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EFFECT OF DIFFERENT TYPES OF HEAD ON THE COEFFICIENT OF UNIFORMITY AND WATER DISTRIBUTION ON A PORTABLE SPRINKLER IRRIGATION SYSTEM

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ABSTRACT

A portable sprinkler irrigation system was installed with the objective of evaluating the performance of the system layout. Two sets of sprinkler heads were used; single and twin. The study was conducted during the period March to September 2012 in the Demonstration Farm of the Faculty of Agriculture, University of Khartoum, Shambat, longitude 32º32'E: latitude 15º40'N and altitude 380 m above mean sea level. After installation of the system the coefficient of uniformity (CU %) and the distribution uniformity (DU %) were determined for each set of sprinkler heads under an operating pressure of 2.5 bars. The completely randomized block design (CRBD) was used. Three replicates were used for each set and the data were analyzed by the SAS program. The statistical analysis showed that there were high significant differences ($P \geq 0.01$) in CU% and DU% values between the different sprinkler heads. The highest CU% and DU% values 87% and 76%, respectively, were obtained under plastic sprinkler heads, while the lowest ones of 81.3% and 68.1% were obtained under the brass sprinkler heads, respectively. It

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can be concluded from the study that the highest values of coefficient of uniformity (CU %) and distribution of uniformity (DU %) were obtained by the plastic sprinkler heads (LEGO 55). The sprinkler head type should be considered as important factors for designing and installing an appropriate portable sprinkler system.

Keywords: Coefficient of uniformity, Distribution uniformity, Different heads

1. INTRODUCTİON

Irrigation comprises artificially providing crops with water. This technique is used in farming to enable plants to grow when there is not enough rain, mostly in arid regions. Bringing more area under irrigation without the improved management may lead to stress water resources and average success in production and productivity (Reddy, 2010). The increasing water demand for agriculture, industries, and urban use has become a severe problem (AlEmadi, 2021). Agricultural Engineering has made use of scientific principles of the most desirable use of natural resources in agricultural production for the gain of humankind. The function of agricultural engineering is increasing in the coming days at the forthcoming challenges of producing more food with less water coupled with climate uncertainty (Ali, 2010). The major constrains to produce more food to meet the increasing demands of the world population is land and water scarcity. The world population will reach 8.5 billion by 2030, 9.7 billion by 2050, and 11.2 billion by 2100 (UN, 2015). Sprinkler irrigation is getting popular in distinctive parts of the Sudan since the mid – 1990s. It is generally adopted in urban and peril- urban farming in Khartoum State forfodderand vegetable production. The technique is mainly used for its excessive efficiency and flexibility in applying small depths of water. Another intent for the spread of sprinkler irrigation is water conservation, especially for farmers the use of groundwater for irrigation (Makki, 1996). It is mainly adopted in urban and sub-urban farming in Khartoum State for fodder and vegetable production. The technique is mainly used for its high efficiency and flexibility in applying small depths of water.Another motive for the spread of sprinkler irrigation is water conservation, particularly for farmers using groundwater for irrigation.

Michael (1978) Concluded that not only the right amount of water applied to the field, but also its uniform distribution over the field is important. An efficient sprinkler system depends on a good design and factors which affect irrigation water uniformity are arranged and spacing nozzles on the laterals and spacing between laterals. The type of pattern is called square. Therefore, the objective of this study is the evaluation of the portable sprinkler irrigation system under Shambat conditions. Determine and compare the performance of a portable sprinkler system under the plastic and brass sprinkler heads.

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2. MATERIALS AND METHODS

2.1. The Study Area

The experiment was conducted during March and September 2012 at the demonstration farm of the faculty of Agriculture, University of Khartoum at Shambat (longitude 32o32'E: latitude 15o40'N and altitude 380 m ASL). After installation of the system, the coefficient of uniformity (CU %) and the distribution uniformity (DU %) were determined under an operating pressure of 2.5 bars. The mean air temperature, evaporation, relative humidity, wind speed, and direction during the study period were recorded. The experiment consisted of two types of sprinkler heads were used: a single nozzle, plastic head (LEGO 55) and a twin–nozzle brass head (JIS2). The pattern layout spacing was 9×9 m. The parameters studied included sprinkler discharge system discharge requirements and distribution efficiency. Catch cans were placed in the centre of each grid. The volume of water from each container was measured using a measuring cylinder and converted to depth by dividing the water volume by the container top surface area. The completely randomized block design (CRBD) with three replicates for each type of sprinkler head. The single point test was adopted and field data were analyzed using the CATCH3D software developed by Allen (1996) to test water distribution under different spacing's. The software determined CU% and DU% using input data of the duration of the test, the direction and speed of wind ,the flow rate and water volume in the catch cans. The software is rapid and reduces the complexity and calculation mistakes of the traditional methods. Data was analyzed for each single test and average values were compared across the test runs for the two sprinkler heads.

2.2.1. Water distribution uniformity:

Uniformity of water application is a measure of the variability in depths of water applied at different points throughout an irrigated zone. Uniformity of water application can be measured using catch cans set on or near the soil surface. Uniformities are normally measured under no-wind conditions. Several uniformity coefficients have been developed as described by Connellan (2002).

2.3. Christiansen's coefficient of uniformity (CU %):

The uniformity coefficient (CU %) was determined using the following formula as stated by Christiansen's (1942):

$$\mathrm{CU\%} = (1 - \frac{\sum \mathrm{x}}{\mathrm{mn}})$$

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Where:

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

X = deviation of individual observation from the mean value.

n = number of observations.

m = mean value.

2.4. Distribution uniformity (DU %):

Water distribution uniformity for each sprinkler pattern was determined from the collected depths in the catch cans using the following equation:

$$\mathrm{DU\%} = \frac{\mathrm{X25}}{\mathrm{X}} \times 100$$

Where:

X25: average low quarter of depths collected in the cans (mm)

X: average water depth collected in all cans (mm).

2.5. Sprinkler discharge determination (m^3/h):

For the determination of the discharge rate of each sprinkler head, a stopwatch, a pan, and a polyethylene pipe (13 mm) were used. The rates of discharge were determined by catching the water from the sprinkler head into the container. The discharge rate (m^3/h) was determined by dividing the volume caught (m^3) by the time of the test (h).

2.6. Statistical Analysis

A computer program (SAS Statistical package) was used to analyze the data. The variations among means were checked by the least significant difference (LSD).

3. RESULTS AND DISCUSSION

3.1. Water distribution uniformity:

Generally, the CU% and DU% values obtained were within the acceptable range according to Keller (1990) and Smajstrla (2005).

3.2. Christiansen's coefficient of uniformity (CU %):

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Analysis of variance showed that there were highly significant differences (P≥0.01) in CU% values among treatments. The highest CU% values 87% were obtained under plastic sprinkler heads, while the lowest ones were obtained by brass sprinkler heads 76% as shown in Table 1 and Figure1.

3.3. Distribution uniformity (DU %):

Generally, the DU% values followed the same trend of CU% values. There were highly significant differences at 1% level of significance DU% values were found between the two types of sprinkler heads. The highest DU% value (81%) was recorded under the plastic sprinkler head, while the lowest value (68.1%) was recorded under the brass sprinkler head as shown in Table 1 Figure 1 and Wireframe 1 and 2. These illustrations also showed the distribution of water applied to the field during the test run. However, the results may be attributed to the overlap which occurred. These results are in line with the findings of Smajstrla (2005) and Keller (1990).

Table 1: Effect of different spray heads at on Christiansen's coefficient of uniformity (Cu %), Uniformity of distribution (Du %) and discharge

Spray head	Coefficient of uniformity (Cu %)	Uniformity of distribution (Du %)	Discharge (m^3/h)
Single (brass)	76b	68.1 b	2.29
Twin (lego)	87a	81.3 a	0.33
LSD	6.3	6.9	0.60
Sig	**	**	**

Means followed by the same letter (s) in the same column are not significantly different at P ≤ 0.01.

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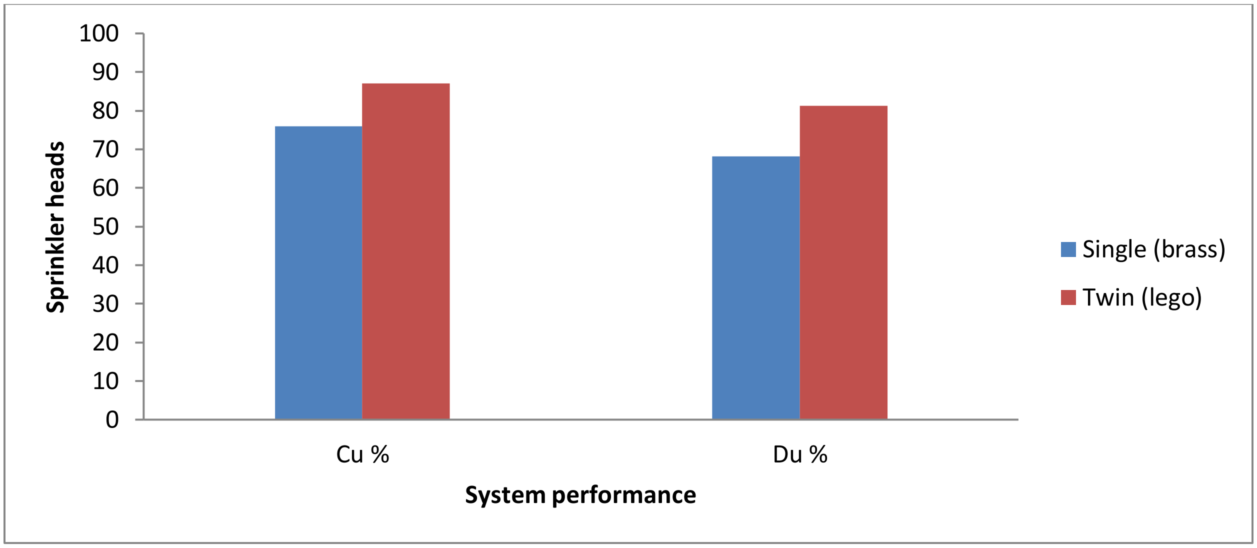

Figure 1: The effect of different sprinkler heads at on Christiansen's coefficient of uniformity (Cu %), Uniformity of distribution (Du %)

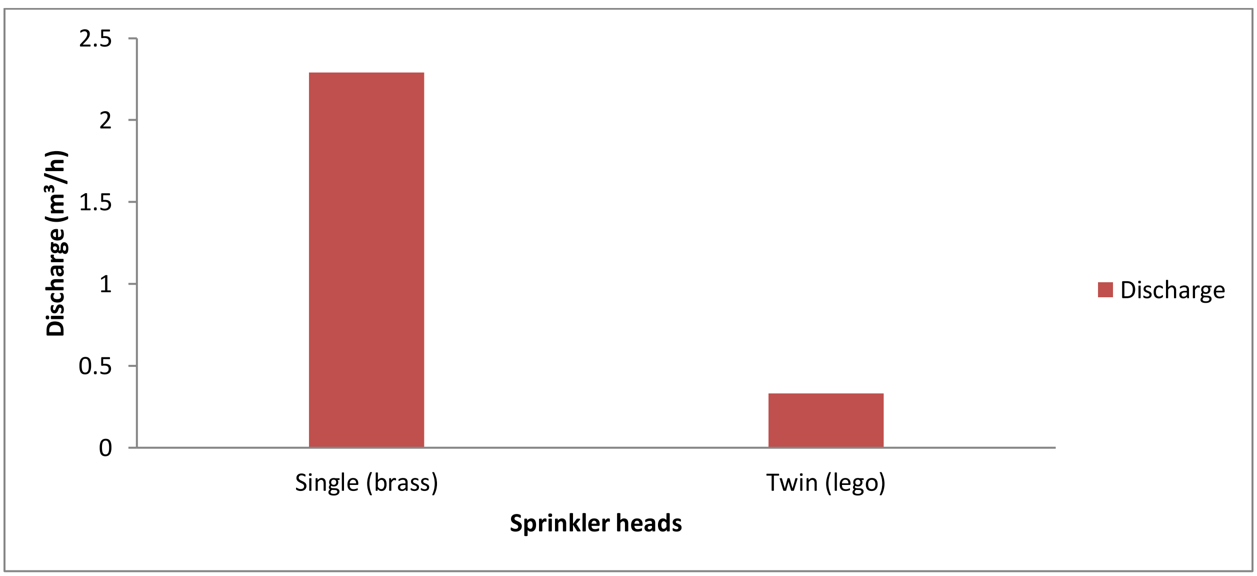

Figure 2: The effect of different sprinkler heads on discharge

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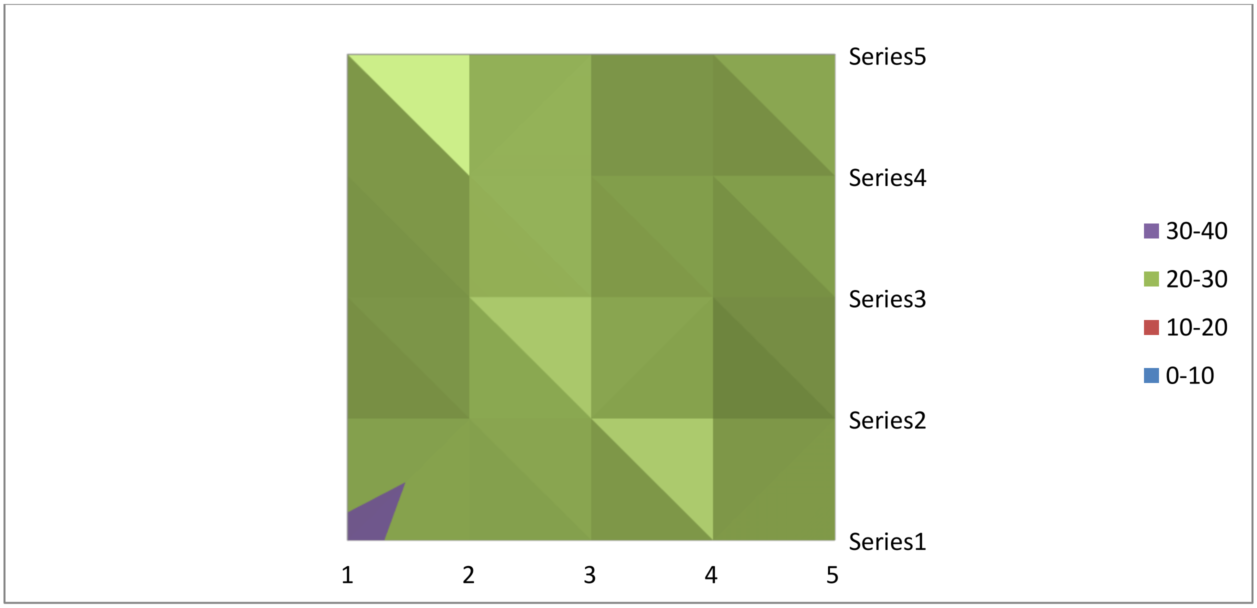
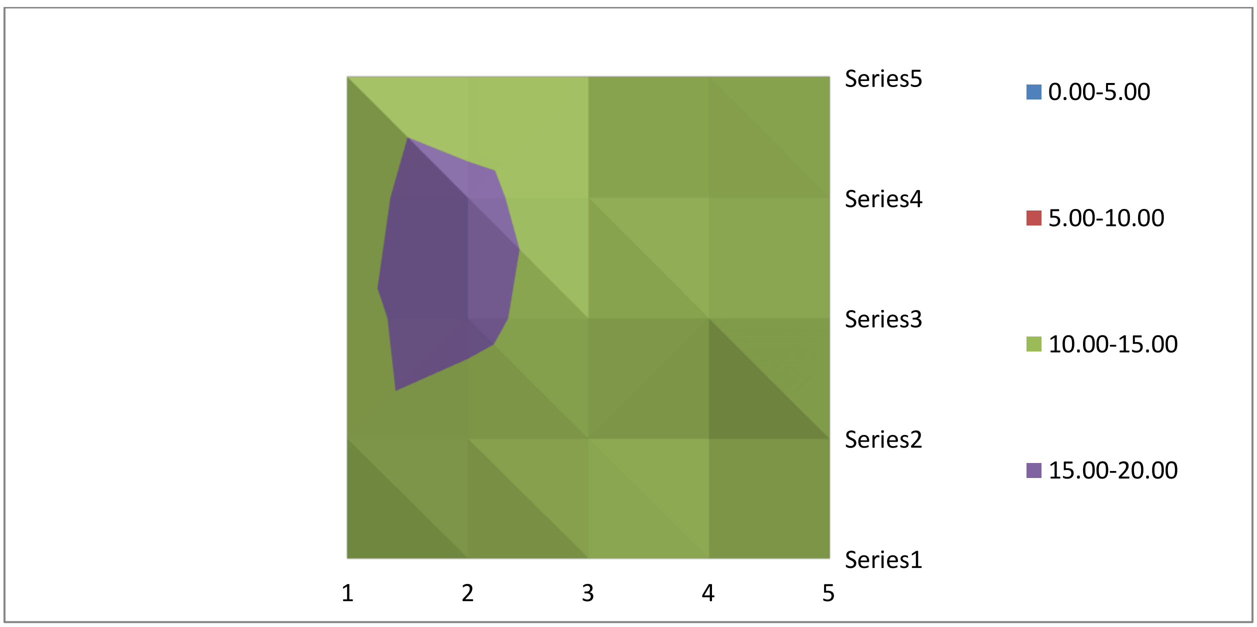


Wireframe 1: Water distribution by Single sprinkler head (JIS 2)



Wireframe 2: Water distribution by Twin sprinkler head (LEGO 55)

4. CONCLUSIONS

From the results of this study, the highest values of coefficient of uniformity (CU %) and distribution of uniformity (DU %) were obtained by the plastic sprinkler heads (LEGO 55). The

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coefficient of uniformity (CU %) and uniformity of distribution (DU %) at different sprinkler heads used were within the acceptable range according to the standards specified by Keller (1990).

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