*IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*
*e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 12, Issue 1 Ver. I (January 2019), PP 01-09*
*www.iosrjournals.org*

# Effect of Weather Conditions, Operating Pressure and Riser Height on the Performance of Sprinkler Irrigation System

Abdelmoneim Elamin Mohamed[1], Abdelrhman Mohamed Nour Hamed[2], Asma Abdelazim Mohamed Ali[1] and Mohmed A. M. Abdalhi[2,*]
[1](*Department of Agricultural Engineering, Faculty of Agriculture / University of Khartoum, Sudan)*
[2](*Department of Agricultural Engineering, Faculty of Agricultural technology and Fish sciences / Al-Neelain University, Sudan)*
*Corresponding Author: Abdelmoneim Elamin Mohamed*

**Abstract:** *This study was conducted during February and May 2016 at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum at Shambat (Longitude 32o 32` E, Latitude 15o 40` N and Altitude 380 m amsl), on a total area of 40m× 30m, with the objective of determining water distribution efficiency due to the effect of different weather conditions during three periods in the day (morning 08:00- 09:00 a.m., mid-day 12:00 - 02:00 p.m., evening). The study also included determination of Christiansen's coefficient of uniformity (CU%) and the distribution uniformity (DU%) for each of the above mentioned periods under two operating pressures of 1.0 and 2.0 bar and two riser heights of 1.0 and 1.5 m. Plastic sprinkler heads (LEGO) sing1e nozzle type were used .The experiment consisted of testing the effect of wind, evaporation and drift losses on water distribution uniformity (Christiansen's coefficient of uniformity - CU% and uniformity of distribution - DU%). The Randomized Complete Block Design (RCBD) was used. The meteorological data (Wind speed, air temperature and relative humidity) were obtained from Shambat weather station at the times of tests. Data were analysed using Statistical Analysis System programme (SAS).The statistical analysis showed that there were significant differences ($P \geq 0.05$) in CU% and DU% values at the different periods of the day under the two operating pressures and the two riser heights. The highest CU% and DU% values of 84% and 78%, respectively, were obtained in the morning tests under the operating pressure of 2.0 bar and riser height of 1.0 m. Higher efficiencies were obtained at low wind speeds , high relative humidity and low temperatures. All CU% and DU% values were within the acceptable range as stated by the previous publications. Operating pressure and riser height should be considered when designing sprinkler systems, while the prevailing weather conditions should be considered when operating the system.*

**Keywords:** *Coefficient, distribution uniformity, evaporation, pressure, sprinkler, weather*

---

Date of Submission: 23-12-2018 Date of acceptance: 07-01-2019

---

## I. Introduction

The global population is expected to increase to about 30% by the year 2030,and as a result demand for food will increase (FAO,2000). Irrigation historically has played and will continue to play a critical role in agricultural development. It supplies the water needed for crop growth when rainfall is limited. The increasing need for crop production for growing population is causing rapid expansion of irrigation throughout the world. The major irrigation method practiced in Sudan is surface irrigation. The demand for labor in this method is very high if compared to that for pressurized systems such as sprinkler and drip irrigation methods. They are of high efficiency, low water losses, and low labor demands (Ali, 2000). A sprinkler irrigation system uses pressure energy to form and distribute 'rain like droplets" over the land surface. This method of irrigation was started about 1900. Although, they are normally designed to supply the irrigation requirements of the farm, sprinkler systems are also used for crop and soil cooling , frost protection, controlling wind erosion, providing water for germinating seeds, application of agricultural chemicals, and land application of waste water. In a sprinkler system, water is conveyed from a source of water under pressure through a network of pipes called mainlines and sub-mains, to one or more pipes with sprinkler laterals (Abo-Ghohar and Al-Amoud, 1992 and Brouwer *et al*, 2001). Michael, (1978) mentioned that not only the application of the right amount of water to the field , but also its uniform distribution over the field is important. Permissible lengths of irrigation runs are controlled to a large extent by the uniformity of water distribution which is possible for a given soil and irrigation management practice. Water distribution uniformity indicates the extent to which water is uniformly distributed along the run (Eq. 1).

Sprinkler irrigation distribution uniformity can be computed using the following equation: -

DU% = Average of the lowest 25% of applied depths ÷ average applied depth (1)

Acceptable values of uniformity coefficient vary with the type of crop being grown and the specific uniformity equation used. Both equations result in approximately the same values when uniformity is high. However, DU values are normally much lower than CU values when uniformities are low. For high cash value crops ,especially shallow rooted crops, the uniformities should be high (DU values greater than 80% or CU values greater than 87%). For typical fields crops ( DU values should be greater than 70% and CU values greater than 81%). For deep rooted orchard and forage crops, uniformities may be fairly low if chemicals are not injected (DU values above 55% and CU values above 72%).Uniformity coefficient should be high (DU values greater than 80% or CU values greater than 87%) whenever fertilizers or other chemicals are injected into the irrigation systems. If uniformity coefficients are lower than these values, system repair, adjustment or modification may be required. 1f uniformity coefficients are periodically measured (at least annually),system repairs or adjustments can be scheduled when coefficients fall below the above values (Smajstrla *et al*., 2005).Many studies e.g. field tests, laboratory, analytic and physical and mathematical, have been conducted to quantify the magnitude of the evaporation and drift losses during water application by sprinkler irrigation. However, these studies were not defined under the same terms and conditions. had different accuracy levels and attained results that varied greatly. Kincaid *et al*. (1996). Kohl *et al*. (1987) and Yazar (1984) reported losses that varied from 2 to 40% (mostly 10 to 20%) from field tests. Analytic and laboratory investigations reported that losses ranged from 0.5 to 2% (Kohl *et al*.,1987). From laboratory tests Kincaid and Longley (1989) found that droplet evaporation losses in sprinkler irrigation are usually less than 2-3%, even under high air temperature and low relative humidity. Under normal condition they Were almost negligible. In comparison, under moderate evaporative condition the losses should not be more than 5-10% (Keller and Bliesner 1990). Droplet evaporation during sprinkler irrigation is not only a direct loss of water, but it also has a significant effect on microclimate, It improves the microclimate of the irrigated area by reducing temperature and vapour pressure deficit which leads to a decrease in the transpiration and soil evaporation (Thompson *et al*., 1993).

There are many equipment-related factors (nozzle size, angle, operating pressure and height of the sprinkler) and climatic factors (air temperature, air friction, relative humidity, solar radiation and wind velocity) that contribute to evaporation losses. Abo-Ghobar (1993) reported that the evaporation losses increased with decreasing nozzle size, relative humidity and increased with air temperature and wind velocity. Yazar (1984) observed that wind speed and vapour pressure deficit are the predominant factors that affect evaporation losses significantly during sprinkler irrigation and conciuded that the losses are exponentially correlated with wind speed and vapour pressure deficit.

Operating pressure had very little effect on the evaporation losses. Droplet size resulting from the nozzle is the most important factor in evaporation losses. Many researchers have reported that the diameter of the nozzle played a major role in the breakup of the droplets and indirectly influenced the evaporation losses (Kohl and Wright 1 974, Solomon *et al*., 1985).

The performance of sprinkler irrigation systems is greatly affected by both the direction and magnitude of the prevailing wind. Wind is the chief modifier that reduces the diameter of throw and changes the profiles of sprinklers. Wind speed in combination with sprinkler spacing bas significant impact on the uniformity of set-move sprinkler irrigation systems. The problem is pronounced especially when wind speed exceeds 8 km/h. Another phenomenon associated with the wind condition is ‘wind skips’, which occurs when there is a large difference in wind speed and/or direction between adjacent irrigation sets. This creates temporary dry zones adjacent to the sprinkler laterals on the upwind side. It is, however, not cumulative and successive irrigations/moves correct this effect (King *et al*., 2000).

Merkley and Allen (2004) reported that occasionally, wind can help improve uniformity as the randomness of wind turbulence and gusts contribute to smoothening out the distribution pattern/profile. There are three main types of sprinkler spacing patterns and a number of variations to adapt these patterns to special situations. These spacings are the square, rectangular and triangular patterns. The square pattern has equal distances running between the four sprinkler positions and it is suitable for irrigating square-shaped areas. The limitation of this pattern is the diagonal distance between sprinklers in the corners and this is usually susceptible to wind effects. To minimize wind effects, closer spacing is recommended depending on the severity of the wind. The rectangular sprinkler spacing has sprinkler positions forming a rectangle with the shorter side of the rectangle across the wind and the longer side with the wind, so as to obtain a good coverage. This pattern has the advantage of fighting windy situations and it is suitable for areas with defined straight boundaries and corners. In the triangular pattern, sprinklers are arranged in equilateral triangle formats so that the distance from each other is equal. This pattern allows for lengthy spacing and therefore requires fewer sprinklers compared to the square spacing, for a specified area. Furthermore, two of the above patterns can also be combined on the same site to achieve optimum sprinkler coverage (Phocaides, 2000). Table I shows sprinkler spacing as affected by wind speed.

**Table1. Effect of wind speed on sprinkler spacing**

| | Diameter of wetted circle (m) | | |
|---|---|---|---|
| | 32 | 37 | 42 |
| Wind speed(m/s) | Sprinkler Spacing (m) | | |
| No Wind | 21 | 24 | 27 |
| 0-2.5 | 18 | 21 | 24 |
| 2.5- 5.0 | 15 | 18 | 21 |
| Over 5.0 | 9 | 12 | 12 |

Source: Kay (1983).

## II. Materials and Methods

### 2.1 Experimental site, design and layout

The study was conducted during February and May 2016 to assess the uniformities of an existing solid set sprinkler irrigation system. The experimental work was carried out at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum, Shambat (longitude 32° 32́ latitude 15° 40́ N and altitude 380 m AMSL).

This study evaluated coefficient of uniformity and distribution uniformity by measuring the water volume applied by different combinations of operating pressure and riser height. Two operating pressure levels (1.0 and 2.0. bar),one sprinkler nozzle diameter (4.0mm) and two riser heights(1.0 and 1.5 m).The experimental design used was the Randomized Complete Block Design (RCBD). The combinations of the different variables are presented in Table 2 .

**Table2. Combinations of operating pressures and riser heights**

| Rep.1 | Rep.2 | Rep.3 |
|---|---|---|
| PIRI | P2RI | PIR2 |
| P2R2 | P2R2 | P2R1 |
| PIR2 | P2R2 | PIR1 |
| P2RI | P1RI | P2R2 |

Where:
P1= Operating pressure (1.0 bar).
P2 = Operating pressure (2.0 bar).
Rl = Riser height (1.0 m).
R2=Riser height(l 5m), and Rep.1, Rep.2 and Rep.3 = Replication 1, 2 and 3 respectively.

The tests were conducted to investigate the effect of wind, riser height and operating pressure on sprinkler performance. Tests were carried out under different wind conditions during the morning (from 9 a.m. to l0 a,m.), mid-day (from 12 p.m. to 1p.m.) and evening (from 3p.m.to 4p.m.).The system was operated at half an hour in each test in the three mentioned periods in the day with the different combination tests with three replicates as shown in Table 2.

### 2.2 Materials used in the installation of the system

A centrifugal 1hp electrical pump (ASIA) and discharge 108.01/min
A centrifugal 1 hp electrical pump (ASIA) and discharge 50.01min
Water storage tank of 7.5m3
A PVC plastic pipe with diameter of 38.1 mm.
A PVC plastic pipe with diameter of 25.0 mm.
Galvanized steel pipes with diameter of 18.0 mm.
Lego 55 part/full circle with diameter 4.0 mm , plastic head (single nozzle)

### 2.3 Materials used in the evaluation of the system

- Pressure gauge (10.0 bars).
- Meter tape(30.0m).
- Catch cans.
-Measuring cylinder (250.0ml).
- Stop watch.

### 2.4 Sprinkler system performance

Before starting the experiment, the sprinkler system was tested to verify its proper operation within the acceptable performance parameters following the procedure adopted by Makki (1996). These parameters were sprinkler discharge and pressure at the sprinkler head, water application rate (cm/h) and system discharge (m3/h). Pressure and discharge at the sprinkler head, distance of throw and water application rates were within the range specified by the manufacturer.

**2.5 System components**

**2.5.1 Pump station**

A centrifugal 1 HP electrical pump (ASIA) withdrawing water from the main domestic supply line with maximum head of 32.0 m and discharge of 108 1/min to supply a water tank. Also, a centrifugal e1ectrica pump (Italian) model (LTNZ, JRM 4BH) of 1HP with maximum head of 5.6 m and discharge of 50 l/mm was used to pump water from the water tank to the system.

**2.5.2 Water tank**

Water was stored in a plastic tank with capacity of 7.5m3. The tank was raised on an iron platform 1.5 m high with square base of 2.0 X 2.0 m.

**2.5.3 Main line**

A PVC plastic pipe with diameter of 38.1 mm was used as a main pipe line.
One end of the line was connected to the pump outlet and the other end was connected to a main valve.

**2.5.4 Sub-main**

A PVC plastic pipe with diameter of 25.0 mm was used as a sub mainline.
One end of the line was connected to the valve and the other end was sealed with a plug . Lateral lines were connected to the sub main using T connecting.

**2.5.5 Lateral lines**

A PVC pipe with diameter of 25.0 mm was used for the lateral lines (3.0 lateral lines).

**2.5.6 Sprinkler riser**

Galvanized steel pipes with diameter of 18.0 mm 1.0 and 1.5 m height were connected to the laterals to serve as risers.

**2.5.7 Sprinkler head**

One type of impact sprinklers was used. The sprinkler head was Lego 55 part/full circle (plastic single nozzle with an opening of 4.0 mm).

**2.6 Data collection**

**2.6.1 Meteorological data**

Meteorological data were obtained from Shambat Weather station as shown in Table 3. Wind speed (km/h), wind direction, air temperature (°C),relative humidity (%),evaporation (mm/day) and vapor pressure (mbar) during the measurement period (February and May) were recorded during each test.

**Table 3 Mean meteorological data from Shambat weather station at the times of the tests**

| Time of the test | Test run | Vapor pressure (m bar) | Relative Humidity (%) | Evaporation (mm /day) | Temperature ( oC) | Wind speed (km/h) | Wind Direction |
|---|---|---|---|---|---|---|---|
| Morning | 1 | 9.2 | 32.7 | 9.4 | 23.0 | 7.4 | North East |
| | 2 | 10.6 | 34.7 | 11.7 | 24.0 | 9.0 | |
| | 3 | 11.6 | 31.7 | 14.2 | 26.2 | 5.2 | |
| | 4 | 10.0 | 36.3 | 15.5 | 29.3 | 11.0 | |
| Mid-day | 1 | 11.2 | 25.0 | 9.4 | 31.3 | 5.7 | |
| | 2 | 10.4 | 18.7 | 11.7 | 34.3 | 11.0 | |
| | 3 | 11.0 | 21.7 | 14.4 | 33.0 | 8.7 | |
| | 4 | 8.4 | 27.7 | 15.5 | 36.3 | 17.0 | |
| Evening | 1 | 12.2 | 20.3 | 9.4 | 36.7 | 9.8 | |
| | 2 | 11.0 | 16.6 | 11.7 | 38.3 | 13.0 | |
| | 3 | 14.9 | 24.3 | 14.6 | 36.3 | 9.3 | |
| | 4 | 17.8 | 24.6 | 15.5 | 39.8 | 14.0 | |

**2.6.2 Operating pressure and discharge measurement**

Operating pressure was measured using a pressure gauge (10 bar) at the beginning of the main line. The experiment was conducted at two operating pressures of 1.0 and 2.0 bar and two riser heights 1.0 and I.5m.To measure the discharge from the nozzle at sprinkler position , a container and a polyethylene pipe 13.0

mm were used. Time taken to fill the container was 1.0 minute noted by stop watch for each combination and the observations were replicated three times. The water collected in the container was measured with a graduated cylinder. Then discharge was taken to be calculated by dividing collected volume by the time in m3/h.

**2.6.3 Measurement of radius of throw**

The wetted radius of throw for each sprinkler was measured at the different pressures of 1.0 and 2.0 bar using a measuring tape.

**2.6.4 Uniformity measurement**

After installation of the system .The pattern of distribution was evaluated by measuring the precipitation in catch cans at different points in the sprinkled area in order to calculate the performance indicators (uniformity coefficient and distribution uniformity). Uniformity measurement was determined by placing 36 catch cans in a grid between two adjacent lateral lines and four sprinklers. The sprinkler spacing was 8m x 8 m. For the purpose of evaluating sprinklers, the catch-can spacing used was 1.25 m. The catch can opening diameter was 10.5 cm and 3.3 cm high placed on a leveled ground surface. The area around the sprinkler was divided into squares of equal areas. Prior to the test, both discharge and operational pressure of the sprinklers in the test site were measured. During uniformity measurement climatic factors such as wind speed, humidity, evaporation, vapor pressure and temperature data were recorded. The duration of each test was half an hour. After completion, the amounts collected in the catch cans were measured.

**2.6.5 Evaporation from catch cans**

The suppression of the evaporation from the catch cans on field distribution tests is difficult to achieve. To overcome this, peripheral collectors surrounding the pattern can be used to estimate collector evaporation during the test (Marek. et al., 1985). A set of four catch cans with 3.3 cm depth of water was located close to the test area to attain an estimate of the volume of water lost by evaporation from catch cans, during the field test and during the reading process.

**2.7 Calculation and analysis of basic parameters**

Data recorded from sprinklers tests used to determine the evaporation and drift losses, distribution patterns, and uniformity parameters were presented in the following sections.

**2.8 Evaporation and drift losses (%)**

By considering the riser height as a variable, the best equation for predicting the evaporation and drift losses from sprinkler method is shown below. The equation is judged by using the criteria suggested by Drapper and Smith (1966) as stated by Abo-Ghobar (1994):

Ln E = 4.506 - 0.518 in D + 0.703 InH+0.137 In U-0.04 In RH +0.022 InT (1)

Where:

E= Evaporation and drift losses, % .

D = Nozzle diameter, mm.

H = Riser height, m.

U = Wind velocity, km/h.

RH = Relative humidity, %.

T = Air temperature, °C .

**2.9 Water distribution uniformity**

**2.9.1 Christiansen's coefficient of uniformity (CU%)**

The pattern or uniformity coefficient (CU%) was determined using the following formula as stated by Christiansen (1942) Eq. 2:

$$CU\% = 100 * \left(1.0 - \frac{\sum x}{m.n}\right) \qquad (2)$$

Where:

CU%= Christiansen's coefficient of uniformity (%).

X = absolute deviation from mean.

m= average depth of application.

n = number of observations.

### 2.9.2 Distribution uniformity (DU%)

Water distribution uniformity was determined from the collected depths in the catch cans using the equation (1) (Keller and Blienser 1990).

### 2.10 Data analysis

Analysis of variance (AOVA) test was used with interaction to know main effects and interaction effects to independent variable blocks represent period levels (morning, mid-day and evening), operating pressure levels (1.0 and 2.0 bars) and riser height levels (1.0 and 1.5m) and its impact on response variable, the experiment was repeated three times at different combination tests and data analysed by using Statistical Analysis System (SAS) programme.

## III. Results and Discussion

To evaluate the on-field performance of sprinkler system, calculation of coefficient of uniformity and distribution uniformity has been made. The results obtained are presented and discussed in the following subsections.

### 3.1 Evaporation and drift losses

By considering the riser height as a variable, evaporation and drift losses ranged from 5.2% for riser height of 1.0 m and operating pressure 2.0 bar to 7.9% for riser height of 1.5 m and operating pressure 1.0 bar. Evaporation and drift losses increased as riser height increased .

Also evaporation and drift losses increased as wind speed and temperature increased and decreased as relative humidity increased as shown in Table 4.

The general trend of the results agreed with the results reported by Yazar (1984). So it is not recommended to operate the sprinkler system at wind speeds of : 9.3 ,1l and 13 km/h. Also nozzle size, operating pressure and wind speed may be the predominant factors that affect losses from sprinkler system as reported by Abo-Ghobar (1993).

### 3.2 Evaporation from catch cans

In every catch can, the volume of water collected can be corrected to quantity losses. It was observed that losses were proportionally greater when decreasing the collected volume which may be due to high temperature, low relative humidity and high wind speed. The results agreed with those obtained by Doorenbos and Pruitt (1984) as shown in Table 5.

### 3.3 Wetted diameter

As shown in Tables 6-9 wind is the chief modifier that reduces the diameter of throw and changes the profiles of sprinklers as reported by King et al. (2000). Wetted diameter inversely related to wind speed and riser height and directly related to operating pressure. So it is important to operate the system at low wind speed conditions to satisfy the recommended design overlapping of the system.

### 3.4 wind speed

As shown in Table 10, the effect of wind speed on water application uniformity was studied at three levels of the day (morning, mid - day and evening) times. Wind speed in the study area showed continual variations. Wind speed showed increasing trend in day time. Random variation of wind speed and direction, the pressure changes at the sprinklers, differences in sprinklers discharge and the effect of the operating pressure and riser height may be the reasons for the variation of CU% and DU% under different wind speeds. At low pressure and high riser height, low CU% and DU% can be recorded and this may be due to low discharge of the sprinkler. Also riser height was significantly affected CU% and DU% and as riser height increased coefficient of uniformity and distribution uniformity were decreased and this may be due to increase in evaporation and drift losses and reduced effective of overlapping and hence poor uniformity was recorded . Also it was observed that CU% and DU% values were improved with some increased of wind speed and this may be due to the fact that the randomness of wind turbulence and gusts contribute to smoothening out the distribution pattern as mentioned by Merkley and Allen (2004).

**Table4. Evaporation and drift losses (%) under different heights and wind speeds**

| Time of test | Riser height (m) | Wind Speed (km/h) | Air temperature (°C) | Relative humidity (%) | Evaporation and drift losses (%) |
|---|---|---|---|---|---|
| Morning | 1.0 | 7.4 | 23.0 | 32.3 | 5.3 |
| Mid-day | | 5.7 | 31.3 | 25.0 | 5.2 |
| Evening | | 9.3 | 36.3 | 24.3 | 5.7 |
| Morning | 1.5 | 9.0 | 24.0 | 34.7 | 7.4 |
| Mid-day | | 11.0 | 29.3 | 36.3 | 7.7 |
| Evening | | 13.0 | 38.3 | 16.6 | 7.9 |

**Table5. Evaporation from catch cans (%) during the tests run**

| Time of test | Operating pressure (bar) | Riser height (m) | Collected Volume (L) | Evaporation and drift losses (%) |
|---|---|---|---|---|
| Morning | 1.0 | 1.0 | 0.7 | 2.8 |
| | 1.0 | 1.5 | 0.6 | 3.2 |
| | 2.0 | 1.0 | 0.9 | 4.0 |
| | 2.0 | 1.5 | 0.6 | 2.8 |
| Mid-day | 1.0 | 1.0 | 0.5 | 6.0 |
| | 1.0 | 1.5 | 0.4 | 4.8 |
| | 2.0 | 1.0 | 0.6 | 4.5 |
| | 2.0 | 1.5 | 0.4 | 4.0 |
| Evening | 1.0 | 1.0 | 0.6 | 4.0 |
| | 1.0 | 1.5 | 0.5 | 4.0 |
| | 2.0 | 1.0 | 0.7 | 3.6 |
| | 2.0 | 1.5 | 0.5 | 3.6 |

**Table6. Wetted diameter at 1.0 bar operating pressure and 1.0 m riser height at different wind speeds**

| Time of test | Wind speed (km/h) | Wetted diameter (m) |
|---|---|---|
| Morning | 7.4 | 18.6 |
| Mid-day | 5.7 | 19.9 |
| Evening | 9.8 | 17.7 |

**Table7. Wetted diameter at 1.0 bar operating pressure and.1.5 m riser height at different wind speeds**

| Time of test | Wind speed (km/h) | Wetted diameter (m) |
|---|---|---|
| Morning | 9.0 | 17.3 |
| Mid-day | 8.7 | 14.9 |
| Evening | 9.3 | 13.0 |

**Table8. Wetted diameter at 2.0 bar operating pressure and 1.0 m riser height at different wind speeds**

| Time of test | Wind speed (km/h) | Wetted diameter (m) |
|---|---|---|
| Morning | 5.2 | 23.3 |
| Mid-day | 8.7 | 22.5 |
| Evening | 9.3 | 21.9 |

**Table9. Wetted diameter at 2.0 bar operating pressure and 1.5 in riser height at different wind speeds**

| Time of test | Wind speed (km/h) | Wetted diameter (m) |
|---|---|---|
| Morning | 11.0 | 23.3 |
| Mid-day | 17.0 | 17.9 |
| Evening | 14.0 | 18.5 |

**Table10. Effect of operating pressures, riser heights and wind speeds on uniformity coefficient (CU%) and distribution uniformity (DU%) during the tests run**

| Time of test | Wind Speed (km/h) | Operating pressure (bar) | Riser height (m) | Coefficient of uniformity (CU%) | Distribution uniformity (DU%) |
|---|---|---|---|---|---|
| Morning | 7.4 | 1.0 | 1.0 | 81 | 71 |
| | 9.0 | 1.0 | 1.5 | 79 | 71 |
| | 5.2 | 2.0 | 1.0 | 85 | 79 |
| | 11.0 | 2.0 | 1.5 | 83 | 76 |
| Mid-day | 5.7 | 1.0 | 1.0 | 81 | 74 |
| | 11.0 | 1.0 | 1.5 | 75 | 71 |
| | 8.7 | 2.0 | 1.0 | 85 | 74 |
| | 17.0 | 2.0 | 1.5 | 77 | 71 |
| Evening | 9.8 | 1.0 | 1.0 | 82 | 72 |
| | 13.0 | 1.0 | 1.5 | 75 | 70 |
| | 9.3 | 2.0 | 1.0 | 84 | 76 |
| | 14.0 | 2.0 | 1.5 | 80 | 73 |

### 3.5 Analysis of performance parameters
### 3.5.1 Christiansen's coefficient of uniformity (CU%)

There were significant differences (P 0.05) between the values of CU% at the different wind speeds at different test periods (morning, mid-day, evening) under two operating pressures (1.0 and 2.0 bar) and two riser heights (1.0 and1.5 m ) From Table 11 . The best values of CU% were recorded under the pressure of 2.0 bar for the different test periods. The highest value of CU% was 84% under 2.0 bar operating pressure and 1.0m riser height which may be due to high discharge. The values obtained under 2.0 bar operating pressure were higher than those obtained under 1.0 bar operating pressure. This result may be due to the fact that under low pressure water is broken up into large drops falling near the sprinkler as stated by Kay (1983). All CU% values at mid-day and evening tests were lower than those obtained in the morning tests. This result may be due to the higher relative humidity, lower temperature and wind speed in morning than at mid-day and evening. Neveheless, all values are acceptable, as stated by Keller and Bliesner (1990).

**Table11. Coefficient of uniformity (CU%) for the different periods and operating pressures**

| Pressures(bars) | Coefficient of uniformity (CU%) | | |
|---|---|---|---|
| | Morning | Mid-day | Evening |
| 1.0 | 80b | 78b | 79b |
| 2.0 | 84a | 81a | 82a |
| LSD | 2.50 | 1.50 | 1.0 |

Means followed by different letter(s) in the same column are significantly different at $P \geq 0.05$.

### 3.5.2 Distribution uniformity (DU%)

There were significant differences ($P \geq 0.05$) between the values of DU% at different test periods (morning, mid-day, evening) under two operating pressures (1.0 and 2.0 bar) and two riser heights (1.0 and l.5m). From Table 12 the best values of DU % were recorded under operating pressure 2.0 bar for the different test periods. The highest value of DU% was 78% under 2.0 bar operating pressure and riser height 1.0 m. The values obtained under 2.0 bar operating pressure were higher than those obtained under 1.0 bar operating pressure. All values were greater than the minimum acceptable DU of 60% as specified by Keller and Bliesner (1990). Lower DU% values were associated with high wind speeds and low operating pressure. All values of DU% at mid-day and evening tests were lower than those recorded in the morning tests .

**Table12. Distribution uniformity (DU%) for the different test periods and operating pressures**

| Pressures(bars) | Distribution uniformity (DU%) | | |
|---|---|---|---|
| | Morning | Mid-day | Evening |
| 1.0 | 71b | 70b | 71b |
| 2.0 | 78a | 73a | 75a |
| LSD | 2. 0 | 2.5 | 0.5 |

Means followed by different letter(s) in same column significantly different at $P \geq 0.05$.

## IV. Conclusions

From the results of this study the following conclusions can be drawn:

- At low wind speeds, low temperatures and high relative humidity, high efficiencies were obtained.
- The results showed that the major factors which are responsible for low performance were low pressure and high wind speed.
- Irrigation in the morning time is better due to low temperature , low wind speed and high relative humidity.
- Riser height affected significantly on system performance.
- All CU% and DU% values were obtained during the three periods laid within the acceptable range.

## References

[1]. Abo-Ghobar, H.M. and A.I. Amoud (1992). Performance Characteristics of Various Impact Sprinkler Types Locally Used. J. King Saud University. 4(2): 175-187.
[2]. Abo-Ghobar, H.M. (1993). Evaporation and Drift Losses from Sprinkler Irrigation Systems under Hot and Dry Conditions. J King Saud University. 5(2): 153-164.
[3]. Abo-Ohobar, H.M. (1994). The Effect of Riser Height and Nozzle Size on Evaporation and Drift Losses under Arid Conditions, J King Saud University. 6 (2): 191-202.
[4]. Brouwer. C.; Prins, K.; Kay, M. and Heibloem, M. (2001), Irrigation Water Management: Irrigation Methods. Training manual No 5. Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.
[5]. Doorenbos. J. and Pruitt ,W.O. (1984). Crop Water Requirements, Irrigation and Drain. Paper 24,FAO. Rome. Italy.
[6]. FAO (2000).Yearbook. Production Vol. 55. Food and Agriculture Organization of the United Nation, Rome.
[7]. Kay. M.( 1983). Sprinkler irrigation: equipment and practice. Batsford, UK.
[8]. Keller, J. and Bliesner, R.D. (1990). Sprinkler and Trickle Irrigation. Van Norstrand Reinhold, New York.
[9]. Kincaid. D.C.; Solomon, K.H. and Oliphant J.C. (1996). Drop size distribution for irrigation sprinklers. Transactions of the ASAE, 39:839-845.

[10]. King, B.A.; Starlk J.C. and Kincaid, D.C. (2000). Irrigation Uniformity, University of Idaho, U.S.A. Accessed on 28th June http://info.ag.uidaho.edu/pdf/BUL/BUL0824.pdf.pp 1-11.

[11]. Kohl, R.A. and Wright, J.L. (1974). Air temperature and vapour pressure changes caused by sprinkler irrigation, Agron. 1, (66) 85-88.

[12]. kohl K.D.; Kohl RA. and De Boer D.W. (1987). Measurement of low pressure sprinkler evaporation loss, Transactions of the ASAE (30) 107 1-1074.

[13]. Makki, E.K.(1996) .Forage Sorghum (Abo Sabien) Production under Sprinkler Irrigation System.MSc. Thesis, Department of Agricultural Engineering, Faculty of Agriculture, University of Khartoum, Shambat- Sudan.

[14]. Merkley, G.P. and Allen, R.G. (2004). Sprinkle and Trickle Irrigation Lecturer Notes, Utah State University, U.S.A. Accessed on 3th August 2007 from: hup://.www.myoops.org/…/SprinkleTriclde. Irritation/ usufiles/LO1 Course Introduction.pdf. 1 0-43

[15]. Michaeil, A.M. (1978). Irrigation: Theory and Practice. Viskas Publishing House, PVT. LTD. New Delhi, India.

[16]. Phocaides, A. (2000). Technical Handbook on Pressurized Irrigation Techniques, FAO, U.S.A Accessed on 6th August 2007 from http://www.fao.org/waicent faoinfo/agricult/aglw/ies. 101-112.

[17]. Smajstrla, A.G. Boman, B.J.; Clark, G.A.; Haman, D.Z.; Pins, D.J. and Zazueta, F.S. (2005). Field Evaluations of Irrigation Systems: Solid Set or Portable Sprinkler Systems. Florida Cooperative Extension Service, 1nstiite of Food and Agricultural Sciences, University of Florida. Bulletin No .266 Website: http://edis.ifas.ufl.edu.

[18]. Solomon, K.H.; Kincaid, D.C. and Bezdek, J.C. (1985). Drop size distribution for irrigation spray nozzles. Transactions of the ASAE, 2 8(6), l966- 1974.

[19]. Thompson. AL; Gilley, J.R. and Norman, J.M. (1993) A sprinkler water droplet evaporation and plant canopy model: II. Model application. Transaction of the ASAE, 36(3), 743-750.

[20]. Yazar, A. (1984). Evaporation and drift losses from sprinkler irrigation system under various operating conditions. Agricultural Water management, (8): 439-449. Elsevier Science Publishers, Amsterdam- Netherlands.

Abdelmoneim Elamin Mohamed. "Effect of Weather Conditions, Operating Pressure and Riser Height on the Performance of Sprinkler Irrigation System. "IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) 12.1 (2019): PP- 01-09.