Sprinkler Irrigation & Soil Moisture Uniformity

Michael D. Dukes, Ph.D., P.E., C.I.D.
Melissa Haley, Stephen Hanks
Nov. 6, 2006, IA Int’l Irrig. Show, San Antonio, TX
Background

• Population served by public supply
  – 5.4 million 1970
  – 17 million 2004
  – 20 million 2020

• + ~1,000 people/day

• 11% U.S. new home construction in FL

• FL uses the most groundwater in the U.S.

• Most new homes in FL include irrigation

• ~60% household water use for irrigation

• High quality landscapes and low water holding capacity
Florida’s Water Crisis

Water Resource Caution Areas: places where water is either scarce or contaminated as defined by Florida’s Water Management Districts

Sensor Based Irrigation

Soil moisture sensors (SMS)

Evapotranspiration (ET) based controllers
Current Turf/Landscape Irrigation Research

1. SMS plots, Gainesville
2. Rain Sensor evaluation, Gainesville
3. SMS plots & ET controllers, Citra (Turfgrass Research Unit)
4. SMS on cooperating homes, Pinellas Co.
5. SMS development scale, Lake Jovita, Pasco Co.
6. ET controller plots, GCREC Hillsborough Co.
Potential Uniformity Impact

Soil Below Root Zone

- Adequate irrigation (100% uniformity not practical)
- Non-uniformity
- Over irrigation
- Under irrigated
Improper Coverage
Narrow Areas
Catch Can Testing
Literature Review

• Analytical yield & uniformity relationship
• Yield reduction due to non-uniformity not well documented in the field
• Redistribution of irrigation water within canopy (ag. crops)
• Minimal information on turf quality & uniformity
Turf Quality & Non-uniformity
Methodology

• Plots
  – 4.6 m X 4.6 m (15 ft X 15 ft)
  – 15Q Spray heads
  – 25 catch cans

• Tests at 3 pressures
  – 414 kPa (60 psi)
  – 138 kPa (20 psi)
  – 69 kPa (10 psi)
Methodology

- Arredondo FS
  - Field capacity 7-10% (no runoff)
  - Permanent wilting point 2-3%
  - Infiltration rate 179 mm/hr (7 in/hr)

\[
DU_{lq} = \frac{V_{low25\%}}{V_{avg}}
\]
Testing Conditions

• Soil moisture content
  – Gravimetric 10 cm (4 in) long X 5.7 cm (2.2 in) dia.
  – TDR 20 cm (8 in) long rods

• Soil sample & TDR collection rotated 90 deg.

• Soil sample locations repacked

• Low wind (< 2.5 m/s; 5 mph)
Uniformity Data Collection
Irrigation Effect on $DU_{lq}$
Statistical Results

- Interaction between measurement type & pressure level on $DU_{lq}$
  - Gravimetric
  - TDR
  - Catch Can
### Pressure Effect on Distribution Uniformity

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0.77 a</td>
<td>0.83 a</td>
<td>0.74 a</td>
<td>0.83 a</td>
<td>0.63 a</td>
</tr>
<tr>
<td>20</td>
<td>0.81 a</td>
<td>0.86 a</td>
<td>0.79 a</td>
<td>0.83 a</td>
<td>0.55 b</td>
</tr>
<tr>
<td>10</td>
<td>0.78 a</td>
<td>0.81 a</td>
<td>0.75 a</td>
<td>0.69 b</td>
<td>0.39 c</td>
</tr>
</tbody>
</table>

Different letters indicate a significant difference within columns
### Pressure Effect on Soil Moisture Content

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0.07 a</td>
<td>0.07 a</td>
<td>0.15 a</td>
<td>0.20 a</td>
<td>0.72 a</td>
</tr>
<tr>
<td>20</td>
<td>0.07 a</td>
<td>0.09 a</td>
<td>0.11 b</td>
<td>0.17 b</td>
<td>0.47 b</td>
</tr>
<tr>
<td>10</td>
<td>0.06 a</td>
<td>0.08 a</td>
<td>0.09 b</td>
<td>0.15 c</td>
<td>0.39 c</td>
</tr>
</tbody>
</table>

Different letters indicate a significant difference within columns.
Effect of Irrigation on Soil Moisture

Change in Soil Moisture Content ($m^3/m^3$) vs. Irrigation Vol (mL)

- $y = 0.0003x + 0.0162$, $R^2 = 0.7111$
- $y = 0.0003x - 0.0264$, $R^2 = 0.5855$

Legend:
- ♦ GRAV
- △ TDR
TDR SMC vs. Gravimetric SMC

PRE

R² = 0.7638

POST

R² = 0.6101
$DU_{lh} = 0.386 + (0.614 \times DU_{lq})$
Conclusions

• SMC uniformity relatively insensitive to irrigation uniformity levels tested here (CC DU$_{lq}$ 0.39-0.63)

• CC DU$_{lh}$ approximates SMC DU$_{lq}$

• CC DU$_{lh}$ may be a reasonable indicator of irrigation system performance
Microirrigation Uniformity Testing
Microirrigation Uniformity Testing cont’d
Microirrigation TDR DU_{lq} vs CC DU_{lq}
Questions?

Thank you!

Acclima, Inc., Lawn Logic, Rain Bird, Toro, Hydropoint, ETWater, Weathermatic

SWFWMD, Hillsborough Co. Water Dept., Pinellas Co. Utilities

Danny Burch, Numerous undergrad and graduate students

www.ifas.ufl.edu
irrigation.ifas.ufl.edu