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Sprinkler design and evaluation of carpet grass (*Axonopus affinis*) irrigation in the Niger Delta Region, Nigeria

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Sprinkler irrigation system was designed and built in response to the need, to irrigate fields and gardens using a technique that would simulate natural rainfall if it were unavailable during the dry season. Research on irrigation farm enhancement is scarce throughout the southern region, according to the data that is currently available. The purpose of this study was to build an irrigation system for carpet grass (*Axonopus affinis*) that uses pressurized water application efficiently to increase crop output productivity on both small and large farms. The design was predicated on irrigating a small plot using a rotating sprinkler system (a pump, plastic pipes, and fittings such as t-joint, end-plug, elbow-joint, pegs, sprinkler nozzles, measuring tape, risers, and hydrometer apparatus such as stopwatch, beakers, millimeter sieve, pestle, and volumetric flask), which offers a valid scientific foundation for appropriate water scheduling, system evaluation, and reducing water waste and runoff. The sprinkler nozzle was designed for crops and was tested on a lawn of 12 m by 8 m. The outcome demonstrated that the sprinkler's discharge rate was calculated to be 12.01 mm/h, and the sprinkler's application rate was 17.155 mm/h, its sprinkler spacing range was 10 m, and the irrigation period was assessed at 6 h. The evaluation of delivery performance ratio (DPR) and coefficient of uniformity (CU) both recorded 86% and was sufficient to suggest the system to irrigators. This system is feasible and less expensive to employ locally made materials and the effective specifications required for sprinkler irrigation.

Key words: Precipitation rate, discharge capacities, spacing, emitters, application, depth.

INTRODUCTION

Nigeria's population was 140 million at the time of the 2006 general census, with an average population growth

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rate of 2.7% (Ahaneku, 2010). However, the World Bank (2020) estimated that the country's population will be closer to 201,135,262 million. Nigeria is located on a land area of 923968 km^2 and has two major seasons (rainy and dry). Total annual rainfall decreases from 3,800 mm at the Forcados on the south coast to less than 650 mm in the northeast of the nation. The length of the rainy season also falls from nearly 12 months in the south to less than five months in the north. Nigeria has relatively high temperatures all year long, which is essential for photosynthesis for the sustainability of most of the Nigeria's population. Despite all odds, agriculture continues to be the backbone of the country's economy. The World Bank (2014), found that just the agricultural sector in Nigeria produces almost 40% of the country's GDP, employs 70% of its labour force, and accounts for 33% of the country's overall GDP (Nigeria National Report, 2006). Nigeria requires irrigated agriculture to sustain its burgeoning population because of its vast land area, pleasant temperatures, and significant rainfall variability (FAO, 2014).

From the country's independence in 1960 until the middle of the 1970s, Nigeria's main source of foreign exchange comes from agriculture. At a time, the country was the world's top producer of cocoa, groundnuts, and palm oil and it was also a major producer of millet, maize, yam, cassava, coconuts, citrus fruits, and sugarcane (Ladan, 2014). But since the early 1970s, when the focus turned to oil earnings, the industry has been neglected and has made less economic contribution (Adelodun and Choi 2018).With a land area of 70,000 m^3, the Niger Delta region of Nigeria is the home to more than 45.7 million people. It is the center of oil and gas hub in Nigeria. Oil and gas production, contributes the highest amount of the foreign exchange and internal revenue is generated from the production of oil and gas. Over 90% of foreign exchange earnings, 90% of export income, and almost 80% of government revenue are derived from the crude oil sector. Furthermore, previously flared gas is starting to contribute more to Nigeria's income, in 2001 gas exports brought in a total of US$ 1,197.0 million (World bank, 2020). Irrespective of the aforementioned, agriculture continues to be the largest employer of labour in the region. With its vast area of rich fertile terrain, pleasant temperatures, and highly variable rainfall, the Niger Delta requires irrigated agriculture to harness development within and beyond the region. As the name suggests, irrigation is the process of adding water to the soil to meet crop water requirements. Despite the oil disaster and other issues affecting the region, carpet crops thrive in the Niger Delta. Herdsmen and other nomadic farmers rely on them to feed their cows more, particularly during the rainy season, which runs from May to October.

Irrigation plays a crucial role in enhancing output and input efficiency for carpet crops and other crops in the regions against the challenges from climate constraints and production potentials. Irrigation techniques have drastically changed in recent years due to advancements in irrigation technology (Afrakhteh et al., 2015). The purpose of this research was to increase agricultural output productivity in both small and large farms between the months of December to March and through till October by designing a cost-effective sprinkler irrigation system that is friendly to crops, soil and has efficient pressurized water application. To promote and address the issue of seasonal crops in the aforementioned area, this study aims to develop, build, and contribute to the small body of literature on the subject. This design and evaluation have several intrinsic benefits, which includes better soil-moisture uniformity, less energy or water needed, deep percolation, less runoff, simpler scheduling and control of irrigation systems, and as well as healthier plant growth. Also, the design and construction of a pressurized sprinkler irrigation system that is economical, efficient in using water, and portable for crops and lawns is the among these objectives. suitable for crops and lawns is the among these objectives. A thorough field layout, pipe size calculation, sprinkler selection and spacing, and an estimation of crop water requirements in relation to the water schedule were all followed in the design (Maina and Luqman, 2022).

Irrigation is the artificial application of water to the soil to improve and give the necessary moisture required for plant growth. When there is a drought, plants can use irrigation water as a substitute for water that is supplied by rainfall, soil moisture, and groundwater capillary rise (Lange et al., 2018; Yadeta et al., 2022). A well-executed irrigation strategy can reduce water consumption, preserve natural resources, and increase yields quality and quantity (Sinha, 2022). Sprinkler systems have completely changed agriculture's enhanced irrigation system. The design and operation of pumps, pipes, and sprinkler systems in sprinkler irrigation entails matching resource, crop, and soil conditions (Shiva-Shanker et al., 2018). A type of pressurized irrigation technique known as sprinkler irrigation involves moving water via a pipe system to a location close to the crop's intended use. Sprinkler systems can be set up and run to efficiently irrigate a variety of surfaces. Most crops may be grown with sprinkler irrigation, which works with almost any type of irrigable soil. Water is sprayed via the air onto the soil surface or crops with the use of sprinklers due to the availability of various discharge capacities (Chinwendu et al., 2021). Water may be applied uniformly thanks to the design of sprinkler irrigation systems. Spray heads are useful for practically all irrigable soils as they help distribute water evenly throughout the whole soil surface. It is practically applicable to all irrigable soils; it is appropriate for nearly all crop types and provides efficient coverage for small to large areas and terrain (Afrakhteh et al., 2015).

In the current farming system, sprinkler irrigation systems are mostly ignored, particularly in rural areas where most farming activities are conducted. As a result, there is a growing need for methods, creativity, and technical expertise to address the challenges associated with seasonal agro-based company. Data that is currently available demonstrates the dearth of study on irrigation farm development throughout the Niger Delta. However, there are no published records of improved irrigation (using sprinklers) in the rural areas, even though the impact of this seems plausible given the operating costs associated with effective agriculture in the local communities. Thus, for efficient agricultural application, there is need for positive improvement on the feasibility and potentials of sprinkler system establishment in rural areas (Chinwendu et al., 2021).

If they are planned, implemented, maintained, and controlled correctly, sprinklers can be a wise investment. Sprinklers give higher yields for each quantity applied per unit area because they deliver water more consistently and efficiently than conventional surface irrigation systems (Ahaneku, 2010).

Evaluation is a vital element in irrigation project management. This includes managing and measuring important facets of irrigation system performance. Irrigation managers will be able to evaluate and assess real performance through evaluation. They will also be able to understand which elements are causing performance that is below optimal levels, their proportional impacts, and potential solutions.

According to Abshiro and Singh's (2018), assessment of sprinkler systems in Iran, poor design and implementation, uneven distribution, and inadequate water flow, inadequate pressure distribution, insufficient lateral pipeline lengths, subpar machinery, and inadequate management and maintenance procedures are the primary issues with sprinkler irrigation systems.A primary design objective according to Darko et al. (2017), is spray irrigation consistency.

How evenly water is applied over a specific region is referred to as uniformity. Since no irrigation system can evenly distribute water throughout the entire field, estimating the uniformity of water distribution is required to evaluate the system's effectiveness. In the case of turf grass and landscapes, uniformity in water application is also intended to reduce variability in crop output or plant quality (Adelodun and Choi, 2018).

MATERIALS AND METHODS

Study area description

This experiment was conducted at the Rivers State University, Port Harcourt, Nigeria. The area is part of the tropical rainforest zone, with an average yearly rainfall of roughly 2400 mm, with 70% of that total falling between May and August. This follows a relative dry season with a relative humidity of 85% and mean temperature (daily minimum and maximum) of roughly 23 and 31.5°C, respectively. The soil has a sandy loam texture and as classified (Ultisol) by the United States Department of Agriculture (USDA). The city is in Nigeria's Niger Delta, an area well-known for its high rate of oil and gas exploration, at latitudes 6.9795575°E and longitudes 4.7911825°N (Ini et al., 2015, Fubara-Manuel et al., 2021).

Design data

The parameters and their units showed below were employed in the design and fabrication of this sprinkler irrigation system and the values were of specific dimensions.

Design specification and pump selection

In Table 1 to 8, the selected parameters were chosen as the design standards. The specifications were chosen for operational suitability in accordance with Maina and Luqman (2022). For this design, a centrifugal pump (volute) was selected. This pump has a low operating cost and produces at a constant steady discharge. The pump is also adapted to a wide range of head discharge conditions.

Field experimental procedure

The effectiveness of the sprinkler irrigation was assessed in a field test on 96 m³ (12 m × 8 m) of mostly carpet grass (*Axonopus affinis*). The tools employed were a pump, plastic pipes and fittings (t-joint, end-plug, elbow-joint), pegs, sprinkler nozzles, measuring tape, risers, and hydrometer apparatus (stopwatch, beakers, millimeter sieve, pestle, and volumetric flask). Prior to the sprinkler experiment, the study area's soil condition was sampled, and a soil auger was used at random depths of 0 to 30 cm to assess the in situ textural characterization and moisture content of the soil.

The composite soil samples were sent to the lab for analysis after being carefully labeled and bagged in plastic bags. To assess the textural classification and soil moisture content (MC) of the investigated region in the laboratory, hydrometer and gravimetric methods were used, 100 g of weighed soil sample was placed into a 500 ml beaker and filled with 5 cm of distilled water. Temperature and hydrometer values were obtained before the texture class was assessed using the textural triangle. An aluminum plate containing the same quantity (100 g) of soil sample was next oven-dried at 105°C. After reweighing, the mass of the soil was determined See (Table 7). The examinations of the soils reveal no undesired salt and no corrosive elements that could harm irrigation equipment, no debris, with other suspended contaminants.

Design analysis and fabrication

Throughout the investigation, there were two distinct dimensions for the lateral spacing along the major lines. As a result, the first and second sprinkler discharge rates were determined. The design considered three primary factors: the irrigation duration, the depth of application, and the limiting application rateEquation 4 (Molden & Gate as quoted by Ngasoh et al., 2018) was used to evaluate the delivery performance ratio (DPR), a measure of system performance, from the generated data (Table 8). as showed in Table 8.

Evaluation of sprinkler performance

Sprinkler performance characteristics are determined by various factors such as wetted diameter (swath radius), droplet size (which

Table 1. Types of crops grown using sprinkler irrigation approach.

Cereal	Flower	Oilseed	Vegetable
Maize	Chrysanthemum	Mustard	Carrots
Sorghum	Trees And Shrubs	Groundnut	Cabbage
Wheat	Jamine	Sunflower	Onion
-	Marigold	Safflower	Spinach
Fodders	Plantain Crops	Fiber	Garlic
Pulses	Rubber	Sisal	Sweet Potato
Alfalfa	Coffee	Cotton	Raddish
Asparagus	Tamarind	-	Kholchol
Pastures	Teak	-	Tapioca
Spices	Tea	-	Cucurbits
Pepper	-	-	Potato
Cardamom	-	-	Letuce
-	-	-	Fenugreek
-	-	-	Sugarbeets

Source: Maina and Luqman (2022).

Table 2. Materials used for the design.

No.	Parameter	Value/Unit
i	Area of land	12×8 m (96 m^2)
ii	GP tank	3000 l
iii	Centrifugal pump	1.5 HP
iv	Sprinkler head	2 pcs
V	Diameter of sprinkler nozzle	1.5 mm
vi	Number of nozzles with high discharge	20
vii	Diameter of main line pipes	25.4 mm
viii	Length of mainline pipes	33 m
ix	Diameter of lateral line pipe	1.25 m
x	Length of lateral pipe	0.30 m
xi	diameter of flexible pipe	12.7 mm
xii	Length of flexible Pipes	12 m
xiii	Water application efficiency	70% E (assumed)
xiv	Pressure head at nozzle	1.5-2.5 kg/cm^3=15-25 m
xv	Coefficient of discharge	0.95-0.96 (given)
xvi	Acceleration due to gravity (g)	9.81 m^2/s
xvii	Net depth of water application	2.25 cm
xviii	Rotation of sprinkler	0.5-1 rpm
xix	Range of sprinkler spacing	9-18 m
xx	Peak rate used by carpet grass	4 mm/day (given)
xxi	Diameter of coverage	20-35 cm

Source: Ngasoh et al. (2018)

is dependent on operating pressure), application rate, flow rate or discharge, and uniformity of water application. The aim of any sprinkler irrigation system is to apply the desired amount of irrigation water to the crop's root zone as efficiently and uniformly as possible.

Swath Radius Determination

A system's sprinkler head can only disperse water over a certain area. It was measured to the furthest distance (throw) that water droplets covered from the irrigation system center line, where the

Table 3. Infiltration rate of some soils.

No.	Soil type	Infiltration (cm/h)
1	Coarse sand	2.0 to 2.5
2	Fine sandy	1.2 to 2.0
3	Fine sandy loam	1.2
4	Silt loam	1
5	Clay loam	0.8
6	Clay	0.5

Source: Niragire et al. (2021)

Table 4. Maximum application rates for sprinkler in relation to soil texture, slope.

Soil texture and profile	Maximum application rate (cm/h)			
	0.5% slope	5-8% slope	8-12% slope	12-16% slope
Coarse sandy soil to 2 m	5	3.7	2.5	1.3
Coarse sandy soil over more compact soils	3.7	2.5	2	1
Light sandy loams to 2 m	2.5	2	1.5	1
Light sandy loams over more compact soils	2	1.3	1	0.8
Silt loams to 2 m	1.3	1	0.8	0.5
Silt loams to over more compact soils	0.8	0.6	0.4	0.3
Heavy textured clays or clay loams	0.4	0.3	0.2	0.1

Source: Niragire et al. (2021).

Table 5. Range of available water holding capacity of soils.

Soil type	% Moisture based on dry weight of soil		Depth of avail. water per unit soil
	Field capacity	Permanent wilting (%)	cm/m depth of soil
Fine sand	3 - 5	1 – 3	2 - 4
Sandy loam	5 - 15	3 – 8	4 - 11
Silt loam	12 - 18	6 – 10	6 - 13
Clay loam	15 - 30	7 – 16	10 - 18
Clay	25 - 40	12 – 20	16 - 30

Source: Afrakhteh et al. (2015).

sprinkler applies water to the collector's inlet surface area. Since the assessment was conducted during the dry season, it was possible to determine the furthest throw distance. The irrigation system was tested with the drive mechanism of the irrigation equipment operating at full pressure and throttle

System operating pressure

Pressure has a significant impact on a nozzle's output, droplet sizes, and sprinkler's water-throwing distance. The system pump's pressure gauge malfunctioned, so the recommended estimating the pressure at the sprinkler head using the water spread area formula (Ahaneku , 2010).

$$R = 1.3\sqrt{dh} \quad (1)$$

where R = swath radius (m), d = diameter of nozzle (mm), and h = pressure head at the nozzle (m).

Uniformity of water distribution

The regularity of the sprinkler system's water distribution was assessed using the test protocol in accordance with ASABE S436.1 (2009) requirements. Four sprinklers surrounded the 25 m x 25 m square plot where the test was held. The sprinkler spacing is 17.73 x 18.83 m, and the sprinkler nozzle diameters are 8 and 6 mm. Every test run lasted 30 min. The test method involved arranging a pattern of 6.5 cm diameter and 6.3 cm high, identical metallic catch cans. The sprinkler system was turned on for a while, and the direction and rate of discharge were noted. At the conclusion of the test period, the volume of water caught in each collector was measured to acquire the distribution data. Since the sprinkler radius of throw was greater than 12 m, the cans were positioned along lines parallel to the pipeline and 1.5 m apart in compliance with

Table 6. Maximum rate of soil moisture used by crops under various climate.

Climatic condition	Peak rate of soil moisture removal mm/day
Cool humid	3
Cool dry	4
Moderate humid	4
Moderate dry	5
Hot humid	5
Hot dry	8

Source: Afrakhteh et al. (2015).

Table 7. Effective Root Zone Depth of Common Crops root Characteristics.

Shallow rooted (60 cm)	Moderately deep rooted (90 cm)	Deep root (120 cm)	Very deep root (180 cm)
Rice	Wheat	Maize	Sugarcane
Potato	Tobacco	Cotton	Citrus
Cauliflower	Castor	Sorghum	Apple
Cabbage	Groundnut	Pearl	Grapevine
Lettuce	Musk	Millet	Safflower
Onion	carrot	Soya bean	Lucerne
Carpet grass	Melon	Sugar beet	

Source: Afrakhteh et al. (2015).

Table 8. Soil characterization and moisture content (MC).

Percentage by mass			
Sand	Clay	Silt	MC
78.4	17.6	4	17.64

ASABE S398.1 (2009) requirements. The water volume was converted to the water depth in millimeters (mm) based on the catch cans' cross-sectional area. There was no usage of evaporation suppressant.

This assessment of uniformity used Christiansen's coefficient (ASABE, 2009), which is the most easily comprehensible and straightforward to compute manually than functions such as standard deviation. Table 9 lists the observed parameters that were used to compute the coefficient of uniformity, which was determined by applying Christiansen's equation (Christiansen, 1942) (Table 9).

$$Cu = 100(1 - \in \frac{x}{mn}) \quad (2)$$

where m = Average value of all observations (average application rate), n = Total number of observation points, and x = Numerical deviation of individual observation from average application rate, mm.

Sprinkler discharge test

The choice of sprinkler system is primarily influenced by the sprinkler discharge, among other factors. The water application rate and the sprinklers' two-way spacing determine the necessary discharge for each individual sprinkler. To conduct the sprinkler discharge test, the actual water flowing from the nozzles was measured directly over a predetermined period. Additionally, the planned or predicted flow rate of the sprinklers was calculated based on their spacing. Equation 3 was used to assess sprinkler discharge (Ahaneku, 2010).

$$Q = S1 \times Sm \times \frac{2}{8bu} \quad (3)$$

where Q = Required discharge of individual sprinkler (l/s), S1 = Spacing of sprinklers along laterals (m), Sm = Spacing of laterals along the main (m), and I = Optimum application rate (cm/h).

Delivery performance ratio

The sprinkler system's delivery performance ratio (DPR), a gauge of system performance was calculated using the data from the discharge tests.

Ahaneku, (2010) used the following connection to determine the DPR.

Table 9. Parameters for computation of uniformity coefficient.

Observation (mm)	Frequency	Application rate × Frequency	Numerical deviations	Frequency × Deviation
7.5	1.1	8.25	1.5	1.65
7.3	1.1	8.02	1.3	1.43
7.2	4.0	28.8	1.2	4.85
7.0	1.1	7.7	1.0	1.1
6.8	3.0	20.4	0.8	2.4
6.5	4.0	26.0	0.5	2.0
6.1	1.1	6.71	0.1	0.11
6.0	1.1	6.6	0.0	0.0
5.8	4.0	23.2	0.2	0.8
5.4	1.1	5.94	0.6	0.66
5.3	6.0	31.8	0.7	4.2
4.9	6.0	29.4	1.1	6.6
4.8	1.1	5.28	1.2	1.32
4.6	1.1	5.06	1.4	1.54
4.4	1.1	4.84	1.6	1.76
Total	36.9	Mn=218	-	£x=30.37

$$DPR = Actual\,\frac{discharge}{Required}\,discharge = \frac{\partial A}{\partial R} \quad (4)$$

where DPR = 1 when QA ≥ QR.

Application rate

The average rate of water application for a single sprinkler was estimated using the relation (Ahaneku, 2010).

$$Ra = \frac{q}{360} \times A \quad (5)$$

where Ra = water application rate (cm/h), q = rate of discharge of sprinkler (l/s), and A = wetted area of sprinkler (m^2).

Fuel consumption

Reduced production costs and the preservation of priceless resources are two benefits of energy efficiency in irrigation. As a result, this aspect of the sprinkler equipment evaluation was done. In this test, the irrigation sprinkler engine's suction line was placed into a container along with a known amount of fuel. The amount of fuel used up was recorded after the engine was ran for a predetermined amount of time two times in a row. The gasoline consumption rate was determined by averaging the two runs. This is in line with the works of Ahaneku (2010).

RESULTS

The comparison of the portable irrigation system's primary specifications is shown in Table 10. Within the bounds of experimental error, the manufacturer's specifications and the measured values were almost the same. The sprinkler system's evaluation parameters, along with their computed values and standard or expected values, are shown in Table 9. The dimensions and types kinds of equipment required for the construction were ascertained using the information shown in Tables 1 to 8.

DISCUSSION

For the suitability of watering system, the evaluated coefficient of uniformity was evaluated as 86%. This indicated a 14% departure from the ideal uniformity. According to Abshiro and Singh (2018), the obtained coefficient of uniformity is within the permissible range for both high-value crops of CU >84%, while common field and fodder crops was CU > 75%. The study's coefficient of uniformity value by Keesen's (2013) and other findings are consistent. The meticulous selection of sprinkler types, spacing, effective working pressures of the sprinkler, and favorable weather circumstances may have contributed to the high value of the reported coefficient of uniformity (Irmak et al., 2011; Dwivedi and Pandya, 2016; Darko et al., 2017).

Advanced coefficient of homogeneity may have been attained if there were no leakage losses. These losses were noticed from the laterals and the coupling joints of the mains. There was always a slight pressure differential between the main and laterals because of the losses, which made the pressure homogeneity in the field a little less than usual. The irrigation system's high coefficient of uniformity means that the irrigator will need to spend more time fine-tuning the system's scheduling to achieve higher crop yields, which are often linked to higher sprinkler uniformity (Ngasoh et al., 2018). In Table 11, the sprinkler's average application rate illustrates that the sprinkler's average application rate fell within the evaluated sandy loam soil's fundamental infiltration rate

Table 10. Comparison of key specifications of the irrigation.

Item	Manufacture's specification	Evaluated value
Water Pressure	25 m	23.4 m
Swath radius	21-26 m	19 m
Fuel consumption rate	7.23 L/h	7.18 L/h
Operation personnel	1 man	1 man

Table 11. Results of evaluation parameters of the sprinkle.

Parameter evaluated	Obtained valued	Expected/Standard value
Delivery performance ratio (DPR) of the system	0.86	1.0
Coefficient of Uniformity of the system	86%	85% and above
Average discharge of the sprinkler	0.87 L/s	0.98 L/s
Average application rate of the sprinkler	2.2cm/h	2-3 cm/s (Basic infiltration of the test soil)

Table 12. Values of evaluated parameters of the sprinkler irrigation.

No.	Parameter	Equations	Output
i	Net depth of water application	d_ (net = (Fc-Pwp) × (RzD × P)	d_net=12.0083 mm/h
ii	Gross depth of water application	d_ (gross) = d_net / E	d_gross=17.155 mm/h
iii	Design capacity of the sprinkler used	Q_1 = (10 × A × d gross) / (I × N_ (s) × T)	Q=0.24 m^3/h
iv	Required discharge of sprinkler	$q_e = \frac{S_l \times S_m \times I}{360}$	q=0.96 L/s
v	Obtained discharge of sprinkler	$q_o = \frac{S_l \times S_m \times I}{360}$	q=0.89 L/s
vi	Discharge of sprinkler nozzle	$q_4 = Ca\sqrt{2gh}$	12.7 l/s
vii	Irrigation time	Depth of water/limit irrigation rate	1.6 h
viii	Total available moisture capacity	Moisture holding capacity of soil × crop root zone	0.45 m
ix	Net depth of irrigation	50% moisture depletion level	0.23 m
x	Depth of water pump per application	0.23/0.7	0.33 m
xi	Total head design	$\mathrm{hf} = \frac{v^2}{2_g}$	0.3 m
xii	Irrigation frequency	$\mathrm{IF} = \frac{d_{net}}{ETc}$	2.523 days
xiii	Friction loss due to fittings	-	0.0076 m
xiv	Friction loss in lateral pipes	-	0.09 m
xv	Friction loss in main pipeline	-	0.021 m
xvi	DPR expected	$DPR_E = {}^{AD}/_{RD}$	1
xvii	DPR obtained	$DPR = {}^{AD}/_{RD}$	0.86

(Ahaneku, 2010).

The rate at which water is applied to the soil is determined by the system application rate. Given that there was no runoff during the watering period, it may be assumed that the sprinkler system's rainfall intensity is enough. The right choice of sprinkler nozzles, pressures, and spacing are the three design parameters that determine an irrigation system's efficiency. The most basic metric irrigation managers used to evaluate operation success is the delivery performance ratio (DPR). Given that it provides information on the quantity of water provided relative to the quantity expected to be delivered at a certain field site, it could be utilized to evaluate sufficiency. (Rather and Baba, 2017).

If DPR stays constant or varies within allowable bounds, it can also be utilized as a dependability/ reliability indicator for an irrigation system at a specific site (Adelodun and Choi, 2018). A DPR of 0.86 was estimated by the suitable watering system (Table 12). This value can be classified as Good in the DPR performance class (Ahaneku, 2010).

The finding of DPR acquired in this investigation corroborates with those obtained from similar studies elsewhere (Chinwendu et al., 2021). This demonstrated the effectiveness of the management input linked to the system. A satisfactory 86% system efficiency is implied by the DPR of 0.86. Thus, the sprinkler system should function at its best provided it is kept at the intended efficiency and uniformity rates.

Conclusion

Irrigation systems with high efficiency might be expensive. But a lot of systems are inefficient, which wastes water and increases energy use and equally lowers earnings. A well-thought-out sprinkler system distributes water evenly throughout the soil's surface without going beyond the soil's minimal capacity for infiltration. A well-designed system considers variables including crop water use rate, soil infiltration rate, weather, nozzle size and spacing, and pressure. Since leakage losses have been shown to lower irrigation system efficiency, they must be avoided wherever feasible.

The evaluation of DPR and CU both recorded 86% and were deemed sufficient to suggest the system to irrigators. To achieve optimal system performance, the sprinkler system must be properly operated and maintained.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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