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IRRIGATION EFFICIENCY FOR THE MODIFIED IRRIGATION SYSTEM UNDER DIFFERENT LINE LENGTHS IN THE EGYPTIAN OLD VALLEY

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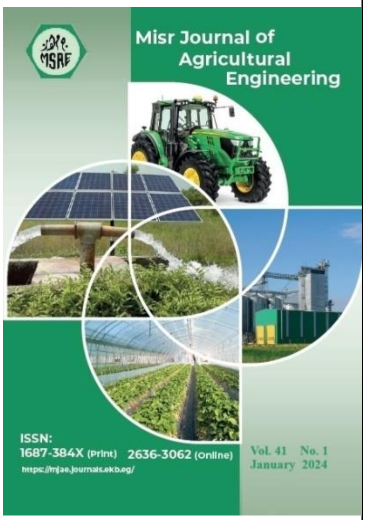


Keywords:
Irrigation efficiency; Furrows lengths; Water application efficiency; Crop production.

ABSTRACT

The purpose of the study is to evaluate the efficiency of surface irrigation systems with a modified perforated pipe system technique. (trailing perforated pipes) (T2), irrigation lengths beneath various furrows lengths and land slope 0.1% under the same condition and Treatments comparing with the traditional irrigation methods (T1). The experimental field was used for the growing season 2021–2022 clay soil on maize yield on the special farm on Kafr Taha – Shepin Elqanater – Qalupia. A plot of experimental area measured around 3.6 feddans. Two 1.8 feddan sub-plots were made from the experimental area plot. There were three treatments (L75) 75 m, (L100) 100 m, and (L125) 125 m for each sub-plot. At every treatment, the field test's breadth measured 18 m. Results showed that: increased crop production by using modified perforated pipe irrigation as compared with traditional irrigation techniques. Obtain the highest value of water application efficiency and water use efficiency under treatment L75 due to accurate leveling by Laser Land Leveling technique 0.1% slope and good water irrigation distribution by T2 system.

INTRODUCTION

Using perforated or gated pipes to improve the surface irrigation system is the aim of Egyptian agricultural and irrigation policy, especially in the old valley. A suitable way to distribute water to crops that are surface irrigation is through perforated or gated pipes system. The perforated or gated pipe system that has disadvantages, as the outflow from outlet that has angle started from the first outlet near the pumping unit resource about 45^{o} and greater until reached to about 90^{o} at the end of the gated or perforated pipe system. Also, both gated pipe and perforated don't claim to irrigate any crops at different furrow spacing. On the other hands increases soil erosion beneath the outlets of both systems. Therefore, the modified perforated pipe (trailing perforated pipes) system eliminates all the disadvantages of both perforated pipe system and gated pipe system. spacing. **El-Shafie et al. (2017)** Showed that the modified gate pipe system known as compensating gated pipes (SCGO) stabilizes the pressure heads and produces a more uniform water discharge along the pipeline. Conventional gated pipes are known to exhibit a range of pressure head variations along the pipeline, causing a non-uniform discharge from orifices. **Hussein et al. (2016)** Showed that Because the farmer is unable to properly regulate the gated pipe irrigation system, the water distribution uniformity is not as consistent as it might be. **Abdel- Rahman, (2010)** recommended that the development of gated irrigation pipe, an important technique for enhancing surface irrigation, depends on substituting the gates with self-adjusting nozzles (poppet nozzle). **Abd-El Hady (2023)** described that the developed surface irrigation (DSIS) system as a perforated pipes in which the conventional head ditch and precision land leveling are used in furrow irrigation **Hassan (1990)**. Mentioned that the optimal flow rate was 2 Ls^{-1} per m of width. **Goyal (2014)** showed that enhanced gated pipes can achieve an irrigation application efficiency of up to 81%. **Cazanescu et al (2010)** showed that efficient land levelling reduces the amount of water used, decreases down on irrigation time, and requires less work to manage the crop. It also improves product quality and production while reducing the need for crop maintenance. Soil levelling ensures proper water discharge in places with excess water, improving water management.

The objective of the research trial is to investigate how an irrigation system and the laser land levelling technique, with varying furrow lengths, affect the amount of water applied overall, the efficiency of water application and distribution, the production of maize yield, the efficiency of water use, and the advance and recession times under the current conditions in the Egyptian Old Valley.

MATERIALS AND METHODS

Materials

Location

On achieving the objective, Field study and experimentation were carried out at a special farm. On Kafr Taha –Shepin Elqanater- with (30° 16' 8.3820" N) (31° 18' 2.3868" E) Lower Egypt El-Qalupia Governorate, Old valley in Egypt, during the maize crop's growing season in clay soil in 2021–2022.

Soil: According to Black et al. (1965), the soil texture of the experimental location as clay soil, as stated in table (1).

Table. (1): The soil's mechanical and physical analysis.

Depth cm	Mechanical analysis				Soil texture	Field capacity %	Wilting Point %	Bulk density g/cm3
	Clay	Silt	Sand					
			F. S	C.S				
0-15	57.2	20.2	16.2	7.62	clay	36.2	17.4	1.13
15-30	59.1	21.6	16.1	6.8		38.1	18.1	1.15
30-45	56.3	22.8	17	5.8		36.5	20.2	1.16
45-60	61.2	22.8	15.3	4.5		35.8	19.0	1.17

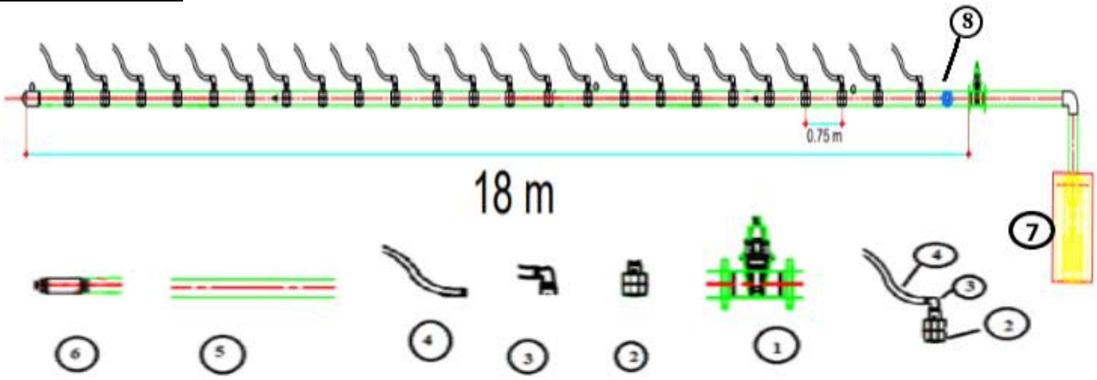
F. S = fine sand   C. S = coarse sand

The pumping unit:

Table. (2): The engine and pump characteristics.

Type	centrifugal pump	**Suction pipe diameter**	6”
Pump made	Locally-Diesel Shobra	**Delivery pipe diameter**	6”
Motor Power	5 HP	**Max operating pressure**	2 m
Max discharge	130 m3/h	**RPM**	1460

Irrigation system



1-	Butterfly valve 6"	2-	Saddle 160mm HDPE	3-	Plastic connection
4-	Rubber hose	5-	UPVC Pipe 160mm	6-	End Cap Pipe 160mm
7-	Centrifugal pump 5 HP	8-	Pressure gage		

Fig. (1): the system of modified perforated pipes.

The pipes used in the system of modified perforated pipes:

A 160 mm outer diameter PVC pipe was used in the production of the modified perforated pipe system, also known as trailing perforated pipe.

Tools and equipment for Made and Measuring Holes:

a) Electric hand drill and b) Watch-Venire calipers

Corn plant

The corn variety was (Maize yellow mono hybrid 2088) planted in furrow.

Table (3): Maize variety, planting, and harvesting data.

Season	Crop type	Crop class (variety)	Planting data	Harvesting
Summer	Maize	Maize yellow mono hybrid 2088	13 May to 13 June.	17 Aug. to 23 Aug.

Table. (4): Mean maximum plant heights for corn, Kc, and maize coefficients.

Crop	$k_{c\ ini}$	$K_{c\ mid}$	$K_{c\ end}$	Maximum Crop Height (h) (m)
Maize	0.3	1.15	1.05	1.5

According to: **Etc. =Eto*kc**

Etc.: water consumption, (mm/day).

Eto: reference evapotranspiration, (mm/ day).

Kc: crop coefficient.

Table. (5): water consumption for maize.

Month	**Kc**	**Eto** (mm/day)	**ETC** (mm/day)
May	0.3	9.06	2.718
June	1.15	9.54	10.971
July	1.149	8.7	10
August	1.049	7.89	8.28

Method:

Fieldwork and experimentation methodology:

Field experiments are being conducted to examine the effects of employing the Laser Land levelling technique and the modified perforated pipe system (trailing perforated pipe) technique under various furrow lengths on the total amount of water applied, corn production, water application efficiency, and water use efficiency under the current conditions in the Egyptian Old Valley. Additionally, the effects are being examined with respect to advance and recession time when compared to the traditional irrigation system under the same conditions. A plot of experimental area measured around 3.6 feddans. Field

The experimental area plot was split into two 1.8 feddan sub-plots, each, as seen in fig (2). After levelling the first sub-plot at a slope of 0.1 percent, irrigation water was pumped into a concrete canal via a 6-inch flow meter and directed into the furrows using a typical irrigation technique. For every subplot, three treatments were assigned. 75-meter-long furrow (L_{75}),100 meters of furrow length (L_{100}) and 125 m furrow length (L_{125}). A 1-meter strip of tilled ground was left between treatments that were contiguous since the field test was 18 meters wide for each treatment. Additionally, a 2-meter tilled strip of ground was left between the second sub-plot was watered using a modified perforated pipe system (trailing perforated pipe) and levelled at a slope of 0.1 percent using laser land levelling technology.

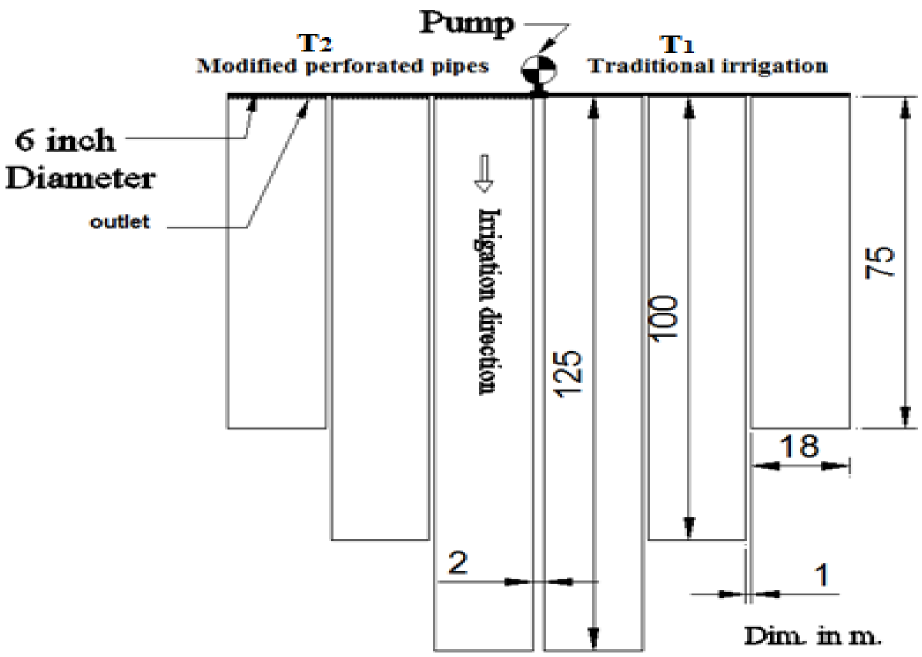


Fig. (2): The experimental layout

For every subplot, three treatments were assigned. The furrow lengths are 75 meters (L75), 100 meters (L100), and 125 meters (L125). proximity sub-plots. Also, the second sub-plot leveled at 0.1 % slope by laser land leveling technique and irrigated by modified perforated pipes (trailing perforated pipe) system. Each sub-plot was divided into three treatments 75 meters furrow length (L_{75}), 100 meters furrow length (L_{100}) and 125 m furrow length (L_{125}).

Second experimental Sub-plot area was being irrigated.by 6- inch diameter PVC modified perforated pipes (trailing perforated pipe) system. There was to be a 0.75 m gap between two successive furrows. A 6-inch modified perforated pipe (trailing perforated pipe) system with a 6-meter length served each treatment. And the required saddle attaches with rubber hoses. At the end of the irrigation run, the irrigation stream was shut off (as traditional dominate).

Following that, every agricultural technique with the same performance was applied to all treatments. Along the length of the furrow, at every station at the end of the irrigation run, the irrigation stream was shut off (as traditional dominate). Following that, every agricultural technique with the same performance was applied to all treatments. Along the length of the furrow, at every station

The actual performance of the modified perforated pipe system (trailing perforated pipe) technique was tested by measuring the outlets flow rate along the modified perforated pipe system (trailing perforated pipe) technique under actual field operating conditions. The outlet discharges experimentally measured by direct method using bucket with capacity 10liter and stopwatch. Also, the discharge coefficient experimentally evaluated.

Every treatment included similar distance (25 m) markers for the water advance and recession times. Additionally, by measuring the amount of time between the advance and recession, the opportunity times—that is, the times when the water was above the surface were calculated.

Using a 6-inch flow meter connected to a pumping unit, the amount of irrigation water needed for each treatment was calculated. Both the efficiency of water application and discharge were measured. Estimating the water savings is another.

The ratio of the average depth of irrigation water that percolates and is stored in the root zone to the average depth of water applied is known as the water application efficiency, or WAE. as follows:

WAE = (Average depth of water infiltrated and stored into root zone) (Average depth of water applied)$^{-1}$ x 100

Water use efficiency as follows:

$$WUE = \text{Maize yield } (kg\ fed^{-1}\ (kg\ m^{-3}) / (\text{Applied irrigation water } (m^3\ fed^{-1}))$$

RESULTS AND DISCUSSION

Field experimental work:

Field experimental work to study the effect of irrigation system and land leveling technique under different furrows lengths on the total water applied, productivity of maize, water application efficiency and water use efficiency under prevailing condition in Egyptian old valley also, its effects on advance and recession time.

Periods of advances and recession:

Along each plot, the water advance and recession periods were noted at equal distances. The three replicates' average data is presented in Fig. (3) through Fig. (5) respectively.

The results indicated that when the lengths of the furrows increased, the average values for the T1 and T2 systems increased., the results also indicated that the average values of water advance time, water recession time, and opportunity time increased as furrow length increased for irrigation with T2, following the same trend as traditional irrigation method T1,Due to accurate levelling by the Laser Land Leveling technique (0.1 percent slope) and good water irrigation distribution by the T2 system

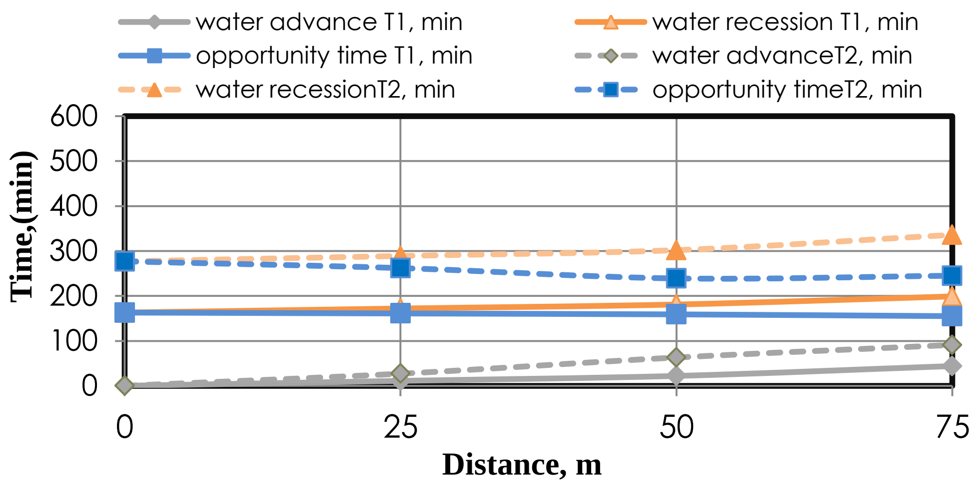


Fig.(3): Advanc,recession and opportunity time curve for tratidional irrigation and modified perforated under (L75).

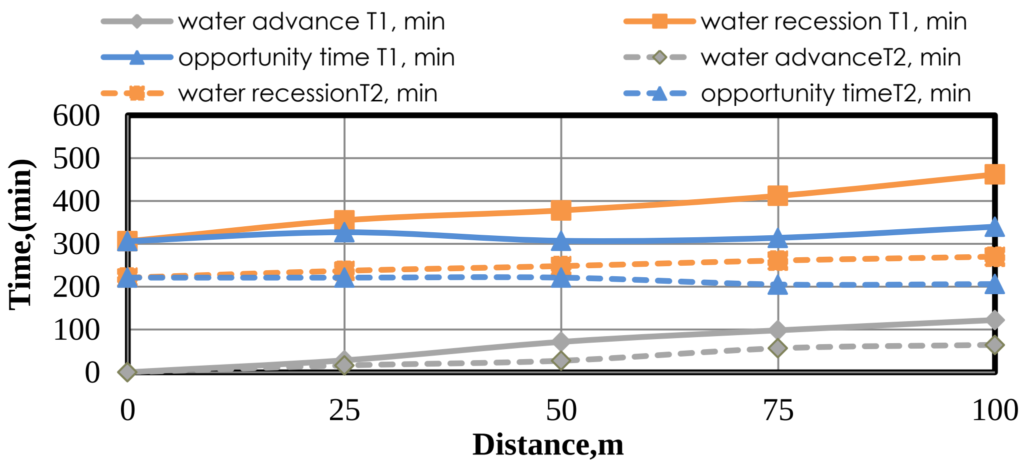


Fig.(4):Advanc,recession and opportunity time curve for tratidional irrigation and modified perforated under(L100).

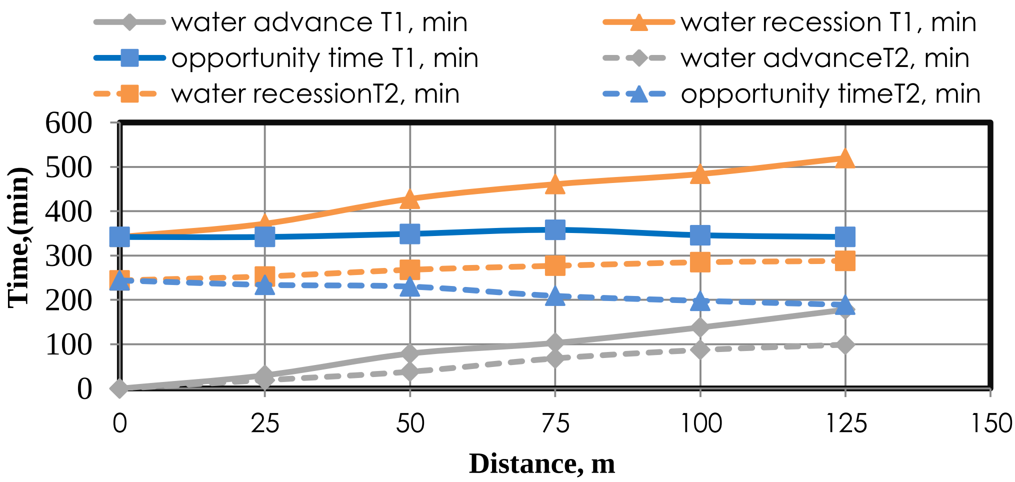


Fig.(5): Advanc,recession and opportunity time curve for tratidional irrigation and modified perforatedunder(L125).

2. Water amounts used for irrigation:

The figure (6) indicated that the average total water received by crop plants during two seasons from six irrigations for (T1) and (T2), under various treatments with furrow lengths of L75, L100, and L125, respectively, According to the figure, the corn plant in the three treatment instances for furrow lengths of L75, L100, and L125 for T1 or T2 got more irrigation water as the furrow length increased because of an increase in water opportunity time. Water losses because of evaporation, runoff, and seepage increased. The results showed that, on average, using the T2system saved irrigation water by 45.0% per feddan when used to three different furrow lengths. Because of good water distribution from outlets throughout the furrow lengths width on the top section of the field and consistent water application, the results showed that T1 system got more irrigation water than T2 system in all three cases of furrow lengths.

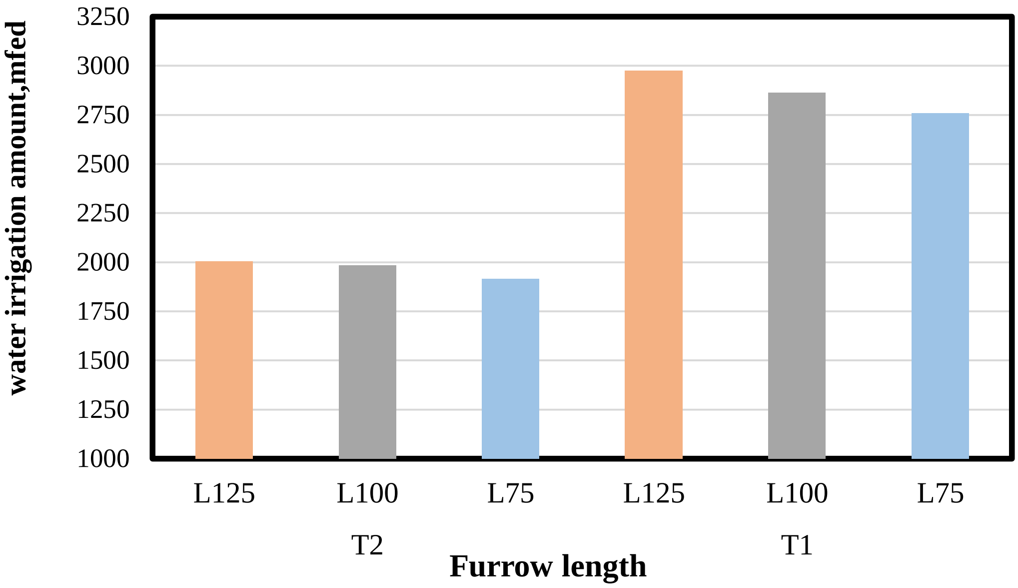


Fig. (6): The total amount of maize yield irrigation effects of irrigation systems and the length of furrows.

3. Efficiency of water application (WAE. %):

Depending on the soil moisture level before and after each irrigation, the average depth of irrigation water stored in the root zone for the T1 and T2 systems under treatments L75, L100, and L125 was 36.5 cm. As seen in figure (7), increasing furrow lengths influenced the average values of water application efficiency (WAE) of maize during two seasons for irrigation with the (T2) system and (T1). Due to increased water irrigation losses from runoff, deep percolation, and evaporation, the results showed that the maximum value of water application efficiency was achieved for both T1 and irrigation with T2 in the case of treatment L75. In conclusion, the results showed that T1 had a lower water application efficiency than T2 for various treatment furrow lengths. A closed conduit to transport water to the field, good irrigation water distribution along the furrows over the upper part of the field through outlets, and a decrease in water irrigation losses through deep-percolation, evaporation, and runoff by good laser technique land levelling at 0.1 percent slop are further reasons why L75, when using the T2, gave the highest efficiency of water application.

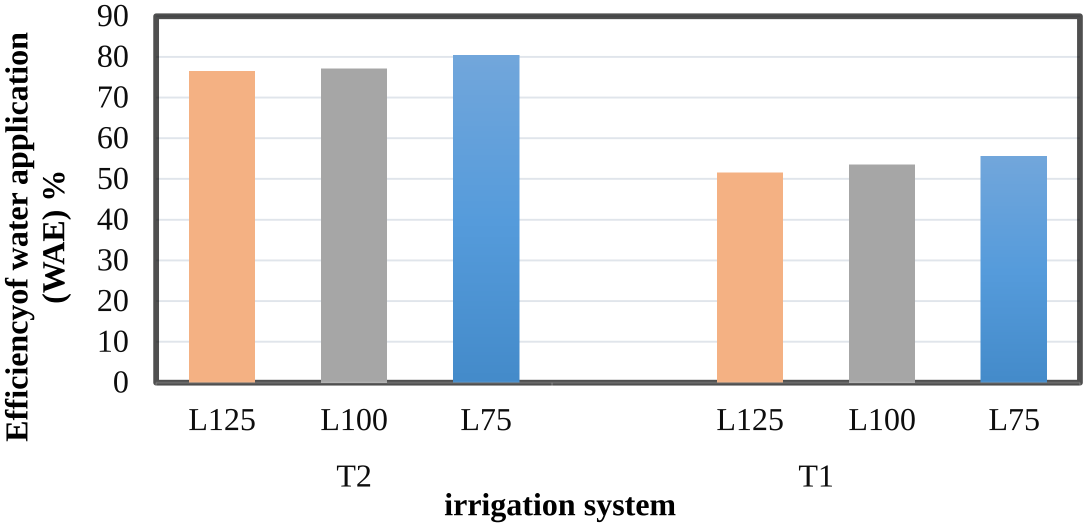


Fig. (7): Efficiency of water application effects of irrigation systems and the length of furrows

4- Productivity of maize yield:

The figure (8) showed that the average maize yield values for the T1 system and irrigation with the T2 system under varying furrow lengths (L75, L100, and L125). The longest L100 furrows produced the highest average maize yield figures. The L125 furrow length produced the greatest average yield values of maize. When it comes to the effects of T1 and T2, the three cases of furrow lengths (L75, L100, and L125) where the average highest values of corn yield were obtained when T2 was used in conjunction with laser levelling technique yielded 0.1 percent slope. This could be attributed to improved water distribution along the furrow. It is possible to draw the conclusion from the explanation above that employing a modified perforated pipe system at furrows length.

5- Efficiency of water use (WUE)

Different furrow lengths and slopes influenced the average values of water use efficiency (WUE) of maize yield for irrigation using the (T2) system and the(T1) system, as shown in figure (9). The results indicated that treatment L75 produced the highest value of WUE for either irrigation with the T2 system or T1 irrigation. In the case of treatment L125, the lowest value of WUE was attained for both the irrigation with the (T2) system and the (T1) system. The best WUE was obtained in the case of over-traditional irrigation due to decreased water irrigation losses by deep-percolation, evaporation, and runoff by accurate good Laser land levelling with 0.1 percent slope, closed conduit to carry water to the field, and good water distribution along the upper part of the field through the modified perforated pipe (trailing perforated pipe) system. These results are discussed in relation to the impact of using the (T2) system or irrigation traditional method on the WUE. Based on this, the results showed that, in comparison to the irrigation with the (t2) system, (T1) reduced the WUE of maize yield by 50.27, 56.76, and 58.7 percent under treatments L75, L100, and L125, respectively. In comparison to a standard irrigation system, the results showed that irrigation using the T2 system under three treatments resulted in longer furrow lengths. It is recommended to use the modified perforated pipe (trailing perforated pipe) system as L 125, The maximum value of corn yield 3698 kgfed^{-1} was achieved in case of using (T2) at L125 with 0.1 % slope treatment, saving irrigation water 45% per feddan in average, and the traditional irrigation method maximum decreased WUE of maize yield 58,7% was achieved under L 125 compared with the irrigation with the modified perforated pipe (trailing perforated pipe) system.

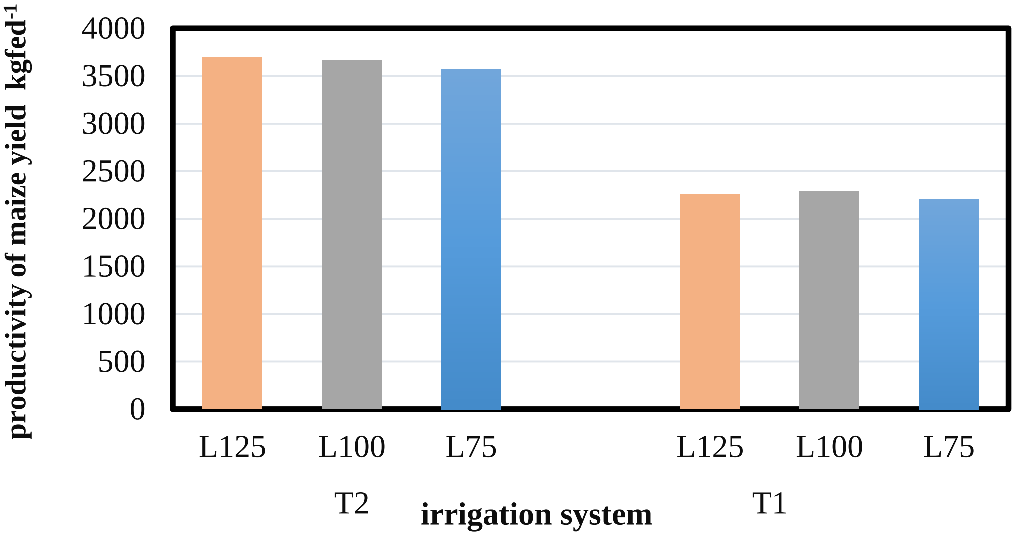


Fig. (8): Productivity of maize yield Effects of irrigation systems and the lengths of furrows.

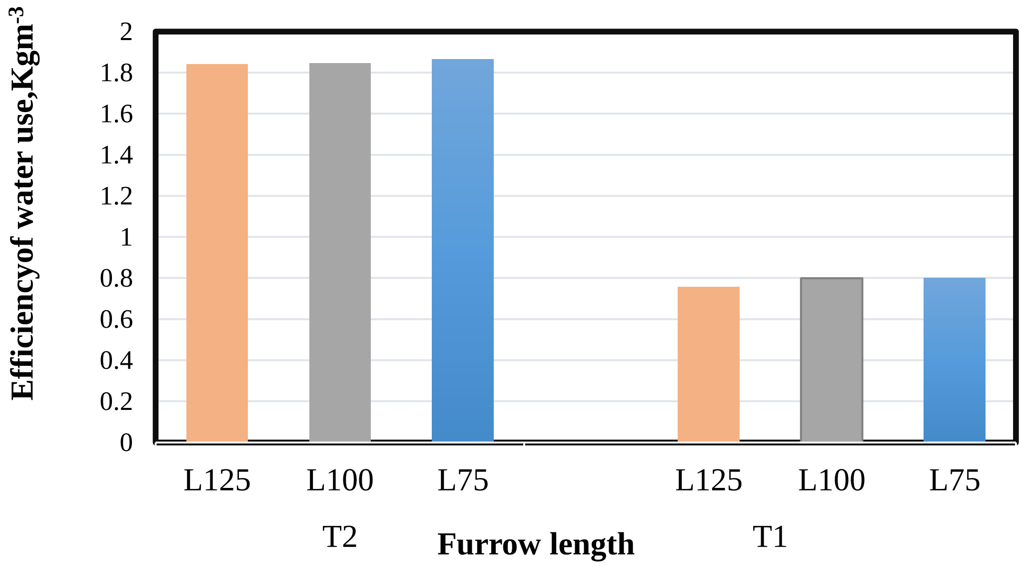


Fig. (9): Efficiency of water use Effects of irrigation systems and the length of furrows

CONCLUSION

- using modified perforated pipes irrigation system (trailing perforated pipes) with LASER land leveling technique at 0.10 slope and the furrows lengths of 75 m gives a highest values of corn crop production and also, a highest values of WAE , WUE and saving about 46.3% of water application than conventional irrigation methods with traditional land leveling at same land slope under three treatments of furrows lengths because good laser technique land leveling at 0.1 % slop

- closed conduit to carry water to the field and good uniformity of water application gives good water distribution from gates outlets along the furrows width over the upper part of the field through outlets decreased the water losses by seepage, deep percolation and runoff due to the advance time and opportunity time decreased and also, decreased losses by evaporation.

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كفاءة الري لنظام الري المعدل تحت أطوال خطوط مختلفة في الوادي المصري القديم

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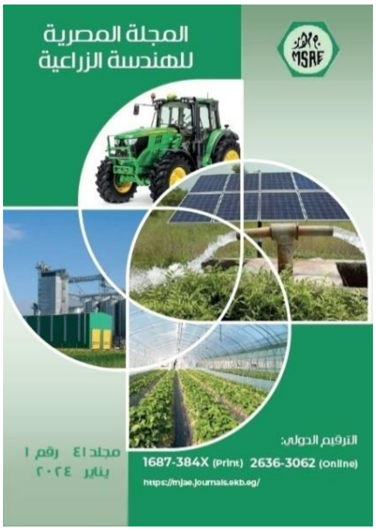

الكلمات المفتاحية:
كفاءة الرى؛ اطوال الخطوط؛ كفاءة اضافة المياه؛ انتاجية المحصول.

الملخص العربي

يهدف هذا البحث إلي دراسة أداء نظام الري السطحي من خلال استخدام نظام الري بالأنابيب ذات الفتحات المطورة (الانابيب ذات الخراطيم المتدلية) ، (T2) مع اطوال مختلفة لخطوط الري (٧٥، ١٠٠، ١٢٥ م) مقارنة بالطرق التقليدية للري,(T1) تحت نفس الظروف والمعاملات. كذلك تأثير طرق اضافة المياه على زمن تقدم وانحسار والوقت المناسب لبقاء المياه وكمية المياه المضافة وكفاءة الاضافة وكفاءة إستخدام المياه على المحصول. تم استخدام الحقل التجريبي للتربة الطينية لموسم النمو ٢٠٢١-٢٠٢٢ على محصول الذرة الصفراء في المزرعة الخاصة في كفر طه – شبين القناطر – القليوبية. قطعة أرض مساحتها التجريبية تبلغ حوالي ٣,٦ فدان. تم عمل قطعتين فرعيتين بمساحة ١,٨ فدان من قطعة أرض المنطقة التجريبية وتوضح النتائج ما يلي:

- زيادة انتاجية محصول الذرة باستخدام نظام الري بالأنابيب المثقبة ذات الخراطيم المتدلية والتسوية الدقيقة بأشعة الليزر بانحدار ٠,١% مقارنة بنظام الري السطحي التقليدي.
- الحصول على أعلى قيمة لكفاءة استخدام المياه وكفاءة إضافة المياه تحت المعاملة L75 تحت نظام الري بالأنابيب المثقبة ذات الخراطيم المتدلية وذلك راجع إلى تحسين إضافة وتوزيع المياه باستخدام الانابيب المثقبة ذات الخراطيم المتدلية على امتداد عرض الشريحة في الجزء العلوي للحقل ومن الجانب الأخر الانحدار الناتج في عملية التسوية بمعدل ٠,١.% الذي يؤدي إلى نقص زمن التقدم بالتالي نقص زمن التلامس وبالتبعية نقص فواقد المياه بالتسرب العميق.