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STUDY ON IRRIGATION WATER QUALITY AND QUANTITY AFFECTING TRICKLE IRRIGATION SYSTEM PERFORMANCE AND MAIZE YIELD PRODUCTIVITY

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ABSTRACT

A field experiment was conducted at a pin private farm at Wadi El-Natrown during the summer season 2008, to study the effect of irrigation water quality, water quantity and lateral line spacing on the trickle irrigation system performance, water saving, maize crop yield, yield components, water use efficiency and net profit in sandy soil conditions. The results obtained can be summarized as follows:

The emitter flow rate indicated that there is gradual decrease with gradual lowering of the operating pressure. The manufacturing coefficient of emitter variation ranged between 0.05-0.07, it could be classified as average. The exponent of emitter x was equal to 0.38 meaning that the flow regime is practically turbaulent. The highest emission uniformity at the 100% of ET_{actual} were 96.50, 91.75 and 86.25% under fresh, fresh & saline and saline water, respectivly . The highest values of EU and AE were found under fresh water and 100% of ET_{actual} and the highest value of emitter clogging were found under 100% of ET_{actual} and saline water.The average water applied of 2355, 1885 and 1415 m^3/fed,were obtained under 100, 80 and 60% of ET_{actual} respectively. Increasing the lateral line spacing from 0.70 to 1.40 m, the irrigation water applied was decreased under all treatments. The results indicated that the average fresh water saving 877 and 1753 m^3/fed compared with irrigating fresh & saline and saline water. The highest grain yield of 4.3 Mg/fed were obtained under fresh water, 100 % of ET_{actual} and 1.40 m lateral line spacing, but the lowest values of 1.3 Mg/fed were obtained under saline water, 60 % of ET_{actual} and 0.70 m

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lateral line spacing, respectively. The highest net profit values at 0.70 and 1.40 m lateral line spacing were 4030 and 4635 LE/fed, for 100% of ET_{actual} and fresh water, but the lowest values were 180 and 720 LE/fed, under 60% of ET_{actual} and saline water. The relationship between irrigation water applied and grain yield at two lateral line spacing can be described by the following formulas:

lateral line spacing	*For fresh water*	*For fresh + saline water*	*For saline water*
0.7m	$y_1=0.25x^2-0.25x+2.6$, $R^2=1$	$y_1=0.2x^2-0.2x+2$, $R^2=1$	$y_1=-0.05x^2+0.7x+0.65$, $R^2=1$
1.4m	$y_2=0.2x^2-0.1x+2.8$, $R^2=1$	$y_2=0.15x^2-0.05x+2.25$, $R^2=1$	$y_2=1E-14x^2+0.5x+0.9$, $R^2=1$

Where: Y: maize grain yield (Mg/fed), x: irrigation water applied (60,80 and 100% of ET_{actual})

Finally, it could be concluded that, under similar conditions, using trickle irrigation, fresh water, water applied of 100% of ET_{actual} and lateral line spacing 1.40 m is recommended for achieving the best trickle irrigation performance, water saving, highest maize crop yield,yield components, water use efficiency and highest net profit.

***Keywords:** trickle irrigation, water quality, water quantity, lateral line spacing, maize yield, water saving and net profit.*

INTRODUCTION

One of the major problems in Egypt (new lands) is the shortage of water supply, Modern irrigation system helps to reduce water losses and increases the water use efficiency under successful. Water quality is the most important factor in managing the non-conventional water resources. Maize is the third most world wide cultivated crop after rice and wheat . One of the approaches to be highly recommended to meet the storage in available water resources, is the use of the non-conventional water resources (saline water and treated municipal waste water) as additional water resources for irrigation to overcome the high gap in the cereals production (wheat, barley and maize), which are fundamental crops having an important role on food security, fighting the poverty and alleviating hunger and mal nutrition. Deficit irrigation considerd of maximizing water use efficiency for higher yields of onion per unit of irrigation water applied (**Bekele and Tilahun, 2007**). Using saline water for irrigation is a subject of increasing interest because of the increasing water requirements for irrigation and the competition between human, industrial and agricultural use and moreover because of the pressure for the disposal of drainage water through reuse. **El-Sherbeni (1988)** reported that the clogging as percent gradually increases with increasing the operation time and decreases sharply by acidification of water. **Hills *et al.* (1989)** mentioned that chemical precipitation and emitters clogging are caused by the deposition of salts and ions inside the emitters. **El-Berry (1990)** reported that the "EU" values for three lateral lengths (40, 60 and 80 m) were 90.42, 92.2 and 91.77%, respectivly from bi-wall irrigation tubes. **EL-Sherbeni (1994)** studied the effect of operating time on average discharge and "EU" under different pressure heads. He obtained that all values of "EU" at the begining of operation were higher than the minimum recommended value (90%) under all pressures. At the beginning of operation, the values of "EU" decreased with increaseing the pressure head where "EU" values were 94.9, 94.0 and 92.7% for pressure head of 50, 100 and 150 kPa respectively. **Tayel and EL-Sebsy (1996)** studied the "EU" under different mean line pressures (50, 100 and 150 kPa). It was clear that the "EU" increased from 77.22 to 86.43% by increasing the mean line pressure from 50 to 150 kPa. **Pereira and Trout (1999)** pointed that the cause of emitters clogging were particles of mineral or organic matter. Clogging reduces discharge rates and the water distribution uniformity; thus filtration is required in most cases. Iron oxide, calcium carbonate, algae and microbial slimes may be problems requiring chemical treatment of the water to prevent clogging. **Schwankl (2001)** poined out to that the irrigation to be used in drip system should be evaluated carefully to assess any potential clogging problems. Calcium carbonate (line) precipitation was the most common reason of chemical clogging in micro irrigation water with pH of 7.5 or above and bicarbonate levels of 120 ppm is susceptible to line precipitation, if comparable calcium levels was present naturally in the system. **Hochmuth and Simonne (2003)** indicated that water quality could be an important factor to consider in design or adaptation of chemigation system, as some water supplies require chemical amendment to prevent bacterial growth or chemical precipitants from clogging the system. **Darusman *et al.* (1997)** found that, when spacing between lateral lines is increased to 1.5 m in the silt loam soils, there would be an associated increase in internal drainage from the root zone and decrease in maize yields. **Lamm *et al.* (1997)** studied the optimum lateral spacing for subsurface drip irrigation corn. They reported that average maize yield were 13.6, 12.8 and 12.2 t/ha for lateral lines spacing of 1.5, 2.3 and 3.0 m, respectively, for a seasonal irrigation amount of 462 mm. Yield decreased to 10.8 and 9.3 ton/ha when irrigation was reduced by 33 and 50% for the wider 2.3 and 3.0 m lateral lines spacing, respectively. The wider lateral lines spacing results in no uniform horizontal distribution of available soil water. The highest yield, highest water use efficiency and lowest year-to-year variation were obtained with the 1.5 m lateral line spacing. **El-Gindy *et al.* (2001)** found that, the highest and the lowest values of ET_c were 9.13 and 2.6 mm/day during mid season and establishment stage, respectively. Irrigation with 100% of Etc increased crop seed and water use efficiency than 80% of Etc. **Shawky *et al.* (2001)** found that the application efficiencies were 92.56, 81.48 and 65.7% for drip, sprinkler and furrow systems, respectively. **Abdel-Aziz (2003)** found that the average application efficiency under drip irrigation system increased by 5.6, 18 and 41% compared to bubbler, gated pipes and traditional irrigation system, respectively. **El-Meseery (2003)** reported that the highest yield production of maize, water use efficiency and application efficiency of 4575 kg/fed, 1.92 kg/m^3 and 83% were obtained under water applied 100% of ET_c, 4 days irrigation intervals and one corn row beside the lateral line. **Grigorov and Borovoi (2002)** recorded that, the highest yield of feed crop was 62.3 ton/ha and the lowest water consumption coefficient 35.3 m^3/ton were obtained with PVC pipes, a distance of 1.75 m between the emitters and an irrigation threshold of 75-80% of field capacity.

The experiment was carried out by the aims of:

1. To determine the effect of irrigation water quality and quantity on trickle irrigation system performance.
2. The potential water saving as well as characterizing the crop stages mostly tolerant to shortage in water application, quality, quantity and lateral line spacing .

3. Determine the effect of irrigation water quality, quantity and lateral line spacing on the total yield, yield components, water use efficiency, total cost and net profit.

MATERIALS AND METHODS

1. Experimental site

The field experiment was conducted in private farm at Wadi El-Natrown during summer season 2008, to study the effect of irrigation water quality, water quantity and lateral line spacing on trickle irrigation system performance, water saving, maize crop yield and yield components, water use efficiency, total cost and net profit in sandy soil conditions. The experimental design was in spilt – split plot, where irrigation water quality were considered as the main treatment plot. The irrigation water applied were assigned as sub plots. The lateral line spacing were taken as the sub - sub plots and the plot area was 70 m^2. The crop cultivated was maize ***(zea mays)*** manually on 1 May 2008 with two seeds at hill after twenty-one days, the seedling were thinned to one plant per hill, the distance between plants in row was 20 cm and harvesting on 1 septemper 2008. All experimental were irrigated by fresh water on the first stage after that started the treatments. It is worthy to mention that irrigation treatments took place after the thinned stage. Conventional analysis of the soil and irrigation water used (fresh and saline) samples were preformed and the results are tabulated in tables (1 and 2).

Table (1): Some physical properties of the soil.

Sample depth	Particle Size Distribution %			Texture class	$CaCo_3$ (%)	F.C. (%)	W.P. (%)
	Sand	Silt	Clay				
0-30	88.00	9.70	2.30	sandy	2.40	13.40	5.40
30-60	86.00	10.80	3.20		2.10	13.70	5.20

Table (2): Some chemical analysis of irrigation water used.

Water quality	PH	EC (dS/m) at 25C°	Soluble anions (meq/l)				Soluble captions (meq/l)				SAR
			$CO^{=3}$	HCO^{-3}	Cl^-	$SO4^{--}$	Ca^{++}	Mq^{++}	Na^+	K^+	
Fresh water	7.80	0.94	0.00	2.90	4.3o	2.60	4.30	2.10	3.00	0.40	1.91
Saline water	7.70	3.50	0.00	5.60	14.0	16.10	5.00	5.40	17.00	0.30	5.14

2. Trickle irrigation system

The trickle system components cosists of : Control head (centerifugal pump, pressure regulater, pressure gauges, non-return valve, flow meter, venturi and filters) connected to main lines (110 mm outside diameter PVC pipes is used) , submain line (75 mm with a flexible PVC) and lateral line (polyethylene pipes included either surface built in lateral line (GR type) were spaced at 0.7 and 1.40 m , 30 m long and 16 mm outside diameter . The lateral were used in line turbulent flow emitters with an average flow rate of 3.98 L/h at operating pressure of 1.0 bar and 0.30 m space between emitters.

3. Fertilizer program

Fertilizer requirements of maize were added acording to the recommendation of the Crop Research Institute, ARC, Minstry of Agriculture and land Reclamantion. All experimental unit received equal amounts of 20 m^3/fed farm manure, calcium superphosphate (15.5% p_2O_5) at rate of 250 kg/fed and potassium fertilizer of potassium sulphate (48.0% K_2O) at rate of 100 kg/fed during the seed bed preparation and ammonium nitrate (33.0 % N) at rate of 400 kg/fed divided into ten doses and injected through irrigation system starting 21 days after planting till the fruit stage.

4. Treatments were used in the experimental fields as follows:

The experiment included 18 treatments which interacted with trickle irrigation system each with as follows:

1- Irrigation water quality i.e., fresh water, fresh & saline water (irrigated by saline water after that irrigated by fresh water) and saline water.

2- Irrigation water quantity i.e., 60, 80 and 100% of actual water consumptive use (ET_{actual}).

3- Lateral line spacing, i. e., 0.70 and 1.40 m (single row bed and double row bed) .

5. Measurements and calculations

1. Assessment of trickle irrigation system performance:

a . Emitter flow rate

The emitter flow rates were determined by collection of the water volume after time and applying the following equation:

$$Q = \frac{V}{T}$$

Where:

Q: emitter flow rate (l/h),

V: volume of water collected (l)

T: time (h)

b. Manufacturing coefficient variation

Manufacturing coefficient of emitter variation (CV) was calculated by using the following equation:

$$CV = \frac{S}{X^-}$$

$$S = \sqrt{\frac{\sum_{i=1}^{n} (xi - x^-)^2}{n-1}}$$

Where:

S : standard deviation of the emitters discharge rate (l/h).

X^- : mean emitter discharge (l/h).

Xi : discharge of an emitter (l/h).

n : number of emitter.

The CV was calcuated for each irrigation line and for the whole system. Under the experimental conditions, the manufacture variation ranged between 0.05-0.07 and according to ASAE stander 1996, it could be classified as average.

c. Determination of the emitter exponent.

Qualitative classification standards for the production of emitters was calculated by using equation (**Kirnak *et al.*, 2004**) :

$$q = k\ H^x$$

Where:

q : emitter discharge rate (l/h).

k : emitter coefficient.

H : operating pressure head (m)

x : emitter exponent that is characterized by emitter discharge.

d. Emission uniformity

Emission uniformity (EU) of laterals as a percentage was determined in the field by using EU test and calculated by using the following equation (**Ortega *et al.*, 2002**):

$$EU = (q_{0.25} / q_a) \times 100$$

Where:

$q_{0.25}$: mean of the lowest 0.25 of emitter discharge (l/h)

q_a : average all emitters discharge. (l/h)

e. Application efficiency

Application efficiency of trickle irrigation (AE) was calculated from the emission uniformty by **Jensen *et al.* (1990)** as follows:

$$AE = 0.59 \times (EU + 60)$$

f. Emitter clogging percentage

Clogging percentage was calculated at the end of season. Clogging ratio was calculated by **El-Berry *et al.* (2003)** using the following equations:

$$CR = (1 - E) \times 100$$

$$E = 100 \times \frac{q_u}{q_n}$$

Where:

E : emitter discharge efficiency (%)

qu : emitter discharge, at the end of the growing season (l/h)

qn : emitter discharge, at the beginning of the growing season (l/h)

CR : emitter clogging ratio (%)

2. Crop water relations.

2.1. Actual water consumptive use (ET_{actual})

For obtaining the crop water consumptive use, soil samples were taken just before and 24 hours after each irrigation, as well as at harvest time. The crop water consumptive use between each two successive irrigations was calculated according to the following equation **(Israelson and Hansen 1962).**

$$ET_{actual} = \frac{(\theta 2 - \theta 1) X\, d}{I}$$

Where:

ET_{actual} : actual consumptive use (mm/day).

d : soil depth (m).

θ2 : percentage of soil moisture after irrigation.

θ1 : percentage of soil moisture before next irrigation.

I : period between irrigation.

2.2. Daily ET_{crop} rate (Calculated)

Water consumptive use was calculated according to the climate data recorded at Wadi El-Natrown weather station using the following general formula:

$$ET_{crop} = K_c \times Et_o$$

Where:

Et_{crop} : crop water consumptive use (mm/day).

Et_o : reference evapotranspiration (mm/day).

K_c : crop coefficient.

2.3. Crop coefficient

Crop coefficient for maize crop was used to calculate the Et_{crop} values according to **(Doorenbos and Pruitt, 1984)**. Reference evapotranspiration (ET_o) measured with evaporation class A pan, crop coefficient (K_c) and water consumptive use (Et_{crop}) for different growth stages.

3. Yield and yield components during the cropping period

After complete maturity of maize the plants were harvested and taken into 6 plants under different treatments. The plant components were oven dried at 70°C for 48 h, and the following measurements have been made : plant analysis: Ear number, Ear diameter, No. of rows/ear , No. of grains/row , 100 seeds weight and total grain yield (Mg/fed).

4. Water Use Efficiency

Water use efficiency (WUE) was used to evaluate various all treatments which produce maximum yield per unit of water consumed by the crop or applied in the field. water use efficiencies were calculated according to ***Hansen, et al. (1980)*** as follows:

$$WUE = \frac{\text{Total grain yield (Mg/}fed\text{)}}{\text{Total applied water (m}^3\text{ / }fed\text{)}}$$

5. Cost of production and net profit

a- Total costs:

The total costs included cultivation, irrigation (fixed and running), fertilization, weed control, pest control, harvesting and labours.

b- Total income:

The total income for maize crop was calculated by using the following formula:

Total income = Grain yield price (LE/fed) + Vegetative yield price (LE/fed).
Grain yield price = Total grain yield (Mg/fed) × Unit cost (LE/Mg)
Vegetative yield price = Total vegetative yield (Mg/fed) × Unit cost (LE/Mg)

c- Net profit:

The net profit for maize crop yield was calculated by using the following formula:

Net profit = Total income - Total costs

d- Cost per unit production (LE/ Mg)

$$\text{Cost per unit production(LE/ Mg)} = \frac{\text{Total cost (LE}/fed)}{\text{Total yield(Mg}/ fed)}$$

RESULTS AND DISCUSSION

1. Trickle irrigation system performance:

a. Emitter flow rate

The discharge of the emitter as a function of the changing operating pressure were studied. Data are illustrated in Fig. (1) show that there is gradual decrease in the emitter flow rate with gradual lowering of the operating pressure. However using an operating pressure between 40 to 140 kPa, the emitter flow rate showed an average value of 3.98 l/h.

b. Determination of the emitter exponent.

By drawing the relation between q and H under log-log curve and trying to draw a trend line the k and x values were found (Fig. 1). The emitter exponent (x) was equal to 0.38 meaning that the flow regimes is practically turbaulent flow.

c. Emission uniformity

Data presented in Fig (2) indicated that by increasing the amount of irrigation water from 60 to 80 and to 100% of ET_{actual}, the emission uniformity increased from 94.25 to 95.75 and to 96.5% at fresh water ; 88.5 to 90.5 and to 91.75% at fresh & saline water and 82.00 to 84.34 and to 86.25% at saline water. The obtained data indicate that all the values of the emission uniformity for fresh water and different water applied were higher than the minimum recommended value (90%) under two lateral line spacing. Meanwhile, under all the values of saline water and different water applied were lower than the minimum recommended value (90%) under two lateral line spacing.

d. Application efficiency.

To study this parameter, each emitter line was considered as an individual system. Data presented in Fig (2) indicated that by increasing the amount of irrigation water from 60 to 80 and to 100% of ET_{actual}, the application effecincy increased from 91.01 to 91.89 and to 92.34% at fresh water ; 87.62 to 88.5 and to 89.53% at fresh & saline water and 79.95 to 81.88 and to 84.05% at saline water.

e. Emitter clogging :

Data presented in Fig (2) indicated that the highest emitter clogging of 22.2 and 18.3% were obtained with saline water under 100 and 80 % of ET_{actual}. On the other hand, increasing the amount of irrigation water from 60 to 80 and to 100% of ET_{actual}, the emitter clogging decreased from 8.3 to 6.5 and 5.2% at fresh water ; 12.1 to 15.2 and to 16.4% at fresh & saline water and 15.2 to 18.3 and 22.2 % at saline water.

2. Crop water relations:

2.1. Actual consumptive use

The results in Fig (3) show the values of seasonal consumptive use (ET_{actual}) of maize crop, as a function of water quality, water quantity and lateral line spacing treatments. By increasing lateral line spacing from 0.7 to 1.4 m, the ET_{actual} decreased by 13%. The data recorded in Fig (3) reveal that irrigation at 100% of ET_{actual} and 0.7 m lateral line spacing gave the highest ET_{actual} values (2520 m^3/fed). Whereas, the lowest ET_{actual} values (1314 m^3/feddan) were resulted from irrigation at 60% of ET_{actual} and 1.4 m lateral line spacing.

2.2. Daily ET_{crop} rate (Calculated)

The data listed in Fig (3) generally, indicated that the seasonal irrigation water requirements for maize are based on the climatic date and crop coefficient. The data showed that the seasonal irrigation water requirements calculated were higher than the estimated values using the soil sampling method by 18% under water quality treatments.

2.3. Crop Coefficient (K_c).

The crop coefficient reflects the crop cover percentage and soil conditions on the ET_o values. The results in Table (3) reveal the K_c values, as a function of the interaction between ET_{actual} and Et_o. The K_c was low during May (initial), then increased during June (development) and reached its maximum values during July (mid-season). Thereafter, the Kc values redecreased again during August (late). Finally, the K_c values of maize for high production were 0.28, 0.66, 1.04 and 0.56 during May, June, July and August, respectively.

Table (3). Crop coefficient under calculated and actual water consumptive use for maize crop.

Growth stages	Calculated water consumptive use			Actual water consumptive use	
	Et_o, mm/day	K_c	Et_{crop}, mm/day	ET_{actual}, mm/day	K_c
Initial (1/5-21/5)	6.95	0.35	2.43	1.98	0.28
Development (22/5-22/6)	7.61	0.36-1.14	5.71	5.02	0.29-1.03 (mean 0.66)
Mid-season (23/6-3/8)	7.7	1.15	8.86	8.04	1.04
Late (4/8-25/8)	7.3	1.14-0.55	6.17	4.08	0.56

3. Water saving

The amount of water applied to maize under the treatments are presented in Fig 3. The average amount of irrigation water 100, 80 and 60% of ET_{actual} were 2355, 1845 and 1415 m^3/fed, respectively. By increasing the lateral line spacing from 0.70 to 1.40 m, the amount of irrigation water values were decreased under all treatments. By increasing the lateral line spacing from 0.70 to 1.40 m, the average water saving were 330 and 768 m^3/fed under fresh water and 100 of ET_{actual}. The results indicated that the average fresh water saving 877 and 1753 m^3/fed through irrigating with fresh & saline and saline water. By decreasing the irrigation water from 100 to 80 and to 60 % of ET_{actual}, the average fresh water saving values were 165, 636 and 1107 m^3/fed, respectively.

4. Maize yield and yield components:

With fresh water, the average Ear No.; Ear diameters; No. of rows/ear ; No. of grains/row and 100 seed weight increased by 33.5 and 46.1% ; 31.8 and 42 %; 13.3 and 19.6 %; 14.7 and 37.7% and 9.55 and 23.05% compared with fresh & saline and saline water, respectively.

Data presented in Fig. (4) showed that the total grain yield at fresh water increased by 28.36 and 79.16 % compared with fresh & saline water and saline water under irrigation water applied of 100% of ET_{actual} and 1.40 m lateral line spacing. The lowest grain yield of 1.3 Mg/fed was remarked at irrigation water applied at 60% of ET_{actual}, saline water and 0.70 m lateral line spacing. Increasing the irrigation water applied from 60 to 80

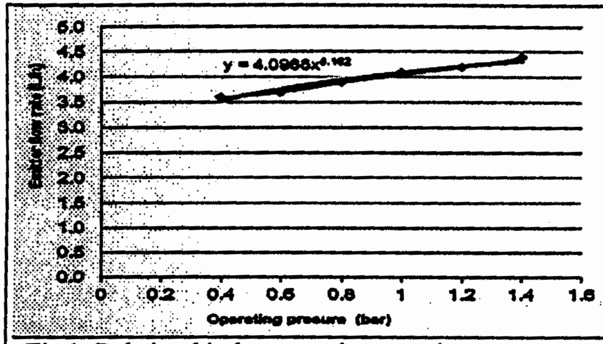


Fig.1. Relationship between the operating pressure and emitter flow rate.

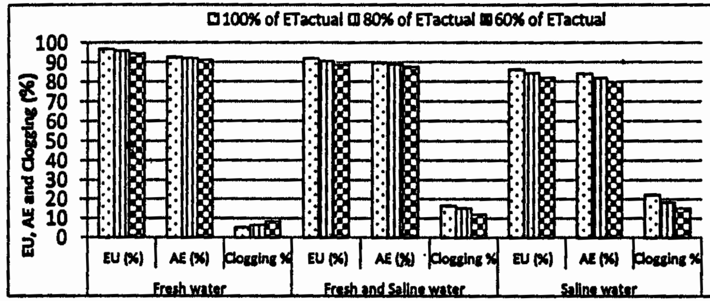
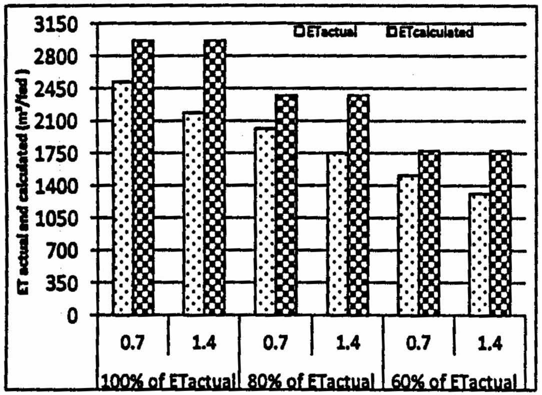


Fig. 2. Emission uniformity, application effecincy and emitter clogging under different treatments.



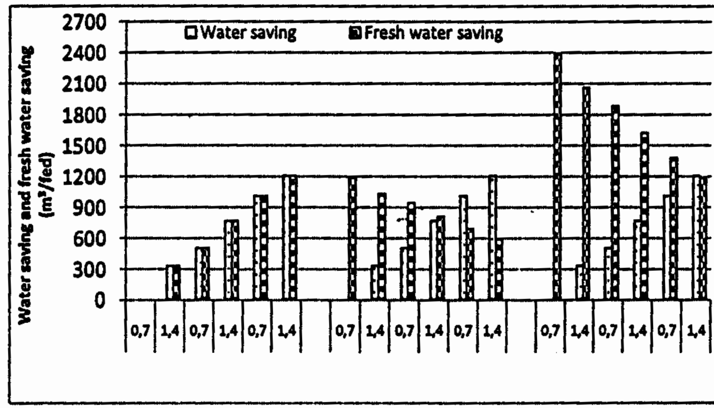


Fig (3): ET_{actual}, $ET_{calculated}$, water saving and fresh water saving under different treatments.

and to 100 % of ET_{actual} at 1.40 m lateral line spacing, the grain yield increased by 26.47 and 48.28 % under fresh water.

5.Water Use Efficiency

The primary objective of used water quality is to improve a water use program that will provide the maximum yield per unit of water consumed by plants. Efficiencies of water use for both crop and field as affected by the water quality of maize are presented in Fig.4 . The highest water use efficiency value at irrigation water quantity of 60% of ET_{actual} and 1.40 m lateral line spacing was 2.21 kg/m^3 under fresh water. But, the lowest value was 0.86 kg/m^3 under saline water, 60% of ET_{actual} and 0.70 m lateral line spacing. It can be concluded that the irrigation of maize by fresh water is the best treatment that resulted in more water use efficiency and achieved the fresh production of fresh yield.

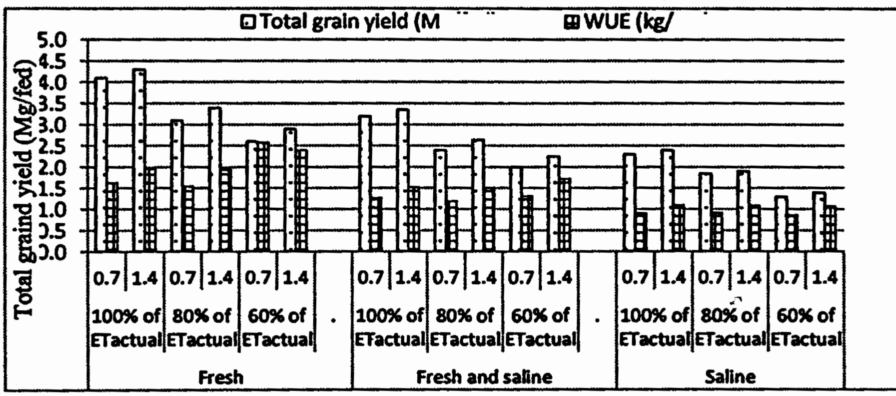


Fig (4):Total graind yield and water use efficiency under different treatments.

6. Water applied and lateral line spacing production function:

Data illustrated in Fig. 5 indicated that the maize yield was affected by irrigation water applied and lateral line spacing under irrigation water quality. The relationship between irrigation water applied and maize yield at two lateral line spacing can be described by the following formulas:

lateral line spacing	*For fresh water*	*For fresh & saline water*	*For saline water*
0.7m	$y_1=0.25x^2-0.25x+2.6,\ R^2=1$	$Y_1=0.2x^2-0.2x+2,\ R^2=1$	$y_1=-0.05x^2+0.7x+0.65, R^2=1$
1.4m	$y_2=0.2x^2-0.1x+2.8,\ R^2=1$	$Y_2=0.15x^2-0.05x+2.25,\ R^2=1$	$y_2=1E-14x^2+0.5x+0.9, R^2=1$

Where: y : maize grain yield (Mg/fed), x: irrigation water applied (60, 80 and100% of ET_{actual})

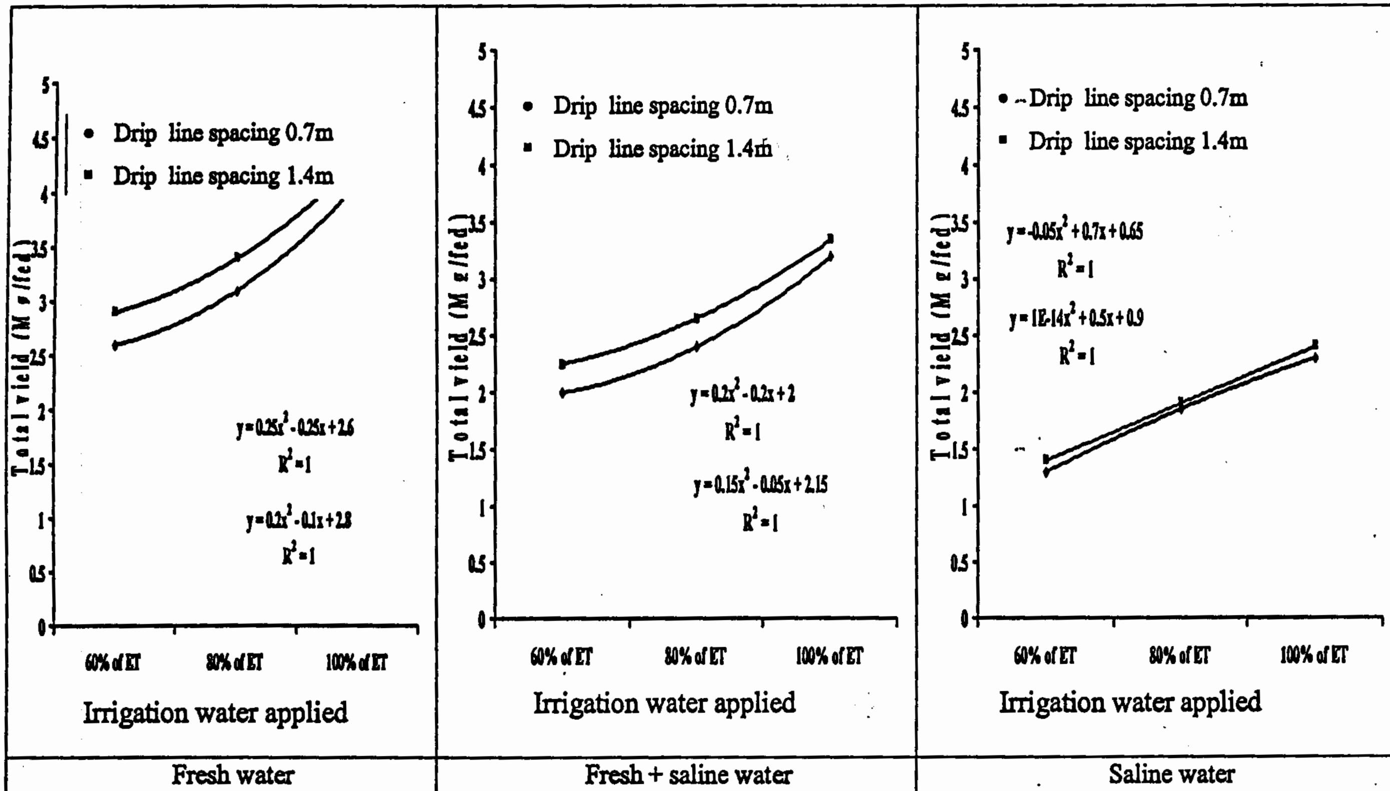


Fig. (5): The relationship between irrigation water amount and maize yield under different irrigation water quality at two lateral line spacing.

7. Total cost and net profit

The cost of production unit as influenced by irrigation water quality, water quantity and lateral line spacing shown in Fig (6). The minimum costs of 2400 and 2325 LE/fed were obtained under 60% of ET_{actual}, saline water and 0.70 and 1.40 m lateral line spacing. But, the maximum values of 2800 and 2725 LE/fed were obtained under 100% of ET_{actual}, fresh water and 0.70 and 1.40 m lateral line spacing. Data in Fig (6) indicate that the highest cost per unit production was 1846.2 LE/Mg for 60% of ET_{actual} and 0.7 m by using saline water, but the lowest value was 633.7 LE/Mg for 100% of ET_{actual} and 1.4 m by using fresh water.

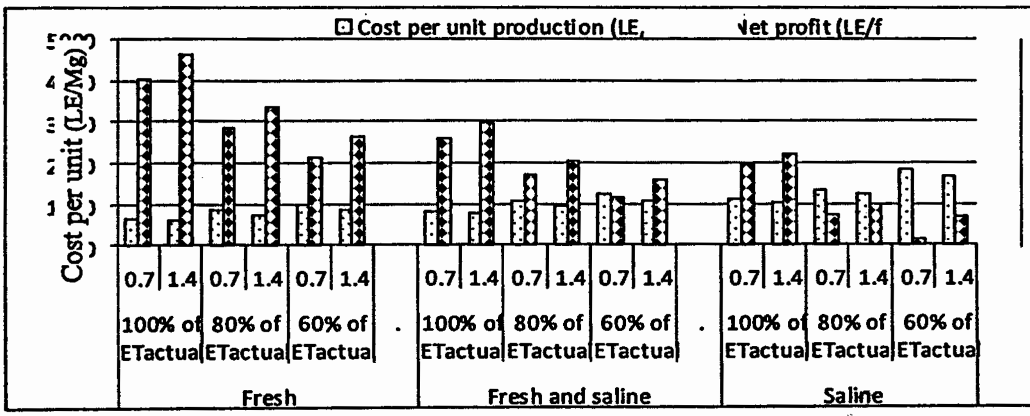


Fig (6):Cost per unit production and net profit under different treatments.

Data in Fig (6) indicate that the highest net profit values were 4030 and 4535 LE/fed, at 100% of ET_{actual} and fresh water, but the lowest values were 180 and 720 LE/fed, at 60% of ET_{actual} and saline water under 0.70 and 1.40 m lateral line spacing respectively.

SUMMARY AND CONCLUSIONS

This study was carried out to evaluate the effect of irrigation water quality, water quantity and lateral line spacing on trickle irrigation system performance, maize crop yield and yield components, water use efficiency, water saving, total cost and net profit under trickle irrigation system in cultivating a newly-reclaimed sandy soil during the summer season of 2008. The results obtained can be summarized as follows:

1. The highest emission uniformity was 96.50 % under fresh water at the 100% of ET_{actual}.
2. The emitter clogging as a percent gradually increased with increasing irrigation water applied under saline water.
3. The K_c values of maize growth stage for high production were 0.28 at initial, 0.66 (mean) at development, 1.04 at mid-season and 0.56 at late.
4. By increasing lateral line spacing from 0.7 to 1.4 m, seasonal ET_{actual} decreased by 13%.
5. The average fresh water saving was 877 and 1753 m^3/fed through irrigating with fresh & saline and saline water. By decreasing the irrigation water quantity from 100 to 80 and to 60 % of ET_{actual}, the average fresh water saving values were 165, 636 and 1107 m^3/fed.
6. Fresh water , 100% of ET_{actual} of water applied and 1.40 m lateral line spacing , gave the highest maize crop yield (4.3 Mg/fed), but saline water , 60% of ET_{actual} of water applied and 0.70 m lateral line spacing, gave the lowest yield (1.3 Mg/fed).
7. The lowest costs per unit production was 633.7 LE/Mg for 100% of ET_{actual} and 1.4 m lateral line spacing by using fresh water, but the highest value was 1846.2 LE/Mg for 60% of ET_{actual} and 0.7 m lateral line spacing by using saline water.
8. The highest net profit values were 4030 and 4535 LE/fed, at fresh water,100% of ET_{actual} water applied, but the lowest values were 180 and 720 LE/fed, at saline water, 60% of ET_{actual} under 0.70 and 1.40 m lateral line spacing.

Finally, it could be concluded that, under similar conditions, using trickle irrigation, fresh water, 100% of ET_{actual} water applied and 1.40 m lateral line spacing were recommended for achieving the best trickle irrigation performance, highest water saving, maximum maize crop yield, yield quality, water use efficiency and highest net profit.

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الملخص العربي

دراسة تأثير نوعية وكمية مياه الري علي اداء نظام الري بالتنقيط وانتاجية محصول الذرة الشامية

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نظرا لمحدودية الموارد المائية وزيادة عدد السكان فى مصر، والذي أدى الى تناقص نصيب الفرد من المياه، لذا كان لابد من العمل علي ترشيد الموارد المائيه المتاحه بهدف زيادة المساحه المرويه. وتقوم الفكرة الأساسية في هذا البحث على دراسة تأثير استخدام نوعيات ومستويات مختلفة من مياه الري ومسافات بين خطوط الري لنبات الذرة الشامية علي أداء نظام الري بالتنقيط وترشيد المياه المستخدمة وانتاجية المحصول ومكوناته وكفاءة استخدام المياه والتكاليف وصافي الربح تحت نظام الرى بالتنقيط في منطقة وادي النطرون محافظة البحيرة.

وقد كانت المعاملات التي تم دراستها هي: ثلاث معاملات لنوعية مياه الرى (مياه منخفضة الملوحة & مياه منخفضة الملوحة مع مياه مالحة بالتناوب& مياه مالحة) وثلاث معاملات ري ٦٠ – ٨٠ - ١٠٠ % من الاستهلاك المائي الفعلي والمسافة بين خطوط الري هي ٠.٧ - ١.٤م.

وكانت أهم النتائج المتحصل عليها هي:

- أعطت المعاملة المستخدم فيها المياه منخفضة الملوحة و١٠٠% من الاستهلاك المائي والمسافة بين خطوط الري ١.٤ متر أعلي كفاءة اضافة (92.34%) وأعلي انتظام لتوزيع المياه (٩٦.٥%) مع اقل نسبة لانسداد المنقطات (5.2%) بالمقارنة بالمعاملات الاخري .
- تم الحصول على أعلي انتاجية لمحصول الحبوب (٤.٣ ميجاجرام/فدان) تحت المعاملة المستخدم فيها المياه منخفضة الملوحة و١٠٠% من الاستهلاك المائي والمسافة بين خطوط الري ١.٤ متر بالمقارنة بالمعاملات الاخري .
- تم الحصول على دالة الإنتاج لمحصول الذرة فى الأراضى الرملية تحت مسافتين بين خطوط الري عند استخدام نوعيات مختلفة من مياة الري وهى:

Lateral line spacing	***For fresh water***	***For fresh + saline water***	***For saline water***
0.7m	$y_1=0.25x^2-0.25x+2.6,\ R^2=1$	$y_1=0.2x^2-0.2x+2,\quad R^2=1$	$y_1=-0.05x^2+0.7x+0.65, R^2=1$
1.4m	$y_2=0.2x^2-0.1x+2.8,\ R^2=1$	$y_2=0.15x^2-0.05x+2.25,\ R^2=1$	$y_2=1E\ -14x^2+0.5x+0.9, R^2=1$

حيث أن: y كمية المحصول ، x : % الماء المضاف من الاستهلاك المائي الفعلي.

- أعطت معاملة المياه منخفضة الملوحه وكمية مياه ١٠٠% من الاستهلاك المائي الفعلي و مسافة بين خطوط الري ١.٤ متر أقل تكاليف لانتاج الميجاجرام من المحصول وهو ٦٣٣.٧ جنية وأعلي صافي ربح هو ٤٦٣٥ جنيه للفدان.

وتوصي الدراسة عند زراعة الذرة الشامية استخدام المياه منخفضة الملوحة و١٠٠% من الاستهلاك المائي الفعلي للمحصول علي مسافة ١.٤ متر بين خطوط الري تحت نظام الري بالتنقيط للحصول علي أعلي أداء لنظام الري بالتنقيط وترشيد مياه الري وأعلى انتاجية للمحصول وأقل تكاليف لانتاج الوحدة من المحصول وأعلي صافي ربح في هذه المنطقة.

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