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EFFECT OF ALTERNATIVE FURROWS IRRIGATION, THE SLOPE OF LAND SURFACE AND WATER QUANTITIES ON MAIZE CROP PRODUCTIVITY

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ABSTRACT: *Two field trials were carried out at Nubaria private farm, during growing seasons 2013 and 2014 to evaluate irrigation water requirements and determine an irrigation schedule for maize crop. The treatments were three alternative irrigation. Irrigated one furrow and un-irrigated one furrow, irrigated two furrows and un-irrigated two furrows and irrigated three furrows and un-irrigated three furrows., two land surface slopes (zero level and 0.05% slope of furrow surface applying laser leveling) and three quantities of irrigation water applied (100% of the ET_C, 85% of the Et_C and 70 %of the Et_C). The results showed that:*

The yield components and yield were increased by using two alternate furrows irrigation while land surface slope of 0.05% decreased the irrigation water applied, and increased both of (the water distribution uniformity, water application efficiency, yield and water use efficiency), on other hand, yield components and yield / fed were increased in the plot received 100% of the calculated evapotranspiration compared with these in the plot which received 85 % of the calculated evapotranspiration also maximum value of the water use efficiency (WUE) was obtained when the plot received 100% of the calculated evapotranspiration. The water application efficiency (Ea), and water distribution efficiency ((Ed) were increased by increasing the discharge rate from 70% to 100% of the Etc. Also (Ea) and ((Ed) increased by 7.70 and 9.80 % when the use of land surface slope 0.05 %. Also the grain moisture and some physical properties were affected by using the alternate furrows irrigation, the amount of the applied water and slope of land surface

Key words: *Alternate furrow irrigation, land surface slope, furrow irrigation efficiencies, maize crop.*

INTRODUCTION

Maize is one of the most important field crops in Egypt. Maize is not a grain crop only but a dual purpose crop , supplying both grain for eats human population and the only green foliage available during the summer months This publication deals with the why's and how's of corn irrigation scheduling. The potential benefits of proper scheduling; the crop, soil, and climatic factors involved and their relationships arediscussed.

Methods of determining irrigation timing; and scheduling irrigation amount, timing and uniformity of water application are the most important factors to be considered when yields have to be maximized and water losses have to be minimized. Improving irrigation system efficiency, distribution uniformity, water use efficiency in respect to the highest yield can be achieved when the water requirement are optimized. El-Saeed (2000) Reported that maize yield was affected by irrigation interval. It was found that with irrigation every two days the ear yield of maize was increased by 10.80% compared with irrigation every day. Thomas *et al*. (1995) reported that an irrigation scheduling method must provide accurate daily estimates of soil water in the root zone of irrigated crops. This requires an accounting method that records the amount of rain received on the field, the amount of irrigation water applied, and accurate estimate of daily crop water use. Joshi *et al*. (1995) reported that irrigation water requirements may be defined as the quantity of water that must be supplied by irrigation to satisfy evapotranspiration, leaching, consumptive use by the crop and miscellaneous water requirements that are not provided by water stored in the soil and perception that enters the soil. The definition also includes the use of water for salinity control, frost protection and plant cooling and yields. Rhoads F. M. and C. D. Yonts (2000). Summarized that properly managed furrow irrigation can apply a relatively uniform amount of water. However, application of small amounts may not be feasible with this system because of the labor input required for each irrigation. Thus, furrow irrigations are normally made with the intent of filling the soil profile, using set times of 8-12 hours. Under these conditions, the soil profile should be near the 50 % depletion level when irrigation begins. El-Refai *et al*. (1988). Said that water consumptive use by maize was determined, the wet treatment (Irrig. At 25%depletion) has the highest value, followed by medium level treatment (Irrig. At 50%depletion), while the dry treatment (Irrig. At 75%depletion), was found to be the least. Freddie Lamm (2000), Summarized Corn yield response to irrigation capacity varied greatly between the wet years and the dry years In wet years, there was better opportunity for good corn yields at lower irrigation capacities, but in dry years it was important to have irrigation capacities at 0.25 inches/day or greater. Ahmed Atti (2005). resulted that in sandy soil the water movement is increased under high pressure and the time is low, he added the following relations was found in the side ward H_{4m}

$$MM = 9.7971t^{0.606}$$

Where:

MM: the distance of moisture movement (cm).

T : the time of irrigation (h).

Mohammed (2008) Concluded that uniformity coefficient, as well as, distribution uniformity increased when inlet discharge increased but acceptable values achieved for all discharge treatments although the Uc (95.70%) and Du (93.10%) were the highest for 6 m^3 / h inlet flow. Application efficiency achieved a value of 92.80% for 6 m^3/h discharge due to increasing water deficit in root zone, but storage efficiency achieved the value of 94 % for 4.50 m^3/h due to decreasing dried soil content in root zone.

MATERIALS AND METHODS

The present work was carried out at Nubaria private farm, during growing seasons 2013 and 2014, to study the effect of the managed furrow irrigation, the amount of the applied water and slope of land surface on the water application efficiency, maize yield / fed and water use efficiency. Three methods were (clown) Fig 1:

Evaporimeter was used as measuring instrument to observe evaporation. World Meteorological Organization and its generally called class (A) pan acknowledge, it as standard Evaporimeter. This Evaporimeter is composed of water tank made of zinc plate, its diameter 1200 mm, depth 250 mm, and the water gauge ranged between 0 – 100 mm scale with accuracy from 0.1 – 0.06 mm.

Irrigation water calculations:

Evapotranspiration (ET_0) and Et_{crop} were calculated according to Doorenbos and Pruitt 1977 as follows:

$$ET_0 = Kp^* E_{pan}$$

Where:

ET_0: Reference Evapotranspiration (mm/day).

Kp: pan coefficient (equals to 0.7).

E_{pan}: pan evaporation (mm).

The average monthly ET_0 use to obtain Et_c for each period for maize growth is presented in Table (1).

Jensen (1983) classified water – application as follows:

Application efficiency (Ea) is the ratio of the average depth of the irrigation water infiltrated and stored in the root zone to the average depth of water applied.

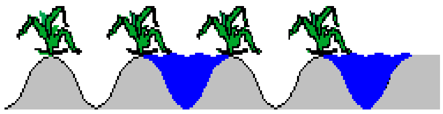
The water application efficiency (Ea).

$$Ea = (Stw/Aw) * 100.$$

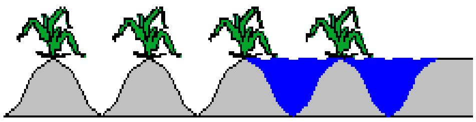
Ea: the water application efficiency%.

Stw: the amount of the stored water in the root zone.

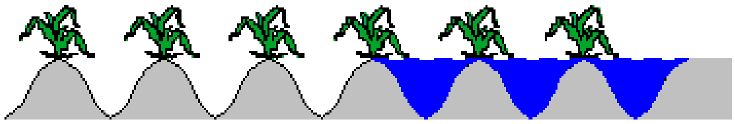
Aw: the amount of the applied water.



F_{1a}: one alternate furrow irrigated.



F_{1b}: Two alternate furrows irrigated.



F_{1c}: Three alternate furrows irrigated.

2- S: the slope of land surface.

s_1: zero level.

s_2: 0.05% slope of furrow surface applying laser leveling.

3- Q: applied irrigation water (m^3/fed)

q_1: 100%of the Etc.

q_2: 85% of the Etc.

q_3:70 % of the Etc.

Fig.1: The alternative furrows irrigation (figs 1a, 1b and 1c).

Table (1): Average monthly ET_0 (mm/day) at Nubaria Research Station.

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ET_0 mm/day	2.2	3.5	4.0	5.4	6.2	7.2	8.2	8.6	6.5	5.4	4.4	4.0

The distribution uniformity, (DU) is the average depth of minimum depth infiltrated at the end of the field divided by average depth infiltrated over actual border length. The (DU) describes how the water was distributed along the border for the condition tested.

Larty and James (1988) reported that the actual border average depth of water applied (Z) m, can be computed by using the following relation ship:

$$Z = \frac{Q \times T}{(L \times Wp)}$$

Where:-

Q: inflow rate on the border (m^3/min).

T: time cut of (min).

L: length of border (m).

WP: wetted width of border (border spacing) (m).

Water use efficiency "WUE" (kg per m^3) was calculated as follows:

WUE= yield (kg/fed)/total applied water (m^3/fed)

Experimental design

The treatments were laid out randomly in split plot design with three replications. The slope of land surface treatments occupied the main plots, the subplots were devoted for the alternate furrows irrigation treatments, whereas, the sub subplots were devoted for the irrigation quantities treatments. An area of half of fedden (2200 m^2) was divided into 54 plots each plot contain 6 furrows each 0.60 m wide and 12 m length.

Maize was planted in 21, 27 May 2013 and 2014 growing seasons. All the experimental treatments received the same agricultural practices as usual in the area. Before beginning the experimental work, soil samples were taken from three locations, at the head, the middle and the tail of the experimental field for the determination of the soil physical properties. During the execution of the experimental work, soil samples were collected after irrigations from each furrow, for the determination of soil moisture content and soil moisture distribution pattern. The samples were taken for each plot. The samples were taken at depths (0-30) and (30-60). The infiltration rate for the experimental soil was measured using the double ring. At harvest time in 12 and 20 Sep. 2013 and 2014 the weight of the crop in each plot was measured for each treatment. The water application efficiency (Ea), the water distribution efficiency (Ed) and the water use efficiency (WUE) were determined (as average of the two seasons).

Soil analysis

Soil analysis was carried out according to Wiled *et al*. (1985), the obtained data are shown in Tables (2and 3).

Table (2): Physical properties of the experimental soil.

Depth (cm)	Particle size distribution%				F.C. %	W .P. %	Texture class
	sand	Fine sand	Silt	clay			
0-30	39.85	36.57	4.40	18.98	9.89	4.30	Sandy
30-60	33.20	40.53	4.60	21.67	8.57	4.40	sandy

Table (3): Some chemical properties of the experimental soil.

Depth (cm)	pH	EC dS/m	Soluble cautions. meg/l				Soluble Anions. meg/l		
			Ca^{++}	mg^{++}	Na^{+}	K^{+}	HCo_3	So_4	Cl
0-30	7.83	1.49	5.75	4.60	3.60	0.2	4.60	2.75	6.80
30-60	7.91	1.27	5.75	4.20	3.40	0.3	4.70	2.80	6.90

RESULTS AND DISCUSSION

Effect of the alternative furrows irrigation on growth, yield components and WUE of Maize Crop.

Data in Table (4) indicated clearly that the yield and yield components were affected by using interactive irrigation technique as average of the two seasons. It's clear that the growth, yield components and yield were increased by using the treatment two furrows irrigated and unirrigated two furrows. The data indicated that, the plant height, ear length, ear diameter, No. of row/ ear, No. of kernels/row, and weight of 100 seeds as well as yield / fed. were increased by 1.76, 7.45, 8.57, 5.88, 7.61, 7.44, and 25.13 % compared with the alternate furrow irrigation (one furrow irrigated and unirrigated one furrow) one alternate furrow irrigated respectively. Also, the treatment (two furrows were irrigated and two furrows were unirrigated) Two alternate furrows irrigated, the yield component and yield were increased compared with the treatment (three furrows were irrigated and three furrows were un irrigated) Three alternate furrows irrigated. The data indicated that, the plant height, ear length, ear diameter, No. of row/ ear, No. of kernels/row, and weight of 100 seeds as well as yield / fed. were increased by 1.05, 4.22, 5.56, 4.13, 4.46, 4.40 and 11.66% compared with the partial furrow irrigation (three furrows irrigated and three furrows un irrigated) respectively . This may be due to the treatment of two furrows were irrigated and two furrows were un irrigated had the higher value of application water efficiency , the distribution uniformity as shown in table (7). And the water use efficiency(WUE) (2.01 kg/fed.).

Effect of the slope of land surface on growth parameters rates, yield components, yield and WUE of Maize Crop. (as average of the two seasons.)

Effect of the slope of land surface on growth, yield components, yield and water use efficiency are presented in Table (5). Results indicated that the plant height, ear length, ear diameter, No. of row/ ear, No. of kernels/row, and weight of 100 seeds as well as yield were increased when the land surface slope was 0.05%. These results may be due to using the land surface slope by 0.05% decreased the irrigation water applied, and increased the distribution uniformity and water application efficiency than the zero level land surface. In the plot which land surface leveled by 0.05% slope, the data indicated that, the plant height, ear length, ear diameter, No. of row/ear, No. of kernels/row, and weight of 100 seeds as well as yield were increased by 5.99, 37.50, 51.47, 19.15, 31.84, 40.27, 64.38 % compared with these In the plot which leveled zero level respectively. Maximum value of water use efficiency (WUE) was obtained when plot land surface leveled by 0.5 % slope.

Table (4): Effect of alternative furrows irrigation on growth, yield components, yield and WUE of Maize Crop.(as average of the two seasons.)

Treatments	Plant height (cm)	ear length (cm)	Ear diameter. (cm)	No. of row/ ear	No. of kernels/ row	Weight of 100 seed (g)	Grai damage %	Grain moistur content %	Yieldto n/fed	Water applied m^3/fed	WUE kg/fed
One alternate furrow	284	16.10	3.50	11.90	38.10	30.90	1.99	15.83	1.99	1236	1.61
Two alternate furrows	289	17.30	3.80	12.60	41.00	33.20	1.96	14.58	2.49	1236	2.01
Three alternate furrows	286	16.60	3.60	12.10	39.25	31.80	2.13	14.23	2.23	1236	1.80

Table (5): Effect of the slope of land surface on growth parameters rates, yield components, yield and WUE of Maize Crop. .(as average of the two seasons).

	Plant height (cm)	ear length (cm)	Ear diameter (cm)	No. of row/ ear	No. of kernels/row	Weight of 100 seed (g)	Grai damage %	Grain moistur content %	Yield ton/ fed	Water applied m^3/fed	Water use efficiency kg/fed
zero level	284	16.00	3.40	11.75	38.00	29.30	2.11	14.92	1.89	2510	0.75
0.05% slope	301	22.00	5.15	14.00	50.10	3.11	1.94	14.62	3.11	2360	1.32

Effect of water quantities on yield components, yield and WUE of Maize Crop.

The effect of irrigation water quantity on growth, yield and yield components of maize are presented in Table (6). The data indicated that, the plant height, ear length, ear diameter, No. of row/ ear, No. of kernels/row, and weight of 100 seeds as well as yield were increased by 4.81, 22.11, 25.61, 2.94, 14.20, 9.87, 19.70 % compared with these in the plot which received 85% of the calculated evapotranspiration respectively. Maximum value of the water use efficiency (WUE) was obtained when the plot received 100% of the calculated evapotranspiration. Also data indicated that the yield and yield components were affected by decreasing the water quantities to 70 % ET_c of the calculated evapotranspiration, i.e., yield ton/fed was decreased by 56.01%, this is may be due to that maize crop is sensitive crop for water and water is essential for plant growth and plant physiological processes and lake in available water caused water stress which affect plant growth and productivity.

4- The evaluation of the furrow irrigation efficiencies as affected by the different treatments.

The water application efficiency (Ea) and the water distribution (Ed) were shown in Table (7) and Figs (2, 3, and 4). It is clear that the water application efficiency (Ea), and water distribution efficiency ((Ed) were increased by increasing the discharge rate. The water application efficiency decreased by 5.95 and 16.09 % when the 100 % of Etc decreased to 85% of Etc and 70 % of Etc respectively. The water application efficiency (Ea) and water distribution (Ed) were affected by the interactive furrows irrigation, slope of land surface and water quantities, the water application efficiency in the treatment (Two alternate furrows irrigated) was increased by 18.71 and 9.05% compared with the water application efficiency in the treatment (one alternate furrow irrigated) and the treatment (three alternate furrows irrigated) respectively. Also the distribution efficiency in the treatment (Two alternate furrows irrigated) was increased by 14.16 and 5.85% compared with the water application efficiency in the treatment (one alternate furrows irrigated) and the treatment (three alternate furrows irrigated) respectively. Also the water application efficiency and water distribution were affected by land surface slope , in the plot which leveled with 0.05 % the distribution uniformity and the water application efficiency increased by 7.70 and 9.80% compared with the water distribution uniformity and the water application efficiency % in the zero level plot respectively.

Table (6): Effect of water quantities on growth, yield components, yield and WUE of Maize Crop. (as average of the two seasons.)

	Plant height (cm)	ear length (cm)	Ear diameter (cm)	No. of row/ Ear	No. of kernels/row	Weight. of 100 seed (g)	Grai damage %	Grain moistur content %	Yield ton/fed	Water applied m^3/fed	Water use efficiency kg/fed
100 % of ETc	305	22.20	5.15	14.00	50.25	41.20	1.86	15.35	3.16	2950	1.07
85% of ETc	291	18,18	4.10	13.60	44.00	37.50	2.00	15.29	2.64	2507	1.05
70 % of ETc	287	13.30	3.55	11.50	37.75	30.30	2.12	13.75	1.39	2065	0.67

Table (7): Effect of the slope of land surface, water quantities and alternative furrows irrigation on average depth infiltration mm, distribution uniformity % and application efficiency %.

	Slope level %		Water quantities			Alternative furrows		
	zero level	0.05% slope	100 % of ETc	85% of ETc	70 % of ETc	One alternate furrow	Two alternate furrows	Three alternate furrows
Average depth of irrigation water applied mm.	70.20	70.20	70.20	59.69	49.16	29.40	46.30	41.10
Average depth of water infiltrated Mm	51.00	56.00	59.00	37.00	26.00	23.00	43.00	35.00
Distribution uniformity %	82.94	89.33	91.65	86.50	78.95	81.90	93.50	88.33
Application efficiency %	72.65	79.77	84.05	61.98	52.89	78.23	92.87	85.16

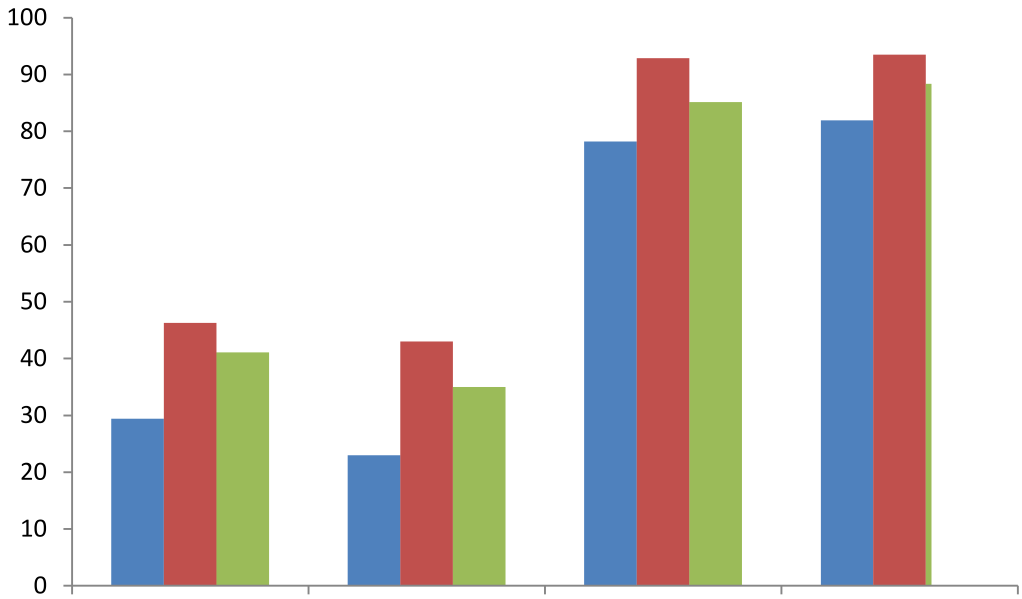


Fig. 2: Effect of partial furrows irrigation on water infiltrated, distribution and application efficiency.

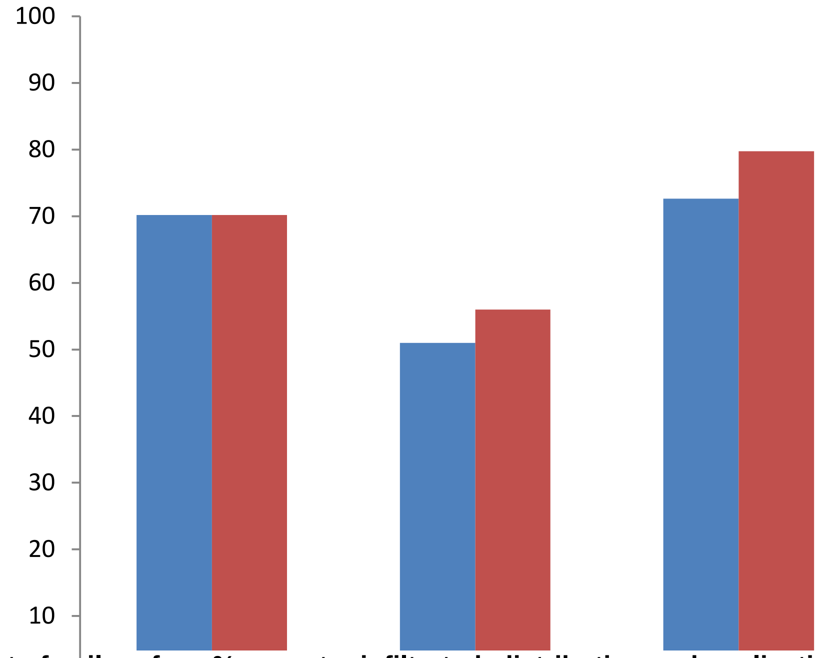


Fig. 3: Effect of soil surface % on water infiltrated, distribution and application efficiency.

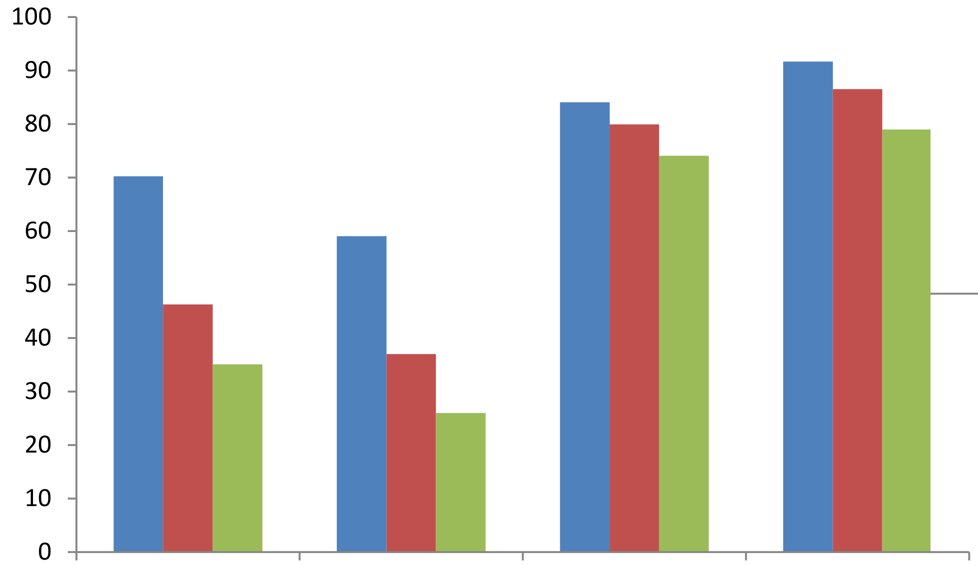


Fig. 4: Effect of irrigation quantities on water infiltrated, distribution and application efficiency.

- The interaction effect of the slope of land surface, alternate furrows irrigation and irrigation water quantities on growth, yield components, Grain moisture content, Grain damage, yield and WUE of Maize Crop.

The yield and yield components of maize crop were affected by the interaction of the three main variables. The interaction data in Table (8) revealed that the slope of land surface 0.05% associated with alternative furrows irrigation (two furrows irrigated & two furrows un irrigated) and 100% of the Etc applied irrigation water produced the highest yield and yield components. Whereas, maximum value of water use efficiency (WUE) was obtained when land surface slope 0.05% with one alternative furrow irrigation (one furrow irrigated & one furrow un irrigated) and 85 % of the Etc applied irrigation water. Also data in table (8) show the effect of the alternative effect of the slope of land surface, alternative furrows irrigation and irrigation water quantities on grain moisture content, grain damage. It is clear that the grain damage percent % increased by increasing and decreasing the grain moisture% the grain damage were 1.95 % and 2.30 % at the grain moisture content were 16 % and 13 % respectively. On the other hand the less grain damage % was 1.65 % at grain moisture content 14.24 % it was in the plot which content the alternative data in table (8) revealed that the slope of land surface 0.05% associated with two alternative furrows irrigation (two furrows irrigated & two furrows un irrigated), 100% of the Etc applied irrigation water the water application efficiency (Ea) was 92.87 % and the water distribution (Ed) was 93.50 % .

Table (8): The interaction effect of the slope of land surface, interactive furrows irrigation and irrigation water quantities on growth, yield components, Grain moisture content, Grain damage yield and WUE of Maize Crop.

			Plant height (cm)	Ear Length (cm)	Ear diameter. (cm)	No. of row/ ear	No. of kernels/ row	Weight. of 100 seed (g)	Grain moisture content %	Grain damage %	Yield ton/fed	Water applied m^3/fed	Water use efficiency kg/fed
zero level	)one alternative furrow	100 % of Etc	291	17.00	4.2	13.20	43.25	36.00	16.00	1.95	3.16	1236	2.56
		85% of Etc	305	22.20	5.15	14.00	50.25	41.20	15.85	2.10	2.65	972	2.73
		70 % of Etc	289	14.20	3.70	12.25	39.00	33.20	14.50	2.20	1.41	648	2.27
	Two alternative furrows	100 % of ETc	293	18,20	4.15	13.62	44.00	37.50	15.75	1.90	3.24	1236	2.62
		85% of ETc	308	23.00	5.30	14.05	50.75	42.50	15.25	2.00	2.66	972	2.74
		70 % of ETc	288	14.00	3.65	11.90	38.50	31.50	13.75	2.25	1.44	648	2.22
	Three alternative furrows	100 % of ETc	290	15.50	3.85	12.90	40.50	34.80	15.30	2.05	2.87	1236	2.32
		85% of ETc	297	21.10	4.85	13.85	48.25	39.80	15.10	2.20	2.54	972	2.61
		70 % of ETc	288	13.60	3.50	11.35	37.50	28.50	13.25	2.35	1.37	648	2.11
0.05% slope	One alternative furrow	100 % of ETc	296	19.50	4.35	13.70	45.25	38.00	15.80	1.75	3.31	1236	2.68
		85% of ETc	305	24.00	5.50	14.10	51.50	43.10	15.65	1.90	2.68	972	2.76
		70 % of ETc	287	13.80	3.60	11.80	38.00	31.00	14.50	2.05	1.41	648	2.18
	Two alternative furrows	100 % of ETc	313	24.80	5.65	14.20	52.00	38.20	14.25	1.65	3.38	1236	2.73
		85% of ETc	296	20.50	4.60	13.80	46.00	43.30	15.00	1.80	2.72	972	2.80
		70 % of ETc	287	13.80	3.55	11.50	37.75	30.30	13.50	2.15	1.39	648	2.15
	Three alternative furrows	100 % of ETc	290	16.20	3.90	13.00	42.00	35.50	15.00	1.85	3.04	1236	2.46
		85% of ETc	301	21,80	4.90	13.95	49.50	40.50	14.90	2.00	2.58	972	2.65
		70 % of ETc	283	13.40	3.40	11.10	37.00	27.50	13.00	2.30	1.33	648	2.05
Control			294	17.60	4.15	12.75	42.25	33.10	19.00	2.60	2.76	2590	1.07

CONCLUSION

Overall, results of researches reviewed in this paper, showed that the higher yield of maize per fadden was observed when using the alternative treatments two furrows irrigated and two unirrigated with land surface slope 0.05% and received 100 %of the calculated evapotranspiration

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تأثير الرى التبادلى وميول سطح التربة وكميات مياة الرى على إنتاجية محصول الذرة الشامية

عصام الدين واصف ، صلاح الدين اسماعيل الخطيب ، سحر السيد أحمد موسى

معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – الدقى – مصر.

الملخص العربى

أجريت تجربتان حقليتان فى مزرعة خاصة بالنوبارية خلال موسمى الزراعة 2013 و 2014 محصول الذرة جيزة 322 فى موسمين متتاليين فى آخر مايو. وذلك لدراسة تأثير الرى الجزئى وميول سطح التربة وكميات مياه الرى على محصول الذرة الشامية صنف هجين جيزة 322 واشتملت الدراسة على ثلاثة معاملات أساسية كمايلى:-

أولاً: الرى التبادلى:حيث تم دراسة ثلاث متغيرات وهى:

1- رى خط وترك خط بدون رى بالتبادل.

2- رى خطين وترك خطين بدون رى بالتبادل.

3- رى ثلاثة خطوط وترك ثلاثة خطوط بدون رى بالتبادل.

ثانياً: ميل سطح الارض: حيث تم دراسة متغيران:

1- ارض بدون ميول.

2- ارض بميول 5 سم / 100 متر.

ثالثاً: كميات مياه للرى: حيث تم دراسة ثلاث متغيرات وهى:

1- 100 % من الاحتياجات الكلية للنبات.

2- 85 % من الاحتياجات الكلية للنبات.

3- 70 % من الاحتياجات الكلية للنبات.

وتم تقسيم التجربة الي ثلاثة احواض بحيث يحتوي كل حوض على 12 خط المسافة بين الخطوط 70سم وطول الخط 12 متر. وتم الزراعة على التوالى. وتم رى محصول الذرة 7 ريات.

واوضحت النتائج التالى:-

1- زاد محصول الذرة ومكوناته باستخدام رى خطين وترك خطين بدون رى بالتبادل.

2- زادت التسوية بميول 5 سم /100 متر من كمية المحصول وكفاءة انتظام توزيع مياه الرى وكفاءة استخدام المياه كما قللت من كمية مياه الرى.

3- زادت كفاءة انتظام توزيع المياه وكفاءة استخدام المياه بزيادة كمية مياه الرى الى (100 % من الاحتياجات الكلية للنبات).

4- تأثرت بعض الخواص الطبيعية لمحصول الذرة ورطوبة الحبوب بأستخدام الرى التبادلى وميول سطح التربة وكميات مياه الرى.

من النتائج يتضح أن المعاملة (رى خطين وترك خطين بدون رى بالتبادل وبميول سطح الارض 5 سم / 100 متر وكميات مياه للرى 100 % من الاحتياجات الكلية للنبات). هى أفضل الطرق لزراعة ورى محصول الذرة الشامية.