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IMPACT OF DRIP IRRIGATION MANAGEMENT ON PEANUT CULTIVATED IN SANDY CALCAREOUS SOIL

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Abstract: Drip fertigation experiments were conducted for two seasons to determine the effect of four irrigation periods (0.25, 0.50, 0.75, and 1.0 h every 2 days intervals) which delivered four amount of irrigation water (980, 1960, 2940, and 3920 m^3 fed^{-1}) in combination with injection of three levels of nitrogen fertilizers (15, 30 and 60 Kg N/feddan) on peanut (Giza-6) yield, and water use efficiency, as well as moisture and salt distribution in the root zone of soil were studied.

Results indicated that the changes in soil moisture content in the root zone were correlated with the applied amounts of irrigation water. The soil under the dripper were leached from salt with increasing amount of irrigation water. Peanut yield was significantly increased with the increasing irrigation water level and N fertilizer in the two seasons. However, water use efficiency (WUE) and irrigation water use efficiency (IWUE) were decreased with increasing the applied irrigation water. In conclusion, applying N at the highest rate (60 kg/fed) with 2940 m^3 fed^{-1} irrigation water treatment, which is non-stress water treatment, produced the highest yield of peanut plants.

Key words: drip irrigation regimes, fertigation, peanut, water use efficiency, salt distribution, moisture distribution

Introduction

Agriculture expansion to desert is the major national agriculture strategy to increase food production in Egypt. Most of the newly reclaimed soils are sandy and calcareous. Crop production in desert soils is particularly sensitive to deficiencies of soil moisture and plant nutrients. Therefore, irrigation water optimization is a very important practice in crop management, which it could reduce irrigation water losses and maintain high yield (Hamdan, 2003; Tantawy et al., 2007). Under desert conditions, micro irrigation system afford many advantages to agriculture irrigation especially increasing yield and reducing water use due to improving water and nutrient management (Hamdan, 2003; Ahmed, 1998; Gameh, 2000). Drip irrigation is a very effective method capable of overcoming many limiting factors in the development of desert agriculture (Moynihan and Haman, 1992; Sivanappan, 1994; Gameh, 2000). Phene et al. (1993) revealed that the drip irrigation has been demonstrated to improve crop productivity, reduce energy costs, improve irrigation efficiency and reduce water loss by deep percolation.

By using the drip irrigation systems both irrigation and fertilization may be managed to increase the nutrients and water use efficiencies, reduce the nutrient leaching and increase the crop production (Rageb, 1997; Bhat et al., 2007).

Peanut is growing in many arid and semiarid regions during dry seasons and therefore it needs good irrigation management to produce economic yields (Plaut and Ben-Hur, 2005). Common irrigation methods practiced for peanut production in this region are surface irrigation. In general, the farmers usually over irrigate the crops, which cause high water losses and low irrigation efficiencies, and thus creating drainage and salinity problem. With the drip irrigation systems, water and nutrients can be applied directly to the crop at the root level, having positive effects on yield and water saving and increasing the irrigation performance (Phene and Howell, 1984; Sezen et al., 2006). Therefore, the objectives of this study were to measure the effect of different amounts of drip irrigation water and N fertigation on peanut yield grown in sandy calcareous soil, and to study the soil moisture and salinity changes in the root zone. Moreover, water-plant relationships were also studied.

Material and Methods

The study was conducted during the 2004 and 2005 summer growing seasons at El-Ghorieb Experimental Station, Faculty of Agriculture, Assiut University, Assiut, Egypt. The farm is located 18 km south of Assiut city. The soil of this farm was classified as sandy calcareous soil (Typic Torripsamments) and has recently been put under cultivation. Some physical and chemical characteristics of representative soil samples of the experimental site are shown in Table 1.

Table(1): Some soil physical and chemical properties

Property	Depth	
	0-25	25-50
Sand (%)	89.1	88.20
Silt (%)	7.8	8.10
Clay (%)	3.1	3.70
Texture	Sandy	Sandy
Max. WHC (%)	19.0	19.1
$CaCO_3$ (%)	14.4	15.3
pH	8.14	8.20
Organic matter,%	0.08	0.03

Total N (%)	0.03	0.01

The drip irrigation system was constructed to provide three different sub-main plots that separately controlled with respect to irrigation and fertilization. Each sub-main covered an area of 10 x 22 meter. The emitter lines were installed at 0.5 m a part . In-line emitters were spaced at 0.3 m apart and has a discharge of 0.002 m^3 h^{-1}. The trial was laid out in a split plot factor factorial design with fertilization treatment placed in the main plot and replicated five times. Irrigation treatments were designed so that 4 different amounts of irrigation water could be delivered into the sub-plot. The total amount of applied irrigation water per season were 980.0, 1960.0, 2940.0 and 3920.0 m^3 fed. for irrigation treatment W1, W2, W3 and W4, respectively. To deliver the amount of irrigation water needed for each irrigation, water was pumped for 0.25, 0.50, 0.75, and 1.0 h every 2 days. Soil moisture content was monitored with gravimetric soil samples taken frequently during the growth season. Soil samples were taken horizontally at 0.00, 0.10, and 0.25 m away from emitter and vertically directly under emitter at 0.10 m intervals to a depth of 0.50 m.

The nitrogen fertigation treatments were three rates: namely, 15, 30 and 60 Kg N /fed. It was applied as ammonium nitrate (33.0% N) by dissolved it in water and was injected directly into the irrigation water using venture-type chemigator (Mazzi injector corporation, Bakers field, California, USA). Each rate was splitted into 6 equal doses, which were applied at 2-week intervals, and started 3 weeks after planting. Recommended rates of basic fertilizer for sandy soil were added. Phosphorus as phosphoric acid and potassium as K_2SO_4 were injected into the water lines to give 31 Kg P_2O_5 and 48 Kg K_2O per feddan. The other agricultural practice were completed according to the usual methods being adopted for peanut crop.

Plant sampling and analysis

At maturity, the plants of whole lines were harvested and separated into shoots and pods. The weight of shoots and pods of each line were recorded. Samples of shoot were taken from each experimental unit for nitrogen determination. Total nitrogen in samples of shoots was determined according to Bremener and Mulvaney (1982). Contour line patterns for moisture and salt distribution were drown with the help of SURFER, a computer software.

Water consumption determination under drip irrigation regimes

a. Water depletion (actual evapotranspiration)

Water depletion (actual evapotranspiration) from each layer was obtained by equation described by Israelsen and Hansen (1962) as follow:

$$Cu = D \times BD \times (\theta 2 - \theta 1) \times 4200/100$$

Where: C.U = actual evapotranspiration (m^3/fed), D = the irrigation soil depth (m), BD = bulk density (g/cm^3), $\theta 1$ = the percentage of soil moisture before irrigation, and $\theta 2$ the percentage of soil moisture after irrigation.

b. Water consumption by Blaney-Criddle equation

Water consumption (ETo) m^3/fed was calculated using the empirical equation by Blaney-Criddle (1962) for grown crop as follow:

$$ETo = 1.8\ K\ P/100\ (t+18)$$

Where: ETo = reference evapotranspiration (m^3/fed), t = mean temperature in (^oC), P = percentage of the summated day length of the respected period relative to total day length through the year, K = Crop coefficient.

C. Pan evaporation

Water consumption (ETp, mm) from class-A pan of Assiut weather station were utilized.

Statistical analysis:

The collected data were statistically analyzed using the statistica computer program (Statsoft, 1995).

Results and Discussion

Changes in soil moisture content and salinity in the root zone of soil

The interpretation of soil water dynamics under drip irrigation system is relevant for crop production as well as on water use and management (Ragheb, 1997; Ahmed, 1998; Hamdan, 2003). Therefore, the moisture content of soil in experimental plots at different depth and distance from laterals were recorded and graphically illustrated on a surface contour bases. It was observed that the changes in soil moisture contents in the root zone (0.00-0.50 m) under dripper were related to the applied amounts of irrigation water during growth season (Table 2).

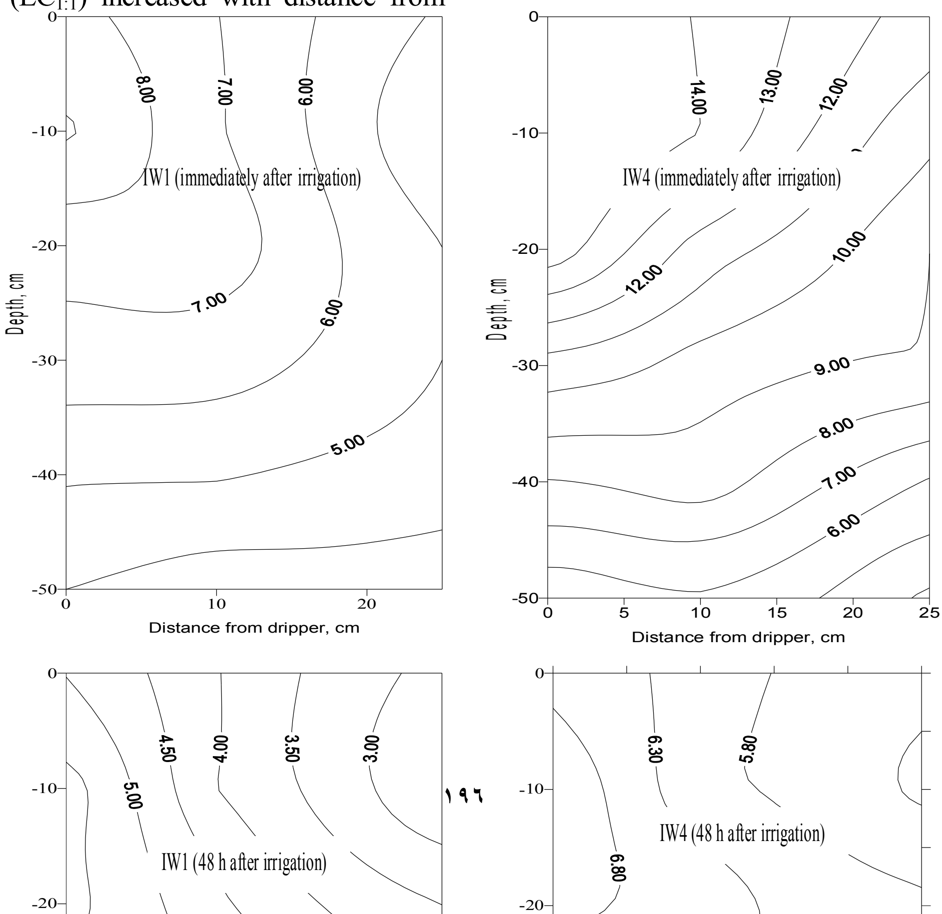
Table(2): Irrigation quantity and changes in soil moisture content at 0.00-0.50 m depth underneath the dripper lateral during different growth periods.

	Amount of irrigation water		Soil moisture content (%)					
Irrigation treatments	mm	m^3 fed^{-1}	Early season		Mid season		End season	
			After irr.	Before irr.	After irr.	Before irr.	After irr.	Before irr.
W1	233.3	980	10.0-4.4	7.5-3.8	9.1-4.0	5.7-3.7	12.0-4.8	9.3-4.4
W2	466.7	1960	13.3-4.7	9.4-3.9	11.7-4.2	6.2-3.9	14.5-4.8	11.0-4.6
W3	700.0	2940	15.0-4.9	10.2-4.1	13.0-4.4	6.6-4.1	16.9-4.9	12.0-4.7
W4	933.3	3920	17.3-5.2	12.0-4.4	14..9-4.9	7.5-4.3	19.0-5.6	13.6-5.0

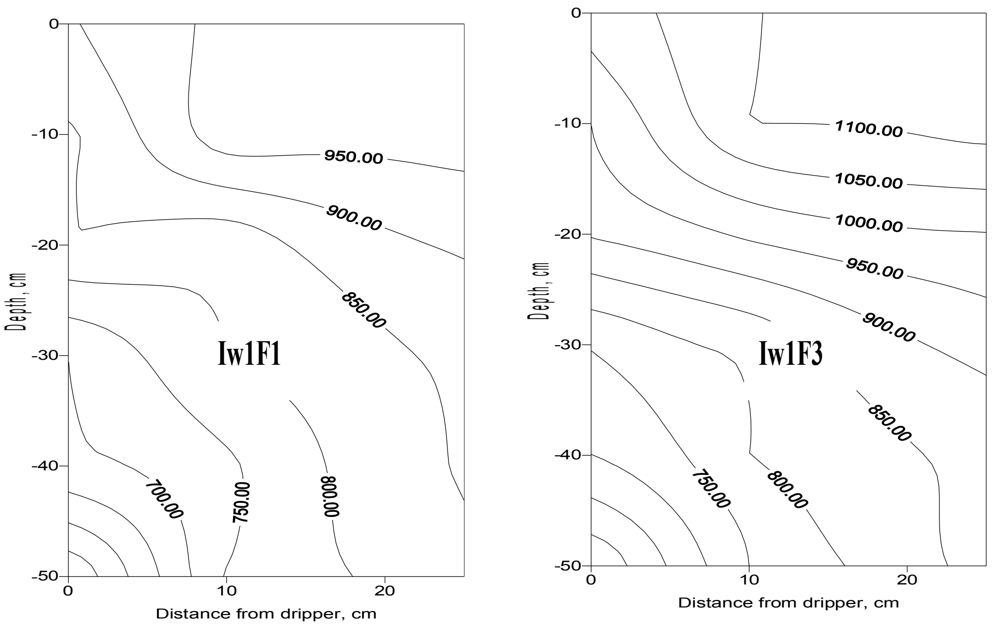
Soil moisture content varied clearly between irrigation treatments and periods of plant growth and it was related to the amount of applied irrigation water. The highest soil moisture content was found at soil surface under dripper. The variation of moisture content between irrigation treatments was the highest at surface layer (0.01 m depth). The variation between the treatments decreased in the lower layer. During growth season, the range of soil moisture content immediately after irrigation in the surface layer (0.00-0.10 m depth) were 9.3-12.0%, 11.7-14.5%, 13.0-16.9% and 14.9-19.0% for treatments W1, W2, W3 and W4, respectively. Before irrigation, the variation in the soil moisture content was 7.5-9.1, 6.2-11.0, 7.3-12.3%, 7.5-13.5% for irrigation treatments W1, W2, W3 and W4, respectively. Overall, the lowest values of soil moisture content were pronounced for mid-season, mainly due to the high temperature in this period.

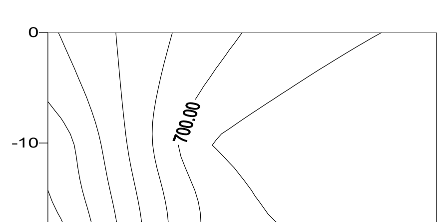
The distribution patterns of soil moisture content in the root zone of peanut plants after and before irrigation were measured during all periods of plant growth. For saving proposes, only at the mid-season patterns presented in Figure 1. The water distribution varied with the amount of applied water. With the lowest amount of irrigation water (W1), the contour lines were more circular under the dripper. While, with increasing amount of irrigation water, they tended to be homogeneous between laterals and dripper.

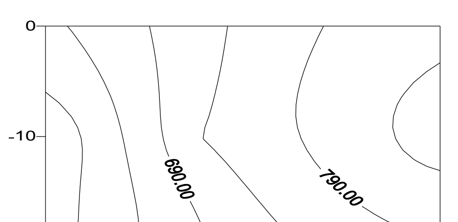
Processes of wetting and drying occur alternatively in the top soil layers. Salt concentration was found changes in such layers with drying and wetting. These dynamic changes are very important in the surface soil layer where the largest mass of the root exist. The importance of this process is even more evident under the tested drip irrigation where wetting takes place only in the confined volume. Results indicated that salt concentrations and distribution in root zone were related to the amounts of irrigation water (Figure 2). Soluble salt concentration ($EC_{1:1}$) increased with distance from dripper in all treatments. The highest EC values were pronounced for the lowest amount of irrigation water (W1) in the surface layer, especially when combined with the highest treatment of injected soluble N fertilizer (F3). While, with increasing the amount of irrigation water, the EC value decreased and no salt buildup was observed for all N fertilization treatments. Generally, the soil salinity increases with distance from trickle nozzle under drip irrigation for all treatments. Our results suggest that salts accumulated at the soil surface and increased from under the dripper toward the wetting front in drip irrigation, as pointed out by many authors (Shmueli and Goldberg, 1971; Ahmed, 1998; Hamdan, 2003).



Figure(1): Soil moisture distribution pattern at the mid-season for irrigation treatments: W1 and W4 immediately after irrigation and 48 h after irrigation.







Figure(2): Salinity distribution pattern ($EC_{1:1}$, μSm^{-1}) at the end-season for irrigation treatments: W1 and W4 combined with fertilization treatments F1 and F3.

Peanut yield and shoot N content

Peanut yield and content of N in shoot was significantly (p 0.01) affected by the irrigation and fertilization management and their interactions (Table 3). Increasing the amount of irrigation water and N fertilization caused significant increases in pods yield, shoot weight and subsequent total biomass, as well as an increase in shoot N content. Overall fertilization treatments, the average economic yield (pods yield) of the first and second seasons increased by 17.7%, 29.2% and 28.8% with increasing the amount of irrigation water from 980 to 1960, 2940 and 3920 m^3 Fed^{-1}, respectively. This result indicates that the highest amount of irrigation water (W4) give the same effects as the W3. This result suggests that irrigation level W3 is good enough to produce insignificant lower yield and save water. The increasing of soil moisture content with increasing the amount of irrigation water seems to create more suitable conditions for plant growth. Decreasing water stress due to increasing the quantity of irrigation water may enhance the photosynthetic activities and other physiological processes in plants leading to an increase in yield of plants. Moreover, the effect of soil moisture content on the availability of nutrient and activities of microorganisms in the root zone, being probably favorable for nutrient uptake by plant, in turn reflecting on the yield. In several studies, peanut production was reduced under water stress (Metochis, 1993; Vorasot et al., 2003). The results also showed that increasing the amount of N fertilizer significantly increased the yield of peanut. Overall irrigation treatments, the average pods yield of the first and second seasons increased by 9.9% and 16.3% with increasing the amount of N fertilizer from 15 kg N/fed to 30 and 60 kg N/fed, respectively. These increases in peanut yield with increasing the amount of N fertilizer demonstrates that peanut plants need N fertilizer to produce maximum yield. Lanier et al. (2005) reported that peanut pod yield appeared to increase with increasing rates of N fertilizer even though peanut was inoculated. In this sandy calcareous soil, the highest rate of N application at 6 doses permitted supplying the growing plant with enough N to produce maximum yield.

Interaction between irrigation and nitrogen fertilization significantly increased the yield of peanut plants. Applying N at the highest rate combined with W3 (2940 m^3/fed. irrigation water) maximized the yield of peanut plants.

Agronomy N use efficiency and water use efficiency

Agronomy nitrogen use efficiency (ANUE) was defined as the ratio between peanut pods yield and quantity of applied N (Bhat et al., 2007). The statistical analysis showed significant variation in agronomy N use efficiency (ANUE) due to irrigation and nitrogen fertilization (Table 4). The significant variation was due to differences in yields. With all irrigation treatments, the agronomic nitrogen use efficiency decreased with increasing the quantity of nitrogen application. When the quantity of nitrogen application increased from 15 to 60 kg N/fed, the average ANUE of the first and second season decreased from 85.16 to 24.75. In contrast, increasing the amount of irrigation water resulted in increasing the ANUE. The values of the average ANUE of the first and second season were 44.30, 51.47, 56.58 and 56.59 for W1, W2, W3 and W4, respectively. Our results indicated that nitrogen use efficiency related to water availability (Battilani et al., 2004).

Table(4): Main effect of treatments on agronomy N use efficiency (AUNE), irrigation use efficiency (IWUE) and water use efficiency (WUE).

Treatments	ANUE (kg/kg)			IWUE (kg/m^3)			WUE (kg/m^3)
	1st season	2nd season	Mean	1st season	2nd season	Mean	1st season
F1	85.65	84.67	85.16	0.64	0.65	0.65	0.76
F2	47.18	46.40	46.49	0.70	0.69	0.70	0.83
F3	25.48	24.03	24.75	0.77	0.72	0.75	0.90
LSD0.01	1.24	1.25		0.02	0.02		0.02
W1	43.85	44.76	44.30	1.19	1.19	1.19	1.22
W2	52.53	50.41	51.47	0.72	0.68	0.80	0.78
W3	57.25	55.92	56.58	0.52	0.51	0.52	0.71
W4	57.46	55.72	56.59	0.39	0.37	0.38	0.60
LSD 0.01	1.43	1.45		0.02	0.02		0.02

In arid and semi-arid regions where water is a limiting factor in the expansion of cultivated area, the primary objective of water management is the improvement of water use efficiency. It was hypothesized that drip irrigation method would improve the water use-efficiency of crops by minimizing the evaporative loss and delivering water directly to the root zone (Ahmed, 1998; Gameh et al., 2000). Irrigation water use efficiency (IWUE) was defined as the ratio between crop yield and total seasonal irrigation water applied. While, water use efficiency (WUE) defined as the ratio between crop yield and seasonal ET. Both irrigation and N levels caused a significant influence on irrigation water use efficiency (IWUE) and water use efficiency (WUE). Decreasing the amount of irrigation water and increasing the level of N resulted in increasing the IWUE and WUE. Similar results were obtained by many authors (Tayel et al., 1990, 1993; Ragheb, 1997) who found that water use efficiency of plants decreased with increasing the amount of irrigation under drip irrigation. This implies that decreasing the amount of water supply increased water economy under drip irrigation and resulted in more water saving achieved the maximum production of yield from the economical point.

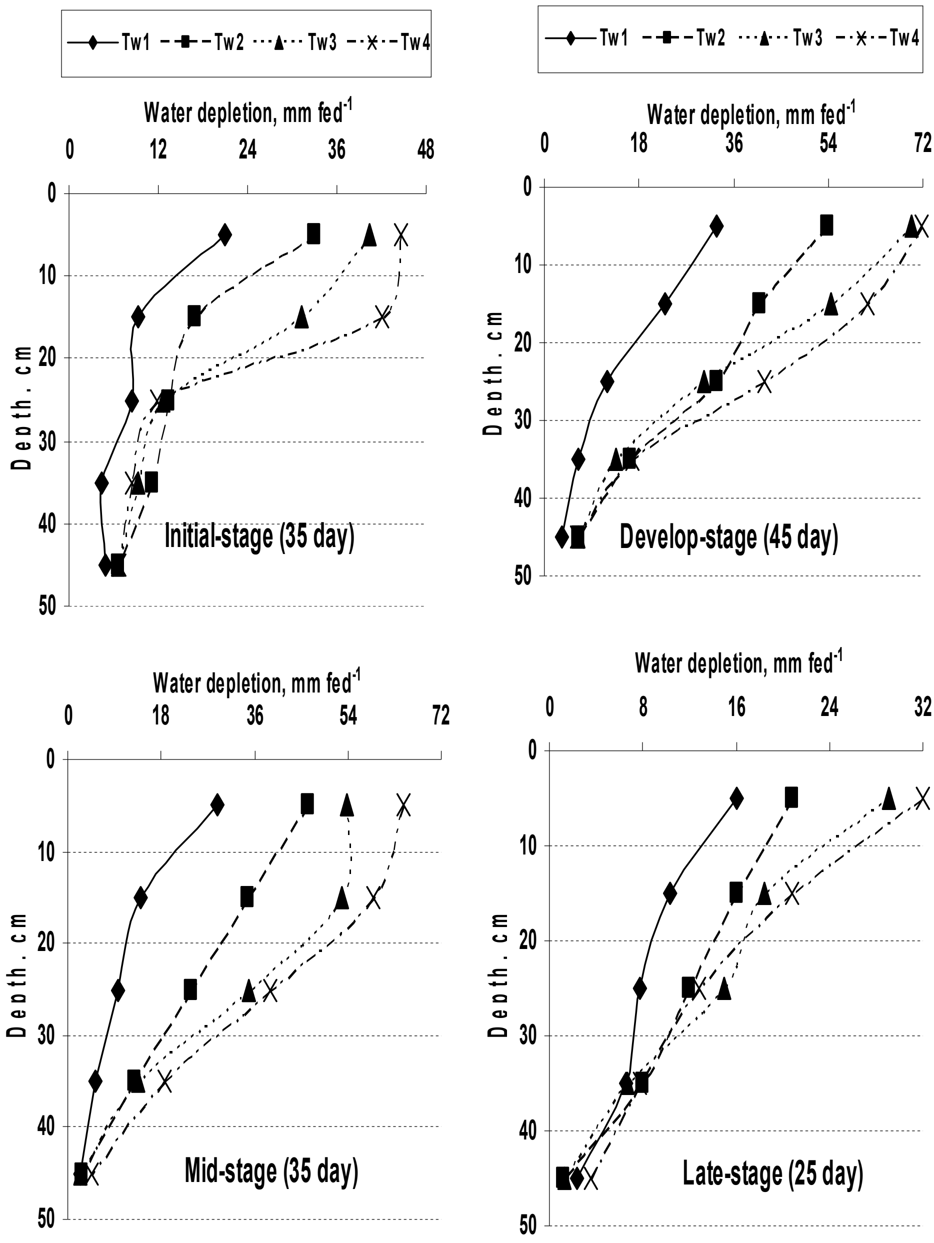
Water-plant relationships

Data in Table 5 show the different values of water consumptive use for peanut as calculated using Blaney-Criddle empirical equation, class A pan, actual applied and depleted water. The seasonal actual applied amounts of irrigation water were 980, 1960, 2940, and 3920 m^3 fed^{-1}. However, the seasonal measured depleted water were 960.83, 1718.92, 2113.10 and 2414.88 m^3 fed^{-1} for W1, W2, W3 and W4, respectively. The maximum water depletion values were found at the develop and mid-stages of plant growth (Figure 3). Generally, the highest water depletion was found at the surface soil (0.00 - 0.10 m depth) and then it tended to decline with depth for all irrigation treatments.

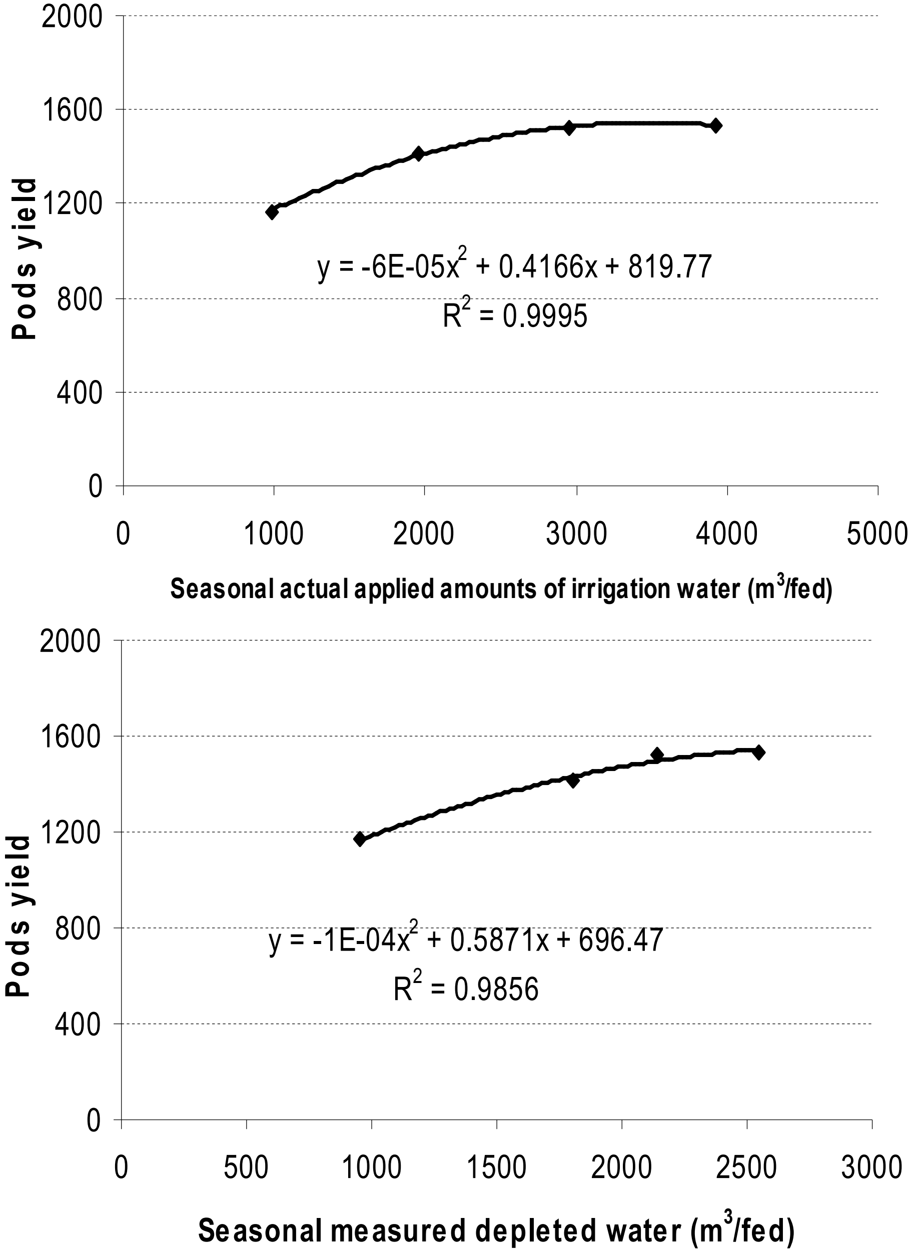
In order to clarify the effects of the applied irrigation water or the measured depleted (evapotranspiration) on yield, regression analysis was carried out. There was a significant second degree polynomial relationship between the applied irrigation water or measured depleted (evapotranspiration) on peanut pods yield (Figure 4).

Table(5): Water consumption calculated by different methods for peanut during the first season

Treatments	Water applied		Water Depletion	Blany-Cridle (Kc.pt)	Kc	Class-A pan (Etp)		Kc
	mm	m^3 fed^{-1}	M^3 fed^{-1}	m^3 fed^{-1}		Mm	m^3 fed^{-1}	
W1	233.3	980.0	960.83	2287.32	0.43	965.80	4056.36	0.24
W2	466.7	1960.0	1718.92		0.86			0.48
W3	700.0	2940.0	2113.10		1.28			0.72
W4	933.3	3920.0	2414.88		1.71			0.97



Figure(3): Water depletion (mm/fed) at the different depths of the root zone under dripper during growing season of peanut.



Figure(4): Relationship between seasonal actual applied water or measured depleted water and peanut pods yield (1st season).

Pan evaporation and some empirical equations such as Blany-Criddle have been used to schedule irrigation for several crops (Hamdan, 2003; Sezen, 2006). Our results indicated that the ETo of Blany-Criddle and class A-pan calculation was 2287.32 and 4056.36 m^3 fed^{-1}, respectively (Table 5). The ratio of applied amounts of irrigation water (W1, W2, W3, and W4) to the calculated values using Blany-Criddle ETo were 0.43, 0.86, 1.28 and 1.71, respectively. However, the ratio of applied amounts of irrigation water (W1, W2, W3, and W4) to the class A-pan ET was 0.24, 0.48, 0.72 and 0.97, respectively. Since the W3 and W4 produced the highest yield without significant difference, therefore, using irrigation amount of 2940 m^3 fed^{-1} (W3) may be recommended to produce KC of 1.28 using Blany-Criddle equation and 0.72 with class-A pan values.

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تأثير إدارة الري بالتنقيط علي الفول السوداني في الأراضي الرملية الجيرية

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أجريت دراسة لمدة موسمين بهدف دراسة تأثير أربعة فترات ري بالتنقيط (٠,٢٥ ، ٠,٥٠ ، ٠,٧٥ ، ١ ساعة) بحيث يتم تشغيل النظام كل يومين وبذلك يتم الري بكميات تقدر ب ٩٨٠ ، ١٩٦٠ ، ٢٩٤٠ ، ٣٩٢٠ متر مكعب للفدان مع ثلاثة مستويات للتسميد النيتروجيني مضافة مع ماء الري (١٥ ، ٣٠ ، ٦٠ كجم نيتروجين للفدان) علي محصول الفول السوداني (جيزة ٦) وكذلك علي كفاءة استعمال المياه وأيضا علي توزيع الأملاح والرطوبة في منطقة انتشار الجذور.

وأظهرت النتائج أن الاختلافات في المحتوي الرطوبي في منطقة انتشار الجذور ترجع الي كمية المياه المضافة وبزيادة كمية مياه الري المضافة يزداد غسيل الأرض من الأملاح تحت النقاطات ويزداد محصول الفول السوداني زيادة معنوية بزيادة مستويات المياه المضافة وزيادة التسميد النيتروجيني .

وأظهرت النتائج أيضا كل من كفاءة استعمال المياه (WUE) وكفاءة استعمال مياه الري (IWUE) تقل بزيادة كمية المياه المضافة وتزداد بزيادة التسميد النيتروجيني.

وقد أظهرت نتائج هذه الدراسة أن إضافة التسميد النيتروجيني بمعدل عالي (٦٠ كجم نيتروجين للفدان) مع الري بمعدل ٢٩٤٠ متر مكعب للفدان كانت أنسب معاملة للحصول علي أعلي محصول للفول السوداني.