Field evaluation of wetting agent efficacy against localized dry spot and hydrophobicity in creeping bentgrass putting green turf – 2010 trial.


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The objective was to determine efficacy of wetting agents on creeping bentgrass putting green turf on a high sand rootzone. Efficacy against localized dry spot, effects on soil moisture content, and on root system growth and health were to be determined.

MATERIALS/METHODS

The experiment was located on the alternative construction putting green at the GTI, which is a typical industry standard green of this type, with 30 cm of USGA specification rootzone mixture (80% sand, 20% peat v/v) on a graded subsoil with tile drains but no gravel drainage layer (Figure 1). Permanent turf cover on this green is ‘Cobra’ creeping bentgrass (*Agrostis stolonifera*) and invasive weedy *Poa annua*. The green has developed hydrophobic layers in previous seasons. Standard cultural practices were maintained (mowing at 5 mm, regular fertility).

Test Design: The test was a complete randomized block design with four replicates per treatment. Each plot measured 2 m x 1 m.

Treatments: Treatments listed in Table 1 were applied via a calibrated compressed air sprayer (20 psi, Teejet 8001VS flat fan nozzles, 20 ml sec⁻¹) on June 3, June 14, June 30, July 28, August 26 and September 23, 2010. All liquid applications were made in 80 ml of water per square meter (8 L 100 m⁻²). Control plots were treated with water only. Treatments were watered following application.

Data collected included

Environmental Data: Environmental data collected included daily max/min air temperature, irrigation records (turfgrass site manager), and rainfall.

Evaluation: Turf health and uniformity were assessed with canopy reflectance measurements (normalized-difference vegetation index; Greenseeker). The NDVI values are decreased by phytotoxicity, drought, localized dry spot, and have been shown to be well correlated with visual estimates of turf quality.

Plots were evaluated for visual rating of localized dry spot when it occurred. The extent of the symptoms was recorded as the percentage exhibiting symptoms.

Soil moisture readings (% volumetric water) were recorded using a ThetaProbe soil moisture meter. Water droplet absorption tests are being made on 4-6 cm soil cores: 4 soil cores, approximately 15 cm each, were taken from each plot, air dried for two weeks at room temperature, and evaluated for hydrophobicity using the water

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate per application</th>
<th>Application schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 OARS 6</td>
<td>1.9 mL m⁻² in 80 mL water</td>
<td>Monthly June- September</td>
</tr>
<tr>
<td>2 OARS 5</td>
<td>1.6 mL m⁻² in 80 mL water</td>
<td>Monthly June- September</td>
</tr>
<tr>
<td>3 OARS 4</td>
<td>1.3 mL m⁻² in 80 mL water</td>
<td>Monthly June- September</td>
</tr>
<tr>
<td>4 PBS150 2x</td>
<td>2.5 mL m⁻² in 80 mL water</td>
<td>Day 0 and Day 14</td>
</tr>
<tr>
<td>5 PBS150 1x</td>
<td>2.5 mL m⁻² in 80 mL water</td>
<td>Day 0</td>
</tr>
<tr>
<td>6 PBS150 4x</td>
<td>1.3 mL m⁻² in 80 mL water</td>
<td>Monthly June- September</td>
</tr>
<tr>
<td>7 Respond</td>
<td>1.3 mL m⁻² in 80 mL water</td>
<td>Monthly June- September</td>
</tr>
<tr>
<td>8 Control</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>
Figure 1. Plot area on research green, May 28, 2010.

droplet penetration test (time to penetration of a 35 μl droplet of distilled water placed at 1 cm intervals along the core starting at the thatch-air interface and ending at 6 cm).

Data Analysis: Data were analysed and means compared using appropriate statistical methods (ANOVA).

An anecdotal photographic record of the trial was kept.

RESULTS

Environmental data. Rainfall and temperature data were recorded at the Environment Canada weather station in the research ranges at the GTI (Figures 2 and 3). The season was wetter than average, with ~500 mm of rainfall during the course of the experiment. Temperatures were slightly below normal for summer in Guelph, with only four days above 30°C. To increase the likelihood of localized dry spot development, irrigation was withheld from the plots after the middle of July.

Turf performance: canopy reflectance. Canopy reflectance readings were significantly different among the treatments on all observation dates (Table 2.) The Greenseeker is very sensitive to NDVI variation, which reflects turf health (chlorophyll content, photosynthetic activity, growth rate), as well as stresses (phytotoxicity

Figure 2. Daily and cumulative precipitation – summer 2010. Data are from the Environment Canada weather station at the GTI.

Figure 3. Daily maximum and minimum air temperatures – summer 2010. Data are from the Environment Canada weather station at the GTI.
Table 2. Canopy reflectance (normalized-difference vegetation index) in treated plots.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>05/10</th>
<th>05/17</th>
<th>05/20</th>
<th>05/25</th>
<th>05/27</th>
<th>05/29</th>
<th>05/31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.623 b</td>
<td>0.625 cd</td>
<td>0.562 c</td>
<td>0.603 b</td>
<td>0.610 c</td>
<td>0.605 bc</td>
<td>0.647 bc</td>
</tr>
<tr>
<td>OARS 4</td>
<td>0.556 d</td>
<td>0.582 f</td>
<td>0.522 e</td>
<td>0.568 d</td>
<td>0.587 d</td>
<td>0.579 e</td>
<td>0.626 d</td>
</tr>
<tr>
<td>OARS 5</td>
<td>0.643 a</td>
<td>0.647 a</td>
<td>0.601 a</td>
<td>0.627 a</td>
<td>0.626 a</td>
<td>0.615 a</td>
<td>0.657 a</td>
</tr>
<tr>
<td>OARS 6</td>
<td>0.639 ab</td>
<td>0.641 ab</td>
<td>0.581 b</td>
<td>0.605 b</td>
<td>0.623 a</td>
<td>0.608 ab</td>
<td>0.652 ab</td>
</tr>
<tr>
<td>PBS150 1x</td>
<td>0.644 a</td>
<td>0.632 bc</td>
<td>0.576 b</td>
<td>0.617 a</td>
<td>0.622 ab</td>
<td>0.611 ab</td>
<td>0.656 ab</td>
</tr>
<tr>
<td>PBS150 2x</td>
<td>0.691 c</td>
<td>0.605 e</td>
<td>0.543 d</td>
<td>0.585 c</td>
<td>0.608 c</td>
<td>0.593 d</td>
<td>0.639 c</td>
</tr>
<tr>
<td>PBS150 4</td>
<td>0.559 d</td>
<td>0.574 f</td>
<td>0.505 f</td>
<td>0.561 d</td>
<td>0.578 d</td>
<td>0.565 f</td>
<td>0.615 e</td>
</tr>
<tr>
<td>Respond 3</td>
<td>0.622 b</td>
<td>0.616 de</td>
<td>0.557 c</td>
<td>0.601 b</td>
<td>0.614 bc</td>
<td>0.597 cd</td>
<td>0.640 c</td>
</tr>
<tr>
<td>msd p=0.05</td>
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<td>0.011</td>
<td>0.012</td>
<td>0.012</td>
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06/042

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<th>06/28</th>
<th>06/30</th>
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<tbody>
<tr>
<td>Control</td>
<td>0.654 f</td>
<td>0.645 a</td>
<td>0.642 a</td>
<td>0.611 a</td>
<td>0.577 a</td>
<td>0.611 a</td>
</tr>
<tr>
<td>OARS 4</td>
<td>0.689 cd</td>
<td>0.571 e</td>
<td>0.623 bc</td>
<td>0.605 ab</td>
<td>0.584 a</td>
<td>0.609 a</td>
</tr>
<tr>
<td>OARS 5</td>
<td>0.703 a</td>
<td>0.595 c</td>
<td>0.630 b</td>
<td>0.590 c</td>
<td>0.485 c</td>
<td>0.540 cd</td>
</tr>
<tr>
<td>OARS 6</td>
<td>0.694 bc</td>
<td>0.612 b</td>
<td>0.622 bc</td>
<td>0.603 b</td>
<td>0.484 c</td>
<td>0.519 d</td>
</tr>
<tr>
<td>PBS150 1x</td>
<td>0.693 bcd</td>
<td>0.614 b</td>
<td>0.628 b</td>
<td>0.602 b</td>
<td>0.544 b</td>
<td>0.558 c</td>
</tr>
<tr>
<td>PBS150 2x</td>
<td>0.697 b</td>
<td>0.587 cd</td>
<td>0.617 cd</td>
<td>0.581 d</td>
<td>0.543 b</td>
<td>0.586 b</td>
</tr>
<tr>
<td>PBS150 4</td>
<td>0.689 d</td>
<td>0.579 de</td>
<td>0.608 d</td>
<td>0.599 b</td>
<td>0.589 a</td>
<td>0.618 a</td>
</tr>
<tr>
<td>Respond 3</td>
<td>0.678 e</td>
<td>0.624 b</td>
<td>0.628 b</td>
<td>0.603 ab</td>
<td>0.572 a</td>
<td>0.600 ab</td>
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07/02

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<th>07/19</th>
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<tbody>
<tr>
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<td>0.547 c</td>
<td>0.582 cde</td>
<td>0.529 bc</td>
<td>0.585 c</td>
<td>0.673 a</td>
</tr>
<tr>
<td>OARS 4</td>
<td>0.547 b</td>
<td>0.576 b</td>
<td>0.597 bc</td>
<td>0.534 abc</td>
<td>0.591 bc</td>
<td>0.617 ef</td>
</tr>
<tr>
<td>OARS 5</td>
<td>0.472 de</td>
<td>0.491 d</td>
<td>0.576 de</td>
<td>0.542 ab</td>
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<td>0.628 de</td>
</tr>
<tr>
<td>OARS 6</td>
<td>0.456 e</td>
<td>0.489 d</td>
<td>0.534 f</td>
<td>0.493 d</td>
<td>0.560 d</td>
<td>0.605 f</td>
</tr>
<tr>
<td>PBS150 1x</td>
<td>0.501 cd</td>
<td>0.531 c</td>
<td>0.591 bcd</td>
<td>0.554 a</td>
<td>0.605 ab</td>
<td>0.649 bc</td>
</tr>
<tr>
<td>PBS150 2x</td>
<td>0.560 ab</td>
<td>0.579 ab</td>
<td>0.620 a</td>
<td>0.534 abc</td>
<td>0.612 a</td>
<td>0.650 b</td>
</tr>
<tr>
<td>PBS150 4</td>
<td>0.576 a</td>
<td>0.601 a</td>
<td>0.609 ab</td>
<td>0.518 c</td>
<td>0.588 c</td>
<td>0.644 bcd</td>
</tr>
<tr>
<td>Respond 3</td>
<td>0.503 c</td>
<td>0.550 c</td>
<td>0.571 e</td>
<td>0.488 d</td>
<td>0.583 c</td>
<td>0.633 cde</td>
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08/03

<table>
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<th>09/07</th>
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<tbody>
<tr>
<td>Control</td>
<td>0.619 b</td>
<td>0.635 d</td>
<td>0.616 cd</td>
<td>0.638 bc</td>
<td>0.669 b</td>
<td>0.489 c</td>
</tr>
<tr>
<td>OARS 4</td>
<td>0.615 bc</td>
<td>0.633 d</td>
<td>0.640 a</td>
<td>0.629 d</td>
<td>0.674 ab</td>
<td>0.510 ab</td>
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<tr>
<td>OARS 5</td>
<td>0.616 bc</td>
<td>0.645 bc</td>
<td>0.625 b</td>
<td>0.640 b</td>
<td>0.660 c</td>
<td>0.486 c</td>
</tr>
<tr>
<td>OARS 6</td>
<td>0.615 bc</td>
<td>0.622 e</td>
<td>0.613 d</td>
<td>0.639 b</td>
<td>0.662 c</td>
<td>0.484 c</td>
</tr>
<tr>
<td>PBS150 1x</td>
<td>0.615 bc</td>
<td>0.634 d</td>
<td>0.623 b</td>
<td>0.649 a</td>
<td>0.670 ab</td>
<td>0.500 bc</td>
</tr>
<tr>
<td>PBS150 2x</td>
<td>0.647 a</td>
<td>0.639 cd</td>
<td>0.627 b</td>
<td>0.638 bc</td>
<td>0.673 ab</td>
<td>0.450 d</td>
</tr>
<tr>
<td>PBS150 4</td>
<td>0.614 bc</td>
<td>0.660 a</td>
<td>0.637 a</td>
<td>0.630 cd</td>
<td>0.675 a</td>
<td>0.512 ab</td>
</tr>
<tr>
<td>Respond 3</td>
<td>0.610 c</td>
<td>0.649 b</td>
<td>0.623 bc</td>
<td>0.639 b</td>
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09/14

<table>
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</tr>
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<tbody>
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<td>0.548 bc</td>
<td>0.622 cd</td>
</tr>
<tr>
<td>OARS 4</td>
<td>0.490 b</td>
<td>0.560 b</td>
<td>0.625 bc</td>
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<tr>
<td>OARS 5</td>
<td>0.490 b</td>
<td>0.568 ab</td>
<td>0.638 abc</td>
</tr>
<tr>
<td>OARS 6</td>
<td>0.468 bc</td>
<td>0.571 ab</td>
<td>0.640 ab</td>
</tr>
<tr>
<td>PBS150 1x</td>
<td>0.476 bc</td>
<td>0.566 ab</td>
<td>0.633 abc</td>
</tr>
<tr>
<td>PBS150 2x</td>
<td>0.411 d</td>
<td>0.518 c</td>
<td>0.598 d</td>
</tr>
<tr>
<td>PBS150 4</td>
<td>0.474 bc</td>
<td>0.534 cd</td>
<td>0.606 de</td>
</tr>
<tr>
<td>Respond 3</td>
<td>0.521 a</td>
<td>0.589 a</td>
<td>0.648 a</td>
</tr>
<tr>
<td>msd p=0.05</td>
<td>0.027</td>
<td>0.024</td>
<td>0.016</td>
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</table>

1 Normalized-difference vegetation index: mean of ~50 readings x 4 replicates; means within columns followed by the same letter are not significantly different (Tukey's HSD test, p=0.05)

2 Observation dates most closely following application dates are bolded.
from treatments, drought stress, localized dry spot development). There was some evidence of a decline in NDVI immediately following applications compared to the control plots, but this change was not consistently seen in repeat applications. There was no corresponding color change detectable visually. Over the course of the trial, the performance of the treated plots as assessed by canopy reflectance was consistently higher than the control only in most of the treatments except the OARS 5, OARS 6, and Respond 3. This is best seen by coding the data to set the control means to 0 (Figure 4). Among the treatments, the general ranking of NDVI was PBS150 monthly, OARS 4, Respond 3 > PBS150 2x, PBS150 1x, Control > OARS 5 > OARS 5. This was a similar pattern to that observed in 2009.

Localized dry spot. The wet summer
resulted in localized dry spot development on only one date during the season. This is in spite of irrigation being withheld from the plot areas. On the date when LDS differences were significant, there were few differences among the treatments, though the PBS 150 monthly application tended to be least affected, which agrees with the NDVI data (Table 3).

**Volumetric water content.** There were significant differences in volumetric water content among treatments only on the first measurement data following treatment application (Table 4). Any differences may not be biologically significant, since water contents are well into adequately watered range (field capacity on a USGA sand rootzone is typically 25-30%), but they may be involved in the detected differences in canopy reflectance.

### Table 3. Localized dry spot development.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>05/25</th>
<th>06/04</th>
<th>07/06</th>
<th>07/28</th>
<th>08/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2.00</td>
<td>0.75</td>
<td>0.50 ab</td>
<td>0.00</td>
<td>0.75</td>
</tr>
<tr>
<td>OARS 4</td>
<td>2.00</td>
<td>1.50</td>
<td>0.50 ab</td>
<td>0.00</td>
<td>0.50</td>
</tr>
<tr>
<td>OARS 5</td>
<td>1.00</td>
<td>0.25</td>
<td>1.00 ab</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>OARS 6</td>
<td>2.25</td>
<td>1.50</td>
<td>1.75 a</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>PBS150 1x</td>
<td>1.75</td>
<td>0.25</td>
<td>1.00 ab</td>
<td>0.50</td>
<td>0.25</td>
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<td>PBS150 2x</td>
<td>2.25</td>
<td>0.75</td>
<td>0.75 ab</td>
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<td>0.25</td>
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<td>3.75</td>
<td>2.25</td>
<td>0.00 b</td>
<td>0.00</td>
<td>0.25</td>
</tr>
<tr>
<td>Respond 3</td>
<td>1.75</td>
<td>1.25</td>
<td>0.75 ab</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>msd</td>
<td>NS</td>
<td>NS</td>
<td>1.52</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

1 Visual rating of dry spot development (0-10, 10=full plot area affected). Means of 4 replicates; means within columns followed by the same letter are not significantly different (Tukey’s HSD test, p=0.05)

### Table 4. Volumetric water content in treated plots.

<table>
<thead>
<tr>
<th>Treatment</th>
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<th>06/08</th>
<th>06/29</th>
</tr>
</thead>
<tbody>
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<td>28.64</td>
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<td>15.44 bc</td>
<td>26.36 ab</td>
<td>27.46</td>
</tr>
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<td>OARS 5</td>
<td>18.90 ab</td>
<td>27.47 a</td>
<td>29.08</td>
</tr>
<tr>
<td>OARS 6</td>
<td>16.25 abc</td>
<td>26.47 ab</td>
<td>27.00</td>
</tr>
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<td>PBS150 1x</td>
<td>19.10 a</td>
<td>26.42 ab</td>
<td>28.38</td>
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<td>PBS150 2x</td>
<td>18.68 ab</td>
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<td>PBS150 4</td>
<td>14.81 c</td>
<td>24.61 b</td>
<td>27.33</td>
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<tr>
<td>Respond 3</td>
<td>17.77 abc</td>
<td>26.25 ab</td>
<td>27.59</td>
</tr>
<tr>
<td>msd p=0.05</td>
<td>3.59</td>
<td>2.84</td>
<td>NS</td>
</tr>
</tbody>
</table>

1 Percent volumetric water content measured with ThetaProbe. Means of 9 readings x 4 replicates; means within columns followed by the same letter are not significantly different (Tukey’s HSD test, p=0.05)

Data from the cores collected during the trial indicate that the rootzone in these plots continues to be severely hydrophobic. In fact, comparison of WDPT tests done in connection with various trials over several years show a steady increase in depth and severity of hydrophobic conditions (Figure 5). The data drop penetration tests from this trial showed the most consistent treatment effect patterns either pre-treatment or in the upper layers of the rootzone (0 and 1 cm deep) (Table 5). The levels of hydrophobicity that developed later in the season were only relieved by treatments at or near the surface. There was a very slight trend toward a rate effect in the OARS treatments, and a stronger effect of repeated application in the PBS150 treatments, where the 2x and monthly application rates produced the most significant improvements in hydrophobicity. These reductions in hydrophobicity were at the shallower depths (0, 1, and 2 cm below the surface).

### Water drop penetration test / hydrophobicity.

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Table 5. Water drop penetration test timings for cores removed from treated plots.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>05/05</th>
<th>08/25</th>
<th>10/13</th>
<th>05/05</th>
<th>08/25</th>
<th>10/13</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>0 cm depth</td>
<td>4 cm depth</td>
<td>1 cm depth</td>
<td>5 cm depth</td>
<td>2 cm depth</td>
<td>6 cm depth</td>
</tr>
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<td>421.4</td>
<td>485.3 ab</td>
<td>461.5 a</td>
<td>337.6</td>
<td>389.1</td>
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<td>OARS 4</td>
<td>444.1</td>
<td>590.5 a</td>
<td>230.1 bc</td>
<td>311.5</td>
<td>346.5</td>
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<td>268.4 abc</td>
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<td>460.1</td>
<td>384.5</td>
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<td>197.5 bc</td>
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<td>391.2</td>
<td>463.8</td>
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<tr>
<td>PBS150 1x</td>
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<td>600.0 a</td>
<td>363.1 abc</td>
<td>433.1</td>
<td>395.4</td>
<td>40.4</td>
</tr>
<tr>
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<td>432.7 b</td>
<td>322.8 ab</td>
<td>251.0</td>
<td>411.6</td>
<td>224.5</td>
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<tr>
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<td>220.1 c</td>
<td>63.9 c</td>
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<td>541.2</td>
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<td>526.3 ab</td>
<td>211.0 bc</td>
<td>353.8</td>
<td>478.3</td>
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<td>224.7</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
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<td>4 cm depth</td>
<td>1 cm depth</td>
<td>5 cm depth</td>
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<td>6 cm depth</td>
</tr>
<tr>
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<td>494.2</td>
<td>473.6</td>
<td>474.3 a</td>
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<td>376.7 ab</td>
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<td>390.9 ab</td>
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<td>563.8</td>
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</tbody>
</table>

\(^1\)Time (sec) for a 35 µL droplet of distilled water to penetrate core (max 600 sec). Mean of 4 cores x 4 replicates. Means within columns followed by the same letter are not significantly different (Tukey’s HSD, p=0.05).
DISCUSSION AND CONCLUSIONS

Wetting agent treatment effects on localized dry spot were limited in 2010, in large part because the wet summer did not allow LDS to develop to any significant extent. There were some significant treatment effects on canopy reflectance, which is indicative of photosynthetic activity and plant health. There was no strong pattern among the wetting agent treatments, but the general trend based on NDVI was: PBS150 monthly, OARS 4, Respond 3 > PBS150 2x, PBS150 1x, Control > OARS 5 > OARS 5, which was similar to the pattern observed in 2009.

Treatment effects on hydrophobicity of the soil as measured by the water drop penetration tests were mostly apparent late in the season and at the shallower depths. The background hydrophobicity of the rootzones is very high, but the PBS150 2x and 4x treatments had the best effect in reducing hydrophobicity, particularly at the shallow depths.

Sponsor: Aqua-aid, Inc.