Performance of cans space, rows No. and calculation formula on center pivot Sprinkler Irrigation uniformity coefficient

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Abstract

A study was conducted west of Iraq at Alanbar province to evaluate the impact of cans space, rows number and calculation formula on irrigation uniformity coefficient under mid elevation spray application MESA center pivot sprinkler irrigation system.

Six catch cans space 2.5, 5.0, 7.5, 10.0, 12.5 and 15.0 m, one or two catch cans row, three system speed timer 100, 75 and 50% and two calculation formulas Christiansen (8) and Hermann & Hein (5) were used for irrigation uniformity coefficient estimation.

Sprinkler irrigation uniformity coefficient values were estimated for each span also for overall system.

Results showed the evaluated system reached a high uniformity coefficient values which ranged between 95.32 and 97.15%, average Christiansen uniformity coefficient CUC value for the studied system was 96.03% when system operated on speed timer of 100% while Hermann & Hein uniformity coefficient CUH was 96.49% at same system speed timer.

Catch cans space and rows number did not have a significant impact on irrigation uniformity coefficients for each studied formulas, also system speed timer was inoperative on irrigation uniformity coefficient for the evaluated center pivot.

Introduction

Many methodologies were presented concerning irrigation uniformity coefficient estimation under center pivot sprinkler irrigation systems. for example (4), (11), (7), (10) and many other researchers. The researchers suggested different spaces between catch cans also different catch cans rows number to be distribute under center pivot sprinkler irrigation system through evaluation process.

Three formulas widely used in calculation of center pivot sprinkler irrigation uniformity coefficient, the first one suggested by Christiansen (8) as follow:

\[ C_U = 100 \left( 1 - \frac{\sum |X - \bar{x}|}{\sum X} \right) \]
Where CU is the Christiansen’s uniformity coefficient (which symbolized in this paper CUC) in percent. X is the depth (or volume) of water in each of the equally spaced catch containers in mm or ml, and X is the mean depth (volume) of the catch mm or ml.

Hermann & Hein converted formula (5) was suggested to calculate the weighing mean of irrigation uniformity coefficient (which symbolized in this paper CUH) under center pivot irrigation systems.

\[
C_{U(H\&H)} = 100 \left\{ 1 - \frac{\left( \sum S_i V_i - \left( \frac{\sum V_i}{\sum S_i} \right) \right)}{\sum (V_i S_i)} \right\}
\]

Where \(S_i\) is the distance (m) from the pivot to the \(i\)th equally spaced catch container and \(V_i\) is the volume of the water in the \(i\)th catch container (mm or ml).

Keller and Bliesner (9) suggested the following formula to estimate the irrigation uniformity coefficient for CU values >70%.

\[
C_U = 100 \left[ 1 - \left( \frac{\sigma}{x} \right) \left( \frac{2}{\pi} \right)^{0.5} \right]
\]

Where \(\sigma\) is the standard deviation of the catch depth (mm) or volume (ml), \(x\) as in Christiansen’s equation above.

Many previous studies focused on center pivot uniformity coefficient, (10) Classified center pivot uniformity coefficient depending on CUC or CUH values to the follow classes:

- 90 to 100 — Excellent; no changes required.
- 85 to 90 — Good; no changes required unless a problem area is obvious.
- 80 to 85 — Fair; no improvements needed but system should be monitored closely.
- Below 80 — Poor; improvements needed, particularly if chemicals are to be injected.

The researchers (6) studied the impact of catch cans size and spacing on center pivot irrigation uniformity coefficient, their results showed determining the uniformity coefficient for a center pivot appears to be relatively insensitive to the collector spacing while the impact of collector catch can size was more operative on center pivot uniformity coefficient values.

Researcher (1) reported that center pivot uniformity coefficient ranged from 82 to 94% at different operation pressure, while (2) showed a uniformity coefficient values ranged between 85 and 95% for two center pivots located at different sites west of Iraq through 12 months of the year. In other study (3) stated 94.1% uniformity coefficient value for MESA center pivot.

The aims of this study is to evaluate irrigation uniformity coefficient under center pivot sprinkler irrigation system by use of many catch cans spaces, rows number also calculation formulas to choose the best way for express irrigation uniformity coefficient with less time, exertion and cost.
Methods

A study was conducted at Al-Qaim county, Alanbar province west of Iraq in order to evaluate the impact of cans space, rows number and calculation formulas on irrigation uniformity coefficient under MESA center pivot sprinkler irrigation system.

Five spans, 20.4 ha land coverage Valley MESA center pivot system with total lateral length about 255m and pivot point main pipe discharge125 m³ min⁻¹ was used in this study. The studied system was installed and used for irrigate winter wheat field since 2008. System supported with Senninger low drift nozzles LDN fixed about 150 cm above ground.

Irrigation uniformity coefficient was evaluated by use of six catch cans space 2.5, 5.0, 7.5, 10.0, 12.5 and 15.0 m, also by use of one or two cans row. A white PVC catch cans were used to collect precipitation under center pivot system, cans placed in two parallel rows stretched from the pivot to the outer tower. The first cans placed at 15m from the pivot point.

Tests repeated by use of three system timer speeds 100, 75 and 50%. Tow uniformity coefficient formulas was used, CUC Christiansen's formula (8) also CUH which was an adjusted formula suggested by (5). Uniformity coefficient calculated for each span as well as overall system.

All tests were conducted in same operation pressure which was 25 PSI at pivot point. The evaluations were carried between 7:00 – 9:00 am at in low wind speed conditions when wind speed was less than 4 Km/hr.

Results and Discussion

Table (1) shows the CUC data influenced by cans rows and space at 100% system's speed timer. The results indicate the CUC was relatively insensitive by the increase of cans space. System over all CUC values for one cans row ranged between 95.40% when cans placed with 7.5m distance between each other and 96.95% when cans space was 12.5m, while the CUC value was 95.71% when the least distance between catch cans used which is 2.5m and 95.83% with the largest distance which is 15m.
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Table (1) CUC data for different catch cans space, rows No and system spans. Speed timer 100%

<table>
<thead>
<tr>
<th>Cans Space, m</th>
<th>All System</th>
<th>Fifth Span</th>
<th>Fourth Span</th>
<th>Third Span</th>
<th>Second Span</th>
<th>First Span</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Two rows</td>
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<td>95.96</td>
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<td>96.57</td>
<td>96.67</td>
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<td>95.91</td>
</tr>
<tr>
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<td>96.76</td>
<td>97.37</td>
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<td>96.20</td>
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<tr>
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<td>95.85</td>
<td>97.56</td>
<td>97.16</td>
<td>94.71</td>
<td>94.23</td>
<td>97.47</td>
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<tr>
<td>97.15</td>
<td>96.95</td>
<td>98.06</td>
<td>98.12</td>
<td>96.64</td>
<td>95.76</td>
<td>96.23</td>
</tr>
<tr>
<td>95.32</td>
<td>95.42</td>
<td>96.94</td>
<td>95.81</td>
<td>96.86</td>
<td>96.30</td>
<td>96.97</td>
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<td>95.83</td>
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</table>

The results in table (1) also show no significant impact for catch cans rows number on CUC for all the spaces which were used between canc. The differences in CUC values due to increase cans row from one to two were less than 0.52%. Variations in CUC values caused by increase of cans row ranged between 0.05 and 0.52% when cans space were 7.5 and 5.0m respectively, while the average variation in CUC values due to increasing of rows number at all cans space was 0.20%.

Results indicate the fifth span reached the highest CUC values for both one or to rows tests which amounted 96.90 and 97.00% respectively while the second span have the lowest CUC values for one or two cans row which were 93.97 and 95.64% on succession.

Table (2) shows the CUC data influenced by cans rows and space at 75% system's speed timer. As the previous results that showed in table (1) CUC values not much affected by increase of distance between catch cans. Over all CUC for one can's row tests range between 95.35 and 95.90% for 5.0 and 10.0m cans space. For the two rows cans the CUC ranged from 96.20% with 2.5m can's distance to 96.58% when the distance between cans was 7.5m.

Catch cans rows had not much impact on the values of CUC which amounted 95.72 and 96.40% for overall evaluated system when one or two cans rows used in tests respectively. The second span achieved lowest CUC values for both one or two cans row which were 93.76 and 95.84% on succession, while the fifth span achieved the highest CUC values for both one or two cans row which were 96.73 and 97.16% respectively.

No much difference occurred due to decrease system's speed timer from 100 to 75% with each one or two cans row, CUC average for overall system were 95.72 and 96.40% with one or two cans row and 75% speed timer (table 2) as compare with 95.83 and 96.03% with 100% system speed's timer (table 1) on succession.
Table (2) CUC data for different catch cans space, rows No and system spans. Speed timer 75%

<table>
<thead>
<tr>
<th>All System</th>
<th>Fifth Span</th>
<th>Fourth Span</th>
<th>Third Span</th>
<th>Second Span</th>
<th>First Span</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two rows</td>
<td>One row</td>
<td>Two rows</td>
<td>One row</td>
<td>Two rows</td>
<td>One row</td>
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<tr>
<td>96.20</td>
<td>95.81</td>
<td>96.13</td>
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<td>97.16</td>
<td>96.73</td>
<td>96.84</td>
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</table>

Table (3) shows the CUC data influenced by cans rows and space at 50% system speed's timer. As the results previously showed in tables (1) and (2) the CUC values were not appeared much sensitive due to increasing distance between cans also the use of one or two cans row for the CUC tests. As well as the second and fifth spans reached the lowest and highest CUC values respectively. The results in tables 1, 2 and 3 shows no significant influence for the systems speed's timer on system's overall CUC values.

Table (3) CUC data for different catch cans space, rows No and system spans. Speed timer 50%

<table>
<thead>
<tr>
<th>All System</th>
<th>Fifth Span</th>
<th>Fourth Span</th>
<th>Third Span</th>
<th>Second Span</th>
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</tr>
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<tbody>
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<td>97.92</td>
<td>96.59</td>
<td>95.13</td>
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</table>

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Figure (1) shows the impact of cans space and rows number on system's overall CUH values. The results indicate that the CUH is not much affected by increasing the distance between catch cans, for the one cans row CUH ranged between 95.66% with 7.5m cans distance and 96.89% when the cans were placed with 12.5m distance between each other.

Increase of cans row from one to two rows slightly increase the CUH values at all the evaluated cans distance, the amount of increase ranged from 0.19 to 0.97% when the distance between cans were 5.0 and 15.0m respectively.

The figures (2-7) shows the collected precipitation amounts in cans distributed with different distance between each other also for one or two cans row which placed under the studied center pivot during uniformity evaluation process and when the system speed's timer was 100%.

Results stated in this paper indicates that all CUC and CUH values were reached the excellent class according to (10) sprinkler irrigation uniformity coefficient classification. The results also indicate that CUC and CUH not significantly affected by increasing of distance between catch cans or by increasing of cans row number. According to the stated results we can recommend increase the space between catch cans for evaluation of uniformity coefficient under MESA center pivot systems to make the evaluation more easy and reduce testing exertion and time. The low distance between cans still important in some cases especially in single nozzle evaluation or in studies required high accurate evaluation.

Evaluation of uniformity coefficient for each single span give an idea about the site of system defects if exists and making the repair easier.
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Fig. (2) system precipitation, CUC and CUH values with 2.5m cans space and 100% speed timer

Fig. (3) system precipitation, CUC and CUH values with 5.0m cans space and 100% speed timer
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Fig. (4) system precipitation, CUC and CUH values with 7.5m cans space and 100% speed timer

Fig. (5) system precipitation, CUC and CUH values with 10.0m cans space and 100% speed timer
Fig. (6) system precipitation, CUC and CUH values with 12.5m cans space and 100% speed timer

Fig. (7) system precipitation, CUC and CUH values with 15.0m cans space and 100% speed timer
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