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EVALUATING COEFFIECNT OF UNIFORMITY FOR CENTER PIVOT SPRINKLER IRRIGATION

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Abstract

The main objective of irrigation is to apply the optimum amount of water to the crop root zone that the crop needs for development and which cannot be provided by rains. When irrigation systems are used to apply fertilizers and pesticides, application uniformity becomes even more critical. Consequently, it is important for center pivot owners and operators to periodically check the uniformity of their systems. Therefore, the main objective of this study was evaluating the coefficient of uniformity for center pivot sprinkler irrigation in order to address the potential of uniform irrigation application using center pivot sprinkler irrigation. The uniformity of water application under a center pivot is determined by setting out 24 catch cans with a 9 cm opening diameter and 11.5 cm height located along a line extending radially from the point 70 meter away from the center of the pivot at 2 m spacing between each can, bringing the irrigation system up to proper operating pressure, and letting the system pass over them. The discharge of the system is measured by using measuring gauges .Record the distance from the center of the pivot and the amount of water collected for each can. This weighing can be done by multiplying the amount of water observed in every catch by either the distance from the center pivot or in number of location. From this information, a coefficient of uniformity can be calculated and usually expressed as a percentage. Results from the field evaluation and calculated using Christiansen Coefficient of Uniformity (CU) was 91.3%, which is very good.

Key words: coefficient of uniformity, center pivot sprinkler, depth of application, catch can

Introduction

Irrigation plays a crucial role in addressing the main challenges caused by food insecurity and rainfall uncertainty. FAO (2002) estimated that 80% of the additional production required to meet the demands of the future will have to come from intensification and yield increase. The main objective of irrigation is to apply water to the crop root zone, the optimum amount of water that the crop needs for development and also that cannot be provided by rains. There are different methods of irrigation water applications, from these methods center pivot sprinkler irrigation method is one of the pressurized irrigation systems that takes water from a source and spray it to the atmosphere as droplets by means of an enclosed system and under pressure. The water is transmitted to the surface of the soil in equal distribution with the sprinkler irrigation system to obtain uniform distribution in the crop root zone. (Keller and Bliesner, 1990). With rising fuel prices it is increasingly important that irrigation systems apply water uniformly in order to achieve maximum benefit from the water applied. When irrigation systems are used to apply fertilizers and pesticides, application uniformity becomes even more critical. Consequently, it is important for center pivot owners and operators to periodically check the uniformity of their systems (Rogers et al., 1994b).

Therefore, this study was proposed and executed with the specific objective of evaluating the coefficient of uniformity for center pivot sprinkler irrigation in order to address the potential of uniform irrigation application using center pivot sprinkler irrigation.

Materials and Methodology

Description of the Study Area

The experiment was conducted at Lay Bir farm, in Jabitehnan Woreda, West Gojam Zone of Amhara Region, which is located 400 km North West of Addis Ababa and 170 km South East of Bahir Dar. The area has an annual rainfall of 1031mm, and average minimum and maximum temperatures of 11.9 and 29.0 ^{o}C, respectively. The altitude is about 1692 m.a.s.l, and at a latitude and longitude of 10^{o}N and 37^{o}E, respectively (Bir Farm Metrological Station).

The soil in the experimental site is red (nitosol) with moderate organic matter content and acidity. The major crops grown include maize, wheat, sorghum, soybean, haricot beans, onion and pepper. Among these crops, onion is the largest irrigated crop. Cereal crops like maize, wheat and sorghum are rainfed. In the study farm, both surface and sprinkler irrigation methods are practiced but the area under sprinkler irrigation is fast expanding.

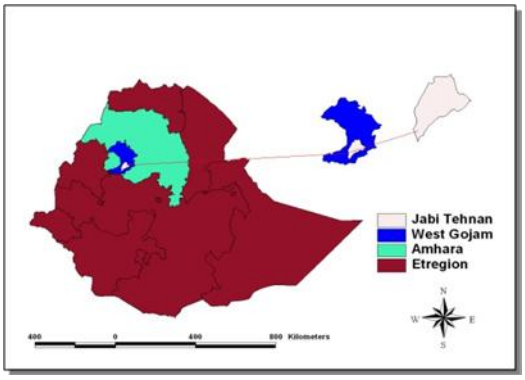

Figure 1. Location map of the study area

Experimental Design

The center pivot sprinkler installed in the experimental area was irrigating a total of 37.7 ha and the height of the laterals is 2m above the ground. 24 Catch cans with a 9 cm opening diameter and 11.5 cm height are used and located along a line extending radially from the point 70 meter away from the center of the pivot at 2 m spacing between each can.

Weather data

The ten year temperature, humidity, sunshine hours, wind speed, rainfall and other necessary data were collected from Bir Farm Metrological Station. The data were used to estimate average values for wind speed and others.

Performing the Test

The basic materials necessary to perform a uniformity test are catch containers, tape measure or roll tape, stopwatch, flags to assist in last tower speed measurement, liquid measuring device (if not using rain gauges), and a worksheet to record the data.

Set out cans or rain gauges in a straight line from the pivot point. Place the first gauge about 150 to 200 feet from the pivot point. It is not necessary to place gauges any closer to the pivot point than this because the uniformity under the first tower is usually not good (Howell, 2003). It is recommended that the gauge spacing be comparable to the sprinkler spacing on the pivot. A 10- to 30-foot spacing is usually preferred. Placing the gauges closer together provides a more accurate representation of the application uniformity. Once the gauges are in place, bring the pivot up to normal operating pressure and then operate (forward or reverse direction) to pass over the gauges completely. The speed of the pivot (percentage timer setting) is not important. Operation at the normal percentage timer setting, however, will tell the operator whether the system is applying the amount of water that is desired. As the pivot is moving, walked the length of the pivot and looked for leaks and sprinklers that might not be rotating or operating properly. Make a note of these locations on the back of the data sheet. These notes helped to make recommendations for improvements.

After the pivot has passed over the gauges, record the distance of each gauge from the pivot and the depth or volume of water collected in each gauge. When calculating the uniformity coefficient, disregarded all gauges at the end of the system in which the volume of water collected begins to drop drastically.

Uniformity

A number of methods can be used for determining application uniformity. For a center pivot irrigation system, the easiest and most widely used method/formula is the Christiansen Uniformity coefficient (Allen, 2003). The uniformity of water application under a center pivot is determined by setting out cans or rain gauges along the length of the pivot, bringing the irrigation system up to proper operating pressure, and letting the system pass over them (Figure 2). Record the distance from the center of the pivot and the amount of water collected for each can or gauge. From this information, a coefficient of uniformity can be calculated. The coefficient of uniformity is usually expressed as a percentage. Interpretation of these values is presented later.

To carry out evaluation of center pivot systems catch cans with a 9 cm opening diameter and 11.5 cm height are used and located along a line extending radially from the point 70 meter away from the center of the pivot at 2 m spacing between each can. The discharge of the system is measured by using measuring gauges. Environmental conditions during testing (i.e. air temperature and relative humidity, wind speed and direction) are registered from nearby metrological station. The values observed in catch cans must be weighed since the amount of water corresponding to every point represents a larger surface far away from center pivot. This weighing can be done by multiplying the amount of water observed in every catch by either the distance from the center pivot or in number of location.

Data for computation of uniformity of water distribution was measured by placing 9 cm opening diameter and 11.5 cm deep cans located along a line extending radially from the point 70 m away from the center of the pivot at 2 m spacing between each cans. The Christiansen uniformity coefficient was then calculated using equation 1 (Allen, 1993).

$$CU = 100 \times \left[1 - \frac{\sum X}{n.m} \right] \quad (1)$$

Where, CU is distribution coefficient Christiansen (%),

$\sum X$ is summation of deviations from the mean depth collected, m is the mean depth collected and n is the number of observations

Figure 2. Catch cap lay out

RESULT AND DISSCUSSON

Evaluating Coefficient of Uniformity

24 catch cans have been conducted in order to identify coeffiecnt of uniformity .During testing there was uniform climatic condition of average minimum and maximum air temperature, relative humidity, wind speed of the sprinkler 9.6 0_c ,30.7 0_c ,46%,1.7 m/s and respectively.

Results from the field evaluation and calculated using Christiansen Coefficient of Uniformity (CU) was 91.3% According to Allen (1993), the distribution uniformity ranked is very good. This very good distribution uniformity might have been observed due to the fact that the system was new (one year old while the study was made) and fully automatic and electronically controlled. According to Hanson (2005), a uniformity of 100 percent means the same amount of water infiltrates everywhere in a field. No irrigation system, however, can apply water at 100 percent uniformity. Regardless of the irrigation method, some parts of a field infiltrate more water than other areas. More drainage below the root zone implies higher non uniformity and differences in infiltrated water throughout the field.

Depth of Application– Distance from Pivot – Relationship

Actual plots of data collected are shown in figure 2 to illustrate this point. The calculated uniformity coeffiecnt was 91.3 %, while this Coeffiecnt is very good (Allen, 1993).The relationship between distance from pivot point (m) and the depth of irrigation water (mm) is shown Figure 3 below.

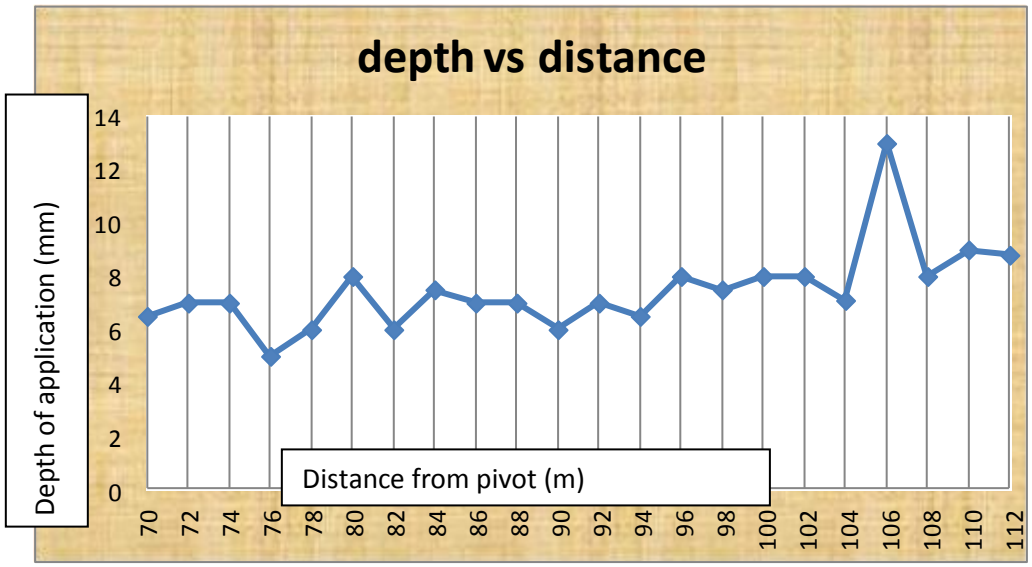

Figure 3. Depth of application– distance from pivot – relationship

From Figure 3, show a simple plot of where high or low application amounts occur and used to indicate the places where attention is needed. The "high" and "low" application amounts are at several locations along the system, making individual sprinkler replacement too involved (Howell, 2003).

SUMMARY AND CONCLUSION

Summary

The main objective of irrigation is to apply to the crop root zone the optimum, amount of water that the crop needs for development and also that cannot be provided by rains. With rising fuel prices it is increasingly important that irrigation systems apply water uniformly in order to achieve maximum benefit from the water applied. When irrigation systems are used to apply fertilizers and pesticides, application uniformity becomes even more critical. Consequently, it is important for center pivot owners and operators to periodically check the uniformity of their systems. In this study, attempt was made to evaluate the coeffiecnt of uniformity for center pivot sprinkler irrigation.

Field studies were conducted to evaluate the Coeffiecnt of uniformity of applied water on center–pivot Field measurements of water application patterns were conducted on three center– pivot systems in bir farm. 24 catch cans have been conducted in order to identify coeffiecnt of uniformity .During testing there was uniform climatic condition such as average minimum and maximum air temperature, relative humidity, wind speed and of the sprinkler 9.6 0_c ,30.7 0_c ,46%,1.7 m/s and respectively. The area irrigated by center pivot was 37.7 ha.

Results from the field evaluation and calculated using Christiansen Coefficient of Uniformity (CU), was 91.3% According to Allen (1993), the distribution uniformity ranked very good. This very good distribution uniformity might have been observed due to the fact that the system was new (one year old while the study was made) and fully automatic and electronically controlled. According to Hanson (2005), a uniformity of 100 percent means the same amount of water infiltrates everywhere in a field. No irrigation system, however, can apply water at 100 percent uniformity. Regardless of the irrigation method, some parts of a field infiltrate more water than other areas. More drainage below the root zone implies higher non uniformity and differences in infiltrated water throughout the field.

Conclusion

From the results obtained in determining coeffiecnt of uniformity experiment the following conclusions is drawn.

1. The coeffiecnt of uniformity obtained is 91.3 % which is ranked as very good.

Recommendation

The recommendations drawn from this research are:

1. This experiment made using sprinkler irrigation was the first of its kind in the Ethiopia universities graduate research system. Lessons have been learned, in the process and incorporated in the thesis compared what was proposed initially. Hence I recommend for future research to review the experience presented in this thesis.
2. The experiment was undertaken by taking a limited number cans for logistical reasons. As one of the predicament of graduate research, the experiment is a one season one place experiment; hence repeating the experiment in space and time, and using other number of catch cans shall improve the validity of the finding
3. The test sprinkler considered here is only one center pivot sprinkler. But other center pivot sprinklers should be also considered in the farm; coefficient of uniformity should be tested for all sprinklers.
4. The experiment was undertaken by taking a limited number cans with spacing of 2 meters for logistical reasons. It is necessary to place cans less than 2 meters to get more accurate values

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