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Effect of Windbreaks and some Design Factors on Performance of Sprinkler Irrigation System

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ABSTRACT

A field experiment was carried out during the successive growth season of 2015/2016 in order to study the effect of windbreaks and some factors of design on the performance of sprinkler irrigation system under open field conditions in sandy soil at Arab El- Awammer Research, Station, Agriculture Research Center- Assiut Governorate, Egypt. The objective of this work is to study the effect of presence or absence the windbreaks, height of rotating sprinkler, climatic conditions (temperature, wind speed and relative humidity) and layout of sprinkler irrigation on the spray evaporation loss, the actual water application, coefficient of uniformity (CU), distribution uniformity (DU), production yield and water use efficiency for sprinkler irrigation systems. The results indicated that; The lowest value of Spray evaporation loss (SEL) was 2.9% in Sep with height of rotating sprinkler (50cm) and the highest value of SEL was 9.6% in August with height of rotating sprinkler (70cm) with the presence of windbreaks. While with the absence of windbreaks, the lowest value of SEL was 10% in Sep with height of rotating sprinkler (50cm) and the highest value of SEL was 28.7% in August with height of rotating sprinkler (70cm). The wind speed increased by an average ratio 38%, the air temperature increased by an average ratio 15% and relative humidity decreased by an average ratio 40% at the windbreaks were completely absent. The highest coefficient uniformity and distribution uniformity were obtained in June, while the lowest coefficient uniformity and distribution uniformity were obtained in August during the presence of windbreaks. The presence of windbreaks increased the productivity of the crop more than the absence of windbreaks, with the same height of rotating sprinkler and the same layout, the maximum Pods yield and the highest percentage of water use efficiency by interaction between presence of windbreaks and the low height of rotating sprinkler (50cm). While, the lowest Pods yield and water use efficiency were produced due to interaction between the absence of windbreaks and the increasing height of rotating sprinkler to 70cm.

INTRODUCTION

Uddin *et al*., 2010 showed that sprinkler irrigation losses may change from 0 to 45% of the water application and that a large amounts of the loss is droplet evaporation in the atmosphere. So, sprinkler irrigation efficiency is affected by the amount of spray evaporation losses. Zazueta, 2011, reported that the amount of water which evaporates from water droplets is related to the evaporative demand of the atmosphere, which is affected by climatic conditions. The energy available for evaporation and the capacity of the air to store and transmit water vapour is called “evaporative demand”. The evaporation process requires 2.42 kJ of energy to convert 1 gm of water from liquid to gas form. So, sufficient energy has to be available from the environment around the sprinkler for evaporation to occur during irrigation. The climatic variables affecting wind drift and evaporation losses are wind speed, air temperature, relative humidity. An example of climatic variables is wind speed, which is one of the most important factors (Playán *et al*., 2005). Smajstrla & Zazueta, 2003 showed that Wind speed leads to evaporation from the surrounding areas by moving warmer or drier air to displace the moist, cool air above an irrigated surface. It also raises the evaporation rates by moving water vapour from the irrigated surface. S, there was an increasing in the renewal of air around the drops with unsaturated air. Air temperature provides energy required for evaporation. As a data, during high levels of air temperature, energy is easily available. Conversely, low levels of air temperatures provide less energy for evaporation. Relative humidity ranged by 0% (low values indicating dry air) to 100% (high values indicating moist air). Since dry air has a greater capacity for moisture, evaporation will occur more easily when the air is dry than when it is moist. Field studies by Bavi *et al*., 2009 showed that spray evaporation losses ranging from 0% to 45%. Kincaid & Longley, 1989 said that in some of the field studies, researchers have combined losses due to spray evaporation and spray drift together, to “spray losses”, due to difficulties with the measurement techniques necessary to separate the two. Rate of evapotranspiration for vegetation is a function of four critical factors: wind speed, vapour pressure, air temperature and solar radiation. Where, solar radiation and wind speed are the most important factors affecting evapotranspiration in the Canterbury region (de Vries *et al*., 2010). Windbreaks have used in many previous periods to defend against the damaging effects of wind and to modify wind profiles and therefore reduce soil erosion and increase crop yield (Guan *et al*., 2003). Decrease of wind speed by windbreaks is beneficial in irrigation systems where;

- Increasing the efficiency of sprinkler irrigation and the atmospheric evaporative demand in the protected area is also decrease. In turn, the Spray evaporation loss between the sprinkler and the surface is reduced, thus decreasing Spray evaporation loss. Hence, the amount of applied water used per unit of crop yield is reduced, which mean increasing water use efficiency;
-Decreasing evapotranspiration. Wind speed is an important factor that measured the evapotranspiration on the field. In windy areas, for example, Canterbury region, decreasing of wind speed by windbreaks lowers crop evapotranspiration and hence water requirements;
-If water requirements are reduced as a result of wind protection, energy costs related with the water applied like pumping are also reduced.

In United States, Dickey (1988) showed that in areas of high evapotranspiration (10 mm/day), a windbreak could improve irrigation application efficiency of fine spray by 10% by decreasing the wind speed from 4.5 m/s to 1.8 m/s and reported that any more reduction in wind speed would result in greater irrigation efficiencies, especially at high of evapotranspiration rates. In North America, shelter that reduced the wind speed especially in hot dry summer in a lucerne crop by 40% with a 10% saving of irrigation water. For dry land crops in the same trial, shelter was responsible for a 9% increase in crop yield, soil moisture being consistently higher beneath the sheltered crops. In New Zealand, studies have also shown that windbreaks can have great benefits in terms of saving water resource use in agriculture. de Vries *et al.* (2010) studied the effect of windbreaks on irrigation requirement and evapotranspiration in the field in the Canterbury region which was protected by a single windbreak using a modeling approach. Irrigation water requirements were estimated by calculating actual evapotranspiration for a pasture crop at different horizontal distances from a windbreak. Data showed that windbreak shading can decrease solar radiation by a ratio 90% on a full sunshine day and, if combined with reduction in wind speed, evapotranspiration can be decreased to 0% for dense windbreak. Data also showed that windbreaks can decrease on-farm water requirement by 10% to 20% and still maintain ideal farm yield. Data showed that for a typical field in Canterbury with a total length of 300 m, the total reduction from just shade is 3% at mid-day and 9% in the afternoon. In general, when crops transpire water, the immediate around environment of the green parts of plant will be moist. In dry climates, the wind speed is most likely to replace this moist air with dry air, which causes an increase in evapotranspiration. Increase in evapotranspiration causes an increase in water requirements. Evapotranspiration is main source of water loss in agriculture. Among the key factors that affect wind speed, solar radiation and Evapotranspiration are the most important factors affecting evapotranspiration in the Canterbury region. So, wind speed can be controlled by use of windbreaks in a farm. Data showed that evapotranspiration of a crop can be determined by using the Standardized Reference Evapotranspiration Equation, if the meteorological variables are known Eric (2015). The aim of this work is to study the effect of presence or absence the windbreaks, height of rotating sprinkler, climatic conditions and layout of sprinkler irrigation on the spray evaporation loss, the actual water application, coefficient of uniformity (CU), distribution uniformity (DU), production yield and water use efficiency for sprinkler irrigation systems.

MATERIALS AND METHODS

Field experiment was carried out during the successive growth season of 2015/2016 at the experimental farm of Arab El- Awammer Research, Station, Agriculture Research Center, Assiut, Egypt. This work was done in four steps: (first) spray evaporation losses and the actual water application were measured under climatic variables;(second) measuring the distribution uniformity and coefficient uniformity;(third) studying the growth and yield of peanut plants grown and (fourth) measuring the water use efficiency under sprinkler irrigation systems to study the effect of presence or absence the windbreaks, height of rotating sprinkler, climatic variables and layout of sprinkler irrigation system on the performance of sprinkler irrigation system.

Sprinkler irrigation experiment.

The sprinkler irrigation system was fixed in square and triangular spacing pattern (12m X 12m). The rotating sprinkler heights were 0.7 and 0.5 m above the ground with flow rate of 1.2-1.4 m3/h at 2-3 bars. The experiment included eight treatments under fixed sprinkler irrigation system which was showed in table 1. The sprinklers line, which was taken measurements in the middle of the experiment land for all treatments, was about 48 meters from the windbreaks.

Table 1. Treatments of the experimental under fixed sprinkler irrigation system.

Treatments with windbreaks.			Treatments without windbreaks		
Treat.	Rotating sprinkler height	Layout of system	Treat.	Rotating sprinkler height	Layout of system
T_1	70 cm	Triangular	T_5	50 cm	square
T_2	70 cm	square	T_6	70 cm	square
T_3	50 cm	Triangular	T_7	50 cm	Triangular
T_4	50 cm	square	T_8	70 cm	Triangular

Peanut crop:-

Peanut seeds (Gize 5, variety) were mixed with peat treated with suitable species of rizobium just before planting process. The seeds were transplanted on the first day of June. Plants were harvested on 10th of October. All field practices for growing peanut were conducted as recommended. Eight different treatments were considered to evaluate fixed sprinkler irrigation system. The actual water applied (m3) for Peanut plants per season were 3785.03 m3/fed/season. The sequence of calculation to estimate the gross irrigation water as shown in table 2.

Table 2. Sequence of calculation to estimate the total irrigation water for sprinkler irrigation system (m^3/fed/season).

NO.	Parameter/month	June	July	august	Sep.	Oct.
1	ETo (mm/mont)	210	248	263.5	180	146.01
2	ETo (mm/day)	7.00	8.00	8.50	6.00	4.71
3	K_c	0.4	0.6	1	1	0.85
4	K_r	0.75	0.85	0.95	0.95	0.95
5	ETc (mm/day)	2.10	4.08	8.08	5.70	3.81
6	Irrigation efficiency (Ea)	0.8	0.8	0.8	0.8	0.8
7	ETc (mm/day)	2.63	5.10	10.09	7.13	4.76
9	Leaching requirement (LR)	0.1	0.1	0.1	0.1	0.1
10	Gross daily (IR) (mm/day)	2.92	5.67	11.22	7.92	5.29
11	Days of water application	30	31	31	30	10
12	Gross month (IR) (mm/month)	87.50	175.67	347.67	237.50	52.86
13	Gross irri. (IR) (cm/ month)	8.75	17.57	34.77	23.75	5.29
14	Total irri. (IR) (cm/fed/season)			90.12		
15	Total irri. (IR) (m^3/fed/season)			3785.03		

Specification of windbreaks:

Casuarin were trees that have been cultivated as windbreaks, where the height of 5.5 meters and the distance between the trees 1.25 meters. The distance between the windbreaks line and the experiment land was 7 meters. Wind was westerly towards the east.

Analysis of soil

The particle size distribution of soil samples was carried out according to the international pipette method (Klute, 1986). Soil bulk density was determined using undisturbed soil samples for the different layers of the soil profile using cylinder method (Klute, 1986). The capacity of available water (AWC) was calculated by the differences in water content at field capacity (FC) and permanent wilting point (PWP) as follows:

$$\mathbf{AWC = FC - PWP}$$

Measurements and calculations of some soil chemical properties were made using the techniques described by (Jackson, 1973. Some soil physical and chemical properties were measured and recorded in table 3 and 4.

Table 3. Soil physical properties of the experimental field before cultivation.

Soil depth, cm	gravel (%)	Particle size distribution(%)			Texture class	O.M (%)	$CaCO_3$ (%)	Moisture content (Volumetric %)			AW (%)	Pb (Mg m^{-1})
		Sand	Silt	Clay				S. P.	F.C.	W.P.		
0 – 15	34.5	90.9	6.7	2.4	sandy	0.32	32.2	25.2	12.5	4.9	7.6	1.57
15 – 30	30.2	90.2	6.8	3.0	sandy	0.28	33.8	23.3	10.0	4.2	5.8	1.65
30 – 45	46.6	89.4	7.4	3.2	Sandy	0.24	25.4	21.7	9.5	4.0	5.6	1.75
45 – 60	46.3	89.0	7.5	3.5	Sandy	0.16	32.0	23.0	11.8	4.9	6.9	1.55
mean	39.4	89.9	7.1	3.0	Sandy	0.25	30.9	23.3	10.9	4.5	6.5	1.63

O. M- Organic matter, S.P- Saturation percentage, F.C- Field capacity, W.P- Wilting point, A.W- Available water, Pb – Bulk density,

Table 4. Soil chemical properties of the experimental field before cultivation.

Soil depth,Cm	pH (1 : 1)	EC, Ds/m (1 : 1)	Soluble cations (mmol/L^{-1})				Soluble anions (mmol/L^{-1})	
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Co_3^{--} HCo_3^{-}	Cl^{-}
0 – 15	8.10	0.42	2.16	1.40	0.29	0.96	2.25	2.00
15 – 30	8.50	0.39	1.46	1.52	0.19	0.95	1.90	1.80
30 – 45	8.55	0.26	1.08	0.89	0.14	0.61	1.42	1.17
45 – 60	8.34	0.24	1.01	0.82	0.13	0.47	1.15	0.89
mean		0.33	1.43	1.16	0.19	0.75	1.68	1.47

Pan evaporation equation.

The class A evaporation pan is circular, 120.7 cm in diameter and 25 cm deep it is made of galvanized iron. The pan evaporation was sitting beside the experiment. Pan evaporation readings were taken daily in the early morning with using micrometer. Reference evapotranspiration values were calculated according to Pan Evaporation method (Doorenbos and Pruitt, 1977) using the following equation:

$$\mathbf{ET_o = K_{pan} \times E_{pan}}$$

Where:

ET_o : Reference evapotranspiration mm/ day.

K_{pan} : Pan evaporation mm/ day.

E_{pan} : pan coefficient (0.7 : 0.8).

Reference evapotranspiration (ET_o)

The reference ET_o was estimated, using available meteorological data of Assiut governorate. Crop evapotranspiration (Etc). (Allen *et al*., 1998)

$$ET_c = ET_0 x Kc$$

Where:

Et_c : Crop evapotranspiration.

ET_o : Reference evapotranspiration with using FAO Penman- Monteith Equation.

K_c :Crop coefficient, as reported by FAO (1979).

Actual irrigation water requirement

The amounts of actual applied irrigation water requirement under each irrigation treatment were determined according to James (1988) using the following equation:

$$I.Ra = \frac{ETc + Lf}{Er}$$

Where:

$I.R_a$: total actual irrigation water applied mm/ interval.

Et_c : Crop evapotranspiration using pan evaporation.

L_f : leaching factor 10 %.

E_r : irrigation system efficiency.

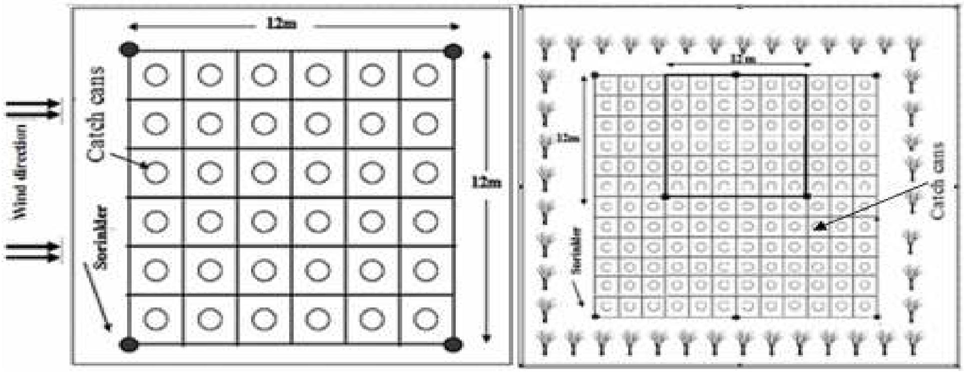
Irrigation water use efficiency (IWUE)

The irrigation water use efficiency (IWUE) values were calculated as follows: (Vite, 1965)

$$IWUE = \frac{Grain\ or\ Seed\ yield\ (Kg\ /\ fed.)}{Irrigation\ water\ applied\ (m^3\ /\ fed.)}$$

Application rate of sprinkler over the field

The collection containers shall be put of equal size so that a grid of squares or rectangles is inside the selected sprayers as in figure (1), which indicates the layout of catch containers for testing the uniformity of sprinkler on lateral line in the field.



Square layout with absence of windbreaks **Triangular layout with presence of windbreaks**

Figure 1. Layout of catch cans for testing the uniformity of distribution for sprinkler in the field.

- Find the depth of water which collected in each cans by dividing the volume of water collected in each cans on the area of the cans section.
- Find the depth of water application (D_g) using the following equation:-

$$D_g = R_a \times T_i$$

Where:

T_i : operating time (h)

R_a : application rate (mm/h)

R_a is found from the following equation:-

$$R_a = \frac{Q_{sp}}{S_S \times S_L}$$

Q_{sp}: actual application rate (mm/h).

Recording weather data at the time of system evaluation, especially wind speed and direction, relative humidity and average air temperature.

Coefficient of uniformity (Cu)

The sprinkler irrigation systems coefficient of uniformity was calculated from the following equation (Christiansen, 1942):-

$$Cu = \left(1 - \frac{\sum_{i=1}^{i=n} |X_i - \overline{X}|}{n \cdot \overline{X}}\right) \times 100$$

Where:

CU : Coefficient of uniformity, %

x_i : Individual depth of catch observations from uniformity test, mm

x : | x_i-x| = absolute deviation of the individual observations from the mean, mm.

n : Number of observed emitter or cans.

$\overline{X}$: Average depth of observations, mm.

Evaporation losses (E):

The percentage of water lost by wind and air temperature can be found from the amount of water application in irrigation, during Operating time of equation:

$$E = \frac{D_g - \overline{X}}{D_g} \times 100$$

Distribution of uniformity (DU)

The distribution of uniformity indicates of application throughout the field and is computed by:-

$$\textbf{DU} = \frac{\text{Average low - quarter depth of water infiltrated}}{\text{Average depth of water infiltrated}}$$

The average low quarter depth of water received is the average of the lowest one- quarter of the measured values, where each represents on equal area (Keller and Bliesner, 1990).

RESULTS AND DISCUSSION

Climatic variables

Average monthly meteorological data of Assiut weather station, which were measured (above 2m on ground surface) during the growth season, are presented in table 5 and showed in figures (2, 3, 4 and 5).

Data showed that the wind speed, in June, significantly increased from 9.8 km/h under test 1 to 15.7 km/h under test 5, respectively, by 37.58%. In the same trend, when the windbreaks was absence, the wind speed increased by 42.95%, 43%, and 30% in July, August and sep. respectively. This means that windbreaks led to reduce wind speeds across a field.

Table 5. Data of climatic variables at the time of measurement with the absence and the presence of windbreaks.

Climatic variables	with windbreaks				without windbreaks			
	Test 1 (June)	Test 2 (July)	Test 3 (August)	Test 4 (Sept.)	Test 5 (June)	Test 6 (July)	Test 7 (Aug.)	Test 8 (Sept.)
Air temperature (C^0)	30.71	29.4	33.76	24.8	36.4	34.1	38.4	30.8
Wind velocity (km\h)	9.8	2.51	4.1	13.09	15.7	4.4	7.2	18.7
Relative humidity (%)	41.3	34.4	44	54.44	25.2	19	24	39

Data also showed that the air temperature, in June, significantly increased from 30.71 Co under test 1 to 36.4 Co under test 5, respectively, by 15.63%. In the same trend, when the windbreaks are completely absence, the air temperature increased by 13.78%, 12.08%, and 19.48% in July, August and sep. respectively.

Data also showed that the relative humidity, in June, significantly decreased from 41.3% under test 1 to 25.2% under test 5, respectively, by 38.98%. In the same trend, when the windbreaks are completely absence, the relative humidity decreased by 44.83%, 45.45%, and 28.36% in July, August and sep. respectively.

Data also showed that the evaporation, in June, significantly increased from 6.3 mm under test 1 to 7.7 mm under test 5, respectively, by 18.18%. In the same trend, when the windbreaks are completely absence, the evaporation increased by 20%, 22.04%, and 20% in July, August and sep. respectively. This means that windbreaks led to reduce evaporation across a field.

Data also showed that evaporation is a function of climatic variables, hence evapotranspiration is a function of climatic variables, and any change of wind speed and air temperature is expected to result in a change in evaporation and evapotranspiration. Comparison between all treatments showed that there was a significant difference between average evaporation. However, data indicated that the average evaporation is affected by wind speed and air temperature. This difference in evaporation for different treatments under different scenarios is attributed to the difference in wind speed and air temperature when windbreaks were either completely removed, evaporation increased proportionately to increase in wind speed and air temperature.

Generally, The increase in relative humidity and the decrease in wind velocity and air temperature at treatments (T1, T2, T3 and T4) were due to the presence of the windbreak and the decrease in relative humidity and the increase in wind velocity and air temperature at treatments (T5, T6, T7 and T8) was due to the absence of the windbreak. The effects of this decreased in relative humidity and the increased in wind speed and air temperature as a result of windbreak removal or reduction is quantified next in terms of water use by crops.

Spray evaporation loss

Data in table 6 showed that the spray evaporation losses (SEL) changed from one catch can to another inside the irrigated area. The results showed that the average SEL from individual catch cans inside the irrigated area is pointed in each test, together with the average climatic variables during the test. SEL values at treatments (T_1, T_2, T_3 and T_4) with the presence of windbreaks ranged from 4.6% to 7.5% under test (1). While ranged from 6.3% to 8.9% under test (2), ranged from 7.4% to 9.6% under test (3) and ranged from 2.9% to 6.5% under test (4). Data showed also that the lowest value for SEL was under test (4) with treatment T_4 (2.9%) and the highest value for SEL was under test (3) with treatment T_2 (9.6%). On the other hand, SEL values at all treatments (T_5, T_6, T_7 and T_8) with the absence of windbreaks increased and became ranged from 12.2% to 17.1% under test (5). While ranged from 17.8% to 26.8% under test (6), ranged from 19.2% to 28.7% under test (7) and ranged from 10% to 12.7% under test (8). Data showed also that the lowest value for SEL was under test (8) with treatment T_5 (10%) and the highest value for SEL was under test (7) with treatment T_6 (28.7%), when wind speed increased, as a result of windbreaks being absence, there was increasing in SEL. This SEL represents the extra water to be pumped from the source.

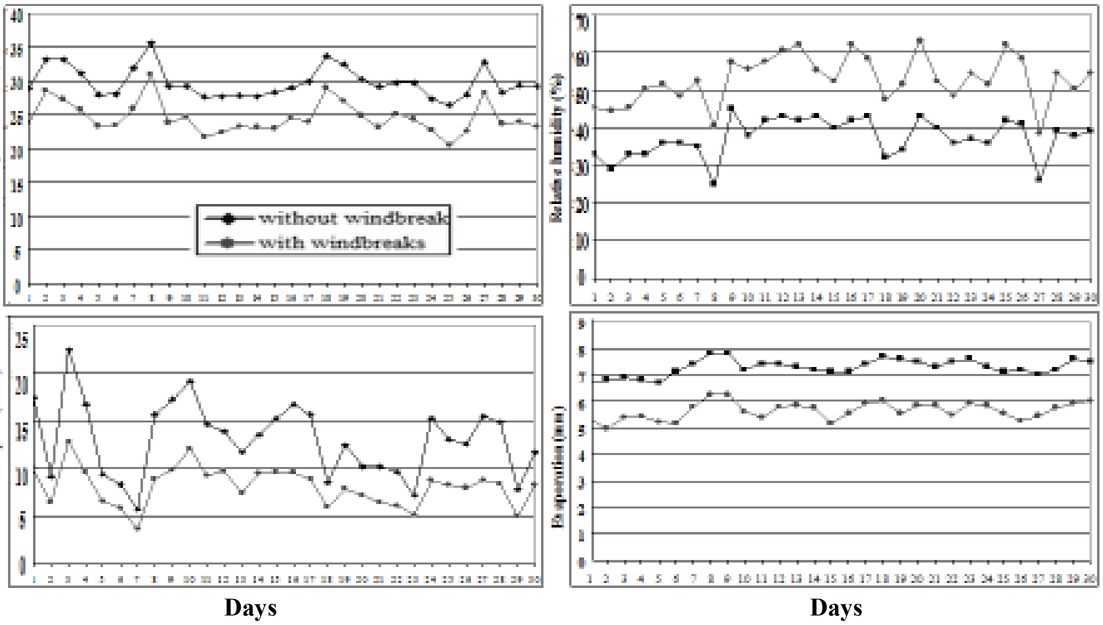


Figure 2. Effect of the presence and absence windbreaks on climatic variables and evaporation during June.

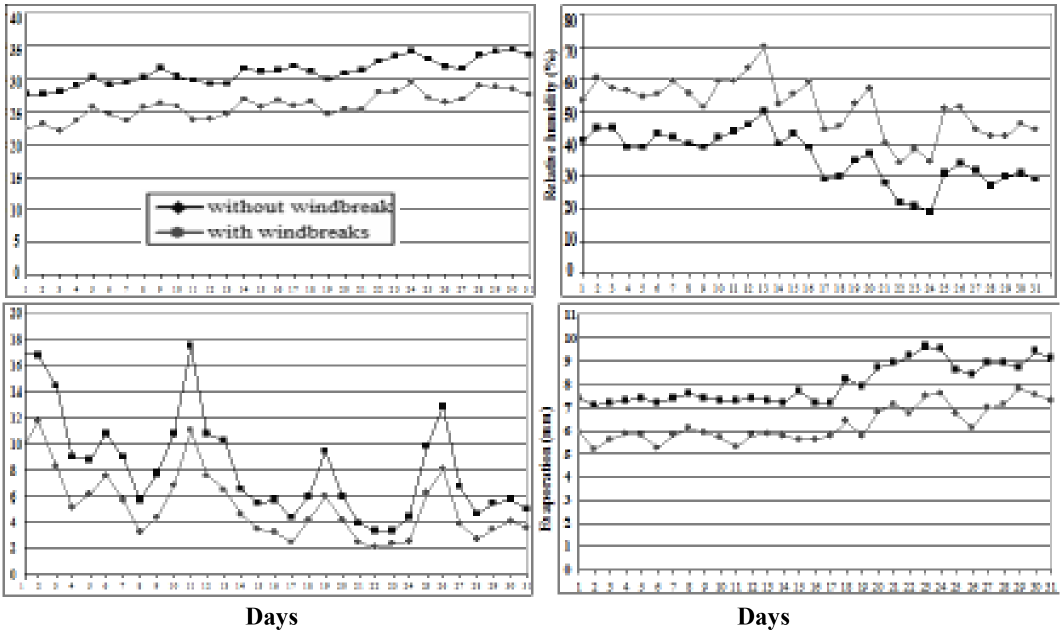


Figure 3. Effect of the presence and absence windbreaks on climatic variables and evaporation during July.

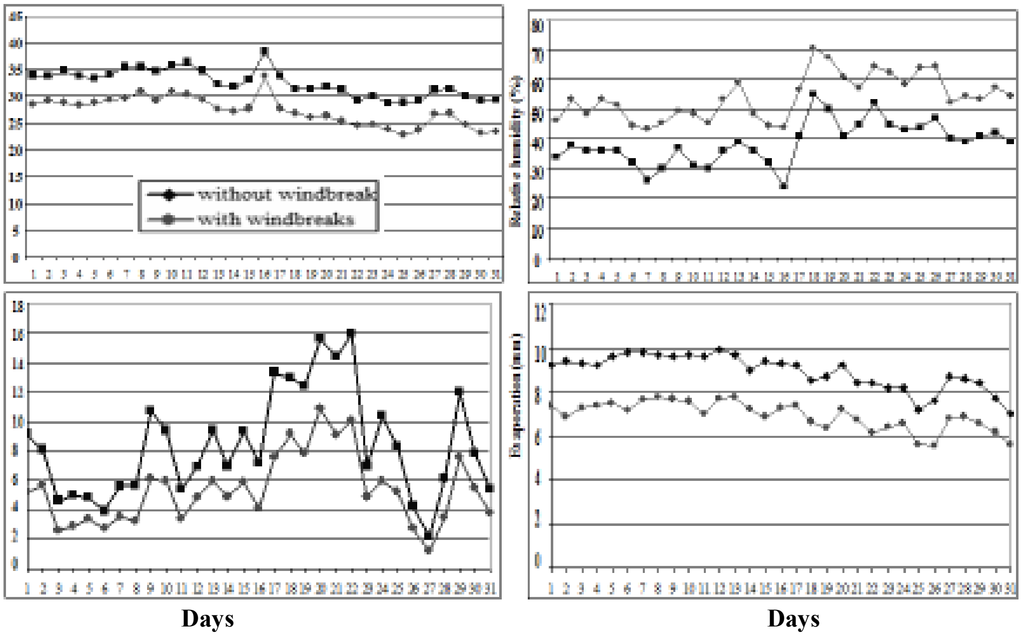


Figure 4. Effect of the presence and absence windbreaks on climatic variables and evaporation during August.

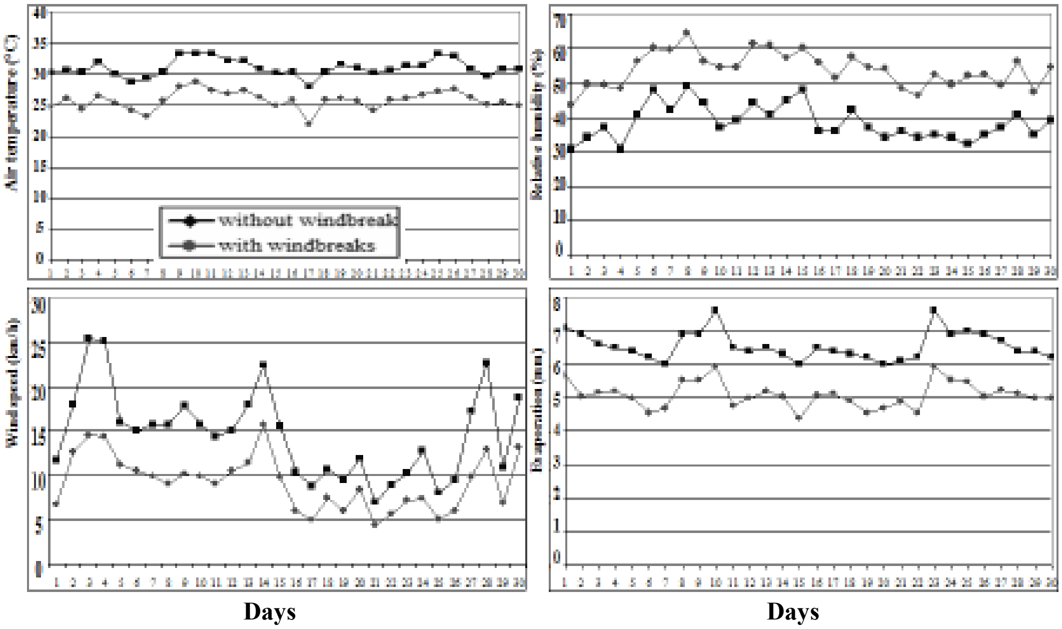


Figure 5. Effect of the presence and absence windbreaks on climatic variables and evaporation during September.

Table 6. Spray evaporation loss (%) in the presence and absence of windbreaks.

With windbreaks.					Without windbreaks				
Treat	Test (1)	Test (2)	Test (3)	Test (4)	Treat	Test (5)	Test (6)	Test (7)	Test (8)
T_1	6.2	7.3	8.7	4.8	T_5	12.2	17.8	19.2	10
T_2	7.5	8.9	9.6	6.5	T_6	17.1	26.8	28.7	12.7
T_3	5.2	7	8.4	3.8	T_7	16	22.3	24	12.2
T_4	4.6	6.3	7.4	2.9	T_8	16.7	23.4	26.4	12.5

On the other hand, the effect of distance from sprinkler on spray evaporation loss (SEL) inside the irrigated area was determined. Data showed that spray evaporation loss in individual catch cans inside the irrigated area increased by the increasing in distance from the sprinkler. To show the variation of evaporation losses with distance, selected data for different climatic variables are given in Figures 6 and 7. At very high wind speeds, air temperature and low relative humidity the data showed that spray evaporation loss increase in the direction of the wind.

Actual application rate (m^3/h)

Data in table 7 showed that, with presence of windbreaks, the higher actual application rate was obtained in treatment (T_4) while the lower actual application rate was obtained in treatment (T_2). On the other hand, with absence of windbreaks, the higher actual application rate was obtained in treatment (T_5) while the lower actual application rate was obtained in treatment (T_6).

Data in table 7 showed also that the higher actual application rate was obtained in Sep. (Test 4 and Test 8) which was 8.09 and 7.50m^3/h in treatments T_4 and T_5 respectively. While the lower actual application rate was obtained in August (Test 3 and Test 7) which were 7.53 and 5.94m^3/h in treatments T_2 and T_6 respectively.

In generally, with the presence of windbreaks, the actual application rate in treatments (T_1, T_2, T_3 and T_4) was higher than with the absence of windbreaks, in treatments (T_5, T_6, T_7 and T_8).

Table 7. Actual application rate (m^3/h) of sprinkler in the presence and absence of windbreaks.

With windbreaks.					Without windbreaks				
Treat	**Test (1)**	**Test (2)**	**Test (3)**	**Test (4)**	**Treat**	**Test (5)**	**Test (6)**	**Test (7)**	**Test (8)**
T_1	7.81	7.72	7.61	7.93	T_5	7.31	6.85	6.73	7.50
T_2	7.71	7.59	7.53	7.79	T_6	6.91	6.10	5.94	7.27
T_3	7.90	7.75	7.63	8.01	T_7	7.00	6.47	6.33	7.31
T_4	7.95	7.81	7.71	8.09	T_8	6.94	6.38	6.13	7.29

Coefficient uniformity (%)

Data in table 8 showed that, with presence of windbreaks, the higher coefficient uniformity was obtained in treatment (T_4) while the lower coefficient uniformity was obtained in treatment (T_2). On the other hand, with absence of windbreaks, the higher coefficient uniformity was obtained in treatment (T_5) while the lower coefficient uniformity was obtained in treatment (T_6). Data showed also that the higher coefficient uniformity was obtained in June (Test 1 and Test 5) which was 96.1% and 77.8% in treatments T_4 and T_7 respectively. While the lower coefficient uniformity was obtained in August (Test 3 and Test 7) which were 80% and 62.5% in treatments T_2 and T_6 respectively.

In generally, with the presence of windbreaks, coefficient uniformity in treatments (T_1, T_2, T_3 and T_4) was higher than with the absence of windbreaks, in treatments (T_5, T_6, T_7 and T_8).

Table 8. Coefficient uniformity (%) in the presence and absence of windbreaks.

With windbreaks.					Without windbreaks				
Treat	**Test (1)**	**Test (2)**	**Test (3)**	**Test (4)**	**Treat**	**Test (5)**	**Test (6)**	**Test (7)**	**Test (8)**
T_1	90.1	85	83	87.2	T_5	77.8	76.2	72	74
T_2	87	82.2	80	83.1	T_6	70.2	68.1	62.5	66
T_3	93	88	85.7	90	T_7	76.4	74.2	70	72.2
T_4	96.1	90	87.5	92.3	T_8	73	72	68	70

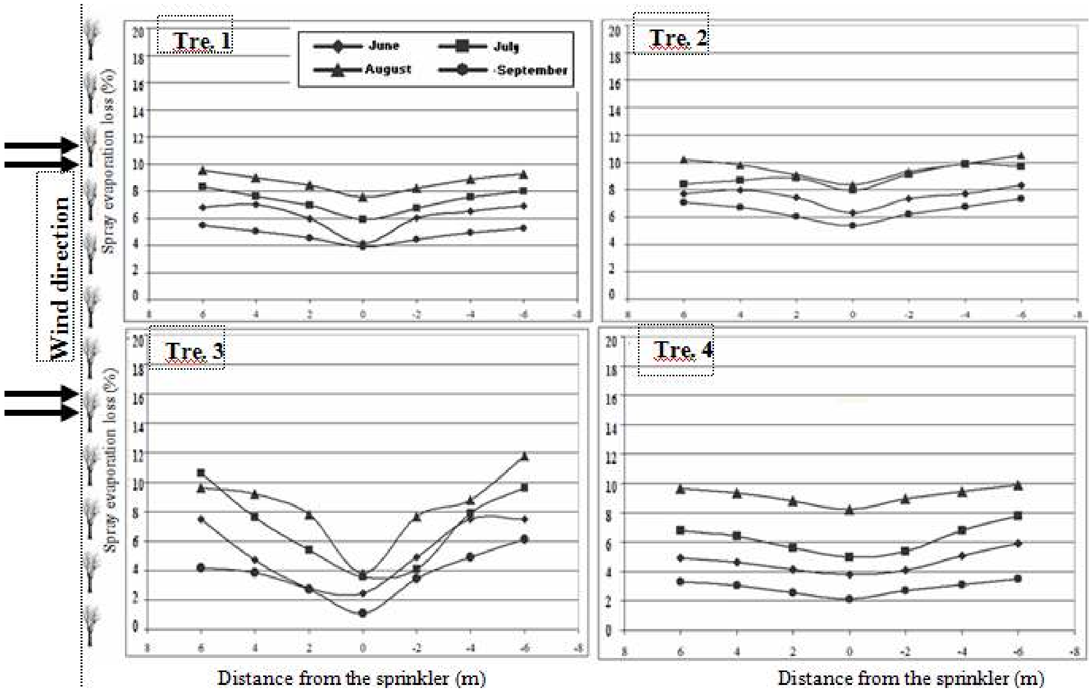


Figure. 6. Spray evaporation loss with the presence of windbreaks.

Distribution uniformity (%)

Data in table 9 showed that, with presence of windbreaks, the higher distribution uniformity was obtained in treatment (T4) while the lower distribution uniformity was obtained in treatment (T2). On the other hand, with absence of windbreaks, the higher distribution uniformity was obtained in treatment (T5) while the lower distribution uniformity was obtained in treatment (T6). Data showed also that the higher distribution uniformity was obtained in June (Test 1 and Test 5) which was 86.2% and 72.6% in treatments T4 and T5 respectively. While the lower distribution uniformity was obtained in August (Test 3 and Test 7) which were 68.5% and 45.3% in treatments T_2 and T_6 respectively.

In generally, with the presence of windbreaks, distribution uniformity in treatments (T_1, T_2, T_3 and T_4) was higher than with the absence of windbreaks, in treatments (T_5, T_6, T_7 and T_8).

Table 9. Distribution uniformity (%) in the presence and absence of windbreaks.

With windbreaks.					Without windbreaks				
Treat	**Test (1)**	**Test (2)**	**Test (3)**	**Test (4)**	**Treat**	**Test (5)**	**Test (6)**	**Test (7)**	**Test (8)**
T_1	80.5	76.5	72.3	78.2	T_5	72.6	69.3	58.5	62.5
T_2	77.5	71	68.5	72.7	T_6	61.4	57.1	45.3	51.4
T_3	82.4	78.6	75.3	80.4	T_7	69.4	64	49.5	53.5
T_4	86.2	81.1	79.6	83.3	T_8	65.4	61.2	54.3	57.3

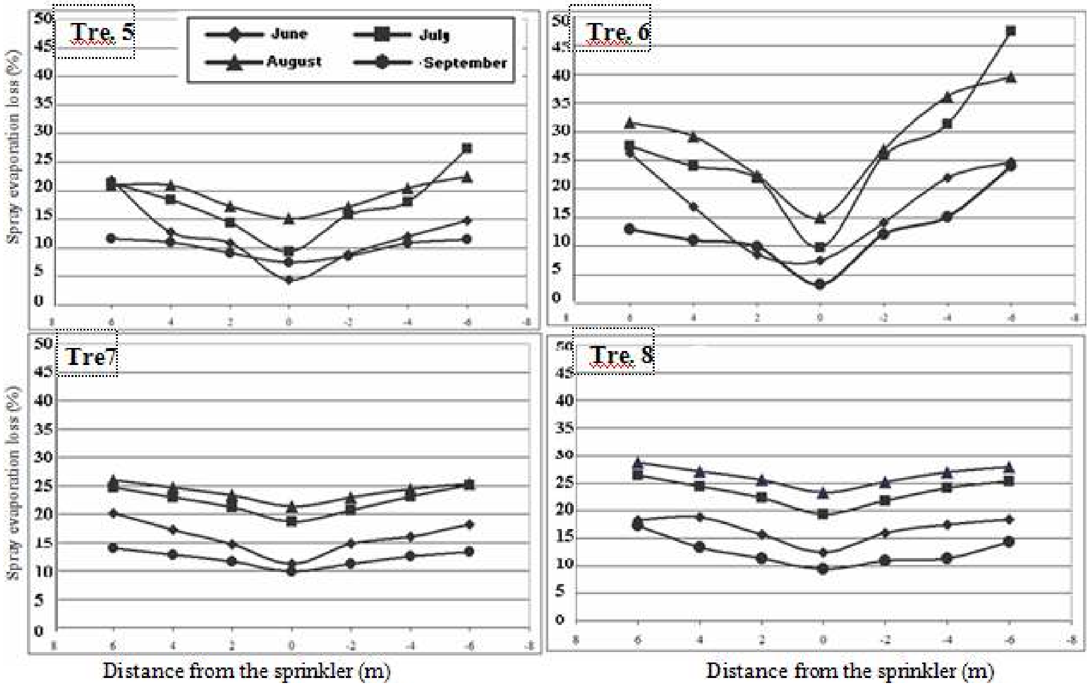


Figure. 7. Spray evaporation loss with the absence of windbreaks.

Yield (kg/fed)

The data in table (10) showed the effects of presence and absence of windbreaks, height of rotating sprinkler and layout (design) of sprinkler irrigation on Pods yield (kg/ fed.) of peanut. The Pods yield was significantly increased due to the presence of windbreaks and the low height of rotating sprinkler (50cm) compared with Pods yield under absence of windbreaks and the increasing in the height of rotating sprinkler to 70cm. The presence of windbreaks increased Pods yield by 23.85%, 25.92%, 28.62% and 30.41% more than the absence of windbreaks, with the same height of rotating sprinkler and the same layout. The higher Pods yield (1630.54 and 1575.83 kg/fed.) in this study was produced by interaction between presence of windbreaks and the low height of rotating sprinkler (50cm). While, the lowest Pods yield (1043.5 and 1096.44 kg/fed.) in this study were produced due to interaction between the absence of windbreaks and the increasing height of rotating sprinkler to 70cm.

Table 10. Pods yield (kg/ fed.) of peanut under all treatments.

No. of treatment	Yield (kg/fed)	No. of treatment	Yield (kg/fed)
T_1	1439.87	T_5	1134.65
T_2	1408.67	T_6	1043.5
T_3	1575.83	T_7	1124.87
T_4	1630.54	T_8	1096.44

Irrigation water use efficiency (kg/m^3)

The results in table (11) indicate the effect showed the effects of presence and absence of windbreaks, height of rotating sprinkler and layout (design) of sprinkler irrigation on irrigation water use efficiency based on pods yield. Irrigation water use efficiency was significantly decreased due to the absence of windbreaks and the low height of rotating sprinkler compared to the presence of windbreaks the increasing in height of rotating sprinkler. The highest IWUE of peanut pods (0.431 and 0.416 kg/m^3) in this study was resulted due to the interaction between presence of windbreaks and the low height of rotating sprinkler (50cm). Meanwhile the lowest values (0.276 and 0.290 kg/m^3) were resulted due to the interaction between absence of windbreaks and the increasing in height of rotating sprinkler (70cm).

Table 11. Water use efficiency (kg/m^3) under all treatments.

No. of treatment	WUE (kg/ m^3)	No. of treatment	WUE (kg/ m^3)
T1	0.380	T5	0.300
T2	0.372	T6	0.276
T3	0.416	T7	0.297
T4	0.431	T8	0.290

CONCLUSION

1-The relationship between different climatic variables (relative humidity, air temperature and wind speed) and spray evaporation loss (SEL) was evaluated to determine SEL related to varies in the climatic variables. This data is important because it provides knowledge of the most important variables if spray evaporation loss is to be lowered.

2-Absence of windbreaks was expected to cause decrease in relative humidity and increasing in the wind speed and air temperature in the field. Accordingly, the increasing in wind speed and air temperature led to an increase in spray evaporation loss, there was a corresponding increase in evapotranspiration. This spray evaporation loss lead to the extra water application to be pumped from the source.

3-Yield performances changed according to absence or presence the windbreak. With the presence of windbreak, peanut productions were higher than those obtained in the zone without the windbreaks by range 23 to 30%.

4-finally, with next climate variables projections showing that the Assuit region will get hotter, windbreaks can prevent water losses associated with sprinkler irrigation.

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تأثير مصدات الرياح وبعض العوامل التصميمية على أداء نظام الري بالرش.

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تم إجراء هذا البحث خلال موسم ٢٠١٥-٢٠١٦ لدراسة تأثيرمصدات الرياح وبعض العوامل التصميمية على أداء نظام الري بالرش تحت ظروف الحقل المكشوف في التربة الرملية بمحطة بحوث عرب العوامر، مركز البحوث الزراعية - محافظة أسيوط، مصر. الهدف من هذا البحث هو دراسة تأثير وجود أوغياب مصدات الرياح، وارتفاع حامل الرشاش، والظروف المناخية (درجة الحرارة وسرعة الرياح والرطوبة النسبية) وتخطيط (تصميم) الري بالرش على الفقد بالتبخر ، المياه الفعلية المضافة، معامل الانتظامية، انتظامية التوزيع ، الإنتاجية (الفول السوداني) وكفاءة استخدام المياه لنظام الري بالرش.) وأشارت النتائج إلى ما يلى: ١- مع وجود مصدات الرياح أقل قيمة للفقد بالتبخر كانت ٢.٩٪ في شهر سبتمبر مع ارتفاع حامل الرشاش (٥٠ سم) وكانت أعلى قيمة للفقد بالتبخر ٦.٩٪ في شهر أغسطس مع ارتفاع حامل الرشاش (٧٠ سم). بينما مع غياب مصدات الرياح أقل قيمة للفقد بالتبخر كانت ٦.٩٪ في شهر سبتمبر مع ارتفاع حامل الرشاش (٥٠ سم) وكانت أعلى قيمة للفقد بالتبخر ٢٨.٧٪ في شهر أغسطس مع ارتفاع حامل الرشاش (٧٠ سم). ٢- وعندما تكون مصدات الرياح غائبة تماما ، ارتفعت سرعة الرياح بنسبة متوسطة حوالي ٣٨ ٪. وارتفع درجة حرارة الهواء بنسبة متوسطة حوالي ١٥٪. وانخفض الرطوبة النسبية بنسبة متوسطة حوالي ٤٠%. ٣- مع وجود مصدات الرياح تم الحصول على أعلى معامل انتظامية وانتظامية للتوزيع في شهر يونيو في حين تم الحصول على أقل معامل انتظامية وانتظامية للتوزيع في شهر أغسطس. ووجود مصدات الرياح زاد من انتاجية المحصول أكثر من غياب مصدات الرياح، مع نفس ارتفاع حامل الرشاش ونفس التخطيط مع ملاحظة أن أقصي انتاجية للمحصول وأعلى نسبة من كفاءة الاستحدام المائي في هذه الدراسة عن طريق التداخل بين وجود مصدات رياح و ارتفاع حامل الرشاش (٥٠ سم). في حين تم إنتاج أقل للمحصول وأقل نسبة من كفاءة الاستحدام المائي في هذه الدراسة بسبب التداخل بين غياب مصدات الرياح و زيادة ارتفاع حامل الرشاش إلى ٧٠ سم.