Residential Irrigation Water Use in the Central Florida Ridge

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Why Study Residential Irrigation?

- Homeowners desire green lawns
- Irrigation systems installed in most newly built homes
- Uneven rain events
Water Use in Florida

- Residential water use comprises 61% of the public supply, responsible for 43% of groundwater withdrawn.

- Between 1970 and 1995 there was a 135% increase in groundwater withdrawals.

- Nearly 30% of the is withdrawn April through June.

- Florida consumes more fresh water than any other state east of the Mississippi River.
Objectives of Study

- Irrigation water consumption
- Irrigation scheduling
- Microirrigation in bedded areas
- Residential System Uniformity
- Control System Uniformity
- Evaluation of Uniformity Procedure
- Uniformity Based on Soil Moisture
Where Research was Conducted
Water Use

- Three treatments with different irrigation scheduling, landscapes, and equipment
- Weather data recorded
- Installed flow meters on main irrigation line
- Recorded total property water consumption
Treatment 1

- Typical landscape
  - Turf area > Bedded area
- Typical irrigation practices
Treatment 2

- Typical landscape
  - Turf area > Bedded area
- Irrigation schedule based on historical ET requirements
Treatment 3

- Atypical landscape
  - Turf area < Bedded area
- Irrigation schedule based on historical ET requirements
- Use of microirrigation in the bedded areas
Examples of Microirrigation in T3
<table>
<thead>
<tr>
<th>Zone</th>
<th>Setting</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Summer</td>
</tr>
<tr>
<td>Spray</td>
<td>Ideal</td>
<td>25 min</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>20-30</td>
</tr>
<tr>
<td>Rotor</td>
<td>Ideal</td>
<td>45 min</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>30-50</td>
</tr>
</tbody>
</table>
## Landscape Percentages

<table>
<thead>
<tr>
<th></th>
<th>Treatment 1</th>
<th></th>
<th>Treatment 2</th>
<th></th>
<th>Treatment 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Turf (%)</td>
<td>Bed (%)</td>
<td>Area (m²)</td>
<td>Turf (%)</td>
<td>Bed (%)</td>
<td>Area (m²)</td>
</tr>
<tr>
<td>Avg.</td>
<td>78</td>
<td>21</td>
<td>1347</td>
<td>74</td>
<td>25</td>
<td>966</td>
</tr>
<tr>
<td>σ</td>
<td>8</td>
<td>8</td>
<td>991</td>
<td>8</td>
<td>8</td>
<td>613</td>
</tr>
</tbody>
</table>
Evapotranspiration and Rainfall

- Weather stations at each of the locations
- Downloaded monthly
- ET calculated
Turf Quality

- NTEP quality rating procedure
- Quality observed seasonally
Monthly Water Input and Requirement

Effective rainfall plus applied irrigation for each treatment compared to evapotranspiration
## Water Use Conclusions

<table>
<thead>
<tr>
<th></th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Use (mm)</td>
<td>103a</td>
<td>176a</td>
<td>134a</td>
<td>155a</td>
<td>142</td>
</tr>
<tr>
<td>% of Total</td>
<td>75</td>
<td>77</td>
<td>82</td>
<td>62</td>
<td>75</td>
</tr>
<tr>
<td>Turf Quality</td>
<td>5.7a</td>
<td>5.9a</td>
<td>5.8a</td>
<td>6.6ab</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>T2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Use (mm)</td>
<td>78b</td>
<td>135b</td>
<td>110ab</td>
<td>148a</td>
<td>119</td>
</tr>
<tr>
<td>% of Total</td>
<td>63</td>
<td>74</td>
<td>66</td>
<td>61</td>
<td>66</td>
</tr>
<tr>
<td>Turf Quality</td>
<td>6.4a</td>
<td>6.6a</td>
<td>5.6a</td>
<td>6.9a</td>
<td>6.3</td>
</tr>
<tr>
<td><strong>T3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Use (mm)</td>
<td>55b</td>
<td>95c</td>
<td>96b</td>
<td>102b</td>
<td>87</td>
</tr>
<tr>
<td>% of Total</td>
<td>37</td>
<td>42</td>
<td>63</td>
<td>55</td>
<td>46</td>
</tr>
<tr>
<td>Turf Quality</td>
<td>5.4b</td>
<td>6.4a</td>
<td>5.1a</td>
<td>5.8b</td>
<td>5.7</td>
</tr>
</tbody>
</table>
Uniformity Testing

- Why is uniformity important?
- How is uniformity different than efficiency?

Under irrigated

Adequate irrigation

Non-uniformity (100% uniformity not practical)

Under irrigated

Over irrigation

100% uniformity not practical
Uniformity Testing

- How to test for uniformity?

- How is uniformity calculated?

\[ DU_{lq} = \frac{\text{Avg. Low Quarter Depth}}{\text{Avg. Total Depth of Irr. Water}} \]
Testing Locations

- **Residential Systems** – existing in-ground irrigation systems
- **Control Systems** – regulated pressure, spacing at 50% of manufacturers rated diameter
Testing Procedures

- Place catch cans in a grid formation
- To reduce edge effects, inset from boundary
- Test system and head pressure
- Wind gusts < 3.2 m/s

Run times
- Spray zones = 25 min
- Rotor zones = 45 min
Comparison of Equipment

- Brands A, B, C
  - Commonly installed by contractors
- Fixed and adjustable nozzles
- Tested at recommended, low and high pressures
Results:
Residential vs. Control Systems

Higher $DU_{lq}$ for control tests

- Control$_{avg}$ = 0.53*
- Homes$_{avg}$ = 0.45**

*recommended pressure
**grid formation
High Uniformity Pattern

- Spray head with quarter circle nozzle at recommended pressure
- $DU_{\text{avg}} = 0.66$
Low Uniformity Pattern

- Spray head at low pressure
- $\text{DU}_{\text{lq avg}} = 0.33$
Comparison of Head Type – Residential Systems

Rotor heads had higher $DU_{|q}$

- $\text{Rotor}_{\text{avg}} = 0.49$
- $\text{Spray}_{\text{avg}} = 0.40$
- $P = 0.09$ (91% confidence)
Comparison of Head Type – Control Systems

Rotor heads have higher $DU_{lq}$

- Regardless of pressure
  - $\text{Rotor}_{\text{avg}} = 0.55$
  - $\text{Spray}_{\text{avg}} = 0.48$
  - $P = 0.007$ (99.3% confidence)
Control Rotor Head Uniformity

- Brands: A, B, C
- Pressures: Low, Recommended
- Significant differences across brand
- No significant difference across pressure
Control Spray Head Uniformity

- Brands: A, A-adj., B, B-adj., C
- Pressures: Low, Recommended, High
- Significant differences across brand
- Significant difference across pressure
- Interaction between pressure and brand
Equipment Testing Conclusions

- Uniformity is affected by:
  - Irrigation design
  - Equipment selection
  - System pressure

- Rotor heads tended to have higher uniformities

- Low pressure reduced uniformity
Testing Method Comparison

- Uniformity procedure in this study
  - grid formation
  - +100 catch-cans per zone
- MIL procedure
  - random placement in center of zone
  - 16-24 catch-cans per zone
Results: MIL Procedures

- Average MIL $D_{U_{lq}} = 0.53$
- Average Home $D_{U_{lq}} = 0.43$
- Average Home $D_{U_{lq}}$ simulating MIL procedure = 0.55
Time Domain Reflectometry (TDR)

- Device used to measure soil water content, by measurements of the volumetric water content (VWC)
- Relates the time needed for an electrical signal to travel along wave guides
- Must be calibrated
- Sensitive to salt content in the soil
Why Test with the TDR

- Determine a quick and easy method for calculating system uniformity
- Compare the uniformity values from the TDR device to the typically practiced catch-can test
- The TDR device *should* provide accurate uniformity values since it is based on the soil moisture content
Testing Procedures

- Place catch cans in a grid formation
- Wind gusts < 3.2 m/s
- Run times
  - Spray zones = 25 min
  - Rotor zones = 45 min
- Use TDR at each measurement location to determine VWC
## Results: Uniformity Comparison

<table>
<thead>
<tr>
<th>Sample</th>
<th>Method</th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
<th>Point Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Volume DU$_{lq}$</td>
<td>0.45</td>
<td>0.09</td>
<td>20</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>TDR DU$_{lq}$</td>
<td>0.68</td>
<td>0.08</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Volume DU$_{lq}$</td>
<td>0.54</td>
<td>0.14</td>
<td>25</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>TDR DU$_{lq}$</td>
<td>0.77</td>
<td>0.07</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>Volume DU$_{lq}$</td>
<td>0.51</td>
<td>0.13</td>
<td>25</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>TDR DU$_{lq}$</td>
<td>0.74</td>
<td>0.08</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>
Comparison of Uniformity Values

![Graph showing comparison of TDR (TDR, DU_{iq}) vs Volume (Volume, DU_{iq})](image-url)
Results: Point Difference

- Average Point Difference between methods
  - 0.20
  - TDR DU is higher
- In agreement with previous work
## Results: Measurements

<table>
<thead>
<tr>
<th>Sample</th>
<th>Method</th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Volume (mL)</td>
<td>294</td>
<td>108</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>VWC %</td>
<td>22</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Control</td>
<td>Volume (mL)</td>
<td>259</td>
<td>207</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>VWC %</td>
<td>25</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>Overall</td>
<td>Volume (mL)</td>
<td>271</td>
<td>180</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>VWC %</td>
<td>24</td>
<td>6</td>
<td>24</td>
</tr>
</tbody>
</table>
Comparison of Measurements

\[ y = 4.8943 \ln(x) - 2.8285 \]

\[ R^2 = 0.2456 \]
Differences in Measurement Range

- TDR Scale
  - 0-45% VWC
- Catch-Can Scale
  - 0-1500 mL
Effects of an Irrigation Event

What is the TDR uniformity before an irrigation event?

- is the DU lower?
- is the DU the same (equally high)?
The DU values were lower

- Pre-irrigation: 0.55
- Post-irrigation: 0.64

This means the soil properties are affecting the uniformity results.
Difference between Methods

- TDR doesn’t measure properly
  - splaying probes
- If TDR is measuring properly
  - Maybe uniformity doesn’t matter that much
  - TDR measures higher because what’s in the cans doesn’t reflect what’s happening in the soil
    - redistribution
Soil Moisture vs. Volume

Conclusions

- Catch-Can DU is worse because of zero values
- Catch-can doesn’t tell us the whole story
  - Ignores the soil properties
- Too much variation between the $\text{DU}_{\text{iq}}$ values determined by the TDR device and the catch-can method.
- The TDR device may not be a viable method for uniformity results
Overall Conclusions

- Homeowners over-irrigate
- Irrigation scheduling decreased water use significantly
- Micro-irrigation in bedded areas helped to decrease water used for irrigation
- Residential system uniformity was lower than expected
- Rotor head zones tend to have higher uniformity than spray head zones
- The reported MIL uniformities were higher than the uniformities from this project
  - The procedure (number and placement of cans) has an effect
- There was not a correlation between soil moisture and can volume
Acknowledgements
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