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THE IMPACT OF SUB-SURFACE DRIP IRRIGATION AND DIFFERENT WATER DEFICIT TREATMENTS ON THE SPATIAL DISTRIBUTION OF SOIL MOISTURE AND SALINITY

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Abstract

The soil moisture and salinity distribution in the plant roots zone by the quantities of water added and the irrigation systems used. A field experiment was carried out in the sandy soil in the field of experiments of the Research and Production Station of the National Research Center in Nubaria Region, El-Buhaira province in the agricultural season 2017/2018. Is a study of the distribution of moisture and salts using different systems of drip irrigation at different depths of the soil 10, 20, 30 cm, under three water amounts a treatment from the field capacity, control 100, 75; 50%. The results were summarized as follows: There is a clear variation in the forms of moisture distribution between the various water treatments and also in the different soil depths where the treatment was 100% the largest in the values of soil moisture followed by the treatment 75% and less under the treatment 50% while the depth of 30 cm is the largest in the value of soil moisture followed by the depth of 20 cm and the lowest soil moisture value was in depth 10 cm, and the distribution of salts in contrast to this arrangement under both water treatments and different depths with no significant variation in the values of salts under both study factors. Interaction was the largest between both different drip irrigation systems and water treatments, while the effects of between 75% and 50% of the irrigation process was used to provide large saving in water quantities of irrigation water by 25% and 50% respectively. The treatments were the best in terms of distribution of moisture and salts under different drip irrigation systems.

***Keywords*:** Sub-surface, Drip irrigation, Irrigation systems, Field capacity, Soil, Salinity, Moisture, Distribution.

Introduction

Drip irrigation has many advantages, including the maintenance of soil moisture within the effective roots of plants, where the length of the plant life during the growth season is maintained by regular and timely irrigation and adding water in the appropriate quantity, which makes it capable of adapting With the effect of low soil moisture and Balak maintain the growth process of the plant without significant impact water stress and this is in the vicinity of drip irrigation devices (drips). Gerard (1974) commented that the properties of hydro-physics soil are affected by the state of the earth's moisture in the range under study. In the case of poor soil ability to maintain the moisture balance around the root area, this will lead to a large loss in the amount and effective roots of roots. The effective size of the soil in the case of the inability of the soil to spread moisture around and thus cannot grow and this leads to the emergence of serious and symptoms of water stress on plants. Earl and Jury (1977) and Eldardiry et al. (2015) reported that in the case of drip irrigation and daily irrigation practices, there is a positive effect on some of the soil types, which is low in strength. The movement of the water below the irrigation system is about 60 cm, it is possible to observe the movement of water downstream of the dots to a depth of 75 cm and sometimes up to 100 cm. The movement of fertilizers and chemicals added during the irrigation process as well as the distribution of soil salts can be tracked.

Soil moisture distribution can be obtained differently if the criteria for the drip irrigation process are changed. Levin et al. (1979) and Abd-Elmabod et al. (2019) They also studied the distribution of ground moisture using certain water quantities by using points of different water behavior. If the irrigation process continues after 12 hours until the irrigation water drops to a level below 60 cm, 26% of the total amount of water added during this period, and the same treatment by studying the lateral distribution of water under the drip irrigation in the soil and the distance of the spread of water horizontally from 35 to 45 cm after 12 to 24 hours respectively, and the loss in water was about 12% at depth 60 cm under the soil in the case of intermittent irrigation and horizontal spread distances Ranging from 29 to 40 cm after 12 to 24 hours respectively.Bacon and Davy (1982), and found that the irrigation process led to the occurrence of an external spread of irrigation water, starting from the irrigation system and ending with the last wet area around the points and adopted the propagation time and the maximum distance of the wet area during the period of irrigation and jumps as well as the full irrigation season and the depth was little evidence of poor conduction Hydraulics for soil.

Norris and Tennessee (1985) pointed out that the movement of horizontal humidity increases in the case of the soil type is classy and the initial humidity is low and that horizontal movement does not increase only depending on the state of the soil in terms of high tension of moisture, which increases in the case of the soil finer texture (soft) more than the soil with rough textures, El-Gindy (1988), Goyal and Mansour (2015) and El-Hagarey et al. (2015) reported that under drip irrigation, surface soil up to 20 cm recorded the highest moisture value compared to subterranean layers more than 20 cm deep. As for spray irrigation, the lowest moisture value was recorded at the same depth in the case of surface irrigation.Hanafy (1993) commented that the process of tension of soil water in the case of soft textures have a large splits lead to a drop of water to a depth of 30 cm and sometimes greater than that depth and this is because the soil moisture under most crops field roots are growing close to the surface of the earth and help the growth More roots.

Mansour et al. (2015a-f), (2019a,b) and (2016a-c) mentioned that in the drip irrigation areas, irrigation water is distributed through the pores located above the surface of the soil while in the subsurface drip, the wet area below the surface is small for the total area of the land and surface area. The rate of flow or the rate of the conduction of hydraulic points is a specific factor with physical soil properties, the evaporation rate from the surface of the soil and the size of the wet surface area of the horizontal soil through which the infiltration occurs. The surface area of saturated soil increases when the water application rate increases and when the soil's ability to deliver water (which depends on soil strength and physical properties, among other factors). The nature of the land is developed in the area around the points according to the rate of water use, the water flow rate of the drips and the soil properties in that area, the most important of which is the hydraulic conductivity (HC) and is influenced by the water quality and quality according to the value and electrical conductivity(EC) (Tayel et al. (2012a,b), (2015a-e), (2016), (2018), (2019), Mansour (2015) and Mansour et al. (2014) Consequently, the water application rate is one key factor determining the soil water content around the emitter Mansour et al., (2013), Mansour et al., (2014) and the water uptake pattern Mansour et al., 2015a. However, the use of water in an inaccurate and random and without dates or the appropriate quantities lead to a significant reduction in the value of efficiency of the system of drip irrigation and this reflected negatively on the final yield resulting, for example, if the use of water at high rates and timeout of time and the appropriate quantity this will reduce the apparent stress Water at plants but at the same time will reduce the efficiency of irrigation system drip and nutrient flight and fertilizer with the ground water deep leakage and go away from the area of root spread does not benefit the plant and thus there is no economic feasibility of the irrigation process, (Ibrahim et al. 2018 and Mansour and Aljughaiman 2012, 2015, Mansour and El-Melhem 2012, 2015; Attia et al 2019 and Pibars et al. 2015, 2019).

The objectives of the current research work is to investigate the influence of sub-surface drip irrigation system, in different soil deeps 10, 20 and 30 cm, under different water treatments (100, 75 and 50 %) from field capacities on the forms of soil salinity and moisture distribution at the soil depths under study.

Material and Methods

This study was conducted at the Experimental Farm, Research and Production Station, El-Noubaria, El-Behaira Governorate that belong to National Research Center Governorate, Egypt. The aim to study the effect of automation controller of drip irrigation system, different irrigation systems conditions, different Field capacities on soil moisture and salinity distribution patterns.

The experiments: Field experiments were carried out under drip irrigation by automation controller system, three treatments of field capacity were established: 50, 75 and 100 % FC as control. Soil of experimental field represents the desert land with sandy soil texture.Soil Physical characteristics: Soil particle size distribution was carried out using pipette method after Gee and Bauder (1986) as shown in Table (1). Soil bulk density (B.D.) was measured after Black and Hartage (1986).

Soil moisture content at field capacity (F.C) and permanent wilting point (P.W.P) were measured according to Walter and Gardener (1986) as shown Table (1). The available water (AW) was calculated from the following equation:

AW=F.C - P.W.P…………………(1)

Where: AW= available water (⊖w %), F.C = field capacity (⊖w %) and P.W.P = permanent wilting point (⊖w %). Soil aggregate stability aggregation percentage (Agg. %) and mean weight diameter (MWD) was carried out using wet sieving technique without using a dispersion agent after Kemper and Rosenau (1986). Soil hydraulic conductivity (HC) was determined under a constant head technique Klute and Dirksen, (1986). HC was calculating using the following formula :

HC = (QL)/(At. H)………………(2)

Where: Q = volume of water flowing through the sample per unite time (L3/T), A = cross sectional flow area (L2), L = length of the sample (L), and H = differences in hydraulic head across the sample (L).

Soil intake rate was determined using the double wall ring infiltrometer technique described by Kohnk (1968). Kostikove equation was used to represent the infiltration process

$$I = k\ t^n \quad (3)$$

Where: I = the infiltration rate at time t (mm /min), t= the time that water is on the surface of the soil (min), k= the intercept of the curve which represents the infiltration rate at unit time, i.e instantaneous infiltration rate(mm/min), and n= the irrigation system of the curve which represent the relation between log I and log t

$$D = k\ t^n \quad (4)$$

Where: D= is accumulative intake rate (mm/min), and n= is the irrigation system of the curve, which represent the relation between log D and log t.

Table 1: Some physical properties of the soil. *

Depth, cm	Particle Size distribution, %				Texture class	θS % on weight basis			HC (cmh-1)	BD (g/cm³)	P (cm³ voids /cm³ soil)
	C. Sand	F. Sand	Silt	Clay		F.C.	W.P.	AW			
0-15	8.4	77.6	8.5	5.5	Sandy	14.0	6.0	8.0	6.68	1.69	0.36
15-30	8.6	77.7	8.3	5.4	Sandy	14.0	6.0	8.0	6.84	1.69	0.36
30-45	8.5	77.5	8.8	5.2	Sandy	14.0	6.0	8.0	6.91	1.69	0.36
45-60	8.8	76.7	8.6	5.9	Sandy	14.0	6.0	8.0	6.17	1.67	0.37

* Particle Size Distribution after (Gee and Bauder, 1986) and Moisture retention after (Klute , 1986), F.C.: Field Capacity, W.P.: Wilting Point, AW: Available Water, HC: Hydraulic conductivity(cmh^{-1}), BD: Bulk density(g/cm^3) and P: Porosity (cm³ voids/cm³ soil).

Table 2: Some chemical properties of irrigation water used.

pH	EC dS/m	Soluble cations, meq/L				Soluble anions, meq/l				SAR
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{--}	
7.3	**0.37**	**0.76**	**0.24**	**2.6**	**0.13**	**0**	**0.9**	**0.32**	**2.51**	**4.61**

Table 3: Some chemical properties of the soil*.

Depth, cm	pH 1:2.5	EC dS/m	Soluble Cations, meq/L				Soluble Anions, meq/L			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}
0-15	8.3	0.35	0.50	0.39	1.02	0.23	0	0.11	0.82	1.27
15-30	8.2	0.36	0.51	0.44	1.04	0.24	0	0.13	0.86	1.23
30-45	8.3	0.34	0.56	0.41	1.05	0.23	0	0.12	0.81	1.23
45-60	8.4	0.73	0.67	1.46	1.06	0.25	0	0.14	0.86	1.22

*Chemical properties after Rebecca, (2004)

Chemical characteristics

Some soil chemical characteristics were determined as follows: Soil pH and EC were measured in 1:2.5 soil water suspensions and in soil past extract, respectively according to Jackson (1967), $CaCO_3$ content, soluble Cations and anions are measured by Scheibler calcimeter (Soil Survey Staff, 1993) as shown in Table (2).

Irrigation water: Ground water is the source of irrigation water. Irrigation water analysis is given in Table (3).

Electronic Soil measurements: For the determination of soil's Mechanical constitution it was used the Bougioukou method, pH was measured with a pH electronic meter and the organic matter with the method of humid combustion of sample with divine acid. Also, as a result of the distance between drippers and the drip lateral length, it was achieved high uniformity of irrigation that approaches 95-97%. Measurements were taken of the volumetric soil moisture (v/v %) in the experimental plots daily, and were taken from soil at the depths (0, 10, 20, 30, and 40 cm) depths and (5, 10, 15, and 20 cm) distances from dripper in that time. throughout the entire irrigation season.

The TDR (Time Domain Reflectometer) method was used, a non-radioactive method which has been proved to be quick and reliable, irrespective of soil type (except extreme cases of soils). The TDR function based on the direct measurement of the dielectric constant of soil and its conversion to water volume content. (Fig. 1)

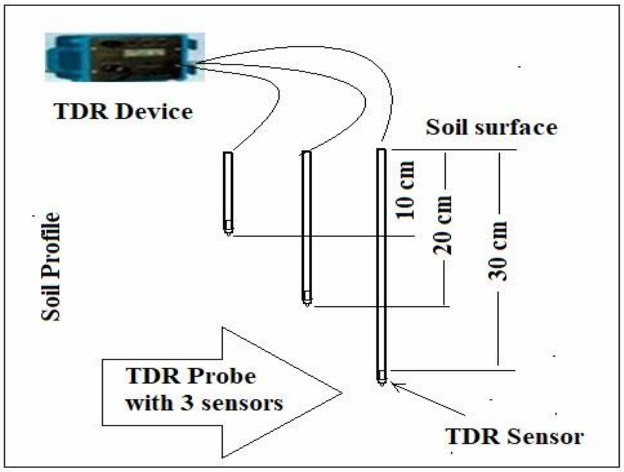

Fig. 1: TDR device and probe with three sensors.

Surfer software program has been used to getting contour maps of water and salinity distribution in figures 2 and 3 in results and discussion partition.

Testing the soil moisture content is a very complex process; also, the placing of a sensor at the root level of the crop in many cases is not enough for a satisfactory performance of the test. As a solution to this problem, researchers were recommended using two or more sensors at various depths, so that a greater area of the root level is covered. In order to do this and to ensure greater accuracy, soil moisture probes with five sensors each were used and lay permanently installed in the 12 experimental plots, where they were in continuous contact with the soil. Each probe had sensors which measured the soil moisture content at three different depths: 0–10, 10–20 and 20–30cm. From the measurements taken at each position, the average value was calculated from the five depths for each treatment.

Statistical analysis: MSTATC program (Michigan State University) was used to carry out statistical analysis. Treatments mean were compared using the technique of analysis of variance (ANOVA) and the least significant difference (L.S.D) between systems at 1 % had been done. The randomized complete block design according to Dospekhov, B. A. (1984).

Results

Moisture and Salinity distribution patterns of soil under different saline water conditions:

Moisture distribution

Moisture and Salinity distribution patterns of soil under different saline water conditions:

4-4-1. Moisture distribution:

Data of Fig. (2) illustrate the effect of different irrigation deficit levels and soil depths on the distribution soil moisture by weight (⊖w %). One can notice that, the mean soil moisture content ⊖w % before irrigation for the drip subsurface irrigation system were 7.24, 6.66 and 7.37 % under 100 % FC, 75 % FC and 50 % FC respectively, whereas, after irrigation the values were 12.39, 11.23 and 10.68 % in the same sequence.

On the other hand, the mean (⊖w %). were 8.66, 6.74 and 7.07 % before irrigation while they were 12.82, 11.42 and 11.22% after irrigation under 100, 75 and 50 % FC, respectively for the surface drip irrigation system (SD). Meanwhile, for 75 % FC, the mean ⊖w % were 6.77, 5.92 and 6.15 % before irrigation while they were 12.12, 11.05 and 10.83% after irrigation under 100, 75 and 50 % FC, respectively.

There is a slight decrease and then increase before irrigation, but only decrease in ⊖w % with depth after irrigation, where the moisture of soil was determined for irrigation operation. This may be attributed to the physical properties of the sandy soil with depth. According to the mean soil moisture content (⊖w %), soil depths used under sub-surface drip irrigation system could be arranged in the following ascending orders: for water deficit used 100 %, 75 % FC and 50 % FC could be ranked the orders of 10>20>30 before irrigation and the same after irrigation. According to the mean soil moisture content (⊖w %), soil depths used could be arranged in the following ascending orders: 10>20>30, before irrigation, and after irrigation for water used 100 % FC and 75 % FC. While under 50 % FC could be ranked the orders of 100 % >75 % >50 % FC before irrigation and after irrigation. Differences in ⊖w % among the different drip irrigation systems recorded as a significant difference at the 5 % level. This attributed to the increasing in salt accumulation in cases of the water treatments has been used 75 % FC and 50 % FC. The highest and lowest values of the soil moisture content ⊖w % were 8.87 % at soil deep (10-20 cm) and 4.39 % at soil deep (10-20 cm) before irrigation under sub-surface drip irrigation system. While after irrigation the values were14.37 % at soil deep (10-20 cm) and 9.61 % at soil deep (20-30 cm), respectively. The obtained contour maps for soil moisture distribution under different emitter types and saline water before and after irrigation are shown as contour maps of moisture distribution in Fig. (2).

The data in and Fig. (3) shown that the effect of water deficit levels and soil depths on soil salinity distribution pattern. It is important to mention that, the mean soil salinity content for subsurface drip irrigation system (SSD) were 0.57, .065 and 0.76 dS/m under the water field capacity FC treatments of 100 %, 75 % and 50 % respectively, salinity values recorded were 0.53, 0.67 and 0.80 dS/m after operation of irrigation, respectively. On the other hand, the mean of soil salinity were 0.58, 0.66 and 0.69 dS/m before irrigation while they were 0.55, 0.68 and 0.75 dS/m after irrigation under 100, 75 and 50 % FC, respectively, for the sub-surface drip irrigation system.

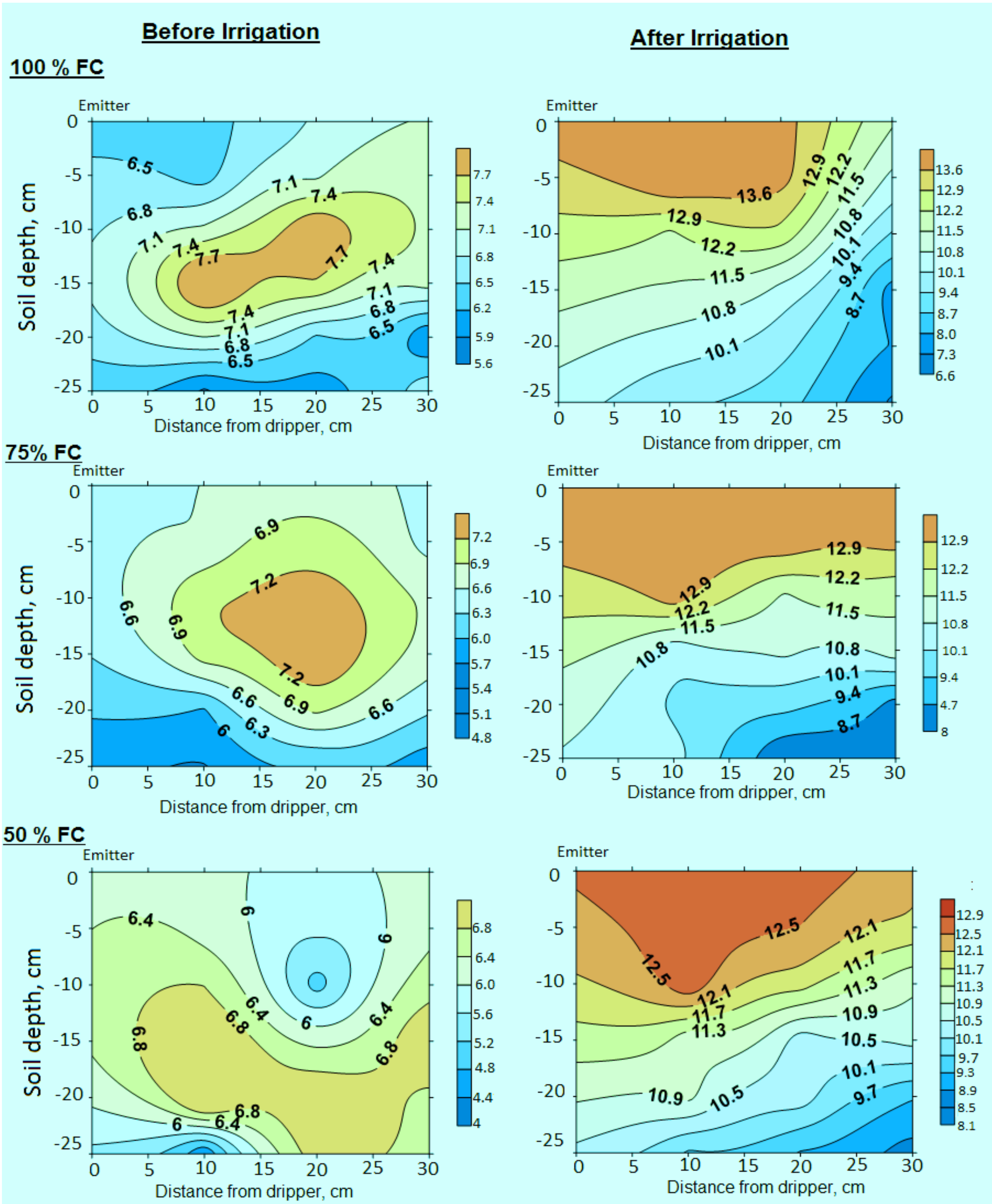

Fig. 2: Contour maps of moisture distribution before and after irrigation under different saline water levels

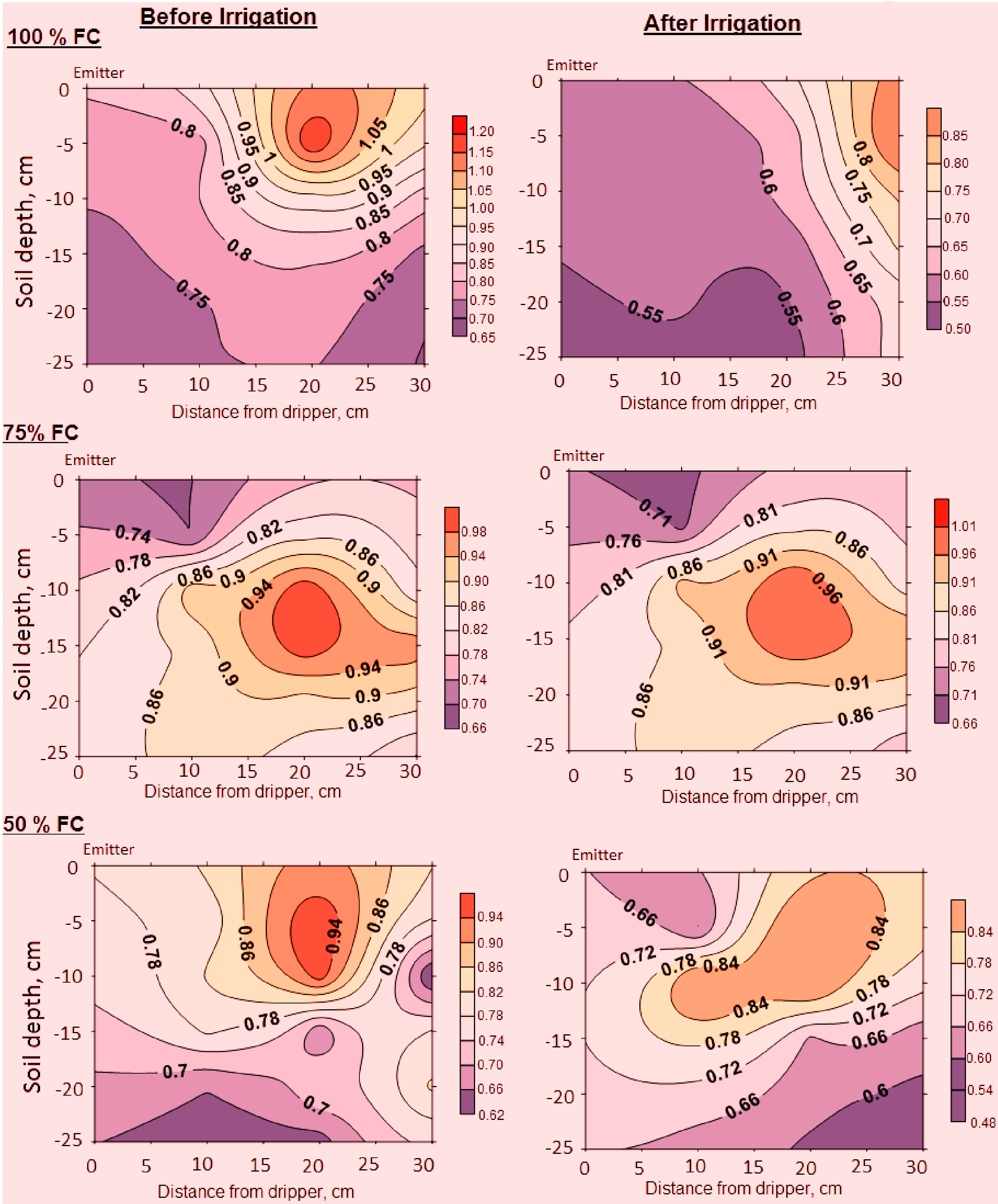

Fig. 3: Contour maps of salinity distribution before and after irrigation under different saline water levels.

Meanwhile, for 75% FC irrigation water level, the mean of soil salinity were 0.54, 0.70 and 0.81 dS/m before irrigation while they were 0.53, 0.74 and 0.88 dS/m after irrigation under 100, 75 and 50 % FC, respectively. There is a slight decrease and then increase before irrigation, but only decrease in of soil salinity with depth after irrigation due to the physical properties of the sandy soil with depth.

According to the mean of soil salinity, soil depths used could be arranged in the following ascending orders: 30>20>10, before irrigation, and after irrigation for water used 100 % and 75 % FC. Also under 100 % FC could be ranked the orders of 30>20>10 before irrigation and 30>20>10after irrigation. Differences in soil salinity among different irrigation systems were recorded as a significant at 5 % level. This may be due the increasing in salt accumulation in cases of water used 75 % and 50 % FC.

According to the mean soil moisture content of soil salinity under 50 % FC water level, soil depths used could be arranged in the following ascending orders: 30>20>10, before irrigation, and after irrigation for water used 100 % and 75 % FC. While under 50 % FC could be ranked the orders of 30>20>10 before irrigation and 30>20>10 after irrigation. Maximum and minimum values of salinity content of soil salinity were 0.51 dS/m (0-10 cm) and 0.94 dS/m (0-10 cm) after irrigation. While before irrigation the values were 0.85 dS/m with depth (0-10 cm) and 0.53 dS/m with (10-20 cm) under sprinkler irrigation. The obtained contour maps for soil salinity distribution under different emitter types and irrigation water before and after irrigation are shown as contour maps of salinity distribution in Fig. (3).

Discussion

In this study, a mapping was used to clarify the details of both moisture distribution and salts in the soil profile under sub-surface drip irrigation system. These contour maps reflect moisture and salts in order to avoid the problems sometimes caused by spacing of irrigation periods or sudden rainfall , In such cases there should be appropriate action for each case, which avoids the occurrence of a threat to the cultivated crop, and also avoid possible contamination of soil and groundwater due to the addition of chemical fertilizers, or the addition of pesticides or herbicides, because these materials, the probability of its movement with the water from the surface of the soil is strong and greatly threatens to increase pollution in the soil or groundwater. Therefore, the distribution of moisture and salts by contour maps under the surface of the soil is of great importance to help not to contaminate the soil, and to know the extent to which the movement of water and salts inside Sector Under sub-surface drip irrigation, there is very good control if chemicals or pesticides are added so that these pollutants are avoided on soil and cultivated plants, these agreed with (El-Gindy 1988, Goyal and Mansour 2015, El-Hagarey et al. 2015, Mansour et al 2019 a,b, Mansour et al 2015 a,d, and Mansour et al 2016a,c).

The use of device Time Domain Reflectometer (TDR), which contains sensors at different depths in the soil under drip irrigation under the surface, made the measurement of moisture and its resulting data more accurate and important details. This has a good effect on obtaining maps of the distribution of soil moisture content (v/v%), and this was agreed with (Mansour 2006, 2012, 2015 and Mansour and Goyal, 2015).

The measurement of electrical conductivity (EC) in the soil sector (salinity distribution) at different depths and at different horizontal distances under sub-surface drip irrigation was done by a digital measuring device that gives a direct reading of the EC value in the dS / m unit. On the contour maps showing the details of the distribution of the navigator in the soil sector, agreed with (Tayel et al 2012 a,d, Mansour 2015, Mansour et al., 2015 a, b, c; Mansour et al., 2016a, b, c)

Conclusion

The results showed that the distribution patterns of moisture and salts were significantly, clearly and morally affected by the different irrigation parameters of the field capacity. The highest soil moisture content was 100% of the field capacity followed by 75% and the lowest value of the soil moisture at 50% in the order is just the opposite.

On the other hand, when studying the form of distribution of moisture and salts at different depths of the soil, the highest soil moisture value at depth was 10 cm, followed by depth 20 cm and the lowest value of ground moisture at depth 30 cm, while the results of the distribution of salts in the opposite order, A significant difference was recorded between different soil depths. The effect of the interaction between the three irrigation parameters and the different drip irrigation systems was significant.

In conclusion, it is recommended to use 75% and 50% of the field capacity, with water saving at 25% and 50% compared with 100% of the field capacity.

References

Abd-Elmabod, S.K.; Bakr, N.; Muñoz-Rojas, M.; Pereira, P.; Zhang, Z.; Cerdà, A.; Jordán, A.; Mansour, H.; De la Rosa, D.; Jones, L. 2019, Assessment of Soil Suitability for Improvement of Soil Factors and Agricultural Management. Sustainability 11, 1588. doi: 10.3390/su11061588

Bacon, P. E. and B. G. Davy (1982). Nutrient availability under trickle irrigation: I. Distribution of water and bray No; 1 phosphate. Soil. Sci. Soc. Am. J. 46:981-987.

Black, G. R. and K. Hartge (1986). Bulk density. Methods of Soil Analysis. Part 1 Agron. 2nd ed. 363 – 376 ASA and SSSA, Madison , WI (c. ed. Klute, R.)

Doorenbos, J. and A. H. Kassam, 1986. Yield response to water, FAO Irrigation and Drainage paper 33, FAO, Rome, Italy, Pp. 101-104.

Dospekhov, B. A. (1984). Field Experimentation. Statistical Procedures. Translated from the Russian by V. Kolykhamatov. Mir Publishers, Moscow.

Earl, K. D. and W. A. Jury (1977). Water movement in bare and cropped soil under isolated trickle emitters:

Analysis of cropped soil experiments. Soil. Sci. Soc. Am. J. 41:856-861.

Eldardiry, E.E., Hellal, F., Mansour, H.A.A. 2015, Performance of sprinkler irrigated wheat – part II.Closed Circuit Trickle Irrigation Design: Theory and Applications, pp.41

El-Gindy, A. M. (1988). Modern chemigation technique for vegetable crops under Egyptian condition. Misr. J. Ag. Eng. ., 5(1): 99-111.

El-Hagarey, M.E.,Mehanna, H.M., Mansour, H.A. 2015, Soil moisture and salinity distributions under modified sprinkler irrigation. Closed Circuit Trickle Irrigation Design: Theory and Applications, pp.3-21.

Gee, G.W. and J. W. Bauder (1986). Particle size analysis. Methods of Soil Analysis. Part 1 Agron. 2nd ed. 383 – 412 ASA and SSSA, Madison, WI (c. ed. Klute, R.)

Gerard, C. G. (1974). Infiltration of antecedent soil Moisture suction saturated hydraulic conductivity of soils. Soil. Sci. Soc. Am. J. 38:506-509.

Gill, K.S., Gajri, P.R., Chaudhary, M. R. and B. Singh, 1996. TiNFRage, mulch and irrigation effects on transgenic and non trangenic corn (Zea mays L.) inrelation to evaporative demand, soil & tiNFRage research, 39, pp. 213-227.

Goyal, M.R. and Mansour H.A.A. 2015.Closed circuit trickle irrigation design: theory and applications, (book), Apple Academic Press, Publisher: Taylor and Frances.

Hanafy, M. (1993). Effect of A lowable soil-water depletion and installation depth on drip irrigation tomatoes in sandy soil. Misr J. Agr. Eng.; 10(3): 628-642, July (1993).

Ibrahim, A., Csúr-Varga, A.,Jolánkai, M., Mansour, H., Hamed, A. 2018, Monitoring some quality attributes of different wheat varieties by infrared technology. Agricultural Engineering International: CIGR Journal 20 (1), pp.201-210.

Jackson, M. L. (1967). Soil Chemical Analysis, Prentice Hall, Inc., Englewood Cliffs, USA.

Kemper, W. D. and R. C. Rosenau (1986). Soil aggregates and size distribution. Methods of Soil Analysis. Part 1 Agron. 2nd ed. 425 – 462 ASA and SSSA, Madison , WI (c. ed. Klute, R.)

Klute, A. 1986. Moisture retention. p. 635–662. In A. Klute (ed.) Methods of soil analysis. Part 1. ASA and SSSA, Madison, WI.

Levin, I.; P. G. Vanrooyan and F. C. Vanrooyan (1979). The effect of discharge rate and intermittent water application by, point source irrigation, on the soil moisture distribution pattern. Soil Sci. Soc. Am. 43:8-16 .

Mansour H. A., Sameh K. Abd-Elmabod and B. A. Engel. 2019a. Adaptation of modeling to the irrigation system and water management for corn growth and yield. Plant Archives Vol. 19, Supplement 1, pp. 644-651.

Mansour H. A., Hu Jiandong, Ren Hongjuan, Abdalla N. O. Kheiry and Sameh K. Abd-Elmabod. 2019b. Influence of using automatic irrigation system and organic fertilizer treatments on faba bean water productivity, International Journal of GEOMATE, Oct., 2019 Vol.17, Issue 62, pp. 256 – 265.

Mansour, H. A., Abdel-Hady, M.,Eldardiry, E.I., Bralts, V.F., 2015a, Performance of automatic control different localized irrigation systems and lateral lengths for emitters clogging and maize (Zea mays L.) growth and yield. International Journal of GEOMATE, Vol. 9, No. 2 (Sl. No. 18), pp. 1545-1552.

Mansour, H. A., 2015, Performance automatic sprinkler irrigation management for production and quality of different Egyptian wheat varieties. International Journal of ChemTech Research. Vol.8, No.12 pp 226-237.

Mansour, H. A., Pibars, S.K., Abd El-Hady, M., Ebtisam I. Eldardiry, 2014, Effect of water management by drip irrigation automation controller system on Faba bean production under water deficit. International Journal of GEOMATE, Vol. 7, No. 2 (Sl. No. 14), pp. 1047-1053.

Mansour, H. A., Sabreen Kh. Pibars, M.S. Gaballah, and Kassem A. S. Mohammed. 2016a. Effect of Different Nitrogen Fertilizer Levels, and Wheat Cultivars on Yield and its Components under Sprinkler Irrigation System Management in Sandy Soil., Vol.9, No.09 pp.1-9.

Mansour, H. A., M. Abd El-Hady, V. F. Bralts, and B. A. Engel, 2016b. Performance Automation Controller of Drip Irrigation System and Saline Water for Wheat Yield and Water Productivity in Egypt. Journal of Irrigation and Drainage Engineering, American Society of Civil Engineering (ASCE), J. Irrig. Drain Eng. 05016005, http://dx.doi.org/10.1061/(ASCE)IR, 1943-4774.0001042.

Mansour, H.A., Aljughaiman, A.S. 2012, Water and fertilizers use efficiency of corn crop under closed circuits of drip irrigation system. Journal of Applied Sciences Research, 8 (11), pp.5485-5493.

Mansour, H.A., E.F.Abdallah, M.S.Gaballah and Cs.Gyuricza, 2015b, Impact of Bubbler Discharge and Irrigation Water Quantity on 1- Hydraulic Performance Evaluation and Maize Biomass Yield. Int. J. of GEOMATE, Dec. Vol. 9, No. 2 (Sl. No. 18), pp. 1538-1544.

Mansour, H.A., Pibars, S.K.; Bralts, V.F., 2015c,The hydraulic evaluation of MTI and DIS as a localized irrigation systems and treated agricultural wastewater for potato growth and water productivity. International Journal of ChemTech Research, Vol.8, No.12 pp 142-150.

Mansour, H.A., Saad, A., Ibrahim, A.A.A., El-Hagarey, M.E., 2016c. Management of irrigation system: Quality performance of Egyptian wheat (Book Chapter). Micro Irrigation Management: Technological Advances and Their Applications.

pp. 279-293.

Mansour, H.A.A. and Aljughaiman, A.S. 2015.Water and fertilizer use efficiencies for drip irrigated corn: Kingdom of Saudi Arabia (book chapter) closed circuit trickle irrigation design: theory and applications, Apple Academic Press, Publisher: Taylor and Frances. pp. 233-249

Mansour, H.A.A. and El-Melhem, Y. 2015. Performance of drip irrigated yellow corn: Kingdom of Saudi Arabia (Book Chapter), closed circuit trickle irrigation design: theory and applications, Apple Academic Press, Publisher: Taylor and Frances. pp. 219-232

Mansour, H.A.A. 2015. Design considerations for closed circuit design of drip irrigation system (Book Chapter). pp.61-133.

Mansour, H.A.A., Mehanna, H.M., El-Hagarey, M.E.,Hassan, A.S. 2015d, Automation of mini-sprinkler and drip irrigation systems.Closed Circuit Trickle Irrigation Design: Theory and Applications, pp.179-204.

Mansour, H.A.A., Tayel, M.Y.,Lightfoot, D.A.,El-Gindy, A.M. 2015e. Energy and water savings in drip irrigation systems. Closed Circuit Trickle Irrigation Design: Theory and Applications, , pp.149-178.

Mansour, H.A.A., El-Hady, M.A., Gyurciza, C.S. 2015f. Water and fertilizer use efficiencies for drip irrigated maize (Book Chapter). Closed Circuit Trickle Irrigation Design: Theory and Applications.. pp. 207-218.

Norris, L. m. and V. A. Tennessee (1985). A review of field-scale physical solute transport processes in saturated and unsaturated project 2485-7 Electric Power Research Institute.

Pibars, S.K., and Mansour, H.A., 2015. Evaluate the response of sunflower productivity to modern chemigation systems in newly reclaimed lands. International Journal of ChemTech Research. 8 (12): 160-169.

Pibars, S.K., Mansour, H.A.A., Abd El-Hady, M., Eldardiry, E.E.I. 2015. Evaluation of emitter clogging for drip irrigated snap beans. Closed Circuit Trickle Irrigation Design: Theory and Applications, , pp.273-286.

Rebecca B. 2004. Soil Survey Laboratory Methods Manual.(Soil Survey Laboratory Investigations Report No. 42) Rebecca Burt Research Soil Scientist MS 41, Room 152, 100 Centennial MaNFR North, Lincoln, NE 68508-3866. (502) 437-5006.

Pibars S. Kh and H. A. Mansour. 2019. Effect of tillage management practices and humic acid applications on some engineering properties of peanut. Plant Archives Vol. 19, Supplement 1, pp. 636-643.

Samir S. Attia, Abdel-Ghany M. El-Gindy, Hani A. Mansour, Soha E. Kalil and Yasser E. Arafa. 2019. Performance analysis of pressurized irrigation systems using simulation model technique. Plant Archives Vol. 19, Supplement 1, pp. 721-731.

Tayel, M. Y., A.M. El-Gindy and H.A. 2012a. Mansour. Effect of drip irrigation circuit design and lateral line lengths iv- on uniformity coefficient and coefficient of variation. Journal of Applied Sciences Research. 8(5): 2741-2748.

Tayel, M. Y., H.A. Mansour, and S.Kh. Pibars, 2015e. Performance of drip irrigated soybean. Book chapter, Closed Circuit Trickle Irrigation Design, Theory and Applications. pp.250-263

Tayel, M.Y., El-Gindy, A.M., Mansour, H.A. 2012b. Effect of drip irrigation circuits design and lateral line length on III-dripper and lateral discharge. Journal of Applied Sciences Research, 8 (5), pp.2725

Tayel, M.Y., Mansour, H.A.A., Pibars, S.K. , 2015a. Performance of maize under bubbler irrigation system. Closed Circuit Trickle Irrigation Design: Theory and Applications, pp.135-147.

Tayel, M.Y., Mansour, H.A.A., Pibars, S.K. 2015b. Performance of sprinkler irrigated wheat – part I. Closed Circuit Trickle Irrigation Design: Theory and Applications, pp.23-40.

Tayel, M.Y., Pibars, S.K., Mansour, H.A.A. 2015c. Evaluation of emitter clogging. Closed Circuit Trickle Irrigation Design: Theory and Applications, pp.287-300.

Tayel, M.Y., Shaaban, S.M., Mansour, H. A. 2015d. Effect of plowing conditions on the tractor wheel slippage and fuel consumption in sandy soil. International Journal of ChemTech Research, Vol.8, No.12 pp 151-159.

Tayel, M.Y., Shaaban, S.M., Eldardiry, E.A., Mansour, H.A. 2018, Wheat yield versus seed bed conditions. Bioscience Research, 15(3), pp. 1943-1951.

Tayel, M.Y.; S. M. Shaaban; H. A. Mansour and E.F. Abdallah, 2016. Response of Fodder Beet Plants Grown in a Sandy Soil to Different Plowing Conditions. International Journal of ChemTech Research. Vol.9, No.09 pp.20-27.

Tayel, M.Y.; S.M. Shaaban and H.A. Mansour. 2019. Impact of seedbed preparation condition on aggregates stability, yield, water productivity and fertilizers use efficiency on maize (zea mays). Plant Archives Vol. 19, Supplement 1, pp. 706-710.