Evaluation of Speed Effect on Center Pivot Irrigation System Performance at Waha Project under Sudan North State Conditions

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Abstract—This study assess the impact of speed on the performance of the center pivot irrigation system in Alwaha project under the conditions of Sudan - Northern State. Four speeds were studied (60%, 70%, 80%, 100%) to compare the uniformity distribution under these speeds using complete randomized design. Values of uniformity distribution obtained were as follows (55.9%, 75.6%, 61.9%, 68%) for different speeds, respectively. Analysis of variance for these results showed a significant differences between these values (P ≤ 0.05) and we noted from the results that the general trend for the uniformity distribution increased with speed.

Keywords—Center pivot irrigation, uniformity distribution, efficiency, technology.

I. INTRODUCTION

The center pivot irrigation is one of the modern irrigation methods introduced in North State because its capable to improve climate, increase productivity and decrease operation costs of irrigation by reduce the power used and this study aim to evaluate the efficiency of this modern method at different operation speeds.

The center pivot has at times been referred to as the most significant piece of technology to change the face of agriculture since the tractor. Its ability to irrigate “hilly” terrain and irregular shaped field has greatly influenced the development of land environment and climates and increased the ability to produce, even in dry years[2].

The center pivot was named because of its radial rotation around center pivot, the center point is called the pivot. This self-propelled sprinkler system rotates around pivot point and has the lowest labor requirements of the system considered. It is constructed using a span of pipe connected to movable towers. It irrigates approximately 125.5 hectares (299fed) out of square quarter section.

Center pivot systems are either electric, water or oil-drive and can handle slopes up to 15 percent. Sprinkler packages are available for low to high operation pressures (55 to 80 psi) at pivot point. Sprinkler can mounted on top of the spans or on drop – tubes, which put them closer to the crop, the water application amount is controlled by the speed of rotation [1].

[2] reported that the depth of water applied by center pivot system is determined by the speed at which the lateral rotates around the field. The maximum hours per revolution to prevent run off can be estimated by the following equation:

\[ Sr \leq \frac{24Dm}{DDIR} \]

Where,

\[ Sr = \text{Rotational speed of center pivot lateral (h / revolution)} \]
\[ Dm = \text{Amount that can be applied per irrigation without run off (mm/day)} \]
\[ DDIR = \text{Design daily irrigation requirement (mm/ day)} \]

Center pivots are adaptable for any crop heights and are particularly suited to lighter soils. They are generally not recommended for heavy soils with low infiltration rates. Deep wheel tracks can be a problem on some soils, but there are a number of management methods available to control this problem. Electric drive pivots are the most popular due to flexibility of operation. Computerized control panel allows the operator to specify speed changes at any place in the field, reverse the pivot turns on auxiliary pumps at specified time and many other features [2].

Corner attachment systems are available, which allow irrigation of most corner areas missed by a conventional center pivot systems. Depending on the method of corner irrigation, pivot system with corner attachments will irrigate 124 to 172.5 feddan out of 193.6 feddan quarter section. The most common method of corner irrigation has additional span, complete with tower, attached to the end of center pivot system main line, which swings out in the corners. As it swing out, sprinklers are turned on to irrigate the corner. The movement of the moving span is controlled either by a buried wire on mechanical switch [1].

Another type of corner system uses several guns mounted on the end of center pivot system main line. The guns are activated in sequence form smaller to largest and back again on machine moves past the corner [1]. System performance: Distribution uniformity (DU) or pattern efficiency. This method sort all data point in the overlap area
and tanks then from low to high with mean value for lowest (25) percent (low quarter) divided by mean value for the entire area. However, this method does not take into account the location of water value or any benefit, which might be divided from water value, immediately adjacent to the low values [3]. Distribution uniformity on pattern efficiency can therefore be stated in the following form.

\[ DU = \frac{\text{Average low quarter caught in the cans} \times 100}{\text{Average depth caught in all cans}} \]

Where

\( DU = \) Distribution uniformity

II. MATERIALS AND METHODS

The experiment was conducted in season 2008/9 at Alwaha project at North state on eastern bank of the Nile 12km south of El Silaim Basin at latitude 10° to 19° N longitude 29° to 30° E and attitude 235m. The total area of the project 11224 feddan the cultivated area is 1500 feddan of which 672 feddan were irrigated by four centre pivot units each 168 feddan. The complete randomized block design (CRBD) was selected. There were four treatments (speeds) and three replications. The main feature of the centre pivot system consist of:

POWER SOURCE AND PUMPING PLANT

Volvo internal combustion engine (250 hp) was used to drive the pump (yanmar 0.1m³/s) to supply water from canal to the system, and at the same time the engine was used to drive an electrical generator (19kw) to provide the system with electrical power required for its movement. A wire mesh used to strain water before pump inlet. A concrete basin was used for silt sedimentation.

Pivot point was a quadruped chain concrete foundation a pipeline 200 mm in diameter raised vertically upwards from ground level where it was connected to rotating elbow fitting. Drive unit consists of a beam on which drive motor and two wheels were mounted. At the top of each tower there was an electrical box throw which the electrical power transmitted to the drive motor. The wheels are operated by the drive motor via a connecting shaft and gearbox.

A pipeline was suspended above the ground by the drive unit. Water was delivered from the pivot to the pipeline across the area. Empty tomato paste cans with 72 mm diameter (36 cans), measuring cylinders, measuring type, sensitive balance and square sampling ring were used.

The cans were placed and distributed at equal distances. Volumetric measurement with graduated measuring cylinders were used and converted to depth (mm) by the following equation:

\[ V = A \times H \]

Where:

\( V = \) volume of water collected in ml
\( H = \) height in cm
\( A = \) bottom surface area of can in cm².

The distribution uniformity (DU) =

\[ \frac{\text{Average low quarter caught in the cans} \times 100}{\text{Average depth caught in all cans}} \]

III. RESULTS AND DISCUSSION

Distribution uniformity treatment were carried out as described. Table I shows the DU value in different speeds. There was a significant difference at \( P = 0.05 \) between treatments. Speed 70% showed higher value followed by 100%, 80% and 60% and their values were 75.6%, 68%, 61.9% and 55.9% respectively. This clarified that the DU increased as speed increased as general treat. The odd value recoded at 70% speed might attributed to some factors such as different spacing between nozzles and wind drifting. The low values of DU can be attributed to clogging of nozzles caused by sedimentation, trashes and/or nozzle being worn out and inaccurate setup of the system.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Means</th>
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<tbody>
<tr>
<td>60</td>
<td>55.9% c</td>
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<tr>
<td>70</td>
<td>75.6% a</td>
</tr>
<tr>
<td>80</td>
<td>61.9% c</td>
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<tr>
<td>100</td>
<td>68% b</td>
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IV. CONCLUSION

The following conclusion can be draw from the study. The ability of centre pivot system to operate under various speeds and the higher percentage obtained as speed increased.

REFERENCES