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Economic of Drip Irrigation System in New Reclamation Lands

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ABSTRACT

Irrigation scheduling in terms of frequency rate and duration expresses how water is used on the farm. The technique involves two decisions: - when to irrigate (timing) and how much to apply (quantity) Ideally, they are planned so that adequate water can be delivered to the farm during the peak crop water-use period. This research aims to comparison two irrigation systems the drip irrigation and open furrow irrigation. Split area of 36m^2 was designed for both irrigation systems. Onions were planted in these areas. Three moisture content levels were selected for this study namely 100 % (M1), 75 % (M2), and 50 % (M3) of the available water. The results show that the generally, the moisture content decreases at deeper soil layers or being far from the dripper or furrow systems. The electrical conductivity (EC) value increases in horizontal and vertical directions and so chloride. The data indicated that salts are accumulated according to direction of water flow. Generally, the EC and chlorides concentration increased by decreasing the quantities of water applied rates. The salinity increased in the following order: drip and furrow irrigations. Comparing the three different applications water under irrigation systems, a significant relation was remarked. Meanwhile, when the two systems irrigation is compared due to the application water, no significant relation obtained. Under drip irrigation, each k watt of power produced 273 kg of yield in the first season increasing by 73.55 and 64.56 % than the furrow system respectively.

Keywords: Moisture; Salinity; Crop yield; WUE; Power requirement; Wadi El- Natrun and Dakahlia Area; Egypt.

INTRODUCTION

To determine the proper amount of water, the planner should thus know soil-plant-weather relationships. Also, the conveyance and application efficiencies should be known. The new lands had their own undesirable conditions and to the shortage of water and harmful salts existing in soil component and wells water, severe weather conditions. Accurate data for consumptive use are required in irrigation system design for improving water use efficiency. Ideally, they are planned so that adequate water can be delivered to the farm during the peak crop water-use period. Other advantages include the minimizing of water and energy as well as deep percolation losses. El-Nashar and Elyamany (2017) found that small water quantity is needed for drip and subsurface irrigation than for surface or sprinkler irrigation less water is lost by direct evaporation and deep percolation. Eid *et al*., (2013) reported that under sprinkler irrigation salt content within soil was mainly affected by the amount of water added components of soil and type of irrigation water. Generally the higher moisture content reduces the EC values of the soil indicating the casiness of leaching the soil. Thus, the salt concentration increases as the moisture content decreases. Rafie and El-Boraie (2017) found that; water use efficiency significantly increased with 100% irrigation water requirements and 4L/h dripper discharge rate when applying surface drip irrigation system. Wazed *et al*. (2017) described the study about solar-powered irrigation technologies that have developed significantly in the past decade assisted by the development of higher efficiency, low cost solar Photovoltaic panels. The technology has come so far as to be able to elapse diesel-powered irrigation systems in terms of the payback period and reduction in greenhouse gasses.

The objectives of this work were as to:

1. Selecte the proper irrigation system in new and in respect to water use efficiency, total yield and cost.
2. Comparing the effect of water system on salts and water distribution through soil layers.
3. Evaluate the consumed power under each system.

MATERIALS AND METHODS

The study area consists of two farms, the first was the El bana farm in Wadi El Natrun district, Al Behera governorate, The second was El-Gamil farm, Bin Obeid District, dakahlia governorate.

Physical and chemical properties of soil

Soil samples taken randomly from each different planted soil in the two studied farms (El bana, and El-Gamil farms), ten soil samples were randomly collected and taken by shovel at (0-35 cm depth), and were mixed then one representative sample (field average sampling) was taken. Thus, two surface soil samples (0-35 cm) were collected samples were from El banna farm and sample were from El-Gamil farm. The obtained soil samples were air-dried, crushed, and passed through a 2-mm sieve. The physical and chemical properties for studied farms were obtained.

Soil moisture and soil salinity distributions

In Drip irrigation, irrigation was carried out in three stages, as we explained previously at (50, 75 and 100%) of the total amount of water consumed and moisture was de-

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termined after irrigation but the salinity it was determined in the end season, was determined by using an electrical conductivity meter in 1:5 soil-water extract, in four different locations at different horizontal distances of (5, 10, 15 and 20 cm) from the dripper, and depths (0-10, 10-20, 20-30, and 30-40 cm) from the soil surface.

As for Furrow irrigation, soil moisture determination and determination were done in the same way as drip irrigation, but soil samples were taken differently, which are in four locations at different horizontal distances (10, 15, 20, and 25 cm) and depths (0-10, 10-20, 20-30, and 30-40 cm) from the soil surface.

Chloride distribution on soil

Chloride distribution was determined in four different locations at different horizontal distances of (5, 10, 15 and 20 cm) from the dripper, (10,15,20, and 25 cm) from the center of the furrow, and depths (0-10, 10-20, 20-30, and 30-40 cm), chloride distribution was determined in using Silver nitrate (Hesse, 1971). Each treatment was performed through the successful agricultural season for onion in 2019-2020.

Amount of applied water

Three treatments of 100, 75 and 50 percent of the maximum available water were investigated. Each treatment was replicated two times under. Drip, and furrow irrigation systems through the successful agricultural season for onion in 2019-2020.

The amount of irrigation water were calculated as the follows equation (Black *et al.*,1965):

$$D = \frac{FC - WP}{100} \times B_D \times D_R \quad \text{.......................................(1)}$$

Where: **D is the depth of available water (cm), and BD is the bulk density, and FC is the field capacity, and WP is the wilting point, and DR is the depth of root (cm).**

The applied amount of irrigation water was calculated with the following equation.

$$Q = q \times t \quad \text{.......................................(2)}$$

Where: Q **is the applied irrigation water, (m^3/fed), and (** q **) is the discharge, m^3/min, and** t **is the total irrigation time (min/Fed).**

The experimental field parameters of irrigation systems and a total of irrigation water for onion and time of irrigated are listed in Tables (1, and 2).

Table 1.The experimental field treatments of irrigation systems

Treatments	Drip	Furrow
Irrigated area (Plot)	6 × 6 m	6 × 6 m
No. of rows/plot	7 rows	7 rows
No. of plants/plot	2520 plants	2520 plants
discharge	4 Lit / h.	6.635 m^3/h.

Table 2. Time and a total of irrigation

Treatments	Drip	Furrow
Application time		
M1 (100%)	3 h. + 15 min	11 min
M2 (75%)	2 h. + 26 min	8.5 min
M3 (50%)	1 h. + 38 min	6 min
Water irrigation depth		
M1	65.0 cm / season	65.0 cm / season
M2	48.8cm / season	48.8 cm / season
M3	32.6 cm / season	32.6 cm / season
No. of onions plants/fed.	294000 plants	294000 plants

Method of analysis and measurements

1- Particles size distribution according to (Piper 1950).
2- Bulk density according to (Black *et al.*, 1965).
3- Calcium carbonate according to (wright 1939).
4- Organic matter according to (Black *et al.*, 1965).
5- Field capacity according to (Thorne and Peterson 1954).
6- Permanent wilting point was obtained depending on sunflower method as described by Dastane (1967).

Water use efficiency, (WUE)

Water use efficiency values as grain yield (kg) m^{-3} of the applied water were calculated for different treatments after crop harvest according to Eq. (3) (Jensen, 1983).

$$WUE = \frac{\text{Onion yield (kg fed}^{-1})}{\text{Water applied (m}^3\text{ fed}^{-1})} \quad \text{.......................................(3)}$$

Power requirement for producing onion (kg/kW)

$$P_0 = \frac{P * Q}{\text{constant}} \quad \text{.......................................(4)}$$

Where: P_0 **is the power required per treatment (kW), and P is the pressure (bar), and Q is the discharge (m^3/sec).**

$$\text{Power requirement} = \frac{Y}{P_0} \text{ kg/kW} \quad \text{.......................................(5)}$$

Where: **Y is the onion yield (kg/treatment).**

RESULTS AND DISCUSSION

Soil physical properties

The analyzed soil samples appear some soil physical properties such as particle size distribution (coarse sand, fine sand, silt, and clay), organic matter, calcium carbonate content, texture, field capacity, and saturation percentage of the investigated soil samples at depth (0-35 cm) as shown in table (3).

Table 3. Soil physical properties of the experimental samples

Farm name	Depth (cm)	Sand (%)		Total sand (%)	Silt (%)	Clay (%)	CaCO3 (%)	OM (%)	FC (%)	SP (%)
		Coarse	Fine							
El banna	0-35	24.1	50.0	74.1	14.2	11.7	1.65	0.50	15.24	30.48
El-Gamil	0-35	15.10	5.00	20.1	31.2	48.7	4.00	1.40	35.0	70.00

El banna farm, it was found that the coarse sand in the studied soil was 24.1%, fine sand was 50.0 %, total sand (TS) was 74.1%, silt percentage was 14.2 %, clay percentage was 11.7%, accordingly, the majority of soil textures were sandy. Saturation percentage (SP) was 30.48 %. Organic matter was very low in the studied soil, it was and 0.50%, and calcium carbonates were 1.65%. In El-Gamil farm, it was found that the coarse sand in the studied soil was15.10%, fine sand was 5.0 %, total sand (TS) was 20.1%, silt percentage was 31.2 %, clay percentage was

48.7%, saturation percentage (SP) was 70 %. SP values were associated with higher clay content, organic matter content was medium. OM was 1.40%, and calcium carbonates were 4.0%.

Soil chemical properties

The analyzed soil samples appear some soil chemical properties of the investigated soil samples taken from depth (0-35 cm) in saturation soil extract as shown in table (4). These properties include pH, electrical conductivity (EC), soluble cations, and soluble anions.

Table 4. Soil soluble cations, anions, pH and EC values

Farm name	Depth (cm)	Soluble cations (meq 100g-1 soil)				Soluble anions (meq 100g-1 soil)			pH 1:2.5	EC1:5 dS m-1
		Ca++	Mg++	Na^+	K^+	HCO_3^-	Cl^-	SO4⁻⁻		
El banna	0-35	1.52	0.93	4.73	0.50	1.61	4.52	1.55	8.13	1.50
El-Gamil	0-35	0.67	0.31	3.69	0.09	0.69	3.01	1.06	8.05	0.93

Calcium ions ($Ca2^+$), was 1.12 meq 100g-1 soil in El banna farm, while it 0.67 meq $100g^{-1}$ soil in El-Gamil farm. Magnesium ions (Mg^{++}) was 1.69 meq $100g^{-1}$ soil in Elbanna farm, while it was 0.31 meq $100g^{-1}$ soil in El-Gamil farm. Sodium ions (Na^+), was 4.07 meq $100g^{-1}$ soil in El banna farm, 3.69 meq $100g^{-1}$ soil in El-Gamil farm, and potassium ions (K^+) she was 0.92 meq $100g^{-1}$ and 0.09 meq $100g^{-1}$ soil in El Gamil farm.

Carbonates ions ($CO3^{--}$) were null in soil paste extracts of the studied soil samples in the two farms, bicarbonate ions ($HCO3^-$) from 2.89 meq $100g^{-1}$ soil in El banna farm, while it was 0.69 meq $100g^{-1}$soil in El-Gamil farm, chloride ions (Cl^-) she was 2.71 meq$100g^{-1}$ soil in El banna farm, while it was 3.01 meq 100g-1soil in El-Gamil farm, sulfate ions ($SO4^{--}$) was 0.53 meq $100g^{-1}$ soil in El banna farm, while it was 1.06 meq $100g^{-1}$soil in El-Gamil farm, soil pH she was 8.18 in El banna farm, and it was 8.05 in El-Gamil farm, and electrical conductivity (EC) was 1.18 in El banna farm, and it was 0.93 in El-Gamil farm. This indicates that the studied soils in the two investigated farms are non-saline, which could be contributed to the good management practices in the studied area.

The Effect of Irrigation System and Amount of Applied Water on Soil Moisture Distribution

Figs. (1 and 2). Indicate that the moisture content generally decreases in horizontal and vertical directions under the two irrigation systems. Under drip system the moisture distribution is increases through the surface layer of (0-30 cm) than the furrow system this may be attributed to the short irrigation in case of drip irrigation. The average values of moisture was the lowest of 11.27, 10.79, and 8.61 % under the furrow system through 30-40 cm under three treatments compared with the drip system (11.71, 10.27, and 9.86%). Figs. 1 and 2. shows that the moisture content decreases by decreasing the amount of applied water. The higher value of moisture contents was obtained under the drip system comparing to furrow systems. The drippers supplied water from a point source, the soil is saturated close to the point source with a gradual decrease in moisture content in the soil in all directions away from the sources.

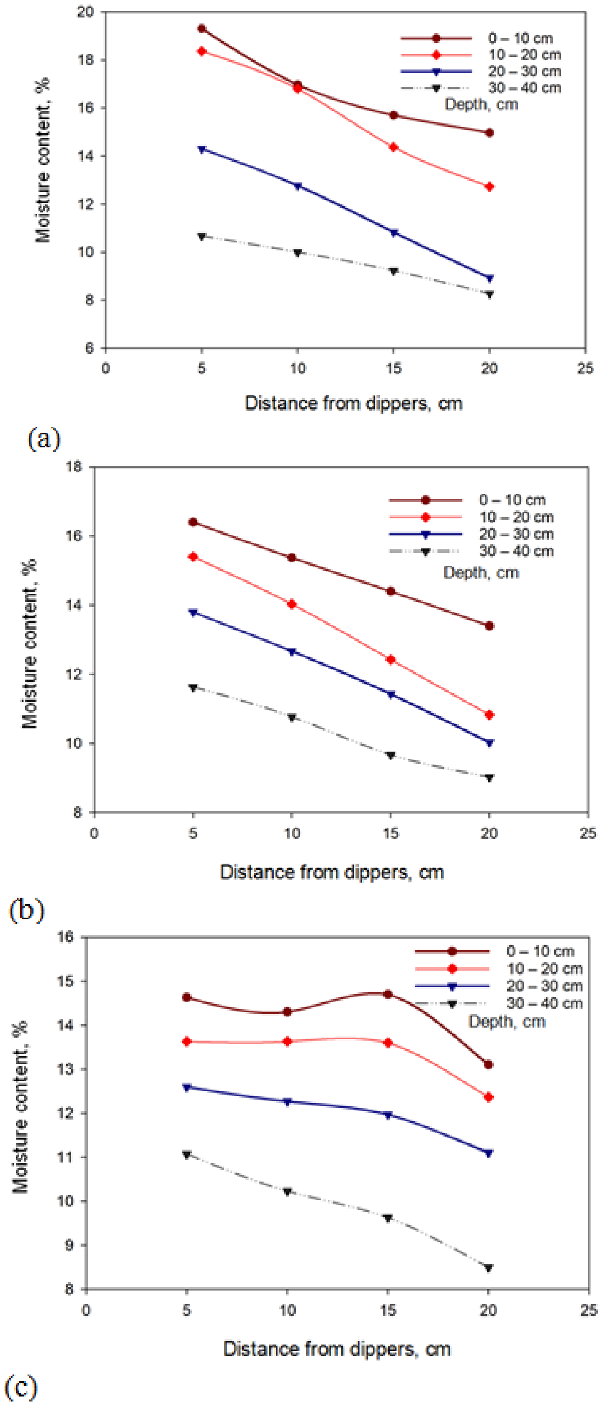

Fig. 1. Water distribution under drip irrigation system, at (a) 100, (b) 75, and (c) 50 %, soil moisture of total applied water

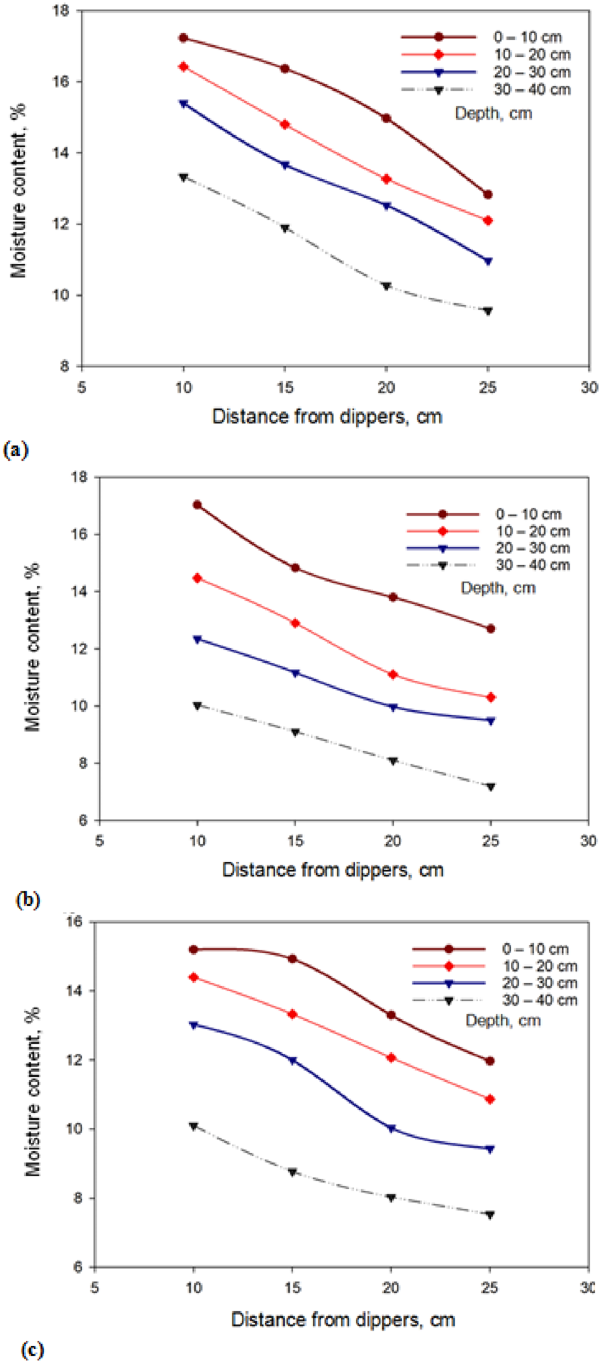

Fig. 2. Water distribution under furrow irrigation system, at (a) 100, (b) 75, and (c) 50 %, soil moisture of total applied water

The Effect of Irrigation Systems and Amount of Applied Water on Salt Distribution

Figs.(3 and 4) indicates that the soil salinity content increased through deep soil layers due to the moisture movement, figs. 3 and 4 reveal that the concentration of salts increased horizontally and vertically through soil layers under drip system in the boundaries of the wetted zones. The highest salinity was accumulated at 20 cm distance from drippers for all irrigation water. The salinity content at any location is subjected to rate of flow, the quality of irrigation water and the amount of irrigation water.

As to the furrow irrigated area, the salts were distributed at zones near the furrows; Figs. 3 to 4 reveal that the salts concentration under furrow system increased in both vertical and horizontal direction dealing with the dynamics of water. The effect of irrigation systems on the salt accumulation can be arranged in the following deciding order: Drip > furrow systems. Generally, this may attributed to the fact that the salts concentration increased by decreasing moisture content.

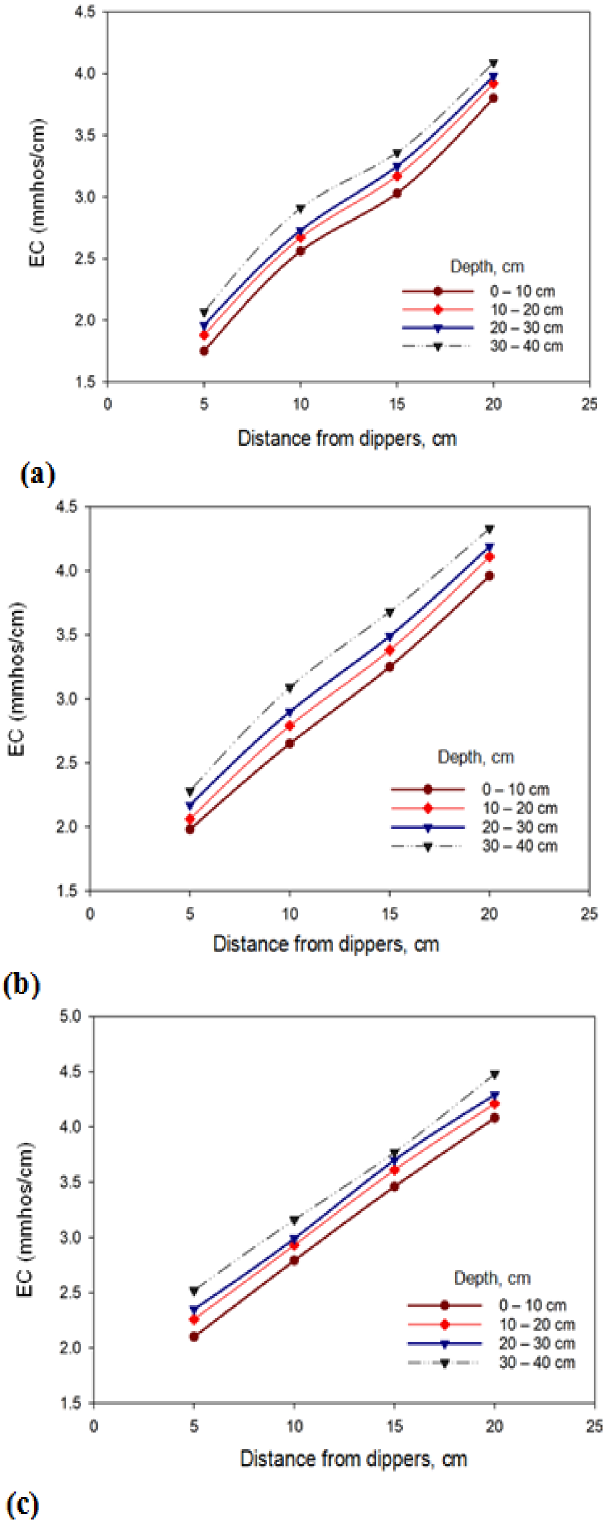

Fig. 3. Electrical conductivity distribution under drip irrigation system, at (a) 100, (b) 75, and (c) 50 %, soil salinity of total applied water

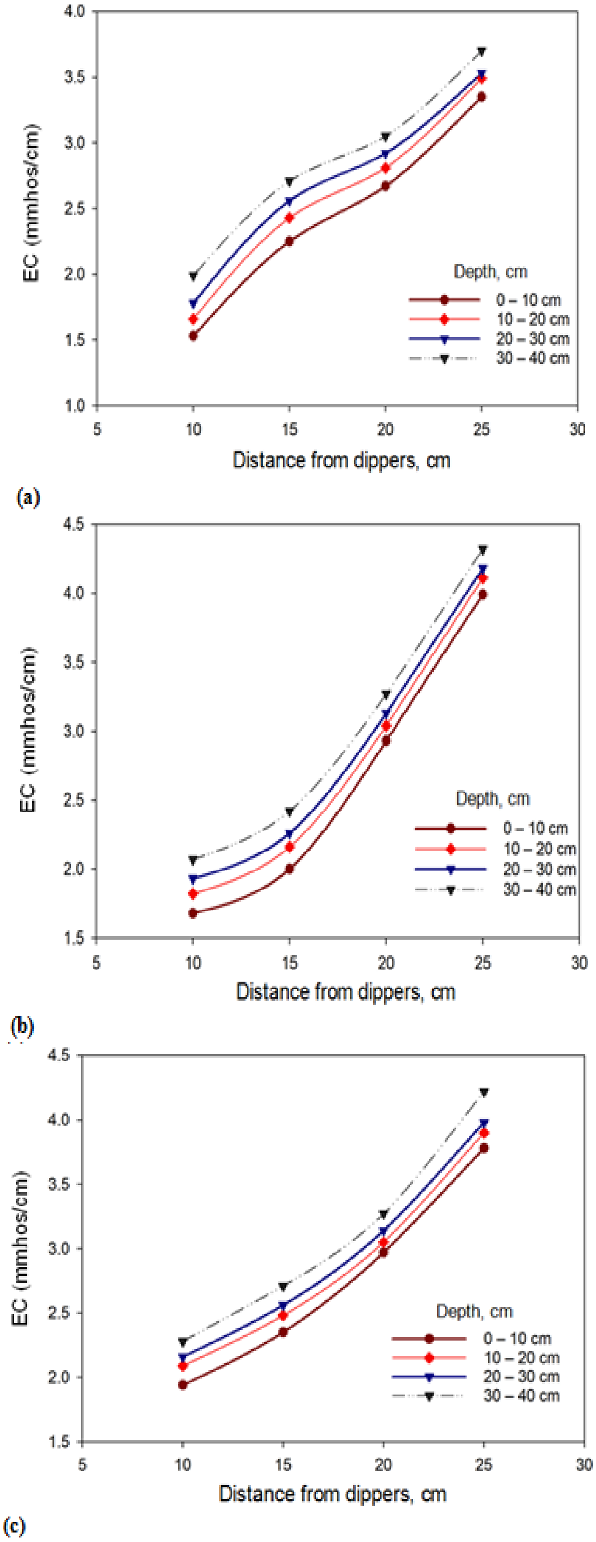

Fig. 4. Electrical conductivity distribution under Furrow irrigation system, at (a) 100, (b) 75, and (c) 50 %, soil salinity of total applied water

The Effect of Irrigation Systems and the Amount of Applied Water on Chloride Distribution, %

Figs. 5 and 6 indicate that the chloride increases in horizontal and vertical directions under the two irrigation systems. Under the drip system, the chloride distribution is decreased through the surface layer of (0-10 cm) than the furrow system this may be attributed to the short irrigation in case of drip irrigation. The average values of chloride were the lowest of (13.40, 14.60, and 11.10 %) under the drip system through (0-10 cm) under three treatments compared with the furrow system (11.50, 12.80, and 9.27 %). Figs. 5 and 6 show that the chloride value increases by decreasing the amount of applied water. The higher value of chloride values was obtained under the drip system comparing to the furrow system. Decrease in chloride values in the soil in all directions away from the sources.

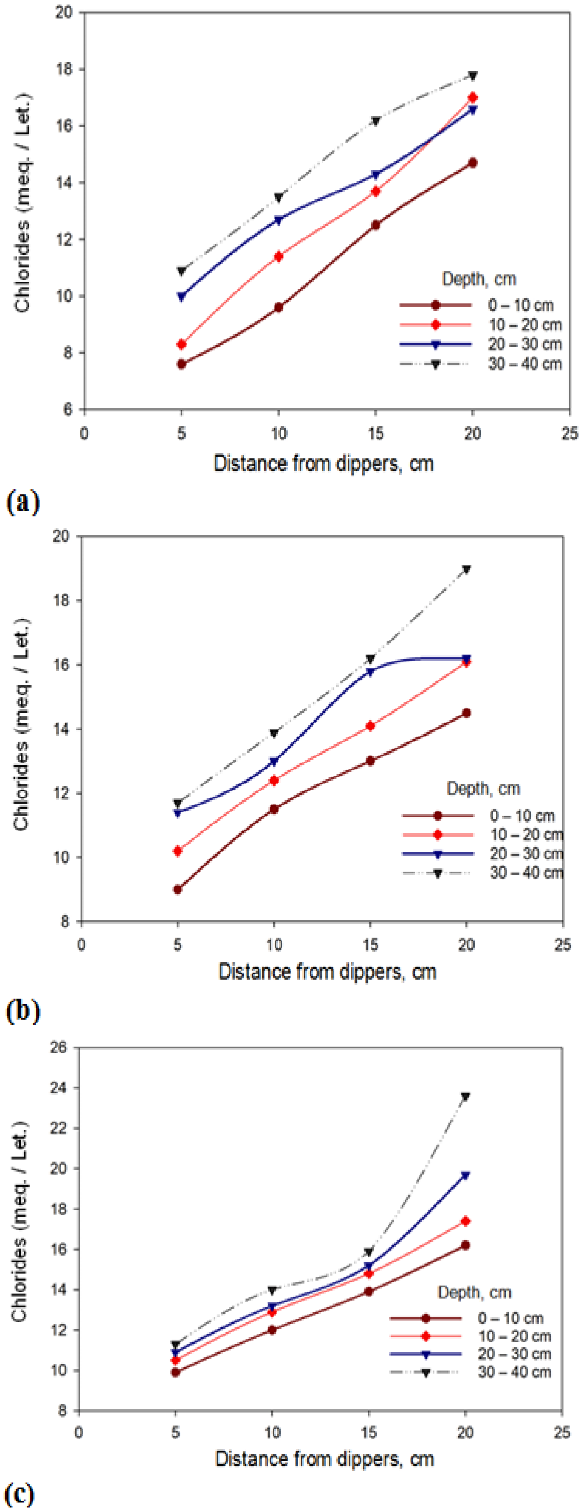

Fig.5. Chlorides distribution under drip irrigation system, at (a) 100, (b) 75, and (c) 50 %, soil chloride of total applied water

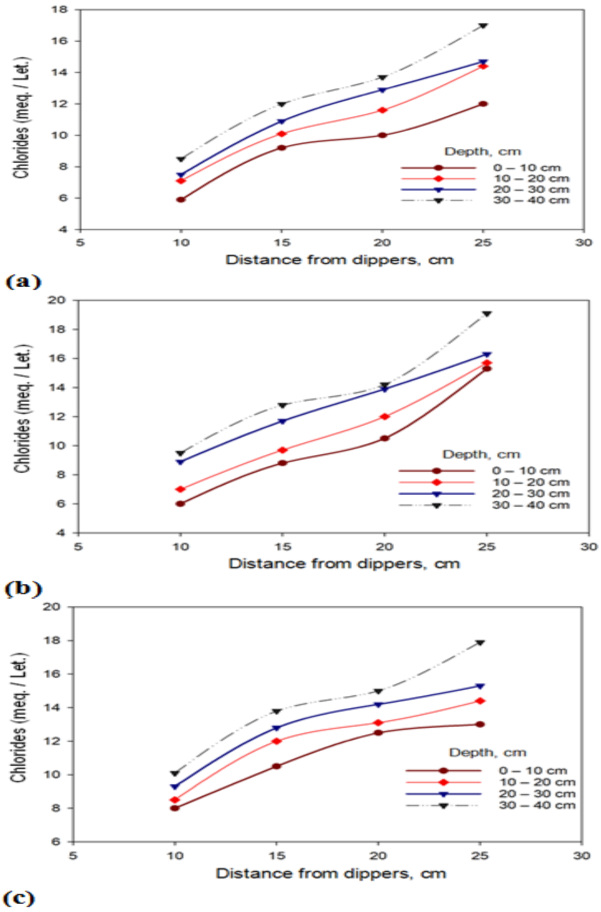

Fig. 6. Chlorides distribution under Furrow irrigation system, at (a) 100, (b) 75, and (c) 50 %, soil chloride of total applied water

Effect of Irrigation Systems and Amount of Applied Water on Crop Yields and Water Use Efficiency, (WUE)

It is noticed that the yield obtained under drip irrigation increased by 14.15% than the furrow system, respectively from the table (5). The values of water use efficiency investigated differences between all of the treatments as shown in Table (5). The highest values of WUE were obtained under the drip irrigation system in all treatments M1, M2, and M3 through the season. The average values of WUE under drip irrigation were 10.96 kg/m^3, increasing by 14.14% than the furrow system. It is interesting to know that the maximum values of WUE are obtained under the amount of applied water 14.30 kg/m^3.

Table 5.Crop yield obtained under different treatments

Irrigation system		Amount of applied water (m^3/Fed.)	Yield, ton /Fed.	WUE, kg/m^3
Drip	M1 (%)	2730	23.22	8.51
	M2 (%)	2050	24.18	11.80
	M3 (%)	1370	20	14.60
Mean		2050	22.47	10.96
Furrow	M1 (%)	2730	19.35	7.09
	M2 (%)	2050	20.92	10.20
	M3 (%)	1370	17.60	12.85
Mean		2050	19.29	9.41

Power Requirement

a. Drip

Pressure, (1.2 bar).
No. of dripper, (2520).
Discharge, (4 liter / hr.).
$\eta = 90\%$.

$$\textbf{Power requirements} = \frac{1.2\times4\times1000\times2520}{0.9\times3600\times75\times10^2} = \textbf{2.09 hp/Fed.}$$

Power requirements = 2.09×0.7355 = 1.54 kW/fed.

b. Furrow

Pressure, (2.2 bar).
Discharge, (6.635 m^3/hr.).
$\eta = 70\%$.

$$\textbf{Power requirements} = \frac{6.635\times2.2\times10^6}{0.7\times3600\times75\times10^2} = \textbf{0.8 hp/Fed.}$$

Power requirements = 0.8×0.7355 = 0.59 kW/Fed.
Amount of applied water on one irrigated/Fed.
M1 (%) = 136.5 m3/Fed.
M2 (%) = 102.48 m3/Fed.
M3 (%) = 68.46 m3/Fed.

The time of operating applied irrigation water for field treatments was computed with the equation (Black et al.,1965): as shown in Table (6, and 7), and as previously ex-plained has been calculated power requirement operating for producing onion (kg/kW) as shown in Table (8, and 9).

Table 6. Time of operating, one irrigated / fed

Treatment	Irrigation systems	
	Dr.	**Fu.**
M1 (%)	3.25	20.6
M2 (%)	2.44	15.44
M3 (%)	1.63	10.32

Table 7. Time of operating, h / season

Treatment	Irrigation systems	
	Dr.	**Fu.**
M1 (%)	65	412
M2 (%)	48.8	308.8
M3 (%)	32.6	206.4

Table 8. Power requirement, one irrigated, kW / fed

Treatment	Irrigation systems	
	Dr.	**Fu.**
M1 (%)	5.01	12.15
M2 (%)	3.76	9.11
M3 (%)	2.51	6.09

Table 9. Power requirement, kW / season

Treatment	Irrigation systems	
	Dr.	**Fu.**
M1 (%)	100.20	243.08
M2 (%)	75.2	182.19
M3 (%)	50.20	121.78

Under drip irrigation, each kW of power produced 298.8 kg of crop yield the increasing ratio was 74.25 and 63.65% than the furrow system, respectively as shown Table (10).

Table 10. Crop yield and power requirement for two seasons as affected by irrigation systems and amount of applied water.

Irrigation system		Operating time, h.	Power requirement, kW	Amount of applied water, m3	Crop yield, kg /Fed.	Crop yield, kg /kW
	M1 (%)	65	100.2	2730	23220	231.74
Drip	M2 (%)	48.8	75.20	2050	24180	321.54
	M3 (%)	32.6	50.20	1370	20000	398.41
Mean			75.2	2050	22470	298.8
	M1 (%)	412	243.08	2730	19350	79.60
Furrow	M2 (%)	308.8	182.19	2050	20920	114.83
	M3 (%)	206.4	121.78	1370	17600	144.52
Mean			182.19	2050	19290	105.88

CONCLUSION

The three treatments of amount of applied water were 100% D (3.25 cm), 75 % D (2.44 cm), and 50% D (1.63 cm). The distances between rows 100 cm and between plants 40 cm in rows.

The moisture content decreases at deeper soil layers or being far from the dripper or furrow systems. Comparing the three different applications of water under each irrigation system, a significant relation was remarked. Meanwhile, when the two systems irrigation is compared due to the application no significant relation obtained.

The electrical conductivity (EC) value increases in horizontal and vertical directions and so chloride. The data indicated that salts are accumulated according to the direction of water flow. Generally, the EC and chloride concentration increased by decreasing the quantities of water applied rates. The salinity increased in the following order: drip> furrow irrigation. Comparing the three different application water under each irrigation system, a significant relation was remarked. Meanwhile, when the two systems irrigation is compared due to the application water, no significant relation obtained.

The effect of irrigation systems on roots distribution. The roots distributed through the surface layer under drip irrigation more than furrow irrigation, while the distribution of roots increased in the vertical direction for furrow irrigation more than drip irrigation.

Yield and water use efficiency. The results clearly showed that the highest yield obtained under the drip irrigation system.

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أقتصاديات استخدام نظام الري بالتنقيط في الأراضي حديثة الأستصلاح

الشحات بركات البنا ، على السيد أبو المجد ، محمد مصطفي أبو حباجة و السنوسي عبدالله حسين

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تتضمن جدولة الري قرارين, متى يتم الري (التوقيت), ومقدار تطبيقه (الكمية), تعتبر هذه القرارات حاسمة لإدارة أي أنظمة ري من الناحية المثالية، يتم التخطيط لها بحيث يمكن توصيل المياه الكافية إلى المزرعة خلال فترة ذروة استخدام المياه للمحاصيل. وتشمل المزايا الأخرى التقليل من المياه والطاقة وكذلك خسائر الترشيح العميقة, مع ضمان توفر المياه الكافية للنباتات دون وضعها تحت ضغط قد يقلل من المحصول. تم تنفيذ التجربة في مزرعتين, الاولي مزرعة البنا وادي النطرون بمحافظة البحيرة – والثانية مزرعة الجميل بني عبيد بمحافظة الدقهلية, خلال الموسم الناجح لزراعة محصول البصل, 2019-2020. كانت التغطية فى هذه الدراسة بمساحة 36م2 , للطريقتين: الري بالتنقيط في مزرعة البنا, والري بالغمر في مزرعة الجميل, تم زرع محصول البصل في هذه المناطق, وتم اختيار ثلاث مستويات لمحتوي الرطوبة وهي (م1- 100%) و(م2- 75%) و(م3- 50%) من المياه المتاحة, وكانت المسافة بين النباتات 20سم والمسافة بين الصفوف 100سم. المتغيرات التـى تـم دراستـها:1- كمية المياه المستخدمة.2- تأثير نظم الري وكمية المياه المستخدمة داخل نظام التربة.3- تأثير نظم الري وكمية المياه على الرطوبة والاملاح والكلوريدات في التربة.4- كفاءة المحصول والماء. 5- كفائة استخدام الطاقة في الري. كميات المياه المطبقة عند المعالجة (م1 %) = 3730 م^3 / فدان, و(م2 %) = 2050 م^3 / فدان, و(م3 %) = 1370 م^3 / فدان. من اجمالي كمية المياه المطبقة. وفقا لهذه التقنية في هذه الدراسة والنتائج, يتأثر نظامي الري وكمية المياه المستخدمة على توزيع مياه التربة, توضح الدراسة أن محتوى الرطوبة ينخفض بشكل عام. في ظل نظام التنقيط يزداد توزيع الرطوبة عند الطبقة السطحية (0-30 سم) أكثر من والغمر التي يمكن أن تعزى إلى الري القصير في حالة الري بالتنقيط, كما توضح الدراسة أن محتوى الرطوبة ينقص من خلال تقليل كمية المياه المستخدمة, تم الحصول على القيمة الأعلى لمحتويات الرطوبة تحت نظام الري بالتنقيط, كما يجعل من التربة في حالة تشبع بالقرب من المصدر النقطي مع انخفاض تدريجي في محتوى الرطوبة في التربة في جميع الاتجاهات بعيدًا عن المصادر. ايضا يزداد توزيع الرطوبة والاملاح وكذلك الكلوريد في الاتجاهين الأفقي والرأسي, أشارت البيانات إلى أن الأملاح تتراكم حسب اتجاه تدفق المياه. وبصفة عامة زاد تركيز الكلوروفلوروكربون والكلور عن طريق تقليل كميات المياه المطبقة. ايضا زادت الملوحة بالترتيب التالي: الري بالتنقيط> ري غمر. ايضا كفاءة المحصول والماء, أوضحت النتائج أن أعلى محصول تم الحصول عليه تحت نظام الري بالتنقيط. كفائة استخدام الطاقة في الري, تحت الري بالتنقيط أنتجت كل كيلو واط من الطاقة 298.8 كجم من المحصول بنسبة 64.56٪ من نظام الغمر حيث أنتج كل كيلو واط من الطاقة 105.88 كجم من المحصول.