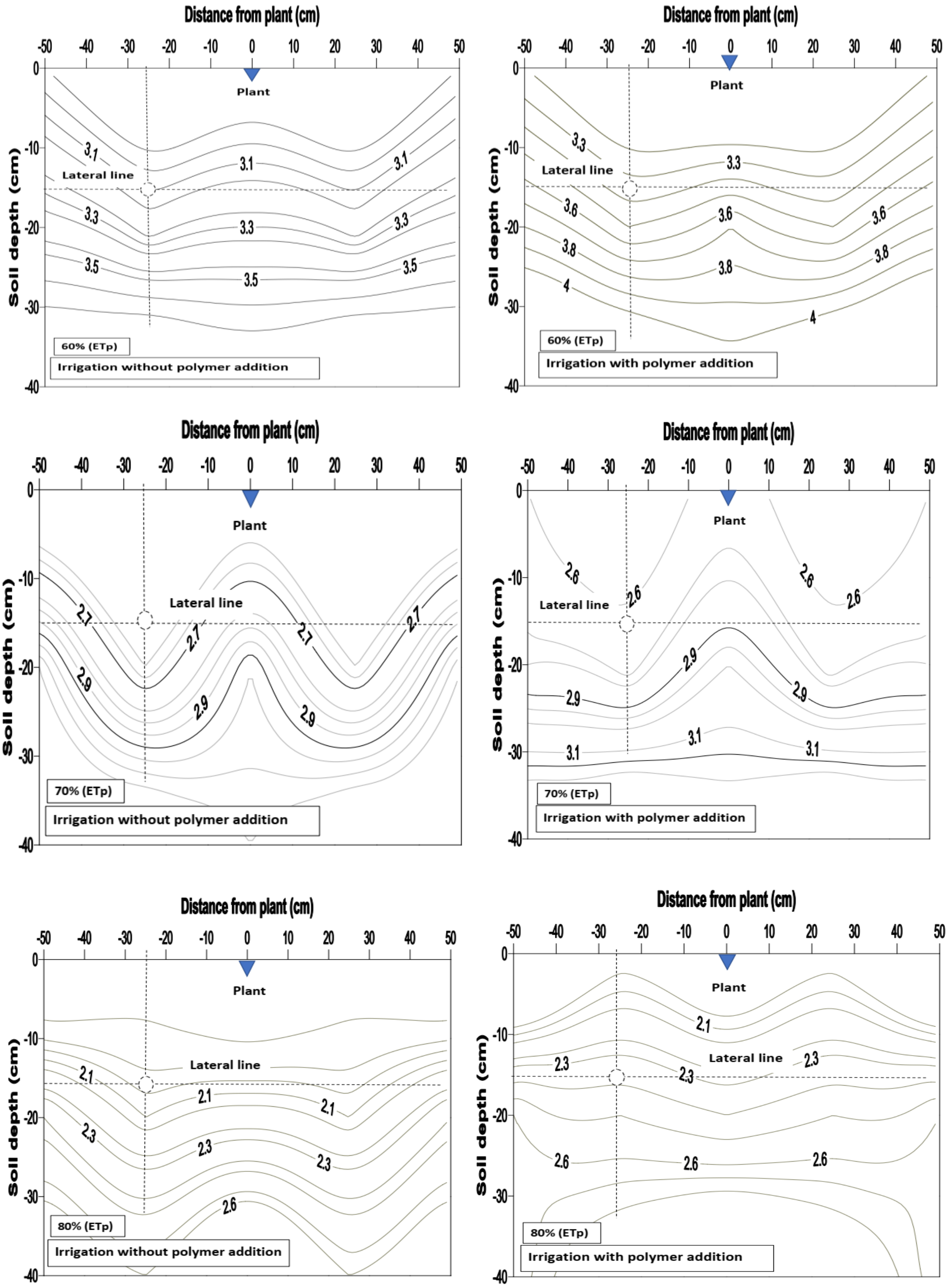

Fig. 4: Contour maps of salt accumulation in soil represented by electrical conductivity (EC) in ds/m at 15 cm of lateral depth under (60,70 and 80% of ETp) of water application rate.

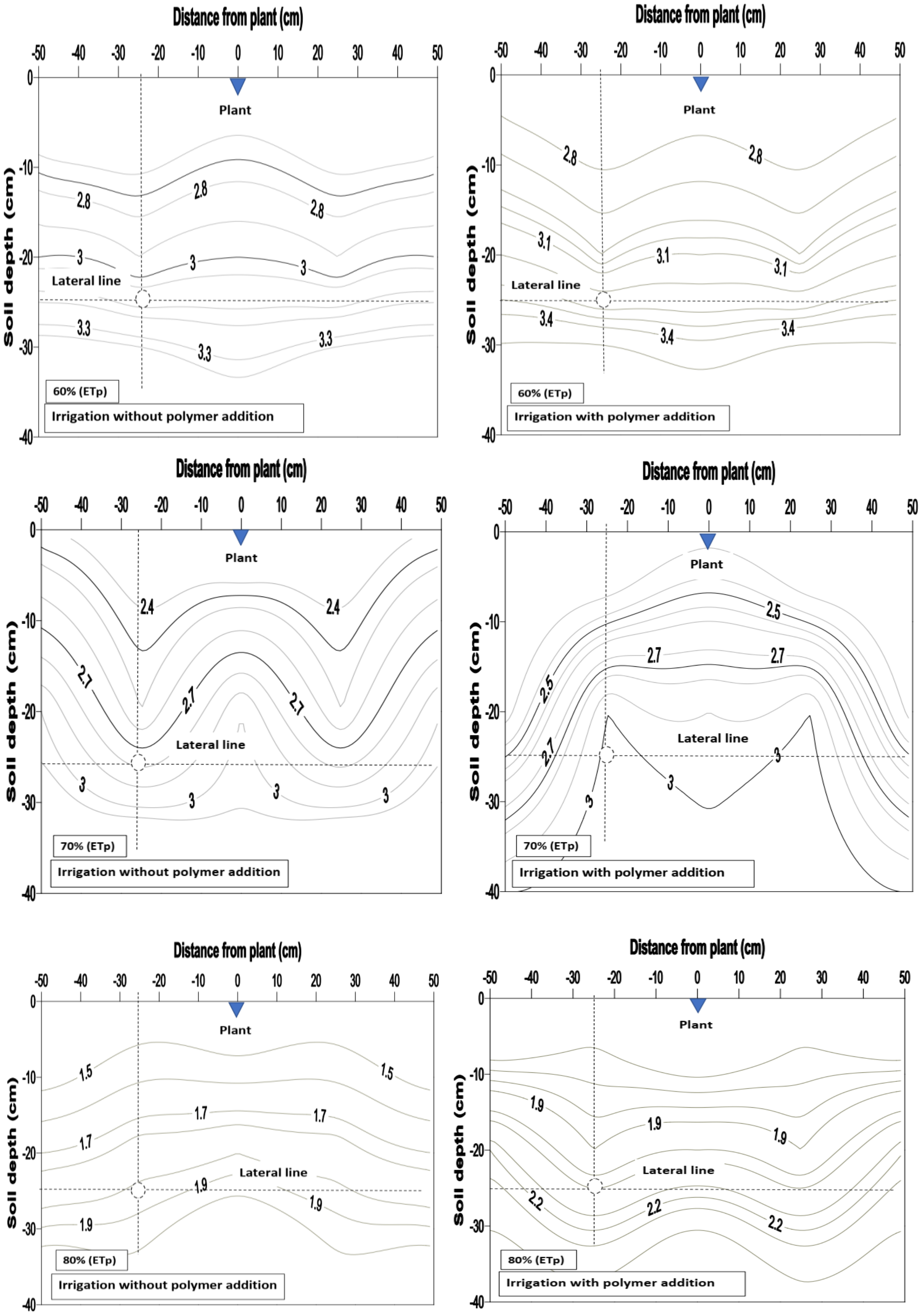

Fig.5: Contour maps of salt accumulation in soil represented by electrical conductivity (EC) in ds/m at 25 cm of lateral depth under (60,70 and 80% of ETp) of water application rate.

Table (1): Root weight (g) and percent of root weight with soil depth (cm) at different lateral depths as well as the water application rate without polymer addition (N.PAM).

Water application rate	Lateral depth (cm)	Total root weight (g)	Soil depth (cm)					
			10		20		30	
			Root weight (g)	Percent of root weight %	Root weight (g)	Percent of root weight %	Root weight (g)	Percent of root weight %
60 % ETp	15	156	90	58	61	39	5	3
	25	168	95	56.5	68	40.5	5	3
70 % ETp	15	160	100	62.5	59	36.9	7	4
	25	185	105	56.8	74	40	6	3
80 % ETp	15	182	112	61.5	60	33	10	5
	25	190	109	57.4	77	40.5	4	2

Table (2): Root weight (g) and percent of root weight with soil depth (cm) at different lateral depths as well as water application rate with polymer addition (PAM).

Water application rate	Lateral depth (cm)	Total root weight (g)	Soil depth (cm)					
			10		20		30	
			Root weight (g)	Percent of root weight %	Root weight (g)	Percent of root weight %	Root weight (g)	Percent of root weight %
60 % ETp	15	172	105	61	62	36	5	3
	25	179	108	60.3	67	37.4	4	2.2
70 % ETp	15	182	112	61.5	60	33	10	5.5
	25	193	120	62.2	69	35.7	4	2
80 % ETp	15	191	110	57.6	77	40.3	4	2
	25	200	125	62.5	70	35	5	2.5

Fig. (6) and (7) illustrated the distribution of roots in both root weight and percent of root weight in the soil profile with 60,70 and 80% ETp of water application rate for irrigation without polymer addition (N.PAM) and irrigation with polymer addition (PAM) at lateral depths of 15 cm and 25 cm. At 60% ETp of water application rate . In the case of irrigation for no polymer addition (N.PAM) and irrigation for polymer addition (PAM) at a lateral depth 15 cm conclude that the value of total root weight at (PAM) increased about 10.3% compered with (N.PAM).In the case of irrigation for no polymer addition (N.PAM) and irrigation for polymer addition (PAM) at a lateral depth 25 cm,we conclude that the value of total root weight at (PAM) increased about 5.5% compered with (N.PAM). At 70% ETp of water application rate. In the case of irrigation for no polymer addition (N.PAM) and irrigation for polymer addition (PAM) at lateral depth of 15 cm conclude that the value of total root weight at (PAM) increased about 7.7% compered with (N.PAM).In the case of irrigation for no polymer addition (N.PAM) and irrigation for polymer addition (PAM) at lateral depth 25cm conclude that the value of total root weight at (PAM) increased about 4.1% compered with (N.PAM).At 80% ETp of water application rate , in the case of irrigation for no polymer addition (N.PAM) and irrigation for polymer addition (PAM) at lateral depth 15 cm was conclude that the value of total root weight at (PAM) increased about 4.2% compered with (N.PAM) ,in the case of irrigation for no polymer addition (N.PAM) and irrigation for polymer addition (PAM) at lateral depth 25 cm conclude that the value of total root weight at (PAM) increased about 4.9% compering with (N.PAM).

The last results showed that, for all treatments , the majority of the root weight was located at the effective soil layer (up to 20 cm) and it varied according to the level of water application rate and the amount of the added polymer. Also, increasing the depth of lateral beneath the soil surface gave a satisfactory distribution of roots in the soil profile .Besides, the addition of polyacrylamide polymer had a remarkable effective role especially when the depth of the lateral was not exceeded largely.

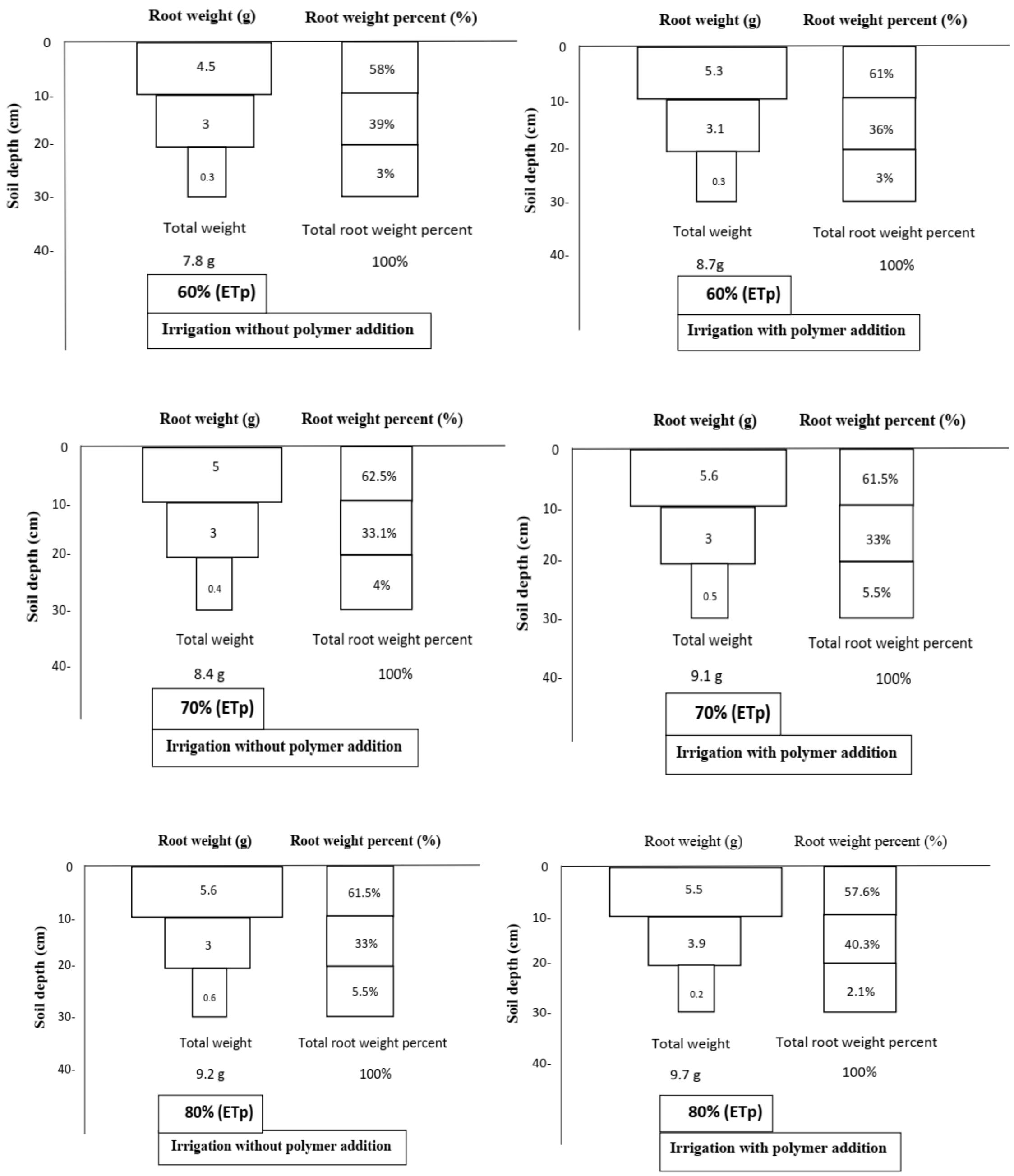

Fig. 6: Root weight and root weight percent distribution with soil depth under the three levels of water application rate (60,70 and 80% of ETp), at a lateral of 15cm depth.

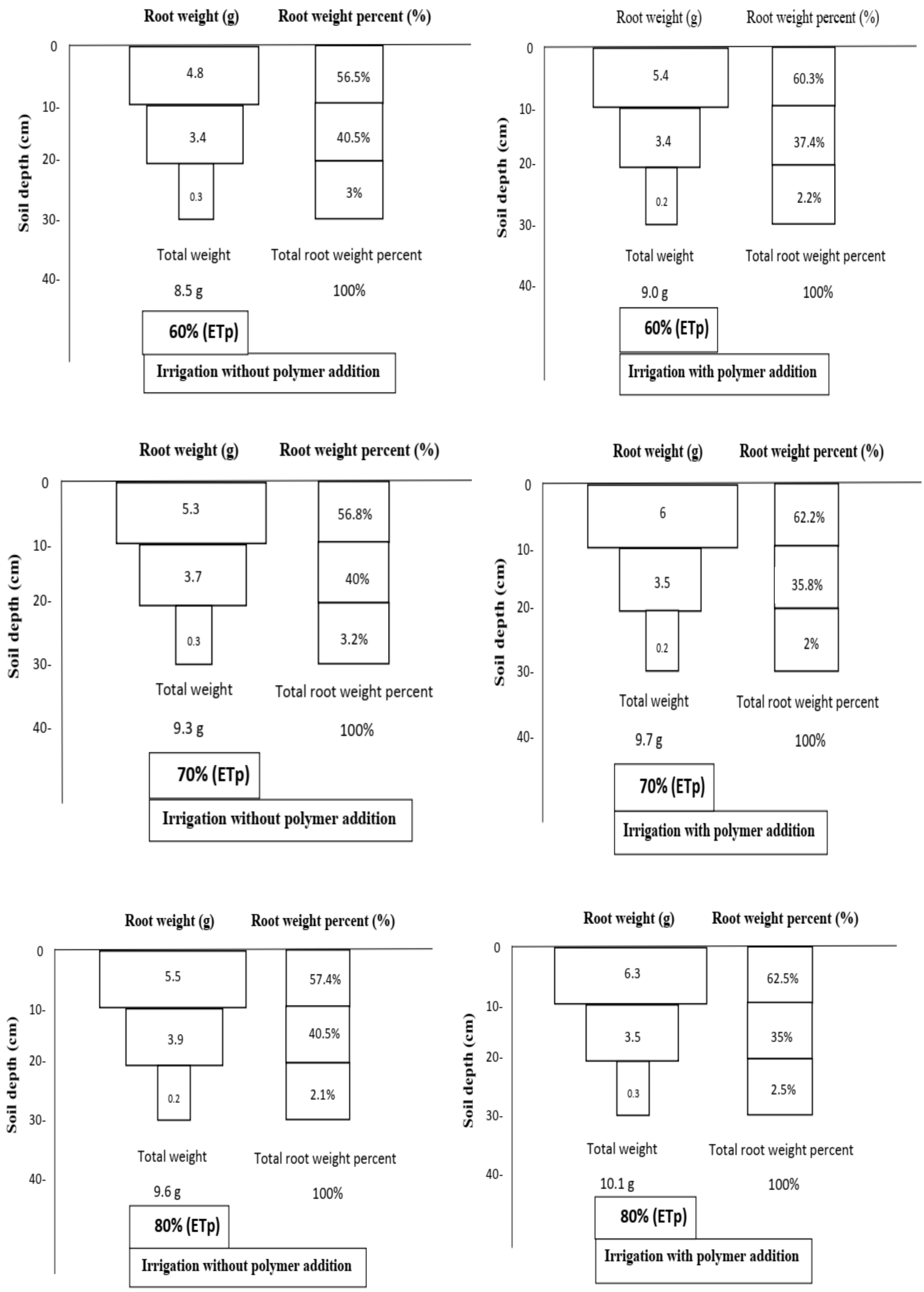

Fig. 7: Root weight and root weight percent distribution with soil depth under the three levels of water application rate (60,70 and 80% of ETp), at a lateral of 25 cm depth.

Water use efficiency

Water use efficiency (WUE) is a measure of irrigation water productivity, i.e., the yield produced by a unit volume of irrigation water. Fig. 8 and Fig.v9 represents the water use efficiency (WUE) for maize, at 15 and 25 cm of the lateral depth of soil during the growing season at a water application level of 60,70 and 80% of evapotranspiration (ETp) for irrigation with polymer addition and without polymer addition. The height value of the water application rate normally gave a higher value of water use efficiency. It is clear that the highest value (2.1 kg/m^3) was observed at lateral depth 25 cm in the polymer addition (PAM) case at water application level 80% of evapotranspiration (ETp), while the lowest value (1.0 kg/m^3) was observed at a lateral depth 15 cm in no polymer addition (NPAM) case at water application level of 80% of evapotranspiration (ETp).

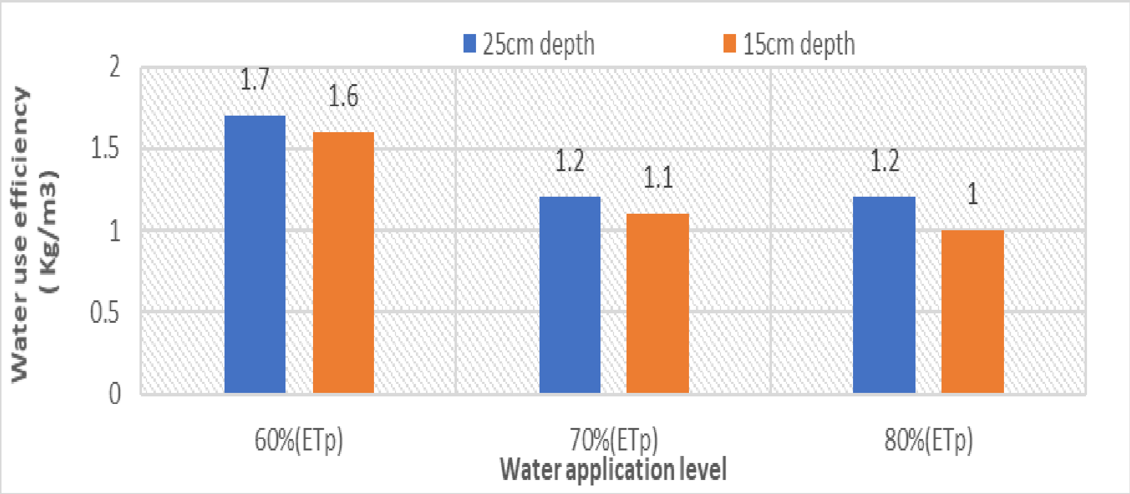

Fig. 8: The effect of water application level on water use efficiency (kg/m^3) under polymer irrigation.

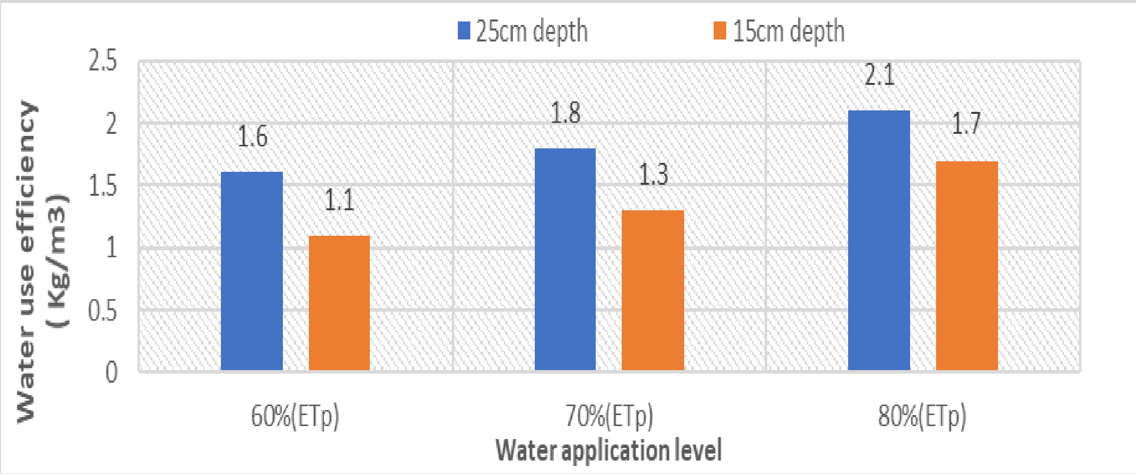

Fig. 9: The effect of water application level on water use efficiency (kg/m^3) during irrigation with polymer addition.

CONCLUSION

Water application during the growing season for the maize was conducted at 60, 70 and 80% of the daily reference evapotranspiration (ETp) under a subsurface drip irrigation system. The commercial computer programme WINSURF was used to measure the soil moisture content and salt accumulation in the soil profile. The best distribution of soil moisture content was achieved at 80% of (ETp) and 25 cm of lateral depth in irrigation with polymer addition. The least distribution of salts achieved at 80% of (ETp) and 25 cm of lateral depth in irrigation with polymer addition, the best distribution of roots in soil profile (195g) achieved at 80% of (ETp) and 25 cm of lateral depth in irrigation with polymer addition, The highest value of water use efficiency (WUE) was (2.1kg/m^3) observed at 80% of (ETp) and 25 cm of lateral depth in irrigation with polymer addition, while the lowest value of (WUE) was (1.0 kg/m^3) observed at 80% of (ETp) and at a lateral depth 15 cm in irrigation without polymer addition at a level of water of 80% of (ETp) and 25cm of lateral depth in irrigation with polymer addition .

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توزيع الرطوبة وتراكم الأملاح في قطاع التربة تحت نظام الرى بالتنقيط تحت السطحى لرى محصول الذره

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الملخص العربى

أجريت هذه الدراسة بقرية جريس التابعة لمركز أشمون بمحافظة المنوفية .واستهدفت استخدام نظام الرى بالتنقيط تحت السطحى لرى محصول الذره *(Hightech 2031)* في الاراضى الطينية الثقيلة ودراسة تأثير اضافة محسن التربة البوليمر *(Polyacrylamide polymer PAM)* على كل من توزيع الرطوبة في قطاع التربة وتوزيع الاملاح وتراكمها وتوزيع الجذور وانتاجية محصول الذرة وكفاءه استخدام المياه وتحديد عمق خط الرى الفرعى بالتنقيط الأمثل تحت سطح التربة في حالتى اضافة البوليمر وعدم اضافة البوليمر وأيضا حساب كفاءه استخدام المياه لمحصول الذرة في حاله استخدم الرى بالتنقيط تحت السطحى في رى المحاصيل المنزرعة على خطوط. وصممت التجربة احصائيا حيث تم تقسيم قطعة الأرض الى قطعتين متساويين أحدهما للرى باضافة البوليمر والاخرى للرى بدون اضافة البوليمر واستخدمت ثلاث مستويات لمعدل اضافة مياه الري هي (٦٠% -٧٠%-٨٠% من البخر نتح المرجعى) فى القطع الرئيسية في حالة اضافه البوليمر وأيضا في حالة عدم اضافة البوليمر مع مياه الري. وتم دفن خط الرى الفرعى على عمقين أحدهما ١٥سم - والاخر٢٥ سم لخط الرى الفرعى تحت سطح التربة وتوصلت الدراسة الى النتائج الاتية:

١. تحقق أفضل توزيع للمحتوى الرطوبى في قطاع التربة عند معدل رى ٨٠% من البخرنتح المرجعى وعند عمق خط ٢٥ سم لخط الرى الفرعى تحت سطح التربة باضافة البوليمر.
٢. تحقق أقل تركيز لتوزيع للأملاح فى قطاع التربة عند معدل رى ٨٠% من البخر نتح المرجعى وعند عمق خط رى ٢٥ سم في حاله الرى بدون اضافه البوليمر .
٣. تحقق أعلى وزن لتوزيع الجذور ومقداره (١٩٥جم) عند عمق ٢٠سم لقطاع التربة عند معدل رى مقداره ٨٠% من البخرنتح المرجعى في حاله الري باضافة البوليمر وعند عمق ٢٥سم لخط الرى الفرعى تحت سطح التربة.

أعلى قيمة لكفاءة استخدام المياه ومقدارها (٢,١ كجم/م٣) كانت عند معدل رى مقداره ٨٠% من البخرنتح المرجعى في حاله الري باضافة البوليمر وعند عمق٢٥سم لخط الرى الفرعى تحت سطح التربة، بينما تحققت أقل قيمة لكفاءة استخدام المياه ومقدارها (١ كجم/م٣) كانت عند معدل رى مقداره ٨٠% من البخر نتح المرجعى في حاله الري بدون اضافة البوليمر وعند عمق١٥ سم لخط الرى الفرعى تحت سطح التربة.