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The Impact of Climate Change on the Performance of Center-Pivot and Fixed Sprinkler Irrigation Systems in Sandy Soil

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ABSTRACT

A field experiment was conducted during the growing season in 2023 to study the impact of climate changes (temperature, wind speed and relative humidity) on the performance of the center pivot and fixed irrigation systems (evaporation losses, Coefficient uniformity (CU), distribution uniformity (DU), water use efficiency and the production yield of peanut) in an open field at sandy soil in Wadi EL-Natroun region - El-Bhera Governorate, Egypt. The higher evaporation losses obtained in July (T= 27Cº, R.H =94% W.S =12.20 km/h) were 20.10% and 33.72% with the center pivot and fixed irrigation systems, respectively. The evaporation losses obtained in October were 8.7% and 10.42% with the center pivot and fixed irrigation systems, respectively (T= 27.70Cº, R.H= 78% W. S=14.40 km/h). The higher distribution uniformity was obtained in October of 80% and 77.8% (T= 28.80 Cº, R.H =78% W.S =15.10 km/h) with the center pivot and fixed irrigation systems respectively. The higher coefficient uniformity was obtained in October (T=27.7 Cº, R.H=78 % and W.S =14.4 km/h.) of 87% and 85% for the center pivot and fixed irrigation systems respectively. Production yield increased by 22.46% for center pivot irrigation system compared with the fixed irrigation system. Water use efficiency of peanuts were 0.345 and 0.457 kg/m^3 with the fixed and center pivot irrigation systems respectively.

Keywords: climate changes center pivot, fixed sprinkler.

INTRODUCTION

Farmers are encouraged because of directly and easily way to increase crop productivity by center pivot system (German and Parker, 2018). These led to the adoption of center pivot irrigation system in farm lands that used in the past traditional irrigation (furrow or flood) making yield more water-efficient and more productive. In addition, woodland and shrubland have been go to new Center pivot irrigation system-irrigated farm land (German *et al*., 2020). Uddin *et al*., 2010 reported that the losses in sprinkler irrigation systems vary between 0 to 45% of the applied water and that many of the losses are from evaporation of droplets in the atmosphere. So, these amounts of the evaporation losses affect sprinkler irrigation efficiency. The water that evaporates from water drops is related to the evaporation demand of the atmosphere, which is affected by climatic conditions. Zazueta, 2011 found that the evaporation demand is a measure of the available energy for the capacity of the air and evaporation to store and transmit water vapor. To get vapor form one gram of water from the liquid form it requires 2.42 kilojoules of the energy evaporation process.

De Vries *et al.* (2010) reported that the rate of evapotranspiration for vegetation (a given environment) is related to more than critical factors like vapor pressure, wind speed, solar radiation, and air temperature and while the most influential factors affect ET in the study area are solar radiation and wind speed. Mohammed *et al* (2023) found that coefficient uniformity with center pivot system was 84.9%, while the distribution uniformity was 75.5%. The application efficiency was 85.2 %

The climatic change affects the evaporative demand of the atmosphere which is related to the amount of water droplets that evaporates demand means the available energy for the capacity of the air and evaporation to store and convert water vapor. This evaporation needs 2.42 kilojoules of energy gas from 1 gram of water liquid. So, the energy has to be accessible surrounding the environment of the sprinkler to prevent evaporation during irrigation (Zazueta, 2011). Climatic changes like relative humidity, temperature and wind speed affect evaporation losses and wind drift. The most important factor is wind speed (Playán *et al*., 2005).

Moving drier or warmer air to displace the cool and moist air above irrigated areas leads to evaporation due to wind speed. It also raises the rates of evaporation by moving vapor of water from the irrigated area. The temperature of air gives needed energy for evaporation. As data, at high degrees of temperature, energy is easily available (Smajstrla and Zazueta, 2003). In agriculture, evapotranspiration is the major source of water loss. The most influential factors affect ET in the study area are solar radiation and wind speed. Furthermore, using windbreaks can decrease wind speed on a farm (Eric, 2015), in the same time studied the evaporation losses, distribution uniformity (DU), actual water application, coefficient of uniformity (CU), productivity and water use efficiency affected by absence or presence of windbreaks, layout of sprinkler, height of rotating sprinkler and climatic conditions. In addition, the coefficient of variation (CV) in application volume can be calculated by dividing the standard deviation of all catch cans measurements on the average catch can volume for a test. Warrick (1983) said that both distributions of uniformity for the low quarter and coefficient of uniformity are related to the

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analytical coefficient of variation (CV). There are many technical solutions to reduce the growing water scarcity phenomenon and governments from around the world have therefore pledged to decrease excessive for agriculture by improving water use efficiency in the agriculture sector (Brennan, 2008). Application efficiency be able to raise by using pressurized systems as sprinkler system (Rana *et al.*, 2006). The objective of this research is studing the impact of climate changes (temperature, wind speed and relative humidity) on the performance of the center pivot and fixed irrigation systems and productivity of penuts crop.

MATERIALS AND METHODS

Description of the study area

A field experiment was conducted on fixed sprinkler and center pivot irrigation systems to measure the effect of some climate change factors on the coefficient uniformity, distribution uniformity and evaporation losses under the conditions of Wadi EL-Natroun region - Egypt. With coordinates 30" 17` 4.92" N and 30" 29` 42.39" E (Figure 1.).

Measurements were taken at three times-monthly intervals from the first of June to the end of October planted peanut crops in an attempt to synchronize the different temperatures, humidity and evaporation conditions as well as the different wind speeds under two systems of irrigation which were center pivot system and fixed irrigation system.

The length of the center pivot system was 258 meters with six spans (the span is the pipeline and support truss between two support towers), the length of every span is 43 meters to irrigate a total area of 50 fedden. FSPS (Fixed spray sprinklers) were used with the overhang of the center pivot along the spans. Table 1 shows the description of the center pivot system and figure 2 shows a view plan of the center pivot system.

While a square spacing pattern (10m*10m) was used in the fixed sprinkler irrigation system. The height of the rotating sprinkler was 90 cm above the ground (figure 3 shows a layout of fixed sprinkler system network) with a flow rate of 1.2 m^3 /h at 2 bar.

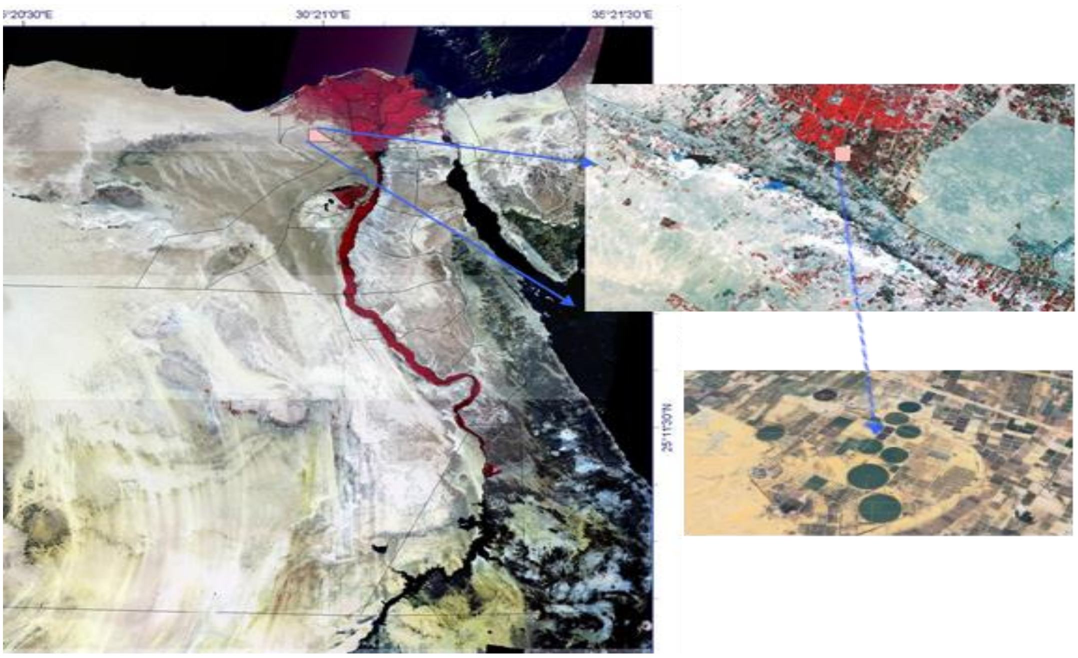

Figure 1. Satellite image showing the study site using Google Earth.

Peanut crop

The peanut variety was Giza 5, and before the planting process, seeds were mixed with the suitable species of rizobium. The seeds were planted on the 1st of June. Plants were harvested on the 10th of October for all treatments. Figure (4) shows the process planned method for calculating the irrigation requirements of peanut crops. All peanut plantation practices were conducted as recommended in the field.

Table 1. Description of center pivot irrigation system

NO. of Span	Length of Span (m)	Area (m^2)	Area (Fed.)	Sprinkler Numbers
1	43	5738	1.4	12
2	86	17426.4	4.1	15
3	129	29044	7	15
4	172	40661.6	10	15
5	215	52279.4	12.5	15
6	258	63896.8	15	15

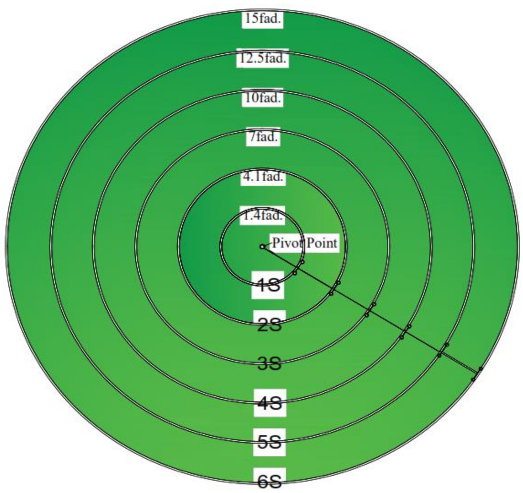

Figure 2. A view plan showing center pivot sprinkler irrigation system

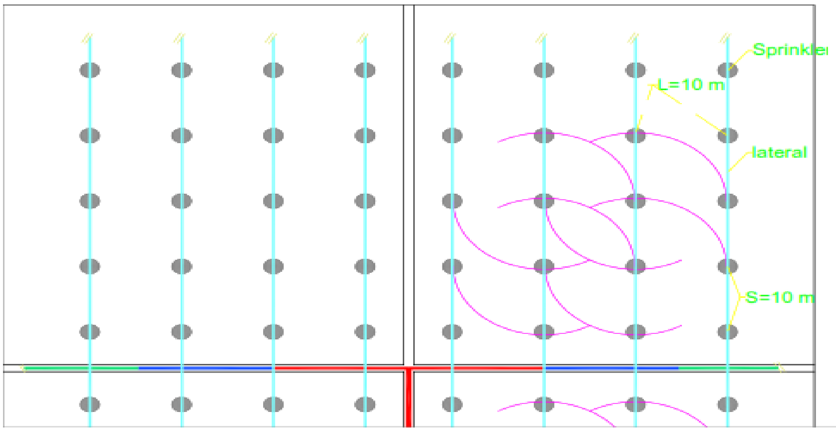

Figure 3. layout of fixed sprinkler system networ

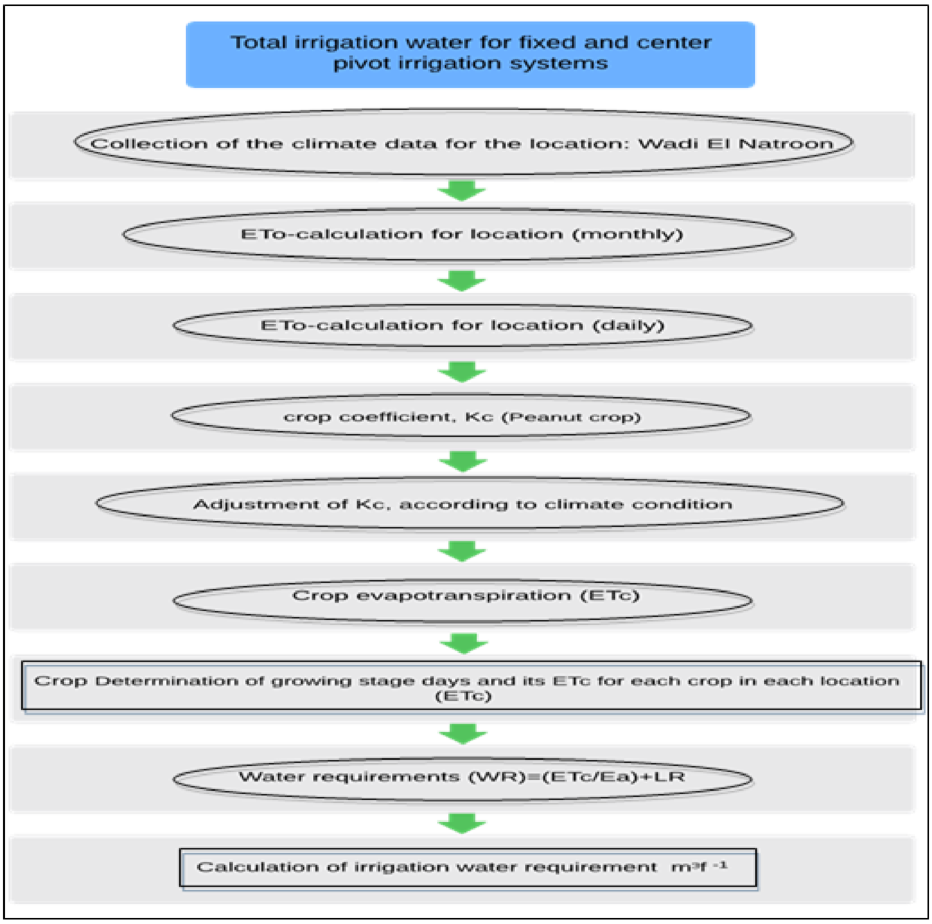

Figure 4. Process planned of method for calculating the irrigation requirements of peanut crop

For different growth stages, values of crop coefficient (Doorenbos and Pruitt, 1977) and root depth (present study) are presented in Table 2.

Table 2. Reference values for crop coefficient (Doorenbos and Pruitt, 1977) and root depth (present study) at different stages of growth

Stage	Growth stage	Month	Crop coefficient	Root depth (m)
		i) Peanut crop		
1	Establishment (initial)	June	0.4	0.1
2	Vegetative (development)	July	0.6	0.3
		August	1	0.5
3	Flowering (mid-season)	September	1	0.7
4	Yield formation (late)	October	0.85	0.7

Data of agro-meteorological

Data on agro-meteorological for the current research was obtained from Wadi EL-Natroun meteorological ground station. The data includes air temperature, atmospheric, vapor pressures, and wind speed at 2 m above sea level, relative humidity, precipitation and solar radiation for 2010–2020. These data were used mainly to calculate the reference evapotranspiration by using a modified Penman-Monteith equation (FAO-56PM), according to Allen *et al*. (1998), Table 3. show the reference climatologic data at Wade El Natron site during months of evaluation. Applied of water (m^3) per season for Peanut plants were 3468.24 m^3/fed per season show in Table 4.

Table 3. Reference climatologic data at Wade El Natron site during months of evaluation

Month	Tempreture mean (C°)	Relative Humidity mean (%)	Wind speed (m/s)	n (hour)	Number of hours	Ra, MJm-2d-1	Et_o
June	32.0	*62.5	3.3	12.4	13.5	40.0	6.4
July	35.0	*62.5	3.3	11.6	13.9	41.2	7.33
August	36.9	*71.5	2.9	11.9	13.8	40.6	7.79
September	34.4	*69.0	3.4	11.8	13.8	40.6	5.5
October	34.0	*68.5	3.1	11.6	13.1	38.0	4.33

Table 4. Total irrigation water for fixed and center pivot irrigation systems (m^3/fed/season)

Month	Irrigation efficiency (Ea)	Leaching requirement (LR)	Gross month (IR) (mm/month)	Total irri. (IR) (m3/fed/season)
	i) Peanut crop			
June	0.8	0.1	80.2	
July	0.8	0.1	161	
August	0.8	0.1	318.6	3468.78
September	0.8	0.1	217.6	
October	0.8	0.1	48.5	

Soil Analysis

Particle distribution of samples was in accordance with the international method (Klotte, 1986). The cylinder method is used in the soil profile for different layers to measure the soil bulk density. The pressure cooker and pressure membrane apparatus are used to determine the values of PWP (permanent wilting point) and FC (field capacity).

AWC (Available water capacity) was calculated by the differences in water content at a permanent wilting point and field capacity as follows:

Available water capacity = field capacity – permanent wilting point.

Calculations and measurements of some soil chemical properties shown by Jackson, 1973 Some soil chemical and physical properties were shown and measured in Tables 5 and 6.

Table 5. Soil physical properties of the experimental field before cultivation

Soil depth, cm	gravel (%)	Particle size distribution (%) Sand	Silt	Clay	Texture class	O.M (%)	CaCO3 (%)	Moisture content (Volumetric %) S. P.	F.C.	W.P.	AW (%)	Pb (Mg m^{-1})
0 – 20	33	88.4	7.2	4.4		0.27	22.4	23.5	11.9	4.8	7.1	1.42
20 – 40	32	87.5	8.0	4.5		0.3	25.3	24.3	10.3	4.3	6.0	1.51
40 – 60	40	89.3	7.4	3.3	Sandy	0.16	23.4	20.2	9.8	4.2	5.6	1.67
60 – 80	45	88.6	6.8	4.6		0.31	25.4	22.3	11.4	4.8	6.6	1.7
mean	37.5	88.45	7.35	4.2		0.26	24.13	22.6	10.87	4.25	6.32	1.58

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

Table 6. 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}) Ca^{+2}	Mg^{+2}	Na^+	K^+	Soluble anions (mmol$^+$ L^{-1}) Co^{3-} HCo^{3-}	Cl^-
0 – 20	8.24	0.40	2.00	1.38	0.23	0.93	2.20	1.97
20 – 40	8.35	0.37	1.30	1.48	0.20	0.92	1.87	1.82
40 – 60	8.37	0.29	1.10	0.90	0.14	0.71	1.52	1.20
60 – 80	8.43	0.22	1.02	0.81	0.12	0.51	1.30	0.90
mean	8.35	0.32	1.35	1.14	0.17	0.76	1.72	1.40

Application rate of sprinkler over the field

- The water depth collected is equal to the water volume collected for all cans divided by the area of the cans.
- Water depth (Dg) using the next formula: -

$$Dg = Ra \times Ti$$

Where:

Ra: application rate (mm/h).
Ti: operating time (h).

Ra: is calculated from the next formula: -

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

Where:

Q_{sp}: actual application rate (mm/h) at the time of system evaluation considering climate changes,
S_L: spacing between sprinklers.
S_S: spacing between lateral.

The cans were put as in figure (5) where a net of squares is inside the selected sprayers, which the layout of catch cans to test the uniformity of sprinkler on lateral line for fixed irrigation system.

On the other hand, Standards have been developed to determine the coefficient and distribution uniformities of center pivot system (ASAE, 2001).

All catch cans which used in the test for measuring the water depth without splash of water in or out. The lip of the catch cans was without depressions and symmetrical.

Collectors with 15 cm height and 20 cm opening diameter were used to collect the water. The tests were made on the outer of the center–pivot system. cans put in 100 m from the center pivot point and the space between cans was one meter.

It means the number was 90 catch cans along a line and to allow the system achieve working conditions catch cans were far from the pipe line.

It is necessary to read as quickly to avoid evaporation losses from the collectors. The depth of water collected was computed by dividing the volume caught on the area of catch cans, figure (6) shows the location of catch cans under center pivot systems.

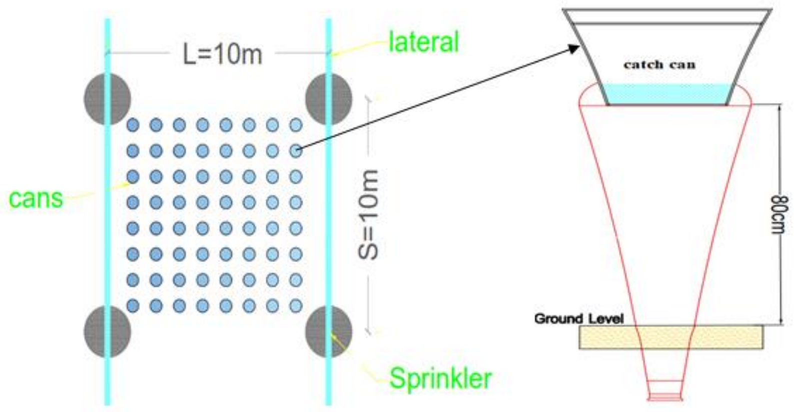

Figure 5. Layout the sprinklers in the field to test the uniformity for fixed irrigation system

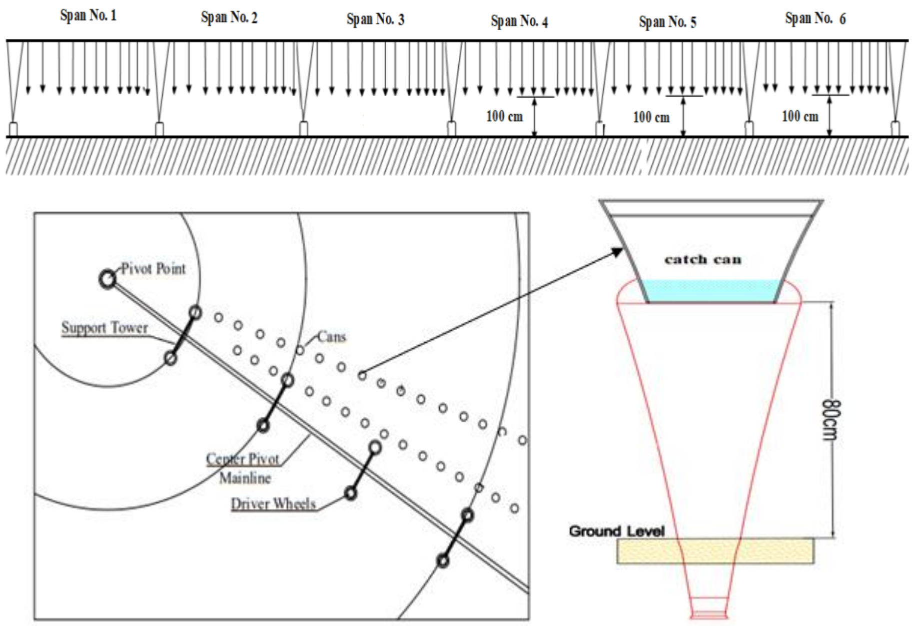

Fig. 6. The location of catch cans under center pivot systems

Evaluation of Uniformity for fixed sprinkler system

Coefficient uniformity (Cu)

Christiansen, 1942 calculated the coefficient uniformity for sprinkler irrigation system from the following equation: -

$$Cu = \left(1 - \frac{\sum_{i=1}^{i=n} |x_i - \bar{x}|}{n \cdot \bar{x}}\right) \times 100$$

Where:

CU: Coefficient uniformity, %

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

n: Number of observed cans.

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

Distribution uniformity (DU)

The distribution uniformity (which refers to the application through the field) was calculated by the following equation:

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

Keller and Bliesner (1990) reported that the average of low quarter water depth received is the average of the lowest one- quarter of the measured values.

Evaluation of Uniformity for center pivot system

There are many quantitative analyses methods of uniformity were used.

1- Coefficient uniformity (CU)

Coefficient uniformity of center pivot system was computed using the modified equation of Heermann and Hein (1968) according to (ASAE, 2001):

$$CU = \left[1 - \frac{\sum_{i=1}^{n} S_s \left| D_s - \frac{\sum_{i=1}^{n} D_s S_s}{\sum_{i=1}^{n} S_s} \right|}{\sum_{i=1}^{n} D_s S_s}\right] \times 100$$

Where:

Ds: depth of water (mm) which collected by catch cans (to a distance S from the center pivot)

s: this is subscript that denotes the position (to a distance S)

n: the number of catch can.

2- Distribution uniformity (DUlq)

Low quarter of distribution uniformity for irrigation (DUlq) was computed using the next formula (Merriam and Keller 1978):

$$DU_{lq} = \frac{ADC_{25}}{ADC} \times 100$$

Where:

ADC25: the lowest quarter of average water depth in catch cans.

ADC: the total average of water depth in catch-cans.

Evaporation losses (E)

The percentage of water losses (%) by air temperature and wind can be presented from the quantity of water application, at operating time of formula:

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

Where:

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

Irrigation water use efficiency (IWUE)

Vite, 1965 calculated the water use efficiency values by the following equation:

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

RESULTS AND DISCUSSION

Climatic changes

Data of average monthly meteorological in Wade El-Natron weather station, that were measured (above 2 meters on the ground surface) at the growth season at three times-monthly intervals (first test, second test and third test) from the first of June to the end of October, were shown in figures (7, 8 and 9).

Data in figures 7, 8 and 9 showed that, in June, the temperature of air increased from 36.10 C° at first test to 41.10 Co at second test, these air temperature increments represent 12.16%. In the same month, temperature of air decreased from 41.10 C° at the second test to 32.20 C° on the third test, these air temperature reductions represent 21.65%. While wind speed was 20 km/h. at first test and decreased to 14.10 km/h. and 13.10 km/h. on the second and third tests respectively. Relative humidity was 83% at first test and increased to 88% on the second and third tests.

While, data showed that, in July, the temperature of air increased from 38.8 C° on the first test to 42.7 C° on the third test, these air temperature increments represent 9.13%. In the same month, wind speed was 13.02 km/h. at first test and increased to 15.20 km/h. at second test and decreased again to 12.20 km/h. at third test. Relative humidity ranged from 90% to 94% under all tests in this month.

On the other hand, data showed that, in Aug., the temperature of air decreased from 38.80 C° on the first test to 32.2 C° on the second test, these air temperature reductions represent 17%. In the same month, the temperature of air increased from 32.20 C° on the second test to 36.10 C° on the third test, these air temperature increments represent 10.8%. While wind speed was 19 km/h on the first test decreased to 16.4 km/h on the second test and increased again to 17.20 km/h on the third test. Relative humidity was 73% on the first test and increased to 83% and 89% on the second and third tests, respectively.

Also, data in figures 7, 8, and 9 showed that in Spt., the temperatures of air were almost the same degree on the first and third test (37.7 C° and 37.2 C° respectively) and decreased to 32.2 C° on the second test and wind speed were almost the same at first and second test (14.4 km/h and 14.3 km/h) then decreased to 12.3 km/h on the third test. Relative humidity was the same percentage 83% on the first and second tests but increased to 94% on the third test.

At the same time, data showed that, in Oct., The difference between the degrees of temperature was not more than 1 C° or 2 C° at the first, second, and third tests. The same trend for wind speed which was not more than 1 km/h. or 2 km/h, while the relative humidity was the same (78%) on the first and second tests and increased to 94% on the third test.

From the above, it became clear that there were variations in temperatures, wind speed and relative humidity during one month, other than the variations between the five months of measurement from June to October.

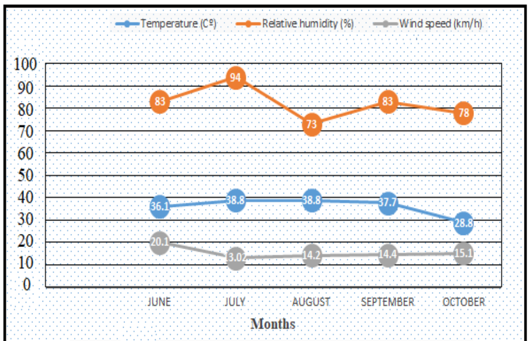

Figure 7. Climate data at first test

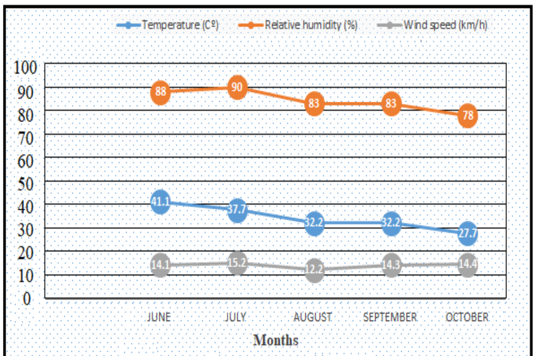

Figure 8. Climate data at Second test

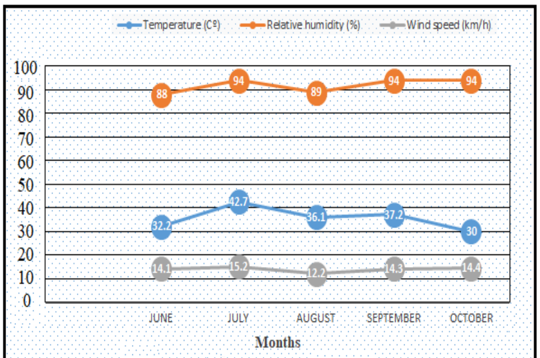

Figure 9. Climate data at third test

So these changes in weather and climate should have been studied and this inequality and variability and its impact on the performance of fixed sprinkler and center pivot systems in terms of evaporation loss, coefficient uniformity, distribution uniformity and application efficiency.

Evaporation Loss

Data in Figure (10) showed that, in June, evaporation losses (EL) changed from the catch can to another catch can in an irrigated area. The average of evaporation losses from individual catch cans in irrigated areas is presented in every test, together with the average of climatic conditions at the time of the test. The highest and lowest evaporation loss values, under the center pivot irrigation systems, were 15.5% to 12.35% on the second and third tests respectively. While the highest and lowest evaporation losses values, under fixed sprinkler irrigation system, were 30.75% to 20.10% on the second and third tests respectively. Evaporation losses values increased by 15.25% and 7.75% on the third and second tests respectively for center pivot to fixed sprinkler irrigation systems.

In July, the highest and lowest evaporation losses values, under the center pivot irrigation system, were

20.10% to 18.50% on the third and second tests respectively. While the highest and lowest evaporation losses values, under the fixed sprinkler irrigation system, were 33.72% to 26.72% on the third and second test respectively. Evaporation losses values increased by 13.62% and 8.22% at third and second test respectively from center pivot to fixed sprinkler irrigation systems (Figure 10).

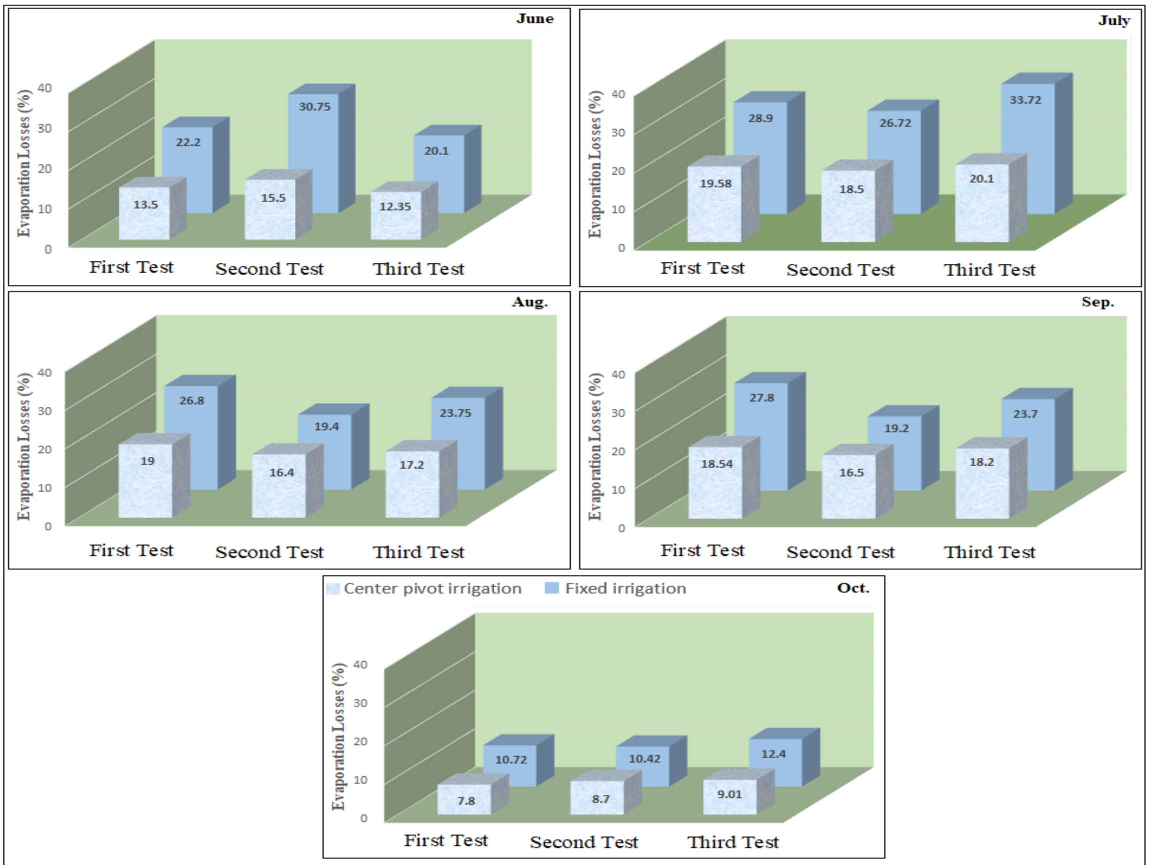

Fig. 10. Evaporation Losses (%) with center pivot and fixed irrigation systems at during season

On the other hand, the data showed that, in Aug., the biggest and lowest evaporation losses values, under center pivot irrigation system, were 19% to 16.4% at first and second test respectively. While the biggest and lowest evaporation losses values, under fixed sprinkler irrigation system, were 26.8% to 19.4% on the first and second test respectively. Evaporation losses values increased by 7.8% and 3% on the first and second test respectively from center pivot irrigation to fixed sprinkler irrigation system (Figure 10).

While data in Figure (10) showed that, in Spt., the biggest and lowest evaporation losses values, under center pivot irrigation system, were 18.54% to 16.5% on the first and second test respectively. While the biggest and lowest evaporation losses values, under fixed sprinkler irrigation system, were 27.8% to 19.2% on the first and second test respectively. Evaporation losses values increased by 9.62% and 2.7% on the first and second test respectively from center pivot irrigation to fixed sprinkler irrigation system.

Also data in Figure (10) showed that, in Oct., the highest and lowest evaporation losses values, under center pivot irrigation system, were 9.01% to 7.8% at third and first test respectively. While the highest and lowest evaporation losses values, under fixed sprinkler irrigation system, were 12.4% to 10.72% on the third and first test respectively. Evaporation losses values increased by 3.4% and 2.92% on the third and first test respectively for center pivot to fixed sprinkler irrigation systems.

From the above, the data also appeared that evaporation and evapotranspiration are a function of climate changes, and any change in relative humidity, wind speed, and air temperature is expected to lead to a change in evaporation losses where, data indicated the average of evaporation losses affected by relative humidity, wind speed and air temperature.

This significant difference in the evaporation losses for different sprinkler systems under many scenarios is attributable to climate changes (the differences in relative humidity, temperature and wind speed during the month and between the months) in addition to the sprinklers for center pivot was above the ground surface directly (100 cm) and speed of device was 100%, where the riser of sprinklers for fixed irrigation was 90 cm translated to the evaporation losses increased proportionately with increased relative humidity, air temperature and wind speed due to increased wind speed reducing aerodynamic resistance to water vapor transmission, increasing crop transmission (Nuberg, 1998), When replacing an air layer with drier air and increased wind speed removes this layer, the crop will increase its recovery rate while evaporation from the ground increases.

Coefficient uniformity CU (%)

In June, the highest and lowest coefficient uniformity values under the center pivot irrigation systems were 84.1% to 83% on the first and third tests. The highest and lowest coefficient uniformity values under fixed sprinkler irrigation systems were 82.3% to 72.5% on the third and second tests. Coefficient uniformity values decreased by 4% and 10.51% on the first and second tests for center pivot irrigation to fixed sprinkler irrigation system (Figure 11).

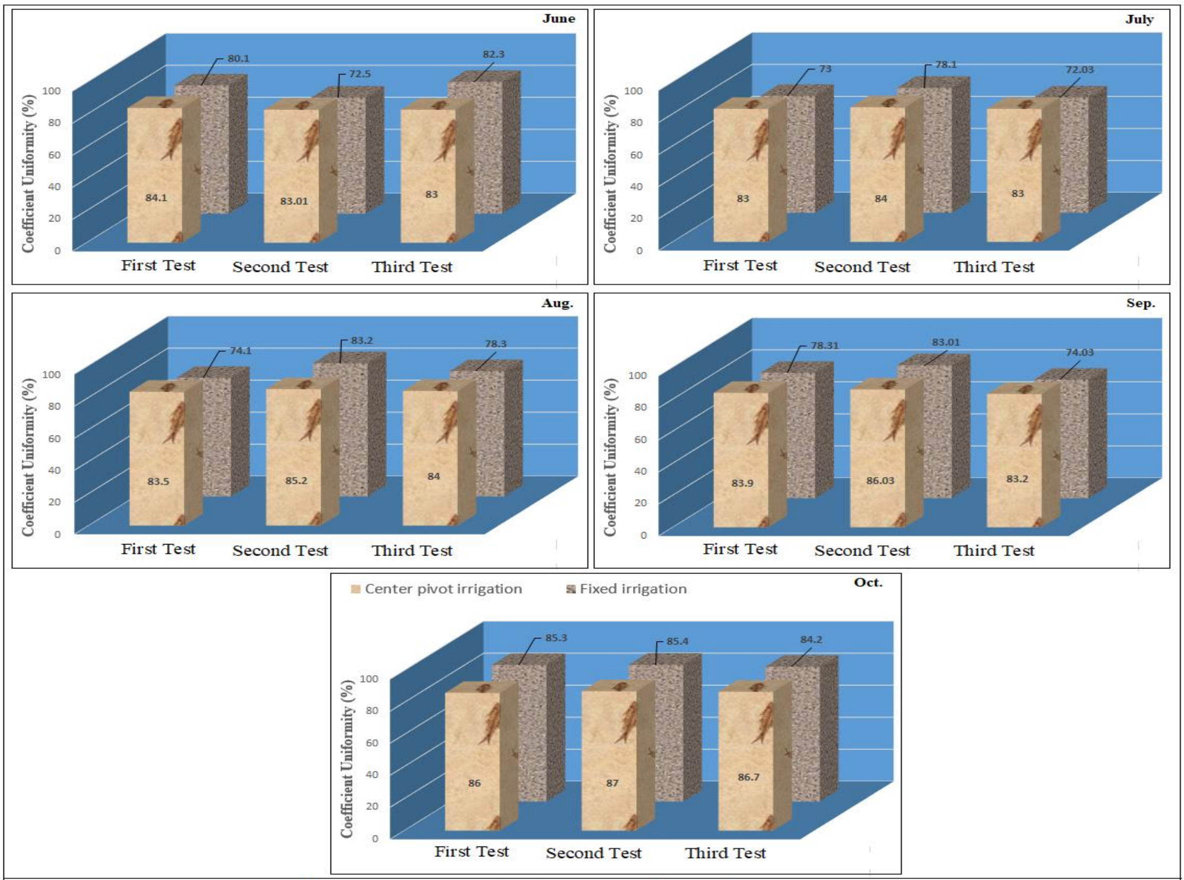

Fig. 11. Coefficient Uniformity (%) with center pivot and fixed irrigation systems at during season

Also data in Figure (11) showed that, in July., the highest and lowest coefficient uniformity values, under the center pivot irrigation systems, were 84% to 83% on the second and first tests respectively. While the highest and lowest coefficient uniformity values, under fixed sprinkler irrigation systems, were 78.1% to 72.03% on the second and third tests respectively. Coefficient uniformity values decreased by 10%, 5.9% and 10.97% on the first, second and third tests respectively for center pivot irrigation to fixed sprinkler irrigation system.

While data in Figure (11) showed that, in Aug., the highest and lowest coefficient uniformity values, under center pivot irrigation systems, were 85.2% to 83.5% on the second and first tests respectively. While the highest and lowest coefficient uniformity values, under fixed sprinkler irrigation systems, were 83.2% to 74.1% on the second and first tests respectively. Coefficient uniformity values decreased by 9.4%, 2% and 5.7% on the first, second and third tests respectively for center pivot to fixed sprinkler irrigation systems.

On the other hand, the data showed that, in Sep., the highest and lowest coefficient uniformity values, under center pivot irrigation systems, were 86.03% to 83.2% on the second and third tests respectively. While the highest and lowest coefficient uniformity values, under fixed sprinkler irrigation systems, were 83.01% to 74.03% on the second and third tests respectively. Coefficient uniformity values decreased by 5.6%, 3.02% and 9.17% on the first, second and third tests respectively for center pivot irrigation to fixed sprinkler irrigation systems (Figure 11).

Data in table (16) showed that, in Oct, changes in coefficient uniformity values were not significant between the two systems or between tests which ranged between 86% to 87% under all tests, also ranged between 84% to 85% with two systems.

Distribution uniformity DU (%)

Data in Figure (12) showed that, in June, the highest and lowest values of distribution uniformity with a center pivot systems were 79% to 73% on the second and third tests, respectively. The highest and lowest values of distribution uniformity for a fixed sprinkler system were 77.2% to 66% on the second and third tests, respectively. Distribution uniformity values decreased by 2%, 7%, and 1.8% on the the first, second, and third tests, respectively, from center pivot irrigation to fixed sprinkler irrigation system.

While data in Figure (12) showed that, in July., the highest and lowest values of distribution uniformity, under center pivot systems, were 79.4% to 77.0% on the second and third tests respectively. While the highest and lowest values of distribution uniformity, with fixed sprinkler systems, were 74.81% to 66% on the second and third tests respectively. Distribution uniformity values decreased by 12%, 4.6% and 10% on the first, second and third tests respectively for center pivot to fixed sprinkler systems.

On the other hand, the data showed that, in Aug., the highest and lowest values of distribution uniformity, with center pivot systems, were 78% to 73.4% on the second and first tests respectively. While the highest and lowest values of distribution uniformity, under fixed sprinkler systems, were 76.42% to 68.2% on the second and first tests respectively. Distribution uniformity values decreased by 5.2%, 1.6% and 3% on the first, second and third test respectively for center pivot irrigation to fixed sprinkler irrigation system (Figure 12).

Also data in Figure (12) showed that, in Spt., the highest and lowest values of distribution uniformity, under center pivot systems, were 78.2% to 73.5% on the second and third tests respectively. While the highest and lowest values of distribution uniformity, with fixed sprinkler systems, were 76.72% to 68% on the second and third tests respectively. Distribution uniformity values decreased by 3.1%, 1.5% and 5.5% on the first, second and third tests respectively for center pivot irrigation to fixed sprinkler irrigation system. In Oct, changes in distribution uniformity values were not significant between tests which ranged between 79% to 80% under all tests for center pivot irrigation system, also was almost 77.4% with fixed sprinkler irrigation system (Figure 12).

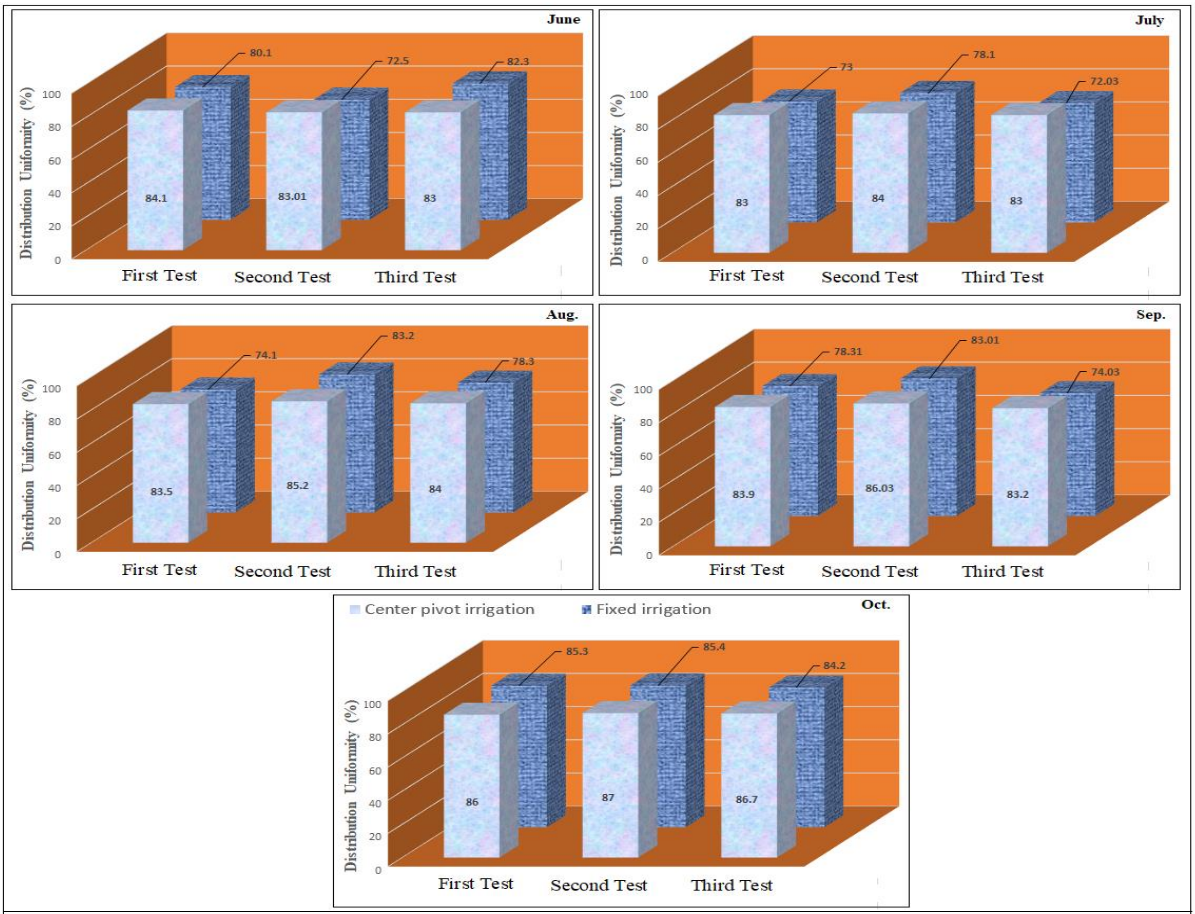

Fig. 12. Distribution Uniformity (%) with center pivot and fixed irrigation systems at during season

Application Efficiency Ea (%)

Data in Table (7) indicated that application efficiency (Ea) was 80.0% under a fixed irrigation system and 88.2% under a center pivot system with an increment of 8.2% due to the reduction in the uniformity for fixed irrigation system because of variables of temperatures, wind speed, and relative humidity changes during planting season.

Production Yield (kg/fed)

The data in table (7) indicated that the performance of irrigation system was affected by climatic changes from temperature, humidity and wind speed, thus effect on the application efficiency and hence production yields of two irrigation systems, where the production crop of the fixed irrigation system was 1228.8 kg/fed. and was 1584.8 kg/fed. under center pivot system by increment 356 kg/fed. with the same application rate of water 3468.24 m3/fed.

Irrigation Water Use Efficiency (kg/m^3)

The data in Table (7) indicated the effects of climatic changes and the performance of water use efficiency (based on pod yield). Irrigation water use efficiency was 0.345 kg/m3 under a fixed irrigation system and increased to 0.457 kg/m3 under a center pivot irrigation system due to more uniformity and efficiency.

Table 7. Application Efficiency (%), Production yield of Pods (kg/fed.) and Water Use Efficiency (kg/m^3) under center pivot and fixed irrigation systems

Irrigation systems	Application Efficiency (%)	Water applied (m^3/fed.)	Production yield of Pods (kg/fed.)	Water Use Efficiency (kg/m^3)
Fixed irrigation	80.0	3468.24	1228.8	0.345
Center pivot	88.2	3468.24	1584.8.	0.457

CONCLUSION

Climatic changes (especially relative humidity, temperature and wind speed) significantly affect the performance of the fixed sprinkler and center pivot irrigation systems (distribution uniformity, coefficient uniformity and application efficiency), However, this effect varies between the two systems under study, as its impact on fixed spray irrigation is much greater than on axial irrigation. The relationship between evaporation loss and climatic changes (wind speed, temperature and relative humidity) was assessed to calculate evaporation loss related to climatic changes. This information about climatic variables is important because it provides knowledge of the most significant variables if evaporation loss is to be reduced. Lastly, in the future climate, the change of the projections indicated that the Wade el-natron area will get hotter. Selecting a suitable irrigation system can help reduce water losses with sprinkler irrigation systems.

RECOMMENDATION

Recommends the use of the center pivot irrigation system as it increases the efficiency and performance of irrigation compared to fixed sprinkler irrigation, also, to reduce the impact of high temperatures with high wind speeds and high humidity must be used windbreak when using different types of sprinkler irrigation systems.

REFERENCES

Allen R.G., Pereira L.S., Raes D. and Smith M. 1998. Crop evapotranspiration; Guidelines for computing crop water requirements. FAO, irri gation and drainage, Rome, 56 p.

ASAE (2001). Test procedure for determining the uniformity of water distribution of center pivot and lateral move irrigation machines equipped with spray or sprinkler nozzles. ANSI/ASAE Standard S436.1, American Society of Agricultural Engineers, St. Joseph, MI.

Brennan, D. (2008). Factors affecting the economic benefits of sprinkler uniformity and their implications for irrigation water use. Irrig. Sci., 26:109–119

Christiansen, J. E. (1942). Irrigation by sprinkler. Univ. of California, Berkeley, BuI. 670. OCT.

de Vries, T. T., Cochrane, T. A., & Galtier, A. (2010). Saving irrigation water by accounting for windbreaks. Paper presented at the Sustainable Irrigation Conference, Bucharest, Romania.

Doorenbos J. and Pruitt W.O. 1977. Crop water requirements Irrigation and drain age. Paper No.24. Food and Agric. Organization of the United Nations. FAO, Rome, Italy. 144p.

Eric K. K. (2015). The effect of windbreaks on the effectiveness of sprinkler irrigation systems. University of Canterbury. Water ways Centre for Freshwater Management. Christchurch, New Zealand. A thesis submitted in partial fulfilment of the requirements for the Degree in Master of Water Resource Management.

German, L.A., Parker, L., 2018. The social construction of “shared growth”: Zambia sugar and the uneven terrain of social benefit. J. Agrar. Chang. 19, 181–201.

German, L.A., Hepinstall-Cymerman, J., Biggs, T., Parker, L., Salinas, M., 2020. The environmental effects of sugarcane expansion: a case study of changes in land and water use in southern Africa. Appl. Geogr. 121, 102240.

Heermann, D.F. and Hein, P.R. (1968). Performance characteristics of self-propped center pivot sprinkler irrigation system. Trans. ASAE 11:11-15.

Jackson, M. L. (1973) Soil chemical analysis. Prentice-Hall, Inc. Englewood Cliffs, N.J. New Delhi, India.

Keller, J. and Bliesner, R. D. (1990) Sprinkler and trickle irrigation. Chapt. 6, (set sprinkler uniformity and efficiency. And Chapt. 20 Emitter selection and design criteria).

Klute, A. (1986) Method of soil analysis. Part -1. physical and Mineralogical methods.2nd American Society of Agronomy, Madison, Wisconsin, USA.

Merriam, J. L., and Keller, J. (1978). Farm irrigation system evaluation: A guide for management, Dept. of Agricultural and Irrigation Engineering, Utah State Univ., Logan, Utah.

Mohammed, A. S. S., Mohamed, O. M., Al Najjar, A., and Awwad, A. H. (2023). Maximizing the Benefit of Old Center Pivot Irrigation Systems in Egypt. International Journal of Engineering Research & Technology (IJERT) Vol. 12 Issue 11, November-2023

Nuberg, I. K. (1998). Effect of shelter on temperate crops: A review to define research for Australian conditions. Agroforestry Systems, 41(1), 3-34. doi: 10.1023/A:1006071821948

Playán, E., Salvador, R., Faci, J. M., Zapata, N., Martínez-Cob, A., & Sánchez, I. (2005). Day and night wind drift and evaporation losses in sprinkler solid-sets and moving laterals. Agricultural Water Management, 76(3), 139-159. doi: 10.1016/j.agwat.2005.01.015

Rana, M. A.;Arshad, M. and Masud, J. (2006).Effect of basin, furrow and raingun sprinkler irrigation systems on irrigation efficiencies, nitrate-nitrogen leaching and yield of Sunflower.Pakistan J. Water Res., 10:17.

Smajstrla, A. G., & Zazueta, F. S. (2003). Evaporation loss during sprinkler irrigation. In I. o. F. a. A. S. Agricultural and Biological Engineering Department, University of Florida, USA. (Ed.).

Uddin, J., Smith, R., Nigel, H., & Foley, J. (2010). Droplet evaporation losses during sprinkler irrigation: An overview. Paper presented at the One Water Many Future, Australian Irrigation Conference and Exhibition,, Sydney, 8-10 June 2010.

Warrick, A. W. (1983). Interrelationships of irrigation uniformity terms.J. of Irrigation and Drainage Engineering. 109: 317-332.

Zazueta, F. S. (2011). Evaporation loss during sprinkler irrigation. BUL290. Revised November 2011. Gainsville, Florida: IFAS Extension, University of Florida.

تأثير التغيرات المناخية على أداء أنظمة الري بالرش المحوري والثابت في التربة الرملية

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الملخص

تم إجراء تجربة حقلية خلال موسم النمو 2023 لدراسة تأثير التغيرات المناخية من درجة حرارة وسرعة رياح ورطوبة نسبية على أداء أنظمة الري المحوري والري بالرش الثابت في حقل مفتوح بالتربة الرملية في منطقة وادي النطرون - محافظة البحيرة بمصر. الهدف من هذا البحث هو دراسة تأثير التغيرات المناخية على الفقد بالبخر، ومعامل الانتظامية (CU) وانتظامية التوزيع (DU) وكفاءة استخدام المياه، وإنتاجية الفول السوداني.وأشارت النتائج إلى ما يلى: تم الحصول علي أعلي قيمة للفقد بالبخر خلال شهر يونيو (درجة الحرارة =27مº رطوبة نسبية 94%-سرعة رياح 12.2 كم/س) حيث كانت 20.1% و 33.72% مع نظام الري المحوري ونظام الري بالرش الثابت علي التوالي. بينما تم الحصول علي أقل قيمة للفقد بالبخر خلال شهر أكتوبر (درجة الحرارة =27.7مº رطوبة نسبية 78%-سرعة رياح 14.4 كم/س) حيث كانت 8.7% و 10.42% مع نظام الري المحوري ونظام الري بالرش الثابت علي التوالي. تم الحصول علي أعلي قيمة لانتظامية التوزيع خلال شهر أكتوبر (درجة الحرارة =28.8مº رطوبة نسبية 78%-سرعة رياح 15.1 كم/س) حيث كانت 80% و 77.8% مع نظام الري المحوري ونظام الري بالرش الثابت علي التوالي.تم الحصول علي أعلي قيمة لمعامل الانتظامية خلال شهر أكتوبر (درجة الحرارة =27.7مº رطوبة نسبية 78%-سرعة رياح 14.4 كم/س) حيث كانت 87% و 85% مع نظام الري المحوري ونظام الري بالرش الثابت علي التوالي. زيادة الانتاجية بنسبة 22.46% مع نظام الري المحوري مقارنة مع نظام الري بالرش. كفاءة الاستخدام المائي لمحصول الفول السوداني كانت 0.345 كجم/م3 مع نظام الري المحوري و 0.457 كجم/م3 مع نظام الري بالرش الثابت.

الكلمات ادالة: التغيرات المناخية –الري المحوري – الري بالرش الثابت .