DETERMINATION OF THE DISTRIBUTION UNIFORMITY OF SPRINKLER IRRIGATION SYSTEM

BY

MAJI, HASSAN NATHANIEL

MATRIC NO 2000/9495EA

DEPARTMENT OF AGRICLTURAL ENGINEERING,

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

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BEING A FINAL YEAR PROJECT SUBMITTED IN FULFILMENT FOR THE AWARD OF BACHELOR OF (B.ENG.) AGRICULTURAL ENGINEERING FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

NOVEMBER, 2006.

DECLARATION

I hereby declare that this project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

	09-11-2006
MAJI NATHANIEL	DATE
2000/9495EA	

CERTIFICATION

This project entitled "Determination of the Distribution Uniformity of Sprinkler Irrigation System" by Maji Nathaniel meets the regulations governing the award of the degree of Bachelor of Engineering (B.Eng.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

09-11-2006

Engr. Dr. Nosa A. Egharevba — Date

Supervisor

10/11/2006

Engr. Dr. (Mrs) Z. D. Osunde — Date

Head of Department

02/11/2006.

External Examiner — Date

DEDICATION

This project is dedicated to all members of my family.

ACKNOWLEDGEMENT

I give all thanks, glory and honour to the Almighty God, for successful completion of my study.

I also appreciate the effort and assistance of my supervisor in the person of Engr. Dr. Nosa A. Egharevba who through his kindness support and guidance he has contributed in making this work a great success. May God bless him richly. I also appreciate all my lecturers for their contribution to my life, both academically and morally, since my inception into the Federal University of Technology Minna till my final year on the campus.

My appreciation and gratitude also goes to my beloved parents, Mr. and Mrs. Maji for their great support and contribution to my life. I cannot but mention, Mrs. Charity Okabe, Pastor George Maji, Mr. Raymond Oparanozie and Mr. David Maji, who supported me financially throughout my academic pursuit in the university.

Finally, I wish to appreciate my friends who have helped me in one way or the other while on this campus. May God Almighty bless you all richly in Jesus name (Amen).

ABSTRACT

Distribution Uniformity of the Sprinkler Irrigation System is the process whereby water is applied or spread evenly on the field by the sprinkler irrigation system. The rotating head sprinkler in the department of Agricultural Engineering, Minna (Nigeria) was used to test the distribution pattern of the sprinkler system to determine the uniformity of water application by the sprinkler system. The average Distribution Uniformity (DU) and Coefficient of Uniformity (CU) obtained from the test for the distribution pattern were found to be 98% and 99% which are well above the standards (DU = 80%, CU = 85%) for Distribution of Uniformity and Coefficient of Uniformity of a Sprinkler Irrigation System, quoted in the literature.

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ABBREVIATIONS OF SYMBOLS OR NOTATIONS

1. CU – Coefficient of Uniformity
2. Σ – Summation
3. Xi – Depth of Water
4. n – Number of Observation
5. S – Standard Deviation of the Observation
6. X – Average Depth
7. $\bar{X}$LQ – Low Quarter Average Depth
8. DU – Distribution Uniformity
9. Ra – Application rate
10. Qn – Discharge from Sprinkler
11. K – Unity Constant
12. Sl – Spacing between Laterals
13. Ss – Spacing between Sprinklers
14. t – Time
15. Qs – Sprinkler Capacity
16. d – Depth to be Applied
17. H – Spacing between the beginning of successive irrigation
18. Tm – Downtime for moving set-move systems or maintenance (hr)
19. Ea – Application Efficiency (%)
20. A – Percent of Total Field Area Irrigation when System is Operating

21. DDIR – Designed daily Irrigation Requirement

22. Si – Spacing of Sprinkler along laterals

23. Sm – Spacing of Laterals along the main

24. I – Application rate

25. Q – Nozzle Discharge

26. a – Cross-Sectional Area

27. h – Pressure head

28. C – Coefficient of Discharge

29. S.D – Standard Deviation

30. S.E – Standard Error

31. Xi – Results

32. X – Mean

33. V – Velocity

34. V – Average velocity

35. D – Diameter

CHAPTER ONE

1.0 INTRODUCTION

A sprinkler is a device used for the application of water or spreading of water on a field.

Sprinkler irrigation developed mainly after the Second World War with the introduction of light – weight, portable aluminum pipes. At the same time improved sprinklers and quick – couples that facilitated uncoupling and recoup ling of pipes become available.

In sprinkling of water via the sprinkler, water is sprayed into the air and allowed to fall on the surface, somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small orifices or nozzles. The pressure is usually obtained by pumping.

With careful selection of nozzles or orifice sizes, pressure and sprinkling spacing quality of irrigation water required to refill the crop root zone can be applied nearly uniformly at a rate to suit the infiltration date of maximum yield of the crops.

The sprinkler irrigation system uses pressure energy to form and distribute "rain like" droplets over the land surface. Although they are normally designed to supply the irrigation requirement of the farm, sprinkler systems are also used for crop and soil cooling and bud development controlling wind erosion, providing water for germinating seeds, application of agricultural chemicals and land application of waste waters.

Sprinkler irrigation is adaptable to many crops, soils and topographic conditions. Sprinkler systems are classified according to whether the sprinkler heads are operated individually (gun or boom sprinklers) or as a group along a lateral, and according to how they are moved (or cycled) to irrigate the entire field. Fixed – head sprinklers include most of the spray – type/mini sprinklers currently available.

Coefficient means the factors derived that when used to multiply the prescribed uniformity that will make the uniformity more real, true or efficient.

1.1 PERFORMANCE PARAMETERS

The distance of the throw and application pattern must also be known to select a proper sprinkler. There parameters are qualitatively evaluated on the basis of such factors as wind and system type.

Distribution patterns of the sprinkler can become distorted if the operating pressure is too low, the wetted diameter is reduced and an excessive number of large droplets form. If too high, the diameter increases and a high percentage of droplets become too fine, which can result in excessive wind – drift ad evaporation? In both cases there is an impairment of the uniformity of water application, even if the sprinklers are properly spaced. The nozzle angle used depends on wind speed and the height of the sprinkler. Low nozzle angles are used in windy areas and in orchards where sprinkler systems are used. High nozzle angles are used where wind speed are normally low and when sprinklers are mounted approximately at crop height (James L.G 1998).

Sprinklers with relatively large droplets are recommended for windy conditions since their distribution patterns are less affected by windy than those of finer droplets sprinkler.

In practice, a common arrangement is a rectangular one with the larger or absent, triangular distribution patterns are expected to produce an acceptable distribution uniformity when the distance between sprinklers on a lateral is equivalent to about 40 percent of the wetted diameter.

1.2 OBJECTIVES

The objectives of the study are:

i) To determine the uniformity of water distribution of the Sprinkler Irrigation System.

ii) Finding possible methods that will make the Sprinkler irrigation system more uniform in water distribution.

1.3 JUSTIFICATION

Distribution uniformity coefficients are used to characterize the water distributions evaluated in field tests.

Several coefficients have been proposed since sprinkler irrigation was first introduced. One of the earliest was that proposed by Wilcox and Swaites, in which the coefficient is based on the standard deviation.

Uniformity is how evenly a sprinkler delivers water over the ground. This is the major problem in the sprinkler irrigation system. Therefore, this is important to know because uneven distribution systems create areas that are either too wet or too dry. The non – uniformity causes havoc with irrigation scheduling. If enough water is applied adequately to dampen the dry spot, too much water would be placed on the wet spot and if the wet spots is managed, the dry spots is most likely to turn “dead”. These make healthy plants and efficient water use in difficult portion. Thus, there is need to evaluate the performance of a sprinkler system with a view to knowing whether or not water is being uniformly applied to the crop.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 SCOPE OF IRRIGATION

Irrigation process can be explained in two ways.

a) Distribution of water in the field after reserving them and transporting them.

b) Use of the input water in the most economical and efficient way is a function of highest rate available between plants need and the practical portion of water given through the irrigation system by the operator.

We can divide the irrigation system into:

a) Open systems: Gravitational flow (surface irrigation systems)

b) Closed systems – Pressurized flow (sprinkler and drip irrigation systems)

The quest for survival and the need to boost food supplies dictated the scope and importance of irrigation. More so, since rainfall on which many agricultural conditions depend, sometimes does not occur at the right time or when it does so at inadequate quantity enough for plant requirement.

The scope of irrigation is not some of the application of water alone, but to some of the immediate effects. The science must cover the study of the watershed, the management and distribution of the water, seepage and drainage problems.

For an irrigation system to be efficient a number of requirements have to be made.

i) The system must be properly designed and constructed.

ii) The distribution system must be adequate for effective control of water over the field.

iii) The land must be properly prepared to permit uniform distribution of water over the field.

2.2 OBJECTIVE OF IRRIGATION

i) To supply the essential moisture for plant growth which include the transport of essential nutrients.

ii) To leach or dilute salt in the soil.

iii) Irrigation also helps in cooling the soils temperature.

2.3 SPRINKLER IRRIGATION

Sprinkler irrigation systems can be classified as closed systems or pressure flow systems. A sprinklers irrigation system uses pressure energy to form and distribute “rain like” droplets over the land surface. Sprinkler irrigation system is made of the following components, sprinkler, riser pipe, lateral distribution pipes; main – line pipe and the pumping plant.

Sprinkler irrigation is adapted to many crops, soils and topography conditions. Sprinkler systems are classified according to whether the sprinkler heads are operated individually (gun or boom sprinklers) or as a group along a lateral and according to how they are moved (or cycled) to irrigate the entire field. Fixed – head sprinklers include most of the spray – type/mini sprinklers include most of the spray – type/mini sprinklers currently available.

2.4 ADAPTABILITY OF SPRINKLER IRRIGATION

Sprinkler irrigation can be used for almost all soils. It is however not usually suitable in very fine – texture soils such as heavy soil because of the infiltration rate which is less than 4mm per hour (Michael, 1981). The method is particularly suited to sandy soils that have a high infiltration rate.

The flexibility of the sprinkler equipment and its efficient control of water application makes this method adaptable to most topographic conditions without extensive land preparation. It is especially suitable for steep slopes on irrigation topography.

If soil erosion is an hazard, sprinkler can be used in conjunction contour building terracing making and strip cropping.

Land leveling is not essential for sprinkler irrigation.

However grading is sometimes advisable if the surface drainage is a problem or to provide a more uniform surface for seeding tillage and harvesting.

2.5 LIMITATION OF SPRINKLER SYSTEM

The weather has to be still for proper functioning of the sprinkler system: i.e. wind cause uneven distribution of the water. The water must be clean and free of sand and debris in order not to block the sprinklers nozzles. A stable water supply is needed for most economical use of the equipment.

2.6 EVAPORATION AND WIND DRIFT LOSSES

The amount of water that evaporates from drop depends on the surface area of the drop, and on how long the drop is in the air, which are related to drop size. Wind can easily drift small drop, and can cause them to stay in the air until they are finally evaporated.

2.7 ROTATING IMPACT SPRINKLER

Rotating impact sprinkler are the most commonly used of all sprinklers. They can be fitted with a range of single or double nozzles and offer a wide selection of operating pressures, discharges, spacing and application rates to suit practically all crops, soil and types of soils.

The sprinkler is rotated by the force of water action. The tension of the spring turns it back, which turns the sprinkler slowly as it allows for the emitting of water.

2.8 SPRINKLER DISCHARGE CAPACITY

The sprinkler system must have enough capacity to supply the design daily irrigation requirement (DDIR) plus wind drift and evaporative losses that occur after water leaves the sprinkler and before it reaches plant and soil surface.

2.9 SPRINKLER APPLICATION RATES

Application rate is used to properly match sprinklers to the soil, crop and terrain in which they operate.

2.10 ADVANTAGES AND DISADVANTAGES OF SPRINKLER

ADVANTAGES

i) Light frequent watering are possible in shallow soil, and for germination and plant establishment.

ii) Sprinkler system spray uniform amount of water on land.

DISADVANTAGES

i) Sprinkler needs regular supply of water.

ii) The efficiency of supply is affected by factors like, wind.

iii) It is capital intensive

2.11 DISTANCE OF THROW

Spacing usually increases as the distance of throw rises.

The operating pressure, and the size, shape, and angle of the nozzle opening determine the distance a sprinkler throws water. Distance of throw rises as pressure is increased within the range of recommended operating pressure. Distance of throw also tends to increase as nozzle size increases. Nozzles opening shape that evaluate smaller diameter droplets tends to wet a smaller area than nozzle that emits large droplets.

2.12 DROPLET SIZE

Droplet size is an important factor affecting the formation of "seal" in base soil surfaces that restricts water movement in to the soil. Because small droplets poses less power than they impact the soil surface, “seal” that limit infiltration form more slowly than with larger droplets. For these reason it is possible to reduce runoff and erosion by converting from sprinklers that emit large droplets to ones with smaller droplets.

Higher operating pressures normally increase the volume of water applied as smaller droplets while decreasing the volume of large droplets.

Nozzles opening shape can have an important effect on droplet size while nozzle angle has little, if any effect.

2.13 METHODS THAT WILL MAKE SPRINKLER IRRIGATION SYSTEM MORE EFFECTIVE AND UNIFORM

2.13.1 BY INTRODUCING THE AUTOMATIC TIMERS

An automated sprinkler system can help the farmer water efficiently and uniformly his farm or crops if the timer is used properly.

The farmer should be familiar with his automatic timer and how to take advantage of its features.

2.13.2 PROGRAMMING THE TIMER TO CYCLE WATERING EVENTS

For example, clay type soils and areas with mild or steep slopes usually cannot absorb water fast enough to prevent it from running off. If such conditions exist on the farmland, the Timer should be programmed to water for several shorter periods, with about an hour in – between, to let the water percolate into the soil.

2.13.3 BY MAKING THE SPRINKLER SYSTEM COMPUTERIZED OR BY BUILDING THE SYSTEM WITH A COMPUTERIZED SYSTEM.

- Programming the sprinkler system to discharge faster (increase speed) when it is windy and also to discharge larger droplets when it is windy. And the speed and droplets reduces to normal when the wind stops.
- And the computerized sprinkler system will also help to control droplets size depending on if the weather is sunny or not. Larger droplet when it is sunny and lighter droplets when it is not sunny. when it is sunny the larger droplet should be emitted with more speed in order to prevent evaporation before the water reaches the ground. Because if the system emits lighter droplets at a slow speed part of the emitted water will evaporate before it reaches the ground which will affect the uniformity of the sprinkler irrigation system.

2.13.4 INSTALLATION OF THE SAME SPRINKLER HEAD

Never install a spray head and a rotor head on the same valve. Different head types put out very different amounts of water in the same zone, he will need to over – water certain areas to get sufficient water to the entire zone. Fir one to have uniformity of a sprinkler irrigation system he should install the same Sprinkler head.

Sprinkler Types There are many varieties of sprinkler heads, but three general categories are: spray, rotor and drip.

i) **Spray Heads**

Spray heads either pop – up out of the ground or have a stationary head. Spray heads are mostly commonly used on small area, turf (soil – surface with grass – roots growing on it) shrubs or flower beds.

Spray heads put out a lot of water in a short amount of time. This means they have a high application rate. There is a large range of precipitation rates for different types and brands, but the average output is 1.5 to 1.7 inches per hour. Spray heads work well on flat surfaces and with soils that can absorb the water quickly, such as sand. If spray heads are used on steep slopes or with a clay soil, the watering times should be cycled to allow the water to infiltrate into the soil instead of running off onto the street.

ii) **Rotor heads** Rotor heads come in two main styles: stream (driven by a gear) or impact. They are useful in covering large areas; typically apply water more uniformly than spray head. Rotor can spray in full or part circle patterns, and some brands are adjustable to a wide variety if angles. The application rate of a rotor is usually lower than that of a spray head. Typical value are 0.6 to 0.8 inches per hour. The slower output allows them to be used on all soil types with less cycling.

iii) **Drip System** Drip systems have become popular for irrigation non – turf areas. A drip system usually consists of a special tube or hose with holes or emitters along it. These emitters may be spaced with a fixed distance to cover uniform, closely spaced beds, or randomly to allow water certain plants.

Drip irrigation can save time and money when installed properly. It applies water directly to the soil eliminating over – spray head onto roads and driveways. The output of drip systems can vary significantly, anywhere from 0.5 to 0.4 gallows per hours.

2.14 SPRINKLER MAINTENANCE

It is important to do a regular maintenance check on sprinklers. If sprinklers are not kept in good working condition, they waste water as well as have detrimental effects on the landscape. Turn on the sprinklers during daylight hours to inspect the system for broken, clogged or misaligned heads.

A common problem with sprinkler systems is pressure. Without correct pressure, the sprinklers will not be able to perform as designed. One may notice large brown areas of lawn where the sprinkler is not reaching, or shooting over. High pressures can also damage nozzles and heads – sometimes even causing them to break off. Spray heads should be operating at about 25 to 30psi , rotor heads 30 to 50psi. one (the farmer) may need a landscape or sprinkler professional to check the pressure at the sprinkler heads. If the pressure is too high, pressure reducing valve and heads may be installed, or one may be able to retrofit his existing heads with new nozzles instead of replacing them. He can also consult his manufacturer's instructions and specifications to ensure proper pressure.

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 LAND SURVEY

The land is 3m by 3m and an open land with no tree and slopes. The project area is located at the Federal University of Technology Minna on a site located opposite the central workshop on the campus.

3.2 Water Source

The water source is from river, which was conveyed to the project area and stored in two tanks located at the project area. The first tanks capacity is 1000l, while the second tanks capacity is 2000l.

3.3 System Evaluation

Some list of item checked and corrected before proper evaluation of sprinkler system was carried out are:

i) Mismatched heads

ii) Poorly adjusted head

iii) Head that are crooked

iv) Broken heads

v) Pressures that are abnormal i.e. too low or too high

3.4 Tools and procedures

Tools: Catch cans, Measuring tape, Stop watch, Measuring can and Water pump

Procedures

A square type field layout was used in the test i.e. in form of grid. The area around the sprinkler was divided into square grid pattern of 4m by 4m and of 3.75m by 3.75m. The cans were placed at the centre of each square grid to represent precipitation falling on the area. It was ensured that the can grid covers the entire area of the ensured that the can grid covers the entire area of the sprinkler spread. The depth of water was collected in the can after running the system for 15minutes and 50 minutes

3.5 Infiltration test

Objectives

This was carried out to determine the rate at which water percolates into the soil of the project area. The infiltration of the soil was observed, especially in areas around the fastest spray gauge cans.

Materials and Equipment

i) Double ring infiltrometer

ii) Hammer

iii) Flat metal bar

iv) Bucket

v) Ruler scriber

Producer

i) The two rings (outer and inner) were arranged after the other.

ii) A metal bar was placed on the top of the rings to ensure uniform penetration to the required depth.

iii) Two hammer were used at both sides of the metal bar, applying vertical hammering to ensure the required penetration into the soil.

iv) A reference print was taken in the inner ring.

v) Water was poured into the inner ring to the reference point level, the same at the outer ring.

vi) A stop watch was set on it at intervals within which water was allowed to percolate before filling.

vii) Measurement was taken using ruler after the chosen time elapsed and the level of water increased to the reference point.

3.6 Application Uniformity

This means how evenly the sprinkler system distributes water over the field. This was evaluated using the Christiansen Uniformity coefficient. The coefficient of Uniformity was computed using the following equations.

$$CU = 100 - 80.0\ {}^{S}/_{X} \qquad 3.1$$

Where;

S = Standard deviation of the observation

X= Average depth

Equation 3.2 was not used because it is not recommended for surface system, since their distribution pattern are normally distributed.

Perhaps the best known and most widely used distribution uniformly co-efficient is Christiansen's Cu, proposed four decades ago.

$$CU = 100\ \frac{(1 - \Sigma(\,|Xi - \bar{X}|\,)}{Xn} \qquad 3.2$$

Where,

CU = Christiansen's Uniformity coefficient, percent

N = number of collecting cans in the overlapping area.

Xi = Water measurement in the ith collecting can (I = 1,2, ……….,N)

X = mean of n measurements in the overlapping area.

$\Sigma\ |Xi - \bar{X}|$ = sum of absolute deviations from the mean measurement.

CU is still the single most used yard stick for water uniformity. It also indicates on average how uniform the sprinkler pattern is.

3.7 Distribution Uniformity (DU)

Distribution Uniformity is a ratio, expressed in percentage of the average low – quarter amount infiltrated to the average amount infiltrated.

$$DU = 100 \frac{\bar{X}LQ}{X} \quad 3.3a$$

$$DU = 100 - 1.59\,(100 - CU) \quad 3.3b$$

Where;

$\bar{X}LQ$ = Low quarter average depth

X = Average amount depth

3.8 Sprinkler Application Rates

Application rate is used to properly match sprinklers to the soil. Crop and terrain in which they operate.

The application rate.

$$Ra = \frac{KQn}{SlSs} \quad 3.4a$$

Where;

Qn = Discharge from sprinkler, l/min

K = Unit Constant (K = 60 for Ra in mm/hr)

Sl = Spacing (distance) between laterals (m)

Ss = Spacing (distance) between the sprinklers (m)

Or

$$Ra = \frac{X}{t_s} \quad 3.4b$$

Where;

S = average depth, t_s = time

3.9 Sprinkler Discharge Capacity

$$Qs = \frac{(K)\,(d)\,(Sl)\,(Ss)}{(H - Tm)\,(Ea)} \quad 3.5$$

Where: Qs = Sprinkler capacity (l/min)

D = depth to be applied (mm)

Sl = Spacing (distance) between laterals (m)

Ss = Spacing (distance) between sprinklers (m)

H = Spacing (distance) between the beinning of successive irrigation of a given set (hr).

Tm = downtime for moving set – move systems and or maintenance (hr).

Tm = downtime for moving set – move systems and or maintenance (hr)

Ea = application efficiency ().

K = 1.67 for Qs in l/min and Sl and Ss in m

The interval H in equation 3.6 can be determined from:

$$H \leq \frac{(0.24)\ (A)\ (d)}{DDIR} \qquad 3.6$$

Where;

A = percent of total field area irrigated when the system is operating.

d = desired depth of irrigation (mm)

DDIR = desired daily irrigation requirement for d mm.

(DDIR is in mm/day when d is in mm)

Or

Sprinkler discharge was determined by (Michael, A.M 1981)

$$Q = Si \times Sm \times I \qquad 3.7$$

Where;

Si = Spacing of sprinkler along laterals, m

Sm = spacing of laterals along the main

q = Sprinkler discharge

I = application rate.

3.10 Nozzle Discharge

$Q = Ca\sqrt{2gh}$ 3.8

Where;

Q = Nozzle discharge

a = cross – sectional area of nozzle or orifice

h = pressure head

c = coefficient of discharge (0.95 – 0.96)

3.11 Standard Error

S.D = S.E 3.9

Where;

S.D = Standard Deviation

S.E = Standard Error

And S.D = S

Where;

$S = [{}^{1}/_{n-1} \sum (Xi - \bar{X})^2]^{1/2}$ 4.0a

Where;

n = number of Samples (Cans)

Xi = Results

$\bar{X}$ = Means

Therefore; standard error; $S.E = [{}^{1}/_{n-1} \Sigma (Xi - \bar{X})^2]^{1/2}$ 4.0b

3.12 Discharge From Pipe (Main and Lateral Pipe)

$$Q = \frac{Volume}{Time} \quad 4.1$$

Where,

Q = discharge

3.12.1 Discharge from Pipe

$$Q = av \quad 4.2$$

Where;

Q = discharge

a = area

v = velocity

where;

$$a = \frac{\pi D^2}{2}$$

Where;

D = diameter

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

Table 4.1 Shows the depth of water collected from 29 catch cans arranged in the square grid for each of the tests. This was to analyse the result to determine whether the system operated efficiently. These tests showed how the sprinkler irrigation system distribute water over the area at different speeds of 3,600rpm, 3,300rpm and 3,000rpm, respectively.

Table 4.1 Depth of Water in Catch Cans (mm)

CAN (mm)	1 (3,600rpm)	2 (3,300rpm)	3 (3,000rpm)
1	11.5	8.5	5.5
2	11.5	8.5	5.5
3	12.5	9.5	6.5
4	11.5	8.5	5.5
5	11.5	8.5	5.5
6	11.5	8.5	5.5
7	19.0	16.0	13.0
8	19.0	16.0	14.0
9	20.0	17.0	13.0
10	19.0	16.0	13.0
11	19.0	16.0	13.0
12	19.0	9.0	14.0
13	15.5	9.0	13.0

14	16.0	9.0	13.0
15	8.0	5.0	2.0
16	8.0	5.0	2.0
17	8.0	5.0	2.0
18	9.0	6.0	3.0
19	8.0	5.0	2.0
20	8.0	5.0	2.0
21	8.0	5.0	2.0
22	8.0	5.0	2.0
23	0.5	0.2	0
24	0.5	0.2	0
25	0.5	0.3	0
26	0.6	0.2	0
27	0.5	0.2	0
28	0.5	0.2	0
29	0.5	0.2	0
Total	**284.6**	**209.5**	**157.0**
Mean	**9.81**	**7.22**	**5.41**
Standard Error	**6.66**	**5.61**	**5.30**

Table 4.2: Classification and Adaptability of Rotating Head Sprinkler

Types of Sprinkler	Normal under Tree Sprinkler	Low Pressure System	Intermediate Pressure System	High Pressure System
Sprinkler Discharge (1/5)	0.06 to 0.25	0.3 to 1.0	2.0 to 10	10 to 50
Diameter of Nozzle	1.5 to 6.0	3.0 to 6.0	10 to 20	20 to 40
Recommended Speed of Sprinkler Rotation (rpm)	0.5 to 1.0	0.5 to 1.0	0.7	0.5

Source: Michael (1981)

Table 4.3: Performance Parameter

	CU (%)	DU (%)	Application Rate (cm/hr)
Test 1	68	57.70	1.3
Test 2	65	65.90	1.2
Test 3	64	61.51	1.1
Average	66	62	1.3
Recommendation	85	80	2.5

Source: Michael (1981)

4.1 DISCUSSION

Table 4.3 shows the results of coefficient of uniformity (CU), distribution uniformity (DU) and application rate from each test carried out. The average coefficient of uniformity computed was more than the value of 85% recommended for coefficient of uniformity. The distribution uniformity and application rate were also above the recommended value of 80% and 2.5cm/hr respectively. The high uniformity will create areas that are too wet.

4.2 Evaporation from Sprinkler

Table 4.4 shows that wind increases evaporation rate by transporting water vapour away from evaporating surface. This is due to the forces exerted by wind which is proportional to the cross-sectional area of the drop. Wind also increases evaporation by transporting warmer or drier air from surrounding areas to displace the moist, cool air above are irrigated.

Table 4.4: Infiltration Data

Elapsed Time (minutes)	Depth (cm)	Infiltration Rate (cm/hr)
0		
5	2.4	288
10	1.6	192
15	1.0	120
20	0.8	96

25	0.7	84
35	0.7	42
45	0.6	36
60	0.9	36
80	0.9	27
100	1.1	33
120	1.1	33
140	1.1	33

The graph for the infiltration test shows that the infiltration rate of the soil is highest immediately after infiltration begins at 288mm/hr and decreases steadily at 33mm/hr with time towards the steady state. From table 4.3, application rate is less than infiltration rate (33mm/hr) in table 4.4. Therefore, there is no possibility of runoff. Table 4.3 shows an application rate that can be continued indefinitely without runoff.

4.3 Effect of Performance Parameters

In the application rate, higher operating pressure increases the volume of water applies as smaller droplet while decreasing the volume of larger droplets. Nozzle opening shape can have an important effect on droplet size while nozzle angle has little, or no effect. Distribution patterns from sprinkler that emit smaller droplets are more subject to wind distortion and lower application uniformity.

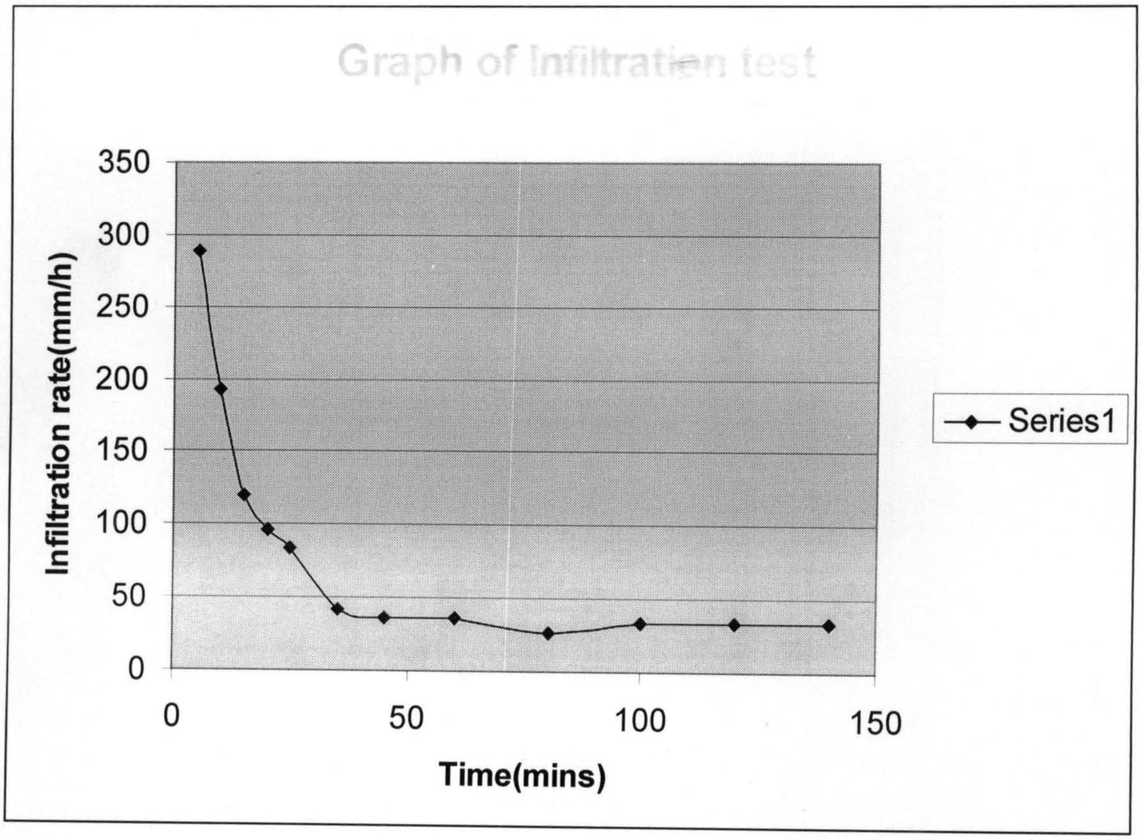

Fig 4.1 Graph of Infiltration rate (mm/h) against Time (mins)

CHAPTER FIVE

5.0 RECOMMENDATION AND CONCLUSION

5.1 CONCLUSION

Looking critically at the meaning of the project topic distribution of uniformity of sprinkler irrigation system; taking each word one step after the other; Distribution means Spreading or applying; while uniformity means evenly; sprinkler is a device used for the application of water or spreading of water on a field; while irrigation is the application of water on a field in the absence of rainfall.

Distribution of uniformity of a sprinkler irrigation system therefore means the application or spreading of water evenly by the sprinkler irrigation system on the field.

At the end the distribution uniformity and coefficient of uniformity were found to be 99% and 98%, respectively. Which indicated that application was not satisfactory. For a satisfactory distribution uniformity and coefficient of uniformity, the distribution uniformity and coefficient of uniformity must be 80% and 85%. The reason for the application not satisfactory is because of the uneven head of the sprinkler irrigation system.

The sprinkler system used is suitable for any topographic condition because of its flexibility and efficient control of water application.

The result obtained from the infiltration test showed that the infiltration rate of the soil is highest immediately after infiltration begins and then decreases steadily with time towards the basic infiltration rate of the soil.

5.2 RECOMMENDATIONS

From the experiment conducted,

i. The sprinkler system should be operated when the weather condition is suitable for the sake or purpose of uniformity. Because when the sprinkler system is operated when the weather condition is not favourable, the field will have an uneven distribution of water.

ii. The sprinkler irrigation system should have the same sprinkler head for even distribution of water. So that some plants won't suffer for too much of water while other suffer for lack of water

iii. The water source should be free from dirt in order not to block the nozzle of the sprinkler head; which can affect the even distribution of water on the field.

iv. And also, the sprinkler system should be operated at a normal pressure, not too high and not too low for an even distribution of water on the field.

v. The introduction of an automatic timer and building the sprinkler system with a computerized system, for a proper and even application of water on the field should be considered.

vi. The sprinkler closest to the abnormal high or low readings should be checked.

REFERENCES

Christiansen, J. E. (1942). Irrigation by Sprinkler. University of California Agricultural Experiment Station. Pp 225 – 230

David, F. Z.; Kenneth, H.S. (1988). Coefficient of Uniformity. http://cati.csufresno.edu/cit/rese/88/880106/index.html

David, F. Z.; Kenneth, H. S. (1988). Sprinkler Systems. http://www.conservewater.uttah.gov/outdooruse/sprinklersystem

David, F. Z.; Kenneth, H. S. (1988). Sprinkler Systems. http://www.conservewater.uttah.gov/outdooruse/irrigation

Egharevba, N. A. (2002). Irrigation And Drainage Engineering. Nma Printers and Publishing Co. Ltd, Minna. Pp 42 – 43

Hunsaker, J. G. (1998). Principals of Farm Irrigation System Design. John Wiley and Son, New York. Pp 194,195,198,203,204.

James, S. F.; George, H. S. (1980). Quantitative Analytical Chemistry (2nd Edition). McGraw-Hill, New York. Pp 190 – 191.

Michael, A. M. (1981). Irrigation Theory and Practice. Vain Education Book House 20.4 Industrial Area, Sahibabad, India. Pp 624,625,642,643 and 644.

Olurunaiye, E. S.(2001). Irrigation Technology Lecture Note. Department of Agricultural Engineering, Kaduna Polytechnic, Kaduna.

Weatherburn, C. E. (1968). Mathematical Statistics. Syndics of the Cambridge University Press Bentley House, 200 Euston Road, London. Pp 73, 110 – 115, 118, 122 – 125, and 130 – 145.

APPENDIX A

Table of Standard Error Computed at the Speed of 3,600rpm

Xi	**Xi – $\bar{X}$**	**(Xi – $\bar{X}$)^2**	**Xi^2**
11.5	1.69	2.86	132.25
11.5	1.69	2.86	132.25
12.5	2.69	7.24	156.25
11.5	1.69	2.86	132.25
11.5	1.69	2.86	132.25
11.5	1.69	2.86	132.25
19	9.19	84.46	361
19	9.19	84.46	361
20	10.19	103.84	400
19	9.19	84.46	361
19	9.19	84.46	361
19	9.19	84.46	361
15	5.19	26.94	225
16	6.19	38.32	256
8	-1.81	3.28	64
8	-1.81	3.28	64
8	-1.81	3.28	64
9	-0.81	0.66	81
8	-1.81	3.28	64

8	-1.81	3.28	64
8	-1.81	3.28	64
8	-1.81	3.28	64
0.5	-9.31	86.68	0.25
0.5	-9.31	86.68	0.25
0.5	-9.31	86.68	0.25
0.6	-9.21	84.82	0.36
0.5	-9.31	86.68	0.25
0.5	-9.31	86.68	0.25
0.5	-9.31	86.68	0.25
Total	**0.11**	**1,241.46**	

Where $\bar{X} = 9.81$

Standard Error = $[{}^{1}/_{n-1}\ \Sigma\ (Xi - \bar{X})^2\ ]\ ½$

$= [{}^{1}/_{29-1}\ \Sigma\ (Xi - \bar{X})^2\ ]\ ½$

$= [{}^{1}/_{28}\ \Sigma\ (1{,}241.46)]\ ½$

$= 6.66$

Therefore Standard Error = 6.66

APPENDIX B

Table of Standard Error Computed at the Speed of 3,300rpm

Xi	$Xi - \bar{X}$	$(Xi - \bar{X})^2$	Xi^2
8.5	1.28	1.64	72.25
8.5	1.28	1.64	72.25
9.5	2.28	5.20	90.25
8.5	1.28	1.64	72.25
8.5	1.28	1.64	72.25
8.5	1.28	1.64	72.25
16.0	8.78	77.10	256
16.0	8.78	77.10	256
17.0	9.78	95.65	289
16.0	8.78	77.10	256
16.0	8.78	77.10	256
16.0	8.78	77.10	256
9.0	1.78	3.17	81
9.0	1.78	3.17	81
5.0	-2.22	4.93	25
5.0	-2.22	4.93	25
5.0	-2.22	4.93	25
6.0	-1.22	1.49	36
5.0	-2.22	4.93	25

5.0	-2.22	4.93	25
5.0	-2.22	4.93	25
5.0	-2.22	4.93	25
0.2	-7.02	49.28	0.04
0.2	-7.02	49.28	0.04
0.3	-6.92	47.89	0.09
0.2	-7.02	49.28	0.04
0.2	-7.02	49.28	0.04
0.2	-7.02	49.28	0.04
0.2	-7.02	49.28	0.04
Total	**0.12**	**880.46**	

Where $\bar{X} = 7.22$

Standard Error $= [{}^1/_{n-1} \Sigma (Xi - \bar{X})^2]^1/_2$

$= [{}^1/_{29-1} \Sigma (Xi - \bar{X})^2]^1/_2$

$= [{}^1/_{28} \Sigma (880.46)]^1/_2$

$= 5.61$

Therefore, Standard Error = 5.61

APPENDIX C

Table of Standard Error Computed at the Speed of 3,000rpm

Xi	$Xi - \bar{X}$	$(Xi - \bar{X})^2$	Xi^2
5.5	0.09	0.0081	30.25
5.5	0.09	0.0081	30.25
6.5	1.09	1.19	42.25
5.5	0.09	0.0081	30.25
5.5	0.09	0.0081	30.25
5.5	0.09	0.0081	30.25
13.0	7.59	57.61	169
14.0	8.59	73.79	196
13.0	7.59	57.61	169
13.0	7.59	57.61	169
13.0	7.59	57.61	169
14.0	8.59	73.79	196
13.0	7.59	57.61	169
13.0	7.59	57.61	169
2.0	-3.41	11.63	4
2.0	-3.41	11.63	4
2.0	-3.41	11.63	4
3.0	-2.41	5.81	9
2.0	-3.41	11.63	4
2.0	-3.41	11.63	4

2.0	-3.41	11.63	4
2.0	-3.41	11.63	4
2.0	-3.41	11.63	4
0	-5.41	29.27	0
0	-5.41	29.27	0
0	-5.41	29.27	0
0	-5.41	29.27	0
0	-5.41	29.27	0
0	-5.41	29.27	0
0	-5.41	29.27	0
Total	**0.11**	**786.58**	

Where $\bar{X} = 5.41$

Standard Error $= [{}^{1}/_{n-1}\, \Sigma\, (Xi - \bar{X})^2]^{1}/_{2}$

$= [{}^{1}/_{29-1}\, \Sigma\, (Xi - \bar{X})^2]^{1}/_{2}$

$= [{}^{1}/_{28}\, (786.58)]^{1}/_{2}$

$= 5.30$

Therefore, Standard Error = 5.30

APPENDIX D

Calculating the coefficient of Uniformity (CU), using the Christiansen's Uniformity Coefficient, and distribution Uniformity (DU) for first, second and third Sprinkler Irrigation Practical performed at different speed. Which are; 3,600rpm, 3,300rpm, and 3,000rpm.

For First Practical at 3,600rpm;

$CU = 100\,(1 - {}^{\Sigma|d|}/_{n\bar{X}})$

Where,

$d = Xi - \bar{X}$

CU = Christiansen's Uniformity Coefficient

n = Number of Observation

where, d = 0.11

n = 29

$\bar{X} = 9.81$

Therefore,

$CU = 100\,(1 - {}^{0.11}/_{29 \times 9.81})$

CU = 99%

For Second Practical at 3,300rpm;

$CU = 100\,(1 - {}^{\Sigma|d|}/_{n\bar{X}})$

Where,

$d = 0.12$

$n = 29$

$\bar{X} = 7.22$

Therefore;

$CU = 100\ (1 - {}^{0.12}/_{29\ X\ 7.22})$

$CU = 99\%$

For Third Practical at 3,000rpm

$CU = 100\ (1 - {}^{\Sigma|d|}/_{n\bar{X}})$

Where;

$d = 0.11$

$n = 29$

$\bar{X} = 5.41$

Therefore,

$CU = 100\ (1 - 0.11/29\ X\ 5.41)$

$CU = 99\%$

Calculation of Distribution Uniformity

$DU = 100 - 1.59(100 - CU)$

For First Practical at 3,600rpm

CU = 99%

Therefore,

DU = 100 – 1.59(100 – 99)

DU = 98%

For Second Practical at 3,300rpm

CU = 99%

Therefore,

DU = 100 -1.59(100 – 99)

DU = 98%

For Third Practical at 3,000rpm

CU = 99%

Therefore,

DU = 100 -1.59(100 – 99)

DU = 98%

APPENDIX E

Computation of discharge through the pipe

$Q = av$

Where,

Q = discharge

a = area

v = velocity

where;

$$a = \frac{\pi D^2}{4} \text{ X } V$$

where; D = diameter

therefore; $Q = \frac{\pi D^2}{4} \text{ X } V$

And average discharge of liquid through a pipe is;

$$Q = \frac{\pi D^2}{4} \text{ X } V$$

Where;

V = average liquid velocity through a pipe. Which has a value of 1.458m/s

Where;

D for main pipe = 4cm, and

D for lateral pipe = 2.5cm

Therefore;

$$Q = \frac{\pi(0.04)^2}{4} \times 1.458$$

$Q = 1.832 \times 10^{-3}\ m^3/sec$

Q for the lateral pipe

$$Q = \frac{\pi(0.025)^2}{4} \times 1.458$$

$Q = 7.157 \times 10^{-4}\ m^3/sec$

APPENDIX F

Table F1: Record of Data and Monthly Meteorological Data

	January		February		March		April		May		June		July		August		September		October		November		December	
2005																								
	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X
Temperature	1045	33.7	1071	38.3	1222	37.6	1127	37.6	1046	33.7	941	31.4	912	29.4	892	28.8	916	20.5	978	31.5	1052	35.1	1100	35
Rainfall	0.0		0.0		0.0		49.1		87.0		207.0		294.2		127.8		216.6		94.8		0.0		0.0	
Evaporation	454.8	14.7	196.3	7.0	307.2	9.9	244.7	8.2	140.8	4.5	86.1	2.9	53.0	1.7	58.8	1.9	62.4	2.1	83.0	2.7	232.6	7.8	299.8	9.8

APPENDIX G

Table F2: Record of Daily and Monthly Meteorological Data

	January		February		March		April		May		June		July	
2006														
	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X	Sum	X
Temperature	1108	35.7	1057	37.5	1167	37.6	1152	38.4	992	32.0	945	31.5	934	30.1
Rainfall	11.2		0.0		TR		29.9		195.0		107.7		229.7	
Evaporation	268.2	8.7	287.1	10.3	313.0	10.1	290.3	9.7	112.1	3.6	90.9	3.0	65.2	2.1