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PEANUT CROP RESPONSE TO NON-UNIFORMITY OF IRRIGATION APPLICATION UNDER SPRINKLER SYSTEM PERFORMANCE

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ABSTRACT

*Experimental study was conducted for peanut (*Arachis hypogaea *L.) in sandy soil, which has 1.57 g/cm^3 average bulk density in 1.2 m soil depth and 25.2 cm/h saturated hydraulic conductivity, located at an arid site in northern Egypt (Moderiat El Tahreer, Behara Governorate, Egypt) for one season started on 19 July 2008 and ended on 30 October 2008. A Complete Randomized Block Design was experimentally accomplished for three sprinkler irrigation layouts as square, rectangular, and triangular, three overlapping percentages as 100, 80, and 60%, and three irrigation levels as 0.6, 0.8, and 1.0 from crop evapotranspiration (ET). A mean of application rate in mm/h was recorded for individual sprinkler and increased by increasing water pressure due to increasing discharge. It was decreased by increasing sprinkler pattern diameter. On the contrary, discharge was unaffected by trajectory angle. But, mean of application rate was increased by decreasing trajectory angle due to decreasing of sprinkler pattern diameter. 1.0ET irrigation treatment achieved 3.908, 3.703, and 3.308 Mg/ha maximum peanut yields in square layout, 4.145, 3.869, and 3.559 Mg/ha in triangular layout, and 3.970, 3.788, and 3.485 Mg/ha in rectangular layout for 100, 80, and 60% water overlapping percentage, respectively. Peanut yield-water function was a linear relationship within sprinkler treatment. Peanut yield was significantly affected by both irrigation amount and non-uniformity caused by sprinkler layouts and water overlapping.*

Keywords: Peanut, Sprinkler irrigation, Crop response, Sprinkler layout and overlapping.

INTRODUCTION

Agricultural expansion and land reclamation in Egypt faces with shortage in water resources. Moreover, water is poorly utilized. Hence, agricultural expansion must depend on the improvement of water-use. The amounts of irrigation water applied to the field are

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determined by how irrigation systems and scheduling are managed. Usually, greater amounts are applied with surface irrigation than with sprinkler or microirrigation systems. The quantity of consumed water in irrigated agriculture or the depletion of water resources within a hydrologic basin is affected by the type of irrigation and the crop. The irrigation system delivers and distributes the water; but, the produced crops consume the amount of needed water. Changing or improving irrigation systems; however, frequently reduces irrigation costs. As water costs increase, growers invest in better irrigation systems that enable more uniform water application and improve management of the amount applied each irrigation. They continue to irrigate when increased return from higher crop yields and improved crop quality exceed the irrigation cost. Therefore, irrigation represents a major cost in crop production wherever it is practiced

In general, irrigation in reclaimed lands depends on modern methods due to several advantages, most important of which are: high water-use efficiency, saving labor requirement, maximizing crop return and economic benefits ...etc. The current irrigation methods are furrow, sprinkler, and trickle. Moreover, every method embraces several practices. However, until recently, there are no definite criteria for the selection of the appropriate system for a certain situation. The following qualifiers enter into system choice which is increasing water-use efficiency, application efficiency, uniformity coefficient, maximizing crop yield and its return by optimizing water applied, and minimizing deep seepage to save water and avoid ground water contamination.

Sprinkler irrigation is one of the most pressurized irrigation method used in sandy soil of Egypt, especially for high value crop. It offers efficiently a high irrigation water of control to meet crop water requirement. Sprinkler water distribution pattern depends on many factors such as sprinkler type, nozzle number and size, operating pressure, and nozzle modifications (e.g. jet-straightening vane, flow control, slot shape, etc.) (Tarjuelo et al., 1999). In field conditions, it also depends on the temperature, humidity, and wind speed and direction (Lorite et al., 2004; Brennan, 2008). Seginer et al. (1991) studied the distribution patterns of a single sprinkler under field conditions. Field water distribution patterns differed in at least three aspects from patterns produced in still and humid air under the same operating pressure: (1) water loss due to wind drift of small droplets; (2) water loss due to spray evaporation; and (3) pattern distortion by wind.

Irrigation water by sprinkler system should be efficiently distributed in root zone in order to obtain similarity in plant growth and water saving. The uniformity distribution pattern is a measure of how unevenly the sprinkler system applies water over the irrigated area. Many factors that cause non-uniformity are regarded to sprinkler performance and hydraulic variation along lateral. Sprinkler hydraulic performance, which is a study of water pattern under a sprinkler layout, are mainly functions of the sprinkler physical features, nozzle configuration, operating pressure, sprinkler spacing, and environmental conditions. Pressure variation is hydraulically caused primarily by friction in submain lines and laterals and by elevation differences in the system. A high degree of sprinkler irrigation system uniformity can be achieved by selecting optimal operating pressure, sprinkler capacity, height, trajectory angle, and layout as well as overlapped pattern. It can also be achieved for the whole system by lessening the pressure loss along laterals which are perpendicular to the submain pipe in portable and solid systems and may be laid on either one or both sides of the submain. The maximum pressure difference between two sprinklers of the irrigation subunit is allowed to be 20% of average pressure. The whole uniformity for an irrigation system can be expressed as a function of coefficient of variation (CV) as defined by Wu and Barragan (2000) and Amer (2005).

Awady et al. (2003) working on pup-up sprinklers used in turf grass studied water distribution uniformity in individual and grouping tests. Water was collected using catch cans for individual sprinkler heads of different types in x-y and radial directions. Results taken in x-y direction were fitted against those from radial. They also correlated between distribution uniformity determined from data in x-y direction against from the collected data along laterals in triangular sprinkler heads layout. A high correlation among results was found. They also found that grass growth was affected by non-uniformity of irrigation application by sprinkler system.

Amer et al. (2009) studied cucumber (*Cucumis sativus* L.) production response to irrigation amount using trickle irrigation. They found that trickle irrigation with a 60% irrigation treatment had a lower yield response compared with 100% and 80% irrigation in both 2006 and 2007 growing seasons. Total irrigation amount for 100% water applied during 2006 and 2007 growing was 498 and 471 mm, respectively. Cucumber yield significantly responded with irrigation amount compared to adequate irrigation treatments. In 2006 and 2007 growing seasons, average yield for 100% irrigation was 30.26 Mg/ha while 60% irrigation averaged as 23.34 Mg/ha under adequate mineral fertilizer treatments, almost a 13.72% increase in yield attributed to the water applied.

Amer (2010) working on corn (Zea Mays) irrigated by furrow found that maximum production yield (Y_m) of 9.12 Mg/ha was achieved for 325 mm of optimum water use (W_m). A yield reduction ($1-Y/Y_m$) was linearly decreased in a rate of 1.15 by increasing water deficit fraction ($1-W/W_m$) in complete deficit irrigation in range of 0.6ET to 1.0ET. He found that the crop yield in non-uniformity condition is decreased in deficit areas by decreasing application water amount under irrigation system. The relative yield in the deficit area (A_D) can be expressed as follows:

$$\frac{Y}{Y_m} = \left(1 - k_y\left(1 - \frac{W}{W_m}\right)\right)\ A_D - - - - - (1)$$

where Y and W are yield and its irrigation water application under deficit area fraction (A_D), Y_m and W_m represent maximum yield and its corresponding adequate irrigation application;; and k_y is a crop reduction coefficient.

The purpose of this work is to study peanut crop response to non-uniformity of different irrigation water applications created by different sprinkler layouts and overlapping percentages in sand soils.

MATERIALS AND METHODS

An experimental work was conducted for peanut (*Arachis hypogaea* L.) in sand soil located at an arid site in northern Egypt (Moderiat El Tahreer, Behara Governorate) in one season started on 19 July 2008 and ended on 30 October 2008. A randomized block design with sprinkler irrigation layout treatments as square, rectangular, and triangular, overlapping percentage treatments as 100, 80, and 60%, and irrigation level treatments as 0.6ET, 0.8ET, and 1.0ET, where ET was crop evapotranspiration. All treatments were randomized in two replicates.

Physical and mechanical analysis of the soil was determined according to Black (1982). Irrigation water as affect the soil chemical and physical properties was analyzed as shown in Table (1). The soil samples were taken until depth 1.2 m to determine the physical and mechanical soil properties such as aggregation, bulk density, and chemical analysis (Table 2).

Table 1. Chemical analysis of irrigation water for the experimental site.

pH	EC dS/m	Soluble ions meq./L							
		Cations				Anions			
		Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{-2}
8.2	0.85	1.31	1.95	3.10	0.14	0.00	2.10	3.90	0.50

Table 2. Soil chemical properties for the experimental site.

Depth cm	pH	EC dS/m	Soluble ions meq/100g Soil							
			Cations				Anions			
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{-2}
0–20	8.0	0.11	0.17	0.12	0.3	0.1	0.0	0.3	0.2	0.19
20–40	8.1	0.15	0.15	0.13	0.38	0.1	0.0	0.3	0.25	0.21
40–60	8.2	0.2	0.2	0.15	0.46	0.12	0.0	0.5	0.2	0.23
60 – 80	8.3	0.15	0.12	0.15	0.48	0.1	0.0	0.5	0.2	0.15
80 -100	8.3	0.17	0.14	0.17	0.4	0.13	0.0	0.45	0.25	0.14
100-120	8.4	0.17	0.16	0.16	0.43	0.15	0.0	0.45	0.3	0.15

Soil in the study area classified a sand soil with 1.57 g/cm^3 average bulk density in 1.2 m soil depth. Soil particle sizes were averaged for 1.2 m of soil profile and distributed as 30.2% coarse sand, 60.5% fine sand, 3.8% silt, and 5.5% clay. Table (2) shows the soil chemical analyses. The volumetric water content values were 24.4, 10.1, and 4.4% at saturated, field capacity, and wilting points, respectively. Infiltration rate (I in cm/h) was found in the experimental field using double-ring infiltrometer. It was functioned to opportunity time t_o in minute for the sand soil as $I = 73.14\ t_o^{-0.212}$ with $r^2 = 0.948$. The minimum value of 25.2 cm/h infiltration rate was found and considered as saturated hydraulic conductivity. Cumulative infiltrated depth Z in cm was integrated from infiltration rate function and reported as Z = 1.548 $t_o^{0.788}$ where Z in cm and t_o in min.

A relationship was described between sprinkler discharge and pressure for an orifice nozzle by Li and Kawano (1998) as follows:

$$q = c A \sqrt{2 g H} \quad -----(2)$$

where q is nozzle discharge rate in m^3/s, A is orifice cross-sectional area in m^2, g is gravitational acceleration in m/s^2, H is sprinkler pressure head in m, and c is discharge coefficient.

Sprinkler layouts were designed in square, rectangular, and triangular layouts. Application rate was determined by the following equation as:

$$A_p = \frac{1000\ q}{A} \quad -------- (3)$$

where A_p is theoretical application rate in mm/h, q sprinkler discharge in m^3/h, and A is served area in m^2. But actual irrigation application rate (I_p) was determined based on average of collected water depths in layout area in catch cans per unit time as follows:

$$I_p = \bar{X} / t \quad ------- (4)$$

where I_p is irrigation application rate (mm/h), $\bar{X}$ is collected irrigation depth using catch cans during operating sprinklers (mm), and t is collected time in h. collected time was 1 h for each set.

Irrigation requirement by sprinkler irrigation was added per irrigation based on meteorological information which was collected from weather station nearby the experiment and peanut vegetative growing stages. Irrigation water scheduled based on determining potential evapotranspiration using FAO Penman-monteith equation modified by Allen et al. (1998). Therefore, the water applied by sprinkler irrigation was determined based on the following equation:

$$IR = k_c\, ET_o \quad ------- (5)$$

where IR is irrigation requirement in mm/day, ET_o is reference evapotranspiration in mm/day, and k_c is peanut crop coefficient in unit.

Depending on climate factors, the water requirements range from 400 to 500 mm for the total growing period of peanut. As related to development stage, the peanut crop coefficient, k_c, value according to Dooronbos and Kassam (1979) for the initial stage was 0.45 for 20 days, the development stage 0.75 for 30 days, the mid-season stage 1.05 for 30 days, the late-season stage 0.75 for 20 days, and at harvest 0.6 for 9 days.

Irrigation uniformity coefficient (UC) for sprinkler was defined as:

$$UC = 1 - 0.798\ CV \quad ------ \quad (6)$$

Distribution uniformity (DU) was determined as follows:

$$DU = 1 - 1.27\ CV \quad ------ \quad (7)$$

where CV is a coefficient of variation.

Analysis variance (ANOVA) was performed on the treatments. The level of the significant difference (Duncan at $p < 0.05$) was used in the ANOVA to test the effect of irrigation treatments on different response variables (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

FAO reference evapotranspiration (ET_o) for peanut season 2008 in Moderate El Tahrer area, Egypt was determined. The periods selected based on the time for field experiments. Figure 1 showed daily ET_o and a four-day moving average ET_o. Moving average is a way to express the trend of average ET_o for a giving duration corresponding to irrigation intervals. The trend showed that the average daily ET_o ranges from 4 to 6 mm of water per day during summer season.

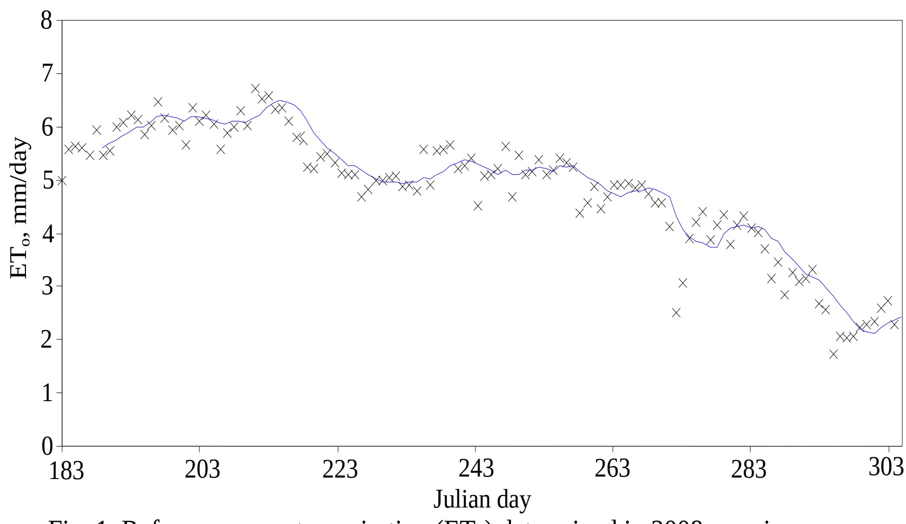

Fig. 1. Reference evapotranspiration (ET_o) determined in 2008 growing season.

The average daily reference ET for almost four months of peanut season was 4.33 mm/day of water for period 120 days. Reference ET increased to 6 mm/day in July days when most of weather elements increased.

Sprinkler discharge with 3.2 mm single nozzle (q in m^3/h) was measured within the pressure range of 100 to 350 kPa and represented as pressure head (H in m) and both formulated in a power relationship as: $q = 0.128\sqrt{H}$. Measured parameters for sprinklers in pattern radius tests are shown in Table 2. Discharge in m^3/h and diameter of throw in meters were measured at 100, 200, 300, and 350 kPa operating pressure. Coefficient of discharge was found as 0.968. Sprinkler discharge was increased by increasing pressure. A mean of application rate, A_p in mm/h, was recorded for individual sprinkler and increased by increasing water pressure due to increasing discharge and decreased by increasing sprinkler pattern diameter. On the contrary, discharge was unchanged by trajectory angle (changed reflector sets from 0 to 5). But mean of application rate was increased by decreasing trajectory angle and sprinkler pattern diameter.

21^o trajectory angle under 200 kPa of optimum operating pressure was selected due to having a high degree of uniformity under different overlapping percentages according to Hegazi et al. (2007). The effective diameter of throw was chosen to create different spacing between sprinklers and overlapped percentages as shown in Table 3 for square, triangular, and rectangular layouts. Area served by four sprinklers under 200 kPa operating pressure was related only to wetted diameter. Wetted diameter was constant for 21^o trajectory angle and achieved 20 m under 200 kPa operating pressure. As discharge of each sprinkler was not changed under 200 kPa, application rate (Ap in mm/h) was only decreased by increasing the served area and vice versa. Application rate (mm/h) could be used for purpose of schedule and management of sprinkler system with the tested head. For 21^o trajectory angle in square layout (Table 3), 100% overlapped percentage achieved low coefficients of variation (CV) and high uniformity coefficients (UC) compared to other percentages of 80 and 60% overlapped layout. In square and rectangular layouts, a minimum coefficient of variation occurred as 18.1% for 100% overlapped percentage (100 m^2 served area). In

Table 2. Configuration of sprinkler with 3.2 mm of single nozzle for different deflector sets.

Pressure (kPa)	Sprinkler parameters	Trajectory angles					
		30^o	26^o	21^o	15^o	9^o	6^o
100	Discharge (m^3/h)	0.41	0.41	0.41	0.41	0.41	0.41
	Diameter (m)	24	20	18	16	14	14
	Application rate, A_p (mm/h)	0.907	1.306	1.08	2.04	2.67	2.67
200	Discharge (m^3/h)	0.57	0.57	0.57	0.57	0.57	0.57
	Diameter (m)	26	22	20	18	16	15
	A_p (mm/h)	1.07	1.5	1.26	2.24	2.84	3.7
300	Discharge (m^3/h)	0.7	0.7	0.7	0.7	0.7	0.7
	Diameter (m)	28	24	22	18	16	16
	A_p (mm/h)	1.14	1.55	1.55	2.75	3.48	3.48
350	Discharge (m^3/h)	0.76	0.76	0.76	0.76	0.76	0.76
	Diameter (m)	30	24	22	18	18	16
	A_p (mm/h)	1.08	1.68	1.24	2.99	2.99	3.78

Table 3. Sprinklers performance under 200 kPa inlet pressure, 21^o trajectory angle, spaced as 50% from throw diameter, and under 0.895 m/s average wind speed.

Layout	Evaluating parameters	Overlapping percentages (%)		
		100	80	60
Square	Dimension (m)	10 ×10	12 ×12	14 ×14
	Served area (m^2)	100	144	196
	Application rate, I_p (mm/h)	5.7	3.958	2.908
	Coefficient of variation (%)	18.1	22.8	31.8
	Uniformity coefficient (%)	85.5562	81.81	74.62
	Distribution uniformity (%)	77.013	71.04	59.61
Triangle	Dimension (m)	10 × 10	12 ×12	14 × 14
	Served area (m^2)	86.6	124.70	169.74
	Application rate (mm/h)	6.582	4.571	3.36
	Coefficient of variation (%)	11.9	18.3	24.1
	Uniformity coefficient (%)	90.54	85.397	80.77
	Distribution uniformity (%)	84.89	76.76	69.39
Rectangular	Dimension (m)	10 × 10	10 × 12	10 × 14
	Served area (m^2)	100	120	140
	Application rate (mm/h)	5.7	4.75	4.071
	Coefficient of variation (%)	18.1	21.1	23.9
	Uniformity coefficient (%)	85.56	83.16	80.93
	Distribution uniformity (%)	77.01	73.20	69.65

triangular layout, the overlap of 100% achieved low coefficient of variation (11.9%) and high uniformity.

Significant differences among sprinkler evaluation parameters were occurred with either changing sprinkler layout or increasing water overlapping (Tables 4 and 5). F-value in Table 4 showed significant differences of application rate (I_p in mm/h) among treatments in sprinklers layout or water overlapping with interaction among them. The highest values of application rate were achieved when 100% overlapping percentage was applied within layout treatment. More water overlapping (100%) increased significantly application rate as it decreases served area per sprinkler that water accumulates in small area. The lowest values were obtained when less water overlapping (60%) applied. Increasing application rate per served area could help to decrease irrigation time but increase irrigation system installation cost. F-value in Table 5 showed significant differences of coefficient of variation (CV in %) as well as uniformity coefficient (UC in %) and distribution uniformity (DU in %) among treatments in sprinklers layout or water overlapping with no interaction among them. For a given layout, CV significantly decreased but UC and DU increased when application rate increased. The lowest values of CV and the highest values of UC and DU were obtained when 100% overlapping percentage supplemented with triangular layout were applied (Table 4). Decreasing water overlapping meant an increase in served area per sprinkler and this appeared logical as the far area could not have adequate water. A significant difference occurred between either layout treatments (LY) or overlapping treatments (OV).

Table 4. Means and standard deviations of A_p, CV, UC, and DU.

Treatments	Mean ± SE			
	I_p	CV	UC	DU
Layout	mm/h	%	%	%
Square	4.2±0.084 $^{A\,\dagger}$	24.23±0.89 ^{A}	80.67±0.71 ^{A}	69.22±1.13 ^{A}
Triangle	4.83±0.084 ^{B}	18.1±0.89 ^{B}	85.56±0. 71 ^{B}	77.01±1.13 ^{B}
Rectangular	4.84±0.084 ^{B}	21.03±0.89 ^{C}	83.22±0. 71 ^{C}	73.29±1.13 ^{C}
Overlapping, %				
100	5.99±0.08 ^{A}	16.03±0.831 ^{A}	87.21±0.79 ^{A}	79.64±1.17 ^{A}
80	4.43±0.08 ^{B}	20.73±0.831 ^{B}	83.45±0.79 ^{B}	73.67±1.17 ^{B}
60	3.45±0.08 ^{C}	26.60±0.831 ^{C}	78.77±0.79 ^{C}	66.22±1.17 ^{C}

†Treatment means with the same letter are not significant at the $p \leq 0.05$ level.

Table 5. Mean Square, F value and probability for of I_p, CV, UC, and DU. †

Items	Mean Square				F value and Probability			
	I_p	CV	UC	DU	I_p	CV	UC	DU
Layout (LY)	0.84	56.46	35.96	91.07	20.09*	11.86*	11.86*	11.86*
Overlapping (OV)	9.91	168.2	107.1	271.2	235.7*	35.32*	35.32*	35.32*
LY* OV	0.35	10.04	6.39	16.19	8.40 *	2.1 ns	2.1 ns	2.1 ns
Exp. error	0.04	4.76	3.03	7.68				

* Significant at the $p \leq 0.05$
†ns = non-significant.

Peanut yield was affected by water overlapping within its irrigation regime by sprinkler layouts (Figs. 2, 3 and 4). Maximum peanut yields (Y_m) were averaged across season under adequate irrigation (1.0ET) as 3.908, 3.703, and 3.308 Mg/ha for 100, 80, and 60% overlapping percentage in square layout, respectively. They were averaged as 4.145, 3.869, and 3.559 Mg/ha in triangular layout, respectively. Maximum yields were 3.970, 3.788, and 3.485 Mg/ha in rectangular layout, respectively. A non-significant difference was found between peanut yield obtained under 1.0ET treatment within both sprinkler layout and water overlapping treatments. Peanut yield significantly decreased in linear relationship as water deficit increased under sprinkler system (Tables 6, 7 and 8). The bars in Figs. 2, 3, and 4 and the standard deviations in Table 6 clarify the error range using 5% percentage level. The highest yields were achieved with the 1.0ET treatment. F-values in Table 7 showed a significant effect of sprinkler layout and water overlapping treatments on peanut yield with yields increased highly with increasing water applied within irrigation system treatment. Yield was significant among all treatments with no interactions among them. The highest yields were achieved using 1.0ET compared to the other water deficit treatments. The minimum value of yield was achieved when less water and overlapping were applied. Results showed that layout, water overlapping, and irrigation deficit effects on peanut yield were significantly occurred (Table 7). The interaction did not actually exist among all treatments.

Peanut yield-water function was a linear relationship within sprinkler treatment. Crop yield (Mg/ha) increased by increasing irrigation water applied in range of 321 to 502 mm in 2008 summer season. The peanut production function is shown in Table 8. Yield reduction coefficient (k_y) derived from Eq. 1 for deficit irrigation within the water overlapping treatments is provided in Table 8. Crop response to water was changed according to amount of water applied; however, the yield response to water overlapping showed inconsistencies due to varying water distributed in served areas. The mean reduction coefficient was 0.881 with deficit irrigation.

Table 6. Means and standard deviations of peanut yield.

Treatments	Parameters	Mean ± SE
Layout	Square	2.979±0.0562 $^{A\ \dagger}$
	Triangle	3.2097±0.0562 ^{B}
	Rectangular	3.08395±0.0562 ^{AB}
Overlapping, %	100	3.36875±0.0562 ^{A}
	80	3.10944±0.0562 ^{B}
	60	2.79538±0.0562 ^{C}
ET	1.0ET	3.74846±0.0652.^{A}
	0.8ET	3.09665±0.0562 ^{B}
	0.6ET	2.42847±0.0562 ^{C}

†Treatment means with the same letter are not significant at the $p \leq 0.05$ level.

Table 7. Mean Square, F value and probability for peanut yield.

Items	Sum of Squares	df	Mean Square	F value and Probability
Layout	0.47675	2	0.23837	4.1949 *
Overlapping	2.9678	2	1.4839	26.1137 *
ET	15.682	2	7.841	137.9863 *
LY * OV	0.06583	4	0.01646 ns	0.2896 ns
LY * ET	0.00712	4	0.00178	0.0313 ns
OV * ET	0.01752	4	0.00438	0.077094 ns
LY * OV* ET	0.01688	8	0.00211	0.037127 ns
Exp. error	1.534262	27	0.056825	

* Significant at the $p \leq 0.05$

†ns = non-significant.

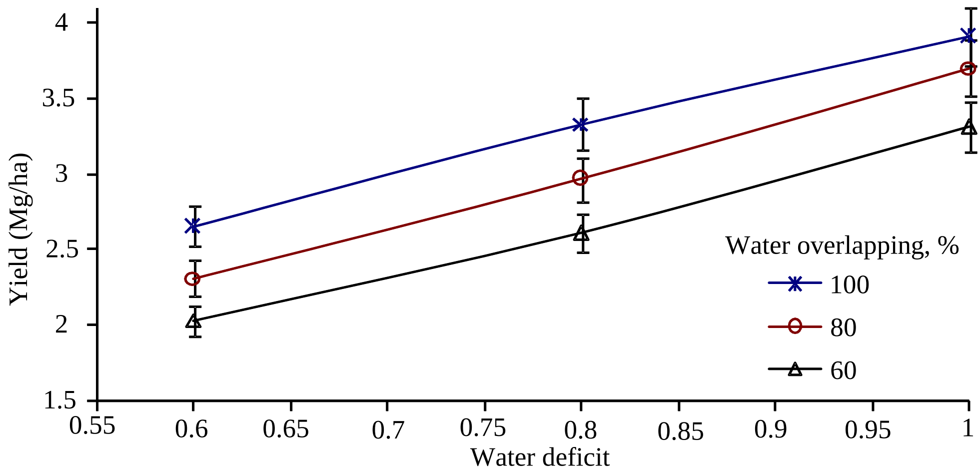

Fig. 1. Peanut yield under sprinkler square layout.

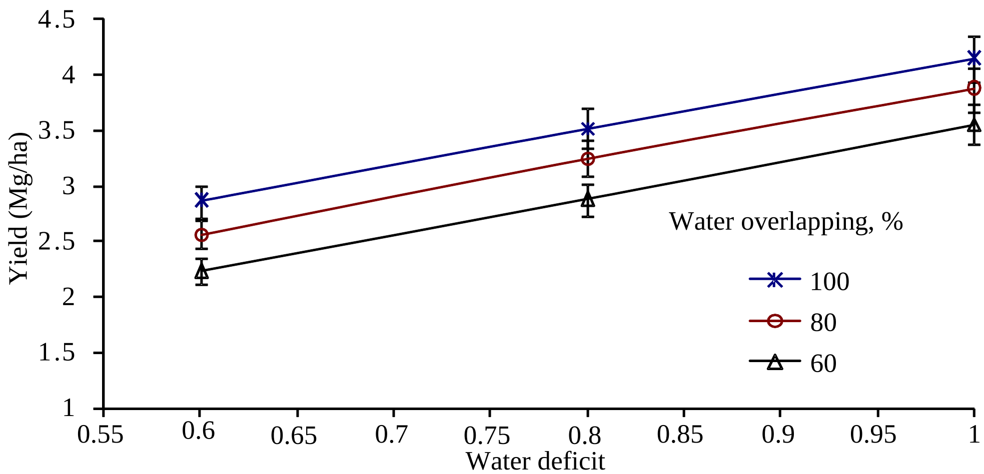

Fig. 2. Peanut yield under sprinkler triangle layout.

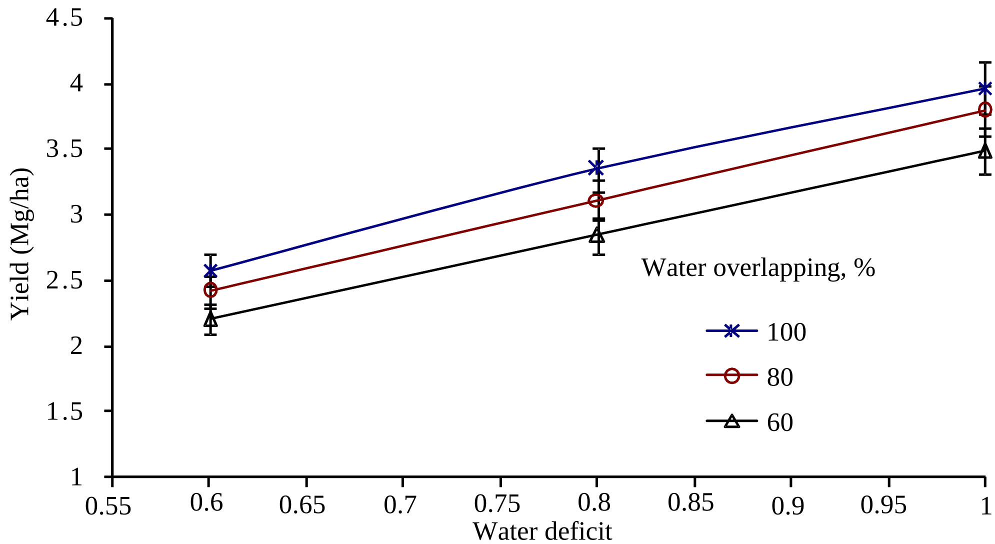

Fig. 3. Peanut yield under sprinkler rectangle layout.

Table 9. Peanut yield-water function coefficients (m and c) and deficit reduction coefficient (k_y). †

layout	Coefficients	Water overlapping, %			Average
		100	80	60	
Square	m	0.0073	0.0081	0.0074	0.0076
	c	0.7826	0.2602	0.0934	0.378733
	k_y	0.781	0.952	0.9834	0.9055
	r^2	0.997	0.998	0.9967	0.9972
Triangular	m	0.0074	0.0075	0.0077	0.007533
	c	0.9401	0.6221	0.2425	0.601567
	k_y	0.771	0.8326	0.9353	0.8463
	r^2	0.9996	0.9986	0.9997	0.9993
Rectangular	m	0.008	0.0079	0.0074	0.007767
	c	0.5238	0.3606	0.2898	0.3914
	k_y	0.8561	0.9023	0.9174	0.8919
	r^2	0.995	0.997	0.997	0.9963

† k_y is reduction coefficient; m and c are, respectively, slope and intercept in linear regression equation, Y = m W + c, where Y is peanut yield in Mg/ha and W is water applied in mm.

CONCLUSION

Sprinkler irrigation is one of the most pressurized irrigation method used in sand soil of Egypt especially for high value crop. However, for irrigation systems in large field, it is difficult to optimize irrigation amount because of non-uniformity conditions. Therefore, sprinkler irrigation systems need to be managed under the field conditions founded on sprinkler performance, layout, and overlapping percentage. For a given sprinkler system, an optimal irrigation scheduling can be found by extrapolating data from a small experiment, which has high uniformity of irrigation applications using a wide range of crop water use (crop ET) to a big field, which has high non-uniformity.

Experimental work was conducted for peanut (*Arachis hypogaea* L.) in sand soil, which has 1.57 g/cm average bulk density in 1.2 m soil depth and 25.2 cm/h saturated hydraulic conductivity, located at an arid site in northern Egypt (Moderiat El Tahreer, Behara governorate) for one season started on 19 July 2008 and ended on 30 October 2008. A Randomized Block Design was carried out for sprinkler irrigation layouts as square, rectangular, and triangular, three overlapping percentages as 100, 80, and 60%, and three irrigation levels as 60, 80, and 100% from crop evapotranspiration (ET).

A 21^{o} optimum trajectory angle under 200 kPa of optimum operating pressure was selected due to having a high degree of uniformity under different overlapping percentages according to Hegazi et al. (2007). Wetted diameter was constant for 21^{o} trajectory angle and achieved 20 m under 200 kPa operating pressure. For 21^{o} trajectory angle in square layout, 100% overlapped percentage achieved low coefficients of variation (CV) and high uniformity coefficients (UC) compared to other percentages of 80 and 60% overlapped layout. In square and rectangular layouts, a minimum CV occurred as 18.1% for 100% overlapped percentage. In triangular layout, the overlap of 100% achieved low coefficient of variation (11.9%) and high uniformity. The highest value of application rate (4.5 mm/h) was achieved when 100% overlapping percentage was applied within layout treatment. More water overlapping (100%) increased significantly application rate as it decreased served area per sprinkler that water accumulates in small area. The lowest values were obtained when less water overlapping (60%) applied. Increasing application rate per served area could help to decrease irrigation time but increase irrigation system installation cost. Significant differences of coefficient of variation (CV) as well as uniformity coefficient (UC) and distribution uniformity (DU) among treatments in sprinklers layout or water overlapping with no interaction among them. For a given layout, CV significantly decreased but UC and DU increased when application rate increased. The lowest values of CV and the highest values of UC and DU were obtained when 100% overlapping percentage supplemented with triangular layout was applied. Decreasing water overlapping meant an increase in served area per sprinkler and this appeared logical as the far area could not have adequate water.

Resulted showed that peanut yield was affected by water overlapping within an irrigation regime by sprinkler layouts. Maximum peanut yields (Y_m) averaged across season for the 1.0ET irrigation treatment were 3.908, 3.703, and 3.308 Mg/ha for 100, 80, and 60% water overlapping percentage in square layout, respectively. They averaged as 4.145, 3.869, and 3.559 Mg/ha in triangular layout, respectively. Maximum yields were 3.970, 3.788, and 3.485 Mg/ha in rectangular layout, respectively. A non-significant difference was found between peanut yield obtained under 1.0ET treatment within both sprinkler layout and water overlapping treatments. Peanut yield significantly decreased in linear relationship with increasing water deficit under non-uniformity irrigation application by sprinkler system in range of 321 to 502 mm. Yield reduction coefficient was found as 0.881 for deficit irrigation. The highest yields were achieved using 1.0ET compared to the other water deficit treatments. The minimum value of yield was achieved when less water and overlapping were applied. Results showed that layout, water overlapping, and irrigation deficit effects on peanut yield were significantly occurred.

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الملخص العربي

استجابة محصول الفول السوداني لاختلاف توزيع مياه الري تحت أداء نظام الري بالرش

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يعتبر الري بالرش من طرق الري الحديثة المستخدمة في التربة الرملية في مصر وخاصة بالنسبة للمحاصيل ذات قيمة اقتصادية عالية. ومع ذلك فأن استخدام أنظمة الري الحديثة لري مساحات كبيرة والتي يصعب فيها توزيع المياه بكفاءة عالية تحتاج إلى معرفة التوزيع الأمثل لأماكن الرشاشات، والأداء، وتداخل دوائر الرش، ولكي يتم الإدارة المثلي للنظام لابد من استقراء البيانات بعمل تجارب حقلية في مساحات صغيرة واستخدام هذه البيانات في تطبيقها على مساحات كبيرة بهدف الاستهلاك الأمثل للمياه مع تحقيق عائد اقتصادي.

أجريت تجربة حقلية بمدرية التحرير- محافظة البحيرة بزراعة الفول السوداني في التربة الرملية ذي كثافة ظاهرية ١,٥٧ جم/سم^{٣} ومعامل توصيل هيدروليكي ٢٥,٢ سم/س في الحالة المشبعة لموسم صيفي واحد ابتدأ في ١٩ يوليو ٢٠٠٨ وانتهي في ٣٠ أكتوبر ٢٠٠٨. تم تصميم التجربة في قطاعات كاملة العشوائية لمعاملات توزيع الرشاشات هي مربعة ومستطيلة ومثلثة وثلاث معاملات نسب تداخل هي ١٠٠، ٨٠، ٦٠٪ مع ثلاث مستويات ري هي ٦٠، ٨٠, ١٠٠٪ من بخرنتح النبات حيث تم توزيع المعاملات عشوائي داخل القطعة التجريبية.

تم اختيار رشاش دوار لزاوية رش هي ٢١° وضغط تشغيل أمثل ٢٠٠ ك باسكال لإعطائه توزيع مياه أمثل عند أداء مجموعة من الرشاشات لنسب تداخل مختلفة وفقاً لحجازي وآخرون (٢٠٠٧), وكان قطر دائرة الرش هو ٢٠ م، حيث أظهرت النتائج أن نسبة التداخل ١٠٠٪ حققت معامل اختلاف منخفض وكفاءة عالية في انتظامية توزيع المياه بالمقارنة مع النسب الأخرى ٨٠, ٦٠ ٪ لكلاً من التخطيط المربع والمستطيل والمثلث، فكان معامل الاختلاف الأقل لتوزيع المياه عند نسبة التداخل ١٠٠٪ هو ١٨,١, ١٨,١ , ١١,٩٪ في التخطيط المربع والمستطيل والمثلث، على التوالي. وكان أعلى معدل رش عند ١٠٠٪ نسبة تداخل هي ٤,٥ مم/س حيث تقل مساحة خدمة الرشاش مما يزيد تراكم المياه , وتم الحصول على أدنى القيم عند تداخل مياه ٦٠٪ ولكن زيادة التداخل يزيد كلاُ من معدل الرش لوحدة المساحة وكفاءة توزيع المياه ويقلل وقت الري ولكن تزداد تكلفة نظام الري بالمقارنة بتقليل تداخل دوائر الرش, أظهر التحليل الإحصائي أنه يوجد فروق معنوية بين معاملات تخطيط الرشاشات ومعاملات تداخل دوائر الرش مع عدم وجود تفاعل فيما بينهم.

أظهرت النتائج أن محصول الفول السوداني تأثر معنوياً بكلاً من توزيع الرشاشات ونسب التداخل وكذلك مستويات الري المختلفة, فكان محصول الفول السوداني الأقصى (Y_m) عند مستوي الري ١٠٠٪ هو ٣,٩٠٨، ٣,٧٠٣، ٣,٣٠٨ ميجاجم/هكتار عند نسب تداخل١٠٠، ٨٠، ٦٠٪ في وضع الرشاشات على رؤوس مربع، على التوالي, كما بلغ متوسط أعلى محصول في

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التوزيع الثلاثي هو ٤,١٤٥، ٣,٨٦٩، ٣,٥٥٩ ميجاجم/هكتار، على التوالي, وكان في التوزيع ألمستطيلي هو ٣,٩٧٠، ٣,٧٨٨، ٣,٤٨٥ ميجاجم/هكتار، على التوالي, كانت هناك فروق غير معنوية لمحصول الفول السوداني عند مستوي الري ١٠٠٪ بين معاملات توزيع الرشاشات ومعاملات تداخل المياه, انخفض محصول الفول السوداني بشكل ملحوظ في علاقة خطية مع زيادة نقص المياه من ٥٠٢ إلي ٣٢١ مم في وجود اختلاف توزيعي لمياه الري بالرش. كان معامل نقص المحصول للري التناقصي هو ٠,٨٨١, وكان أعلى محصول للفول السوداني باستخدام مستوى ري ١٠٠٪ بالمقارنة مع مستويات الري الأخرى, وتم الحصول على أقل محصول عند أقل مستوى ري مع انخفاض نسبة التداخل للرشاشات.