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*TRICKLE IRRIGATION UTILIZATION FOR WHEAT IN SANDY SOIL

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ABSTRACT

This study was conducted on a calcareous salt – affected soil at Ras Sudr area, South Sinai governorate during season of (2006&2007), to evaluate the influence of trickle irrigation systems (Surface and Sub-surface) on wheat crop cultivation under saline conditions of soil and water. Also, this work includes different water management technique, (quantities and discharges). The objective of the present work is to implement some of these discharges and water deficit in computing actual evapotranspiration of wheat under desert conditions, to maximize the yield production of wheat under trickle irrigation systems to save more water quantities and to keep the soil sustainable from degradation.

Results of this study may be revealed that:

1- *Highest yield (2254.3 kg/fed.) and growth parameters Leaf Area Index "LAI" of (85%), weight grain "W" of (61.6gm) and crude protein "P" of (15.4%) were obtained under subsurface trickle irrigation system at 100% applied water quantity and 8L/h emitter discharge .*
2- *Lowest actual evapotranspiration "Eta", for (Initial, development, mid-season, late-season) growth stages and seasonal, (34, 103, 80.4, 48.1 and 265.3 mm) respectively, were obtained under subsurface trickle irrigation system at 100% applied water quantity and 8L/h emitter discharge.*
3- *Water use efficiency for surface and subsurface trickle irrigation systems at 80% applied water quantity and 8L/h emitter discharge was (1.17 and 2.25 kg/m^3) resp.*

Keywords: *Trickle irrigation system, irrigation water quantities, emitter discharges, actual evapotranspiration and water use efficiency.*

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INTRODUCTION

Egypt is one of the countries that facing great challenges due to its limited water resources, and food shortage especially, in wheat production which is considered as a strategic crop while the population increases greatly.

The first challenge is represented mainly by its fixed share of the Nile water and its aridity as a general characteristic. Formulation of Egypt's water resources policy for the 21st century requires a major shift from the classical paradigm used in water resource planning and management to a new innovative. Therefore, increasing demand for water has created a whole new set of issues and problems confronting irrigated agriculture. For many years, the emphasis of sustainable irrigated agriculture has been improving the effectiveness of water management, water conservation and salinity.

The second challenge is wheat production which is the most important staple crop produced in Egypt. **AbdEl-Rahman (1996)** emphasized that crops grown under subsurface trickle irrigation system might obtain yield more than those grown under surface one. He showed that one advantage of subsurface drip irrigation is saving water by preventing surface wetting and evaporation. To avoid wetting the surface, the emitter should be placed deeper than the radius of the wetted sphere. **Camp et al. (1999)** subsurface drip irrigation offers many advantages for management of water and nutrients, but its effectiveness may be limited by weather or soil conditions. Solving soil problems, such as compaction, in subsurface drip irrigation systems is understandably difficult. They hypothesized that the need for deep tillage in conservation tillage systems may be reduced if the compacted soil layers are kept moist enough for root growth.

El-Boraie (2004) showed that in arid regions as Egypt where irrigation is essential for crop production, improving management of irrigation water may yield substantial water saving, which can be used for agriculture horizontal expansion. One of the best approaches to achieve good water management program is knowing the amount of actual evapotranspiration (ETa) or crop consumptive use. **Camp (1998)** stated that usually SSTI (Sub-Surface Trickle Irrigation) water use saving ranges from 0 to 50 % when compared with traditional irrigation systems. In situations where water saving are not made there is often a significant yield increase resulting in improved production per unit of irrigation water which improved water use efficiency (WUE). **Gaber (2000)** found that the highest values of water use efficiency concerning wheat grains, straw and total yield (1.96, 3.22 and 5.18 kg/m³, respectively) were obtained by adding 507.9 mm of irrigation water per season to Giza 163 wheat variety. Such treatment increased the yield by 16.5, 9.0 and 11.89 % relative to irrigation by the highest amount of water (961.72 mm.) and decreased water consumption by 1082.2 m³/ fed.

MATERIALS AND METHODS

Experimental treatments:

The field study was carried out in split – split plot design with three replicates. The area of experiment was divided into 3 × 1.5 m plots was planted in the season of 2006-2007 with a rate of 3 kg/fed wheat variety of (Treticum aestivum). Three applied water quantities (Q) which obtained from the product of the reference evapotranspiration (ETo) calculated by using Penman-Montieth equation multiplied by crop coefficient for every stage. Three emitter discharge of 2, 4, and 8 L/h were used as water distribution under surface and sub-surface trickle irrigation systems were used also.

The reference evapotranspiration (ETo) was calculated by using "CropWat 4 windows" (version 3.4), **Smith (1991)** Software Program, according to the monthly mean of 30 years. Moreover, Table (1) Illustrate the growth periods (day) of the Wheat crop, i.e., establishment or initial stage, vegetative or development stage, flowering or mid-season and yield formation or late-season.

Table (1): Period (day), crop coefficient (Kc_{FAO}) and reference evapotranspiration (ETo) of wheat growth stages and total season.

Stages	Initial	Develop	Mid	Late	Total
Period (day)	30	60	40	30	160
Kc_{FAO}	0.30	1.15	>>	0.30	--------
ETo (mm)	70.96	135.45	102.73	96.68	405.82

Soil characteristics:

Some physical properties of soil was measured in the laboratory of water requirements and meteorology unit associated to the physical and chemical department in Agricultural Research Center, Ministry of agricultural, El-doky, Cairo, Egypt represented in Table (2).

Table (2): physical characteristics of the soil under study.

Soil depth (cm)	Particle size distribution %				Textural class	$CaCO_3$ %	PD g/cm^3	BD g/cm^3	HC cm/h	FC %	WP %	AW %
	C sand	F sand	Silt	Clay								
0-20	53.69	27.61	7.97	10.73	LS	56.96	2.58	1.53	3.60	20.14	9.45	10.82
20-40	23.34	61.88	7.46	7.32	LS	51.81	2.63	1.55	4.80	20.43	9.54	10.69

LS = Loamy sand, PD = Particle density (g/cm^3), BD = Bulk density (g/cm^3), HC =Hydraulic Conductivity (cm/h), FC = Field capacity (0.1atm.) %, WP= Permanent wilting Percentage (15atm) %and AW =Available soil water %.

The amounts of irrigation water were calculated using the following equation:

$$IW = \frac{ETo * KC_{FAO} * Ti * A * Li(1.2)}{\eta} \quad m^3 \qquad (1)$$

Where:

IW : amount of irrigation water, m^3 per irr.

ETo : potential evapotranspiration, mm / day.

KC : crop coefficient from FAO.

Ti : irrigation frequency in days (2 days).

A : area, m^2.

η : trickle drip irrigation efficiency (90%)

LI : leaching requirements (20%)

Actual evapotranspiration "ETa" (mm/day) determination technique:

To determined water consumptive of wheat, soil samples were collected from each treatment at 0 – 20 cm and 20 – 40 cm soil depth periodically before and after each irrigation. The crop water consumptive use was calculated by the following equation:

$$ETa = \frac{(M_2\ \% - M_1\ \%) \times d_b \times D}{100} \quad mm \qquad (2)$$

Where:

ETa : actual evapotranspiration, mm.
M_2 : moisture content after irrigation %.
M_1 : moisture content before irrigation %.
d_b : specific density of soil .
D : mean depth, mm.

Water use efficiency"WUE" (kg/m^3) determination technique:

Water use efficiency was calculated by dividing the crop yield "Y" (Kg) by the amount of seasonal actual evapotranspiration "Eta" (m^3).

$$WUE = Y/ETa \quad kg/m^3 \qquad (3)$$

Plant measurements:

1- Leaf area index "LAI" (%) can be determination by "planimetric" technique "LAI" and moisture in the surface soil greatly affect the ratio of soil evaporation to the total evapotranspiration. The relationship between this ratio and surface soil moisture and leaf area index was established, and can help to improve field water utilization efficiency.
2- Weight of 1000-grain "W" (g) With seed tests the 1000 grain weight is an important quality criterion, which must be determined with high accuracy. Counting and dosage of mechanical and electronic small articles as SMD's are made increasingly also over the determination of the 1000 grain weight.
3- Crude protein "P" (%) can be determination by modified micro-Kheldahle method.
4- Grain yield (kg/fed.).
5- Straw yield (kg/fed.).
6- Total yield (kg/fed.).

RESULTS AND DISCUSSION

Growth parameters:

Leaf area index “LAI” (%):

Data in Fig. (1) show that the leaf area index “LAI”(%) increases with the increase of applied water quantities and emitter discharges for surface ”STI” and subsarface ”SSTI” trickle irrigation systems and both of wheat varieties. The maximum value of “LAI” was 85% at 100% applied water quantity and 8L/h emitter discharges for SSTI. While the minimum value was 68.4% at 100% applied water quantity and 8L/h emitter discharges for STI. These increasing may be attributed to the produces good moisture distribution in the soil profile and when using subsurface trickle irrigation give a highly wheat production. In addition that the actual evapotranspiration was lower if comparing with STI these results are agreed with the results obtained his **Camp et al. (1999)**.

The data revealed that the values of “LAI” significantly changed by changing emitter discharges between 2 and 4 or 8 L/h. These results may be attributed to the saturated zone below the drip line was obtained only for the highest emitter discharge. These results agreed with the results obtained his **Assouline (2002)**. While there is no significant difference between emitter discharges 4 and 8L/h for all conditions under study. These results may be attributed to “LAI” reached the maximum values when using 4L/h emitter discharge. While using 8L/h emitter discharge didn’t observed any effect on “LAI” value. So, it is recommended to use “D”, (4L/h) to saving coasts and less pressure operation. These results according to **Granberry et al. (1994).**

Weight grain “W” (g):

Data in Fig. (1) show that the weight grain “W” (g) increases with the increase of applied water quantities and emitter discharges for ”STI” and ”SSTI” for wheat variety*(Treticum aestivum)”Ta”* . The maximum value of “W” 61.6gm was obtained at 100% applied water quantity and 8L/h emitter discharge for ”SSTI”. While the minimum value of 50gm was obtained at 100% applied water quantity and 8L/h emitter discharges for ”STI”.

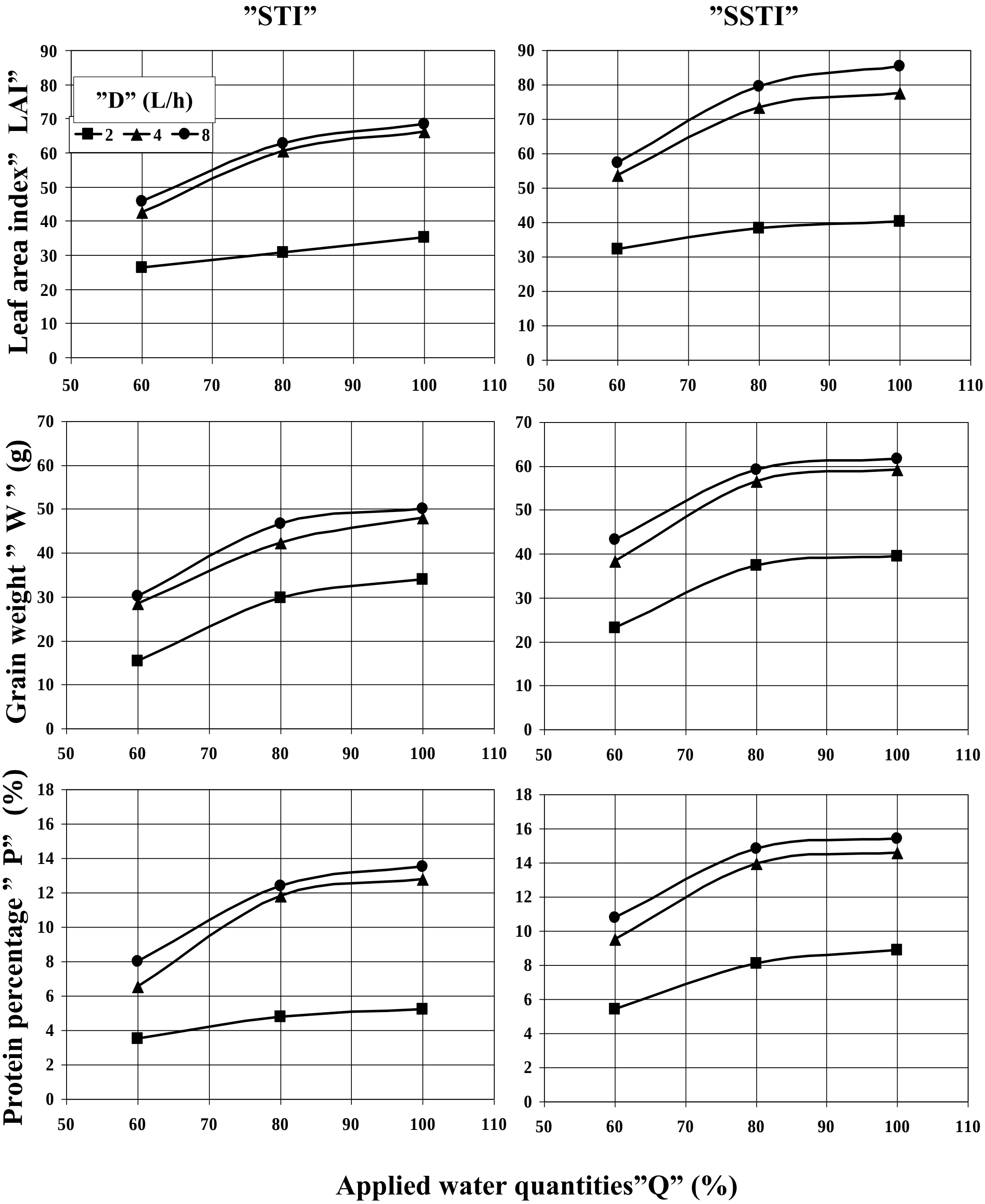

Fig.(1): Leaf area index "LAI"(%), grain weight "W" and protein percentage "P" (%) Vs. applied water quantities"Q" (%) at different emitter discharges "D" (L/h) and surface "STI" and sub-surface "SSTI" trickle irrigation systems for wheat variety of triticum aestivum "Ta".

Crude protein percentage “P” (%):

Data in Fig. (1) show that the crude protein percentage “P” (%) increases with

the increase of applied water quantities and emitter discharges for ”STI” and ”SSTI” for wheat variety *”Ta”*. The maximum “P” value of 15.4% was obtained at 100% applied water quantity and 8L/h emitter discharge for ”SSTI”. While the minimum value of 13.5% was obtained at 100% applied water quantity and 8L/h emitter discharge for”STI”. This increasing may be due to good moisture distribution in the soil profile. In addition, the actual evapotranspiration lower than if comparing with”STI”. These results agreed with the results obtained his **El-Boraie (2004).**

Wheat yield Grain ”G”, straw ”S” and total yield ”Ty” (kg/fed.):

Data in Fig. (2) show that the Grain ”G”, straw ”S” and total yield ”Ty” kg/fed. increases with the increase of applied water quantities and emitter discharges for ”STI” and ”SSTI” for wheat variety *”Ta”*. The maximum value of ”G” (1195), ”S”(1059.3) and ”Ty” (2254.3) kg/fed. was obtained at 100% applied water quantity and 8L/h emitter discharge for ”SSTI”. While the minimum value of was 1017.8, 599.58 and 1617.4 kg/fed. respect., at 100% applied water quantity and 8L/h emitter discharge for ”STI”. These results coincide with data studied by **Aboamera (1999).**

The data revealed that the values of ”G”, ”S” and ”Ty” kg/fed. Significantly affected by changing emitter discharges between 2 and 4 or 8 L/h. Meanwhile there is no significant difference between emitter discharges 4 and 8L/h for all conditions under study.

Actual evapotranspiration “Eta” (mm) for all growth stages:

Data in Fig. (3) show that the maximum value of seasonal actual evapotranspiration “Eta” of 341.6 mm for (Initial, development, mid-season and late-season) growth stages of 44, 133, 99.8 and 68 mm respect., was obtained at 100% applied water quantity and 8L/h emitter discharge for ”STI”.

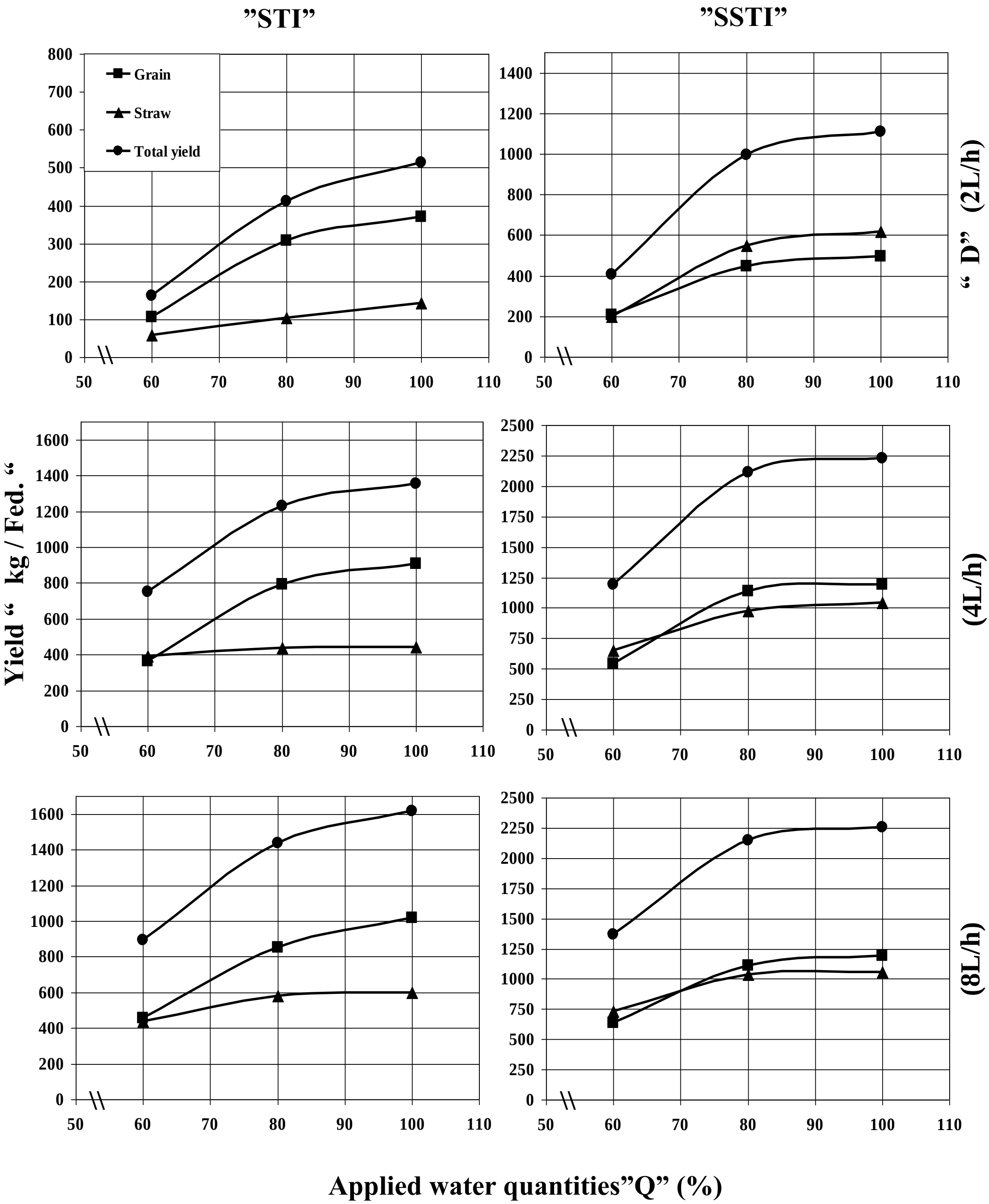

Fig.(2): Wheat yield (Straw "S", grain "G", and total yield "Ty") kg/feddan Vs. applied water quantities "Q" (%) at different emitter discharges "D" (L/h) and surface "STI" and sub-surface "SSTI" trickle irrigation systems for wheat variety of triticum aestivum "Ta".

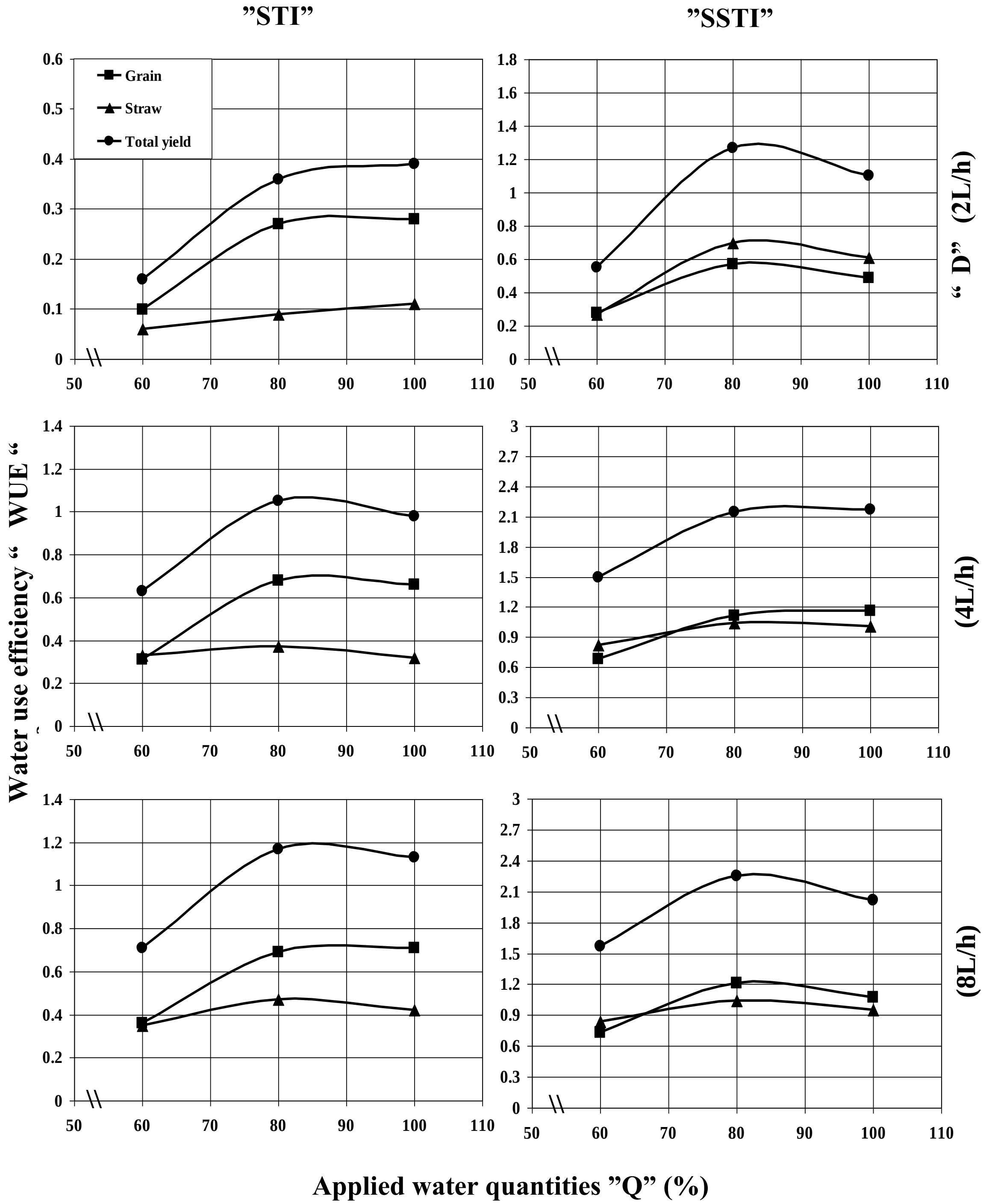

Fig.(4): Water use efficiency "WUE" (Straw "S", grain "G"and total yield "Ty") kg/m^3 Vs. applied water quantities "Q" (%) at different emitter discharges "D" (L/h) and surface "STI" and sub-surface "SSTI" trickle irrigation systems for wheat variety of triticum aestivum "Ta".

While the minimum value of seasonal “Eta” of 265.3 mm for growth stages of 34, 103, 80.4, 48.1 mm/stage respect., was obtained at 100% applied water quantity and 8L/h emitter discharge for ”SSTI”. These increases may be attributed to the advantage of subsurface drip irrigation which saving water by preventing surface wetting and evaporation. These mean that the surface emitters supply ample water to maintain the atmosphere evaporative potential at all infiltration times. The shallow subsurface emitter is evaporating at a potential rate most of the time. At peak evaporative potential, the soil water status becomes a limiting factor for emitters at 0.15 m deep. It results in drying of the soil surface and a gradual change from atmosphere to soil controlled evaporation. Shortly after the time for peak evaporation the supply and demand of water on the surface was balanced again. These results agreed with the results obtained his **Gaber (2000).**

Water use efficiency “WUE” kg/m^3:

Data in Fig. (4) show that the maximum value of water use efficiency “WUE” (total yield ”Ty”) was 2.25 kg/m^3, at 80% applied water quantity and 8L/h emitter discharge for ”SSTI”. While the minimum value was 1.05 kg/m^3, at 80% applied water quantity and 8L/h emitter discharge for ”STI”. These increasing may be attributed to the sub-surface trickle irrigation water use savings range from 0 to 50 % compared with traditional irrigation systems. In situations where water savings are not made there is often a significant yield increase resulting in improved production per unit of irrigation water which improved water use efficiency (WUE). Subsurface drip irrigation can significantly increase water use efficiency and yield with precise management of irrigation water and lateral depth. Because the water delivered uniformly to the soil, salts have pushed away from the root zone with the wetted front. These results agreed with the results obtained his **Gaber (2000) and El-Boraie (2004).**

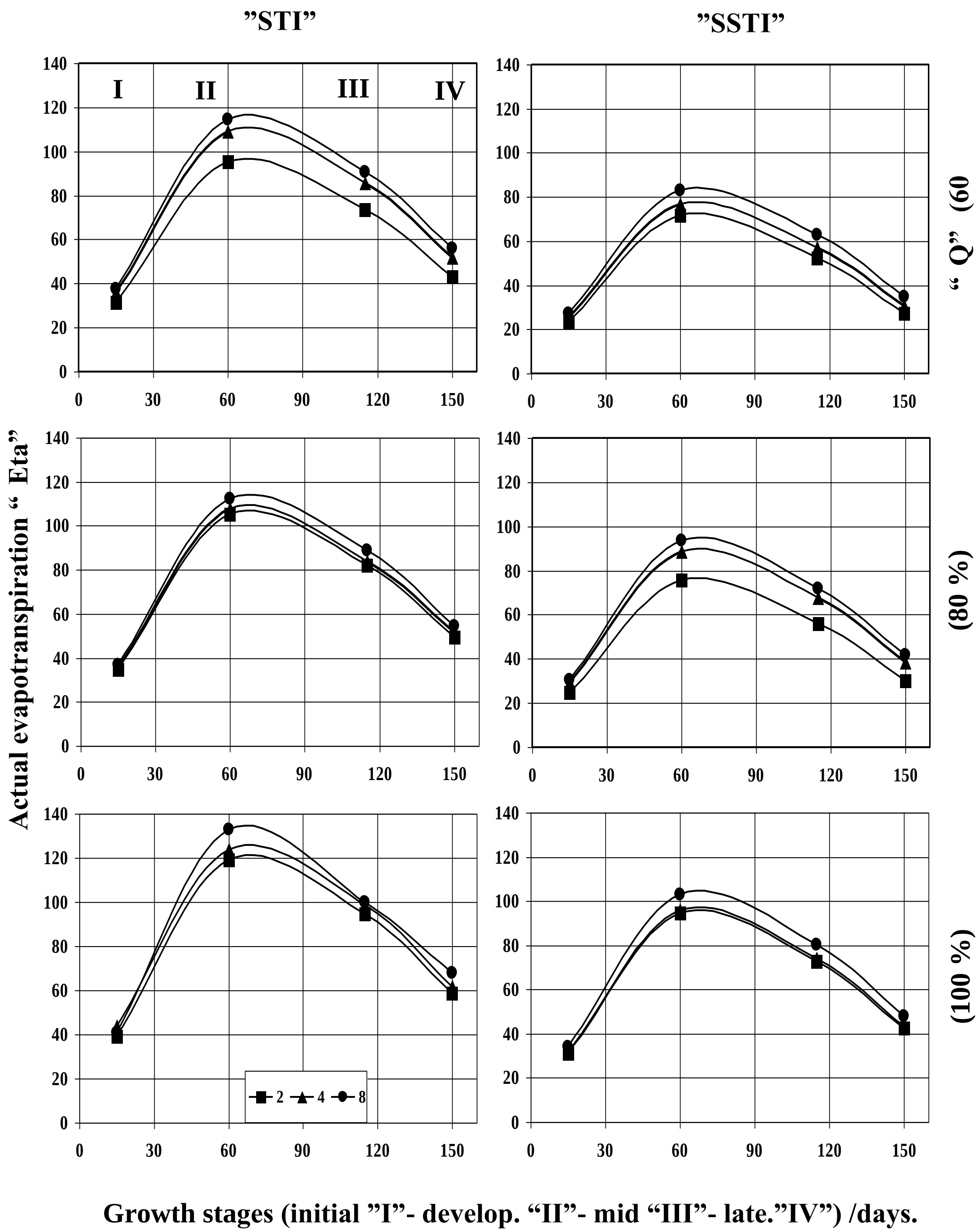

Fig.(3): Actual evapotranspiration "Eta" (mm) for all growth stages Vs. applied water quantities "Q" (%) at different emitter discharges "D" (L/h) and surface "STI" and sub-surface "SSTI" trickle irrigation systems for wheat variety of triticum aestivum "Ta".

CONCLUSIONS

Results could be summarized as follows:

1- The values of wheat yield Grain ”G”, straw ”S” and total yield ”Ty”) and growth parameters “LAI”, “W” (g) and “P” (%) significantly affected by changing emitter discharge differences 2 and 4 or 8 L/h. Meanwhile there were no significant difference between emitter discharges 4 and 8L/h for all conditions under study.

2- The maximum values of wheat yield (Grain ”G”, straw ”S” and total yield ”Ty”) were 1195 , 1059.3 and 2254.3 kg/fed. respectively, and growth parameters “LAI”, “W” (g) and “P” (%) were (85%, 61.6g and 15.4%) respectively at 100% applied water quantity and 8L/h emitter discharges for sub-surface trickle irrigation system. Meanwhile, the minimum values were (1017.8, 599.58 and 1617.4 kg/fed.)and (68.4%, 50g and 13.5%) respectively, under surface trickle irrigation.

3- The maximum values of actual evapotranspiration “Eta” for (Initial, development, mid-season , late-season) growth stages and seasonal total were 44, 133, 99.8 ,68 and 341.6 mm respectively, at 100% applied water quantity and 8L/h emitter discharges for surface trickle irrigation system. Meanwhile, the minimum values were 34, 103, 80.4, 48.1 and 265.3 mm under sub-surface trickle irrigation.

4- The maximum value of water use efficiency “WUE” (total yield ”Ty”) was
2.25 kg/m^3, at 80% applied water quantity and 8L/h emitter discharges for subsurface trickle irrigation system. Meanwhile, the minimum value was 1.05 kg/m^3 under surface trickle irrigation.

- So, it is recommended to cultivate wheat under sub-surface trickle irrigation system at 80% applied water quantity and 4L/h emitter discharges.

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الملخص العربى

*"أستخدام نظام الري بالتنقيط لري القمح في الأراضي الرملية"

محمد فايد عبد الفتاح خيري[1] *علاء الدين على محمد المسيرى[2]* على أحمد على عبد العزيز[3]

أجريت هذه الدراسة خلال الموسم ٢٠٠٦ – ٢٠٠٧م بمنطقة جنوب سيناء (رأس سدر) والتى تهدف الى تطبيق نظامى الرى بالتنقيط السطحى والتحت سطحى وتحديد ايهما أنسب فى انتاج محصول القمح فى الاراضى الصحراوية الملحية بأقل أستهلاك مائى وتحديد أنسب كمية مياة مضافة التى يجب تطبيقها وتحديد أنسب تصرف نقاط وحساب كفاءة الأستهلاك المائى للقمح تحت نظام الرى بالتنقيط تحت ظروف منطقة رأس سدر .

وكانت أهم النتائج المتحصل عليها هى:

١- وجد ان دليل مساحة سطح الورقة ووزن الحبوب للمحصول ونسبة البروتين بالحبوب سجلوا أعلى قيم (٨٥,٣٪ و٦١,٧ جم و١٥,٤٪) على الترتيب وذلك عند اضافة كمية المياه (١٠٠٪) عند التصرف ٨ لتر/ ساعة وذلك تحت نظام التنقيط التحت سطحى .

٢- حقق نظام الرى بالتنقيط التحت سطحى أعلى أنتاجية (٢٢٥٤,٣ كج/فدان) وذلك عند اضافة(١٠٠٪) من كمية المياه عند تصرف ٨ لتر/ ساعة .

٣- سجل محصول القمح أقل قيمه فى الأستهلاك المائى (٣,٢٦٥ و ٢٦٨,٣ مم /موسم) وذلك عند اضافة (١٠٠٪) من كمية المياه عند تصرف ٨ لتر/ ساعة وذلك تحت نظام التنقيط التحت السطحى .

٤- سجل محصول القمح أعلى كفاءة فى أستهلاك المياه (٢,٢٥ و ٢,١٤ كج/م^{3}) وذلك عند اضافة(٨٠٪) من كمية المياه عند تصرف ٨ لتر/ ساعة وذلك تحت نظام الرى بالتنقيط التحت سطحى

٥- وجد أن هناك زيادة معنوية فى قيم المحصول ومكوناته وكفاءة الأستهلاك المائى للمحصول نتيجة لتغيير تصرف النقاطات من ٢ و ٤ أو ٨ لتر/ ساعة بينما ليس هناك زيادة معنوية بين التصرفات ٤ , ٨ لتر/ ساعة لكل الظروف تحت الدراسة .

٦- ينصح بأستخدام كمية المياه الثانية ٨٠٪ لأن الزيادة فى المحصول عند أستخدام الكمية الثالثة ١٠٠٪ كان يقدر بحوالى (١٠٥ كج/ فدان) فقط ولكن أذا تم أستخدام كمية المياه ٨٠٪ وتوفير ٢٠٪ من الماء المضاف سيتم أستصلاح المزيد من الأراضى الصحراوية وعند حساب أذا ماستخدمت ٢٠٪ من الماء الموفر فى زراعة محصول القمح تحت نفس الظروف وجدت انها وصلت الى حوالى (٤٤٦ كج/ فدان) تحت النقاط ٤ لتر / ساعة أى أربع أضعاف المحصول تقريبا أذا ماقورن بالأضافة المباشرة ٢٠٪ عند أستخدام كمية المياه المضافة ١٠٠٪ وكان أنسب استهلاك مائى فعلى (٢٢٣,٦٢ مم/ موسم) لكلا الصنفين على الترتيب تحت كمية المياه ٨٠٪ والتصرف ٤ لتر/ ساعة ونظام الرى بالتنقيط التحت سطحى

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