Effects of Hydrogels on Timing and Severity of Wilt in Container-grown Annuals

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Significance to Industry: Hydrogels have shown potential to increase water retention of media and to reduce irrigation frequency (3), and can potentially increase available water when incorporated into a medium (5). Different sizes of these gels are available but the effects of particle size are not well documented. Extending the time between waterings would be particularly useful in post-production by improving quality and survival of herbaceous plants in the retail sales area for consumers. The purpose of this study was to assess the response of two annual crops with different irrigation requirements (coleus and vinca) to hydrogel in two different sizes. In addition, this study showed that water potential values for vinca reached well beyond the traditional permanent wilting point range, which may indicate a need for more study of water potentials at or near what is considered permanent wilt.

Nature of Work: Hydrophilic polymers (hydrogels) are added to horticultural substrates to increase water-holding capacity and aeration, and to reduce watering frequency (3).There are studies that demonstrate that hydrogels have the potential to delay wilting in container crops and extend crop life and quality during the postproduction periods for the plant, which would reduce labor costs, watering needs, and crop loss in retail outlets (4). However, there are other studies that show either no effect or a detrimental effect of hydrogels in plant performance (4). There is little data on whether or not the particle size of hydrogels has any influence on plant performance.

The term plant available water refers to water being held on to a substrate at a suction low enough so that plants are able to uptake it for use. In field soils, plant available water is water held at suctions less than -1.5 MPa, beyond which water would be unavailable and held as the permanent wilting percentage (PWP). However, this value can vary depending on the plant species between -1.0 and 2.0 MPa (2). PWP is a term used to describe the point at which substrate water potential is too large for plants to pull moisture from the soil to recover. Several studies have shown the ability of plants to recover past the accepted PWP (1, 6).

Recently the WP4C dewpoint potentiameter (Decagon, Pullman, WA) has been shown to produce water potential readings for highly porous soilless container substrates at high potentials more accurately than previous methods, such as the 15 bar pressure plate (2,6). The WP4C dewpoint potentiameter measures the dewpoint of the substrate and calculates the water potential of the sample.

The experiment was implemented on 19, February 2014 at the Teaching Greenhouse at North Carolina State University. Forty-eight plugs each of Coleus (*Solenostemon scutellarioides* 'Kong Salmon Pink'), and Vinca (*Catharanthus roseus* 'Cora Apricot') were potted into substrates containing 3 parts peat moss: 1 part vermiculite: 1 part perlite, with no hydrogels incorporated (control) or with 34 g/ft^3 of two different particle sizes (small: 0.2mm – 0.8mm, and large: 0.8mm – 2.0mm) of a potassium polyacrylate cross-linked powder hydrogel (Stockosorb 660, Evonik Corporation, Garyville, LA). Plants were placed on a greenhouse bench and arranged in a complete randomized block design with nine replications per treatment. Plants were hand watered as needed with 200 ppm N derived from 20-10-20 Peat-Lite Special fertilizer (The Scotts Co. Marysville, OH). To assess wilt, plants were placed in a large plastic tub to saturate the substrate before allowing the plants to dry down (6, May 2014 for coleus; and 8, May 2014 for vinca). Tap water was incrementally added to the tub to saturate the substrate until the water level reached just below the rim of the containers. The containers were allowed to saturate for ten minutes, then they were removed from the tub, allowed to drain for 10 minutes, weighed, and placed on a greenhouse bench. Plants were not irrigated and were allowed to dry under normal greenhouse conditions so that the degree of wilt could be observed. Wilting stages were visibly determined as follows: stage one – initial flagging, stage 2– leaves/petioles drooping (approximately 45°) towards the stem, and stage 3 – complete reduction of leaf surface and loss of turgidity. As plants reached each of the three wilting stages the substrate was sampled by removing the plants from their containers and extracting a 1-2 cm deep, 2 cm wide column of substrate from the entire profile of the root ball. Three replications of each plant species at each wilting stage were collected. Roots were removed from the substrate samples and the samples were placed in 3.7 x 1.1 cm stainless steel sample cups (Decagon, Pullman, WA) which were then placed in the dewpoint potentiameter to determine the water potential of the individual samples. Samples were weighed immediately after measurement in the dewpoint potentiameter, then dried in a forced air oven at 105°C and weighed again to determine moisture content. After the substrate sample was removed from each plant, the plant was irrigated and observed for visual signs of recovery. After all three stages of wilt were finished and plants recovered, shoots were harvested, dried, and weighed. Data were analyzed using Tukeys Studentized Range Test ($p \leq 0.05$) (SAS Institute version 9.1, Cary, NC).

Results and Discussion:

Coleus wilted quickly, taking only 48 hours to go from complete saturation to stage 3 wilt. However, plants with either hydrogel took twice as long to exhibit stage 1 wilt than controls. Plants grown in the control substrate reached stage one wilt after 11.7 hours, whereas the plants grown in the substrates with small and large hydrogels took 22.2 and 22.5 hours, respectively (Figure 1). Although the mean for the controls to reach stage 1 was 11.3, the individual plant values were 6.63, 6.1 and 22.35 hours. Therefore, there was no means separation at stage 1 due to the variation, but clearly there was a horticultural difference in 2 of the 3 plants. Stage 2 occurred between 26 and 27 hours with stage 3 happening 48 to 51 hours after saturation. There were no treatment differences at stages 2 or 3. Moisture content decreased between stages 1, 2 and 3, but there were no treatment differences (Figure 3). Water potentials for stages 1 and 2 were similar, between -0.4 and -0.5 MPa (Figure 5), and -0.9 MPa for Stage 3. However, there were no effects of the gels over controls for water potential. Plant dry weights were similar between 40 to 43 grams for all treatments (Figure 7). All plants recovered within 3 hours after being irrigated at all stages and all treatments.

Vinca took substantially longer before reaching stage 1 wilt compared to coleus (Figure 2). Vinca plants reached stage 1 between 93 and 103 hours after saturation which illustrates its heat and drought tolerance compared to coleus. Although the controls reached stage 1 over 10 hours before the gel treatments, there was no statistical differences. However, the controls did reach stage 2 sooner than the large and small gel treatments (119, 134, and 144 hours, respectively). Stage 3 was reached at 165, 178 and 187 hours for the control, large and small gel treatments, respectively. However, these were not statistically separate. Moisture content at wilt was much lower than Coleus at all stages of wilt (Figure 4). Vinca reached stage 1 at 20 – 25% moisture, stage 2 at 15 – 18% and stage 3 at 15 – 20% moisture. There were no differences among treatments for moisture content or water potential within wilting stages. Although there were no treatment differences, water potentials during wilting were much higher for vinca than for coleus (Figure 6). Stage 1 was reached at -10 MPa while coleus was only -0.4 MPa. Stage 2 occurred at water potentials between -15 and -21 MPa, while stage 3 went as high as -30 MPa. These values are much higher than the -1.5 MPa value usually regarded as where permanent wilt occurs. However, all plants at all stages recovered within 3 hours of rehydration. Shoot dry weight was highest for the plants grown in the control mix, and lowest for plants grown in the largest size hydrogel (Figure 7).

There was a marked difference in the time to wilt, moisture content and water potentials between coleus and vinca. Gel size did not seem to make a difference in the way plants dried. There was a 10 hour extension between saturation and stage 1 wilt for both species with the gel treatments. Vinca reached water potentials not previously reported and much greater than traditional values for permanent wilt with total plant recovery.

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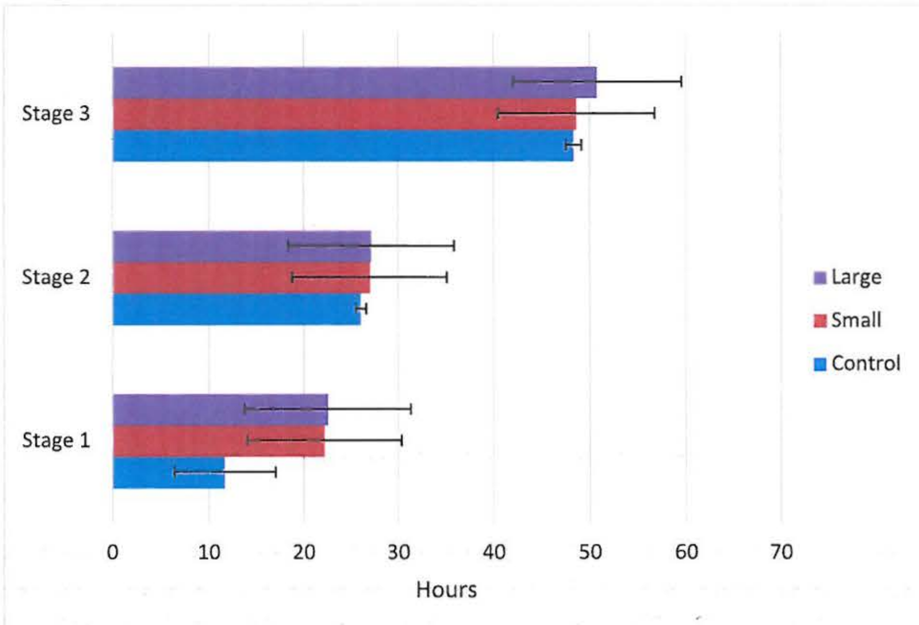

Figure 1. Hours taken to reach the three stages of wilt for coleus (*Solenostemon scutellarioides* 'Kong Salmon Pink') grown in substrates containing 3 parts peat moss: 1 part vermiculite: 1 part perlite, with no hydrogels incorporated (control) or with 34 g/ft^3 of two different particle sizes (small: 0.2mm – 0.8mm, and large: 0.8mm – 2.0mm) of hydrogel.

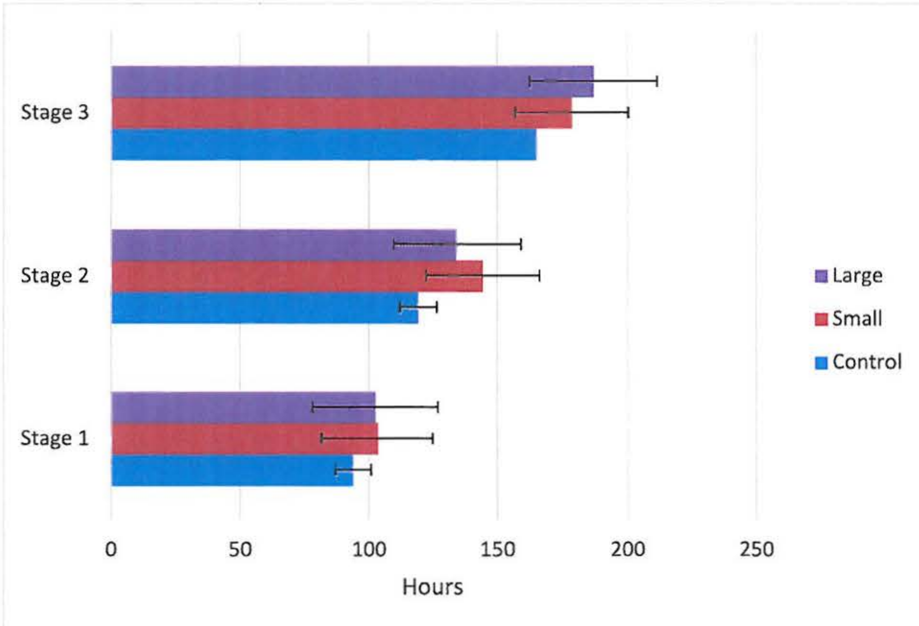

Figure 2. Hours taken to reach the three stages of wilt for vinca (*Catharanthus roseus* 'Cora Apricot') grown in substrates containing 3 parts peat moss: 1 part vermiculite: 1 part perlite, with no hydrogels incorporated (control) or with 34 g/ft^3 of two different particle sizes (small: 0.2mm – 0.8mm, and large: 0.8mm – 2.0mm) of hydrogel.

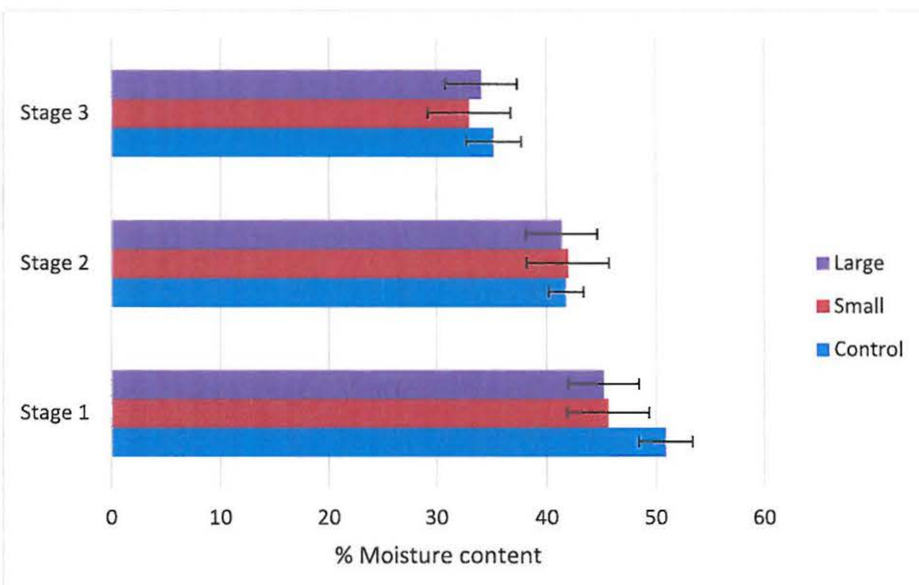

Figure 3. Moisture content of substrate samples of coleus (*Solenostemon scutellarioides* 'Kong Salmon Pink') grown in substrates containing 3 parts peat moss: 1 part vermiculite: 1 part perlite, with no hydrogels incorporated (control) or with 34 g/ft^3 of two different particle sizes (small: 0.2mm – 0.8mm, and large: 0.8mm – 2.0mm) of hydrogel.

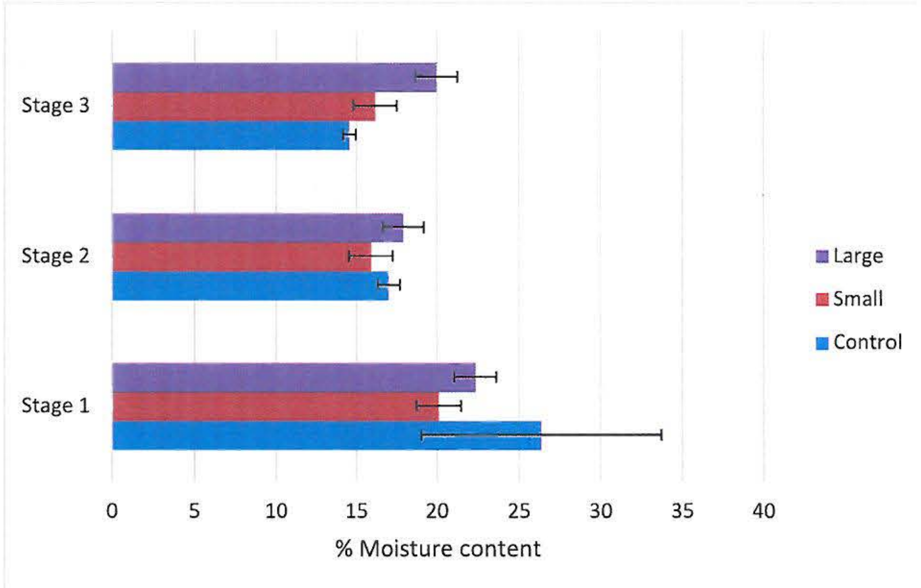

Figure 4. Moisture content of substrate samples of vinca (*Catharanthus roseus* 'Cora Apricot') grown in substrates containing 3 parts peat moss: 1 part vermiculite: 1 part perlite, with no hydrogels incorporated (control) or with 34 g/ft^3 of two different particle sizes (small: 0.2mm – 0.8mm, and large: 0.8mm – 2.0mm) of hydrogel.

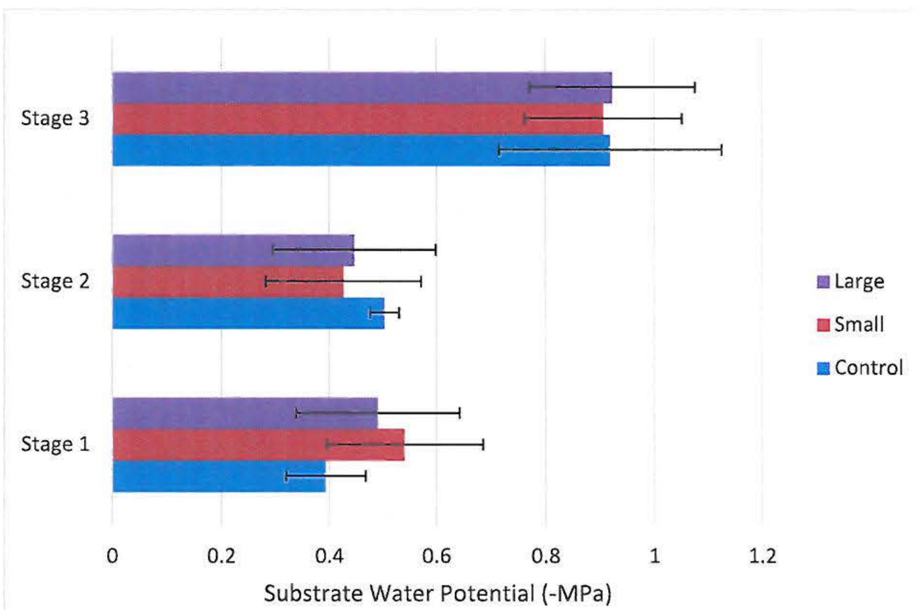

Figure 5. Substrate water potential for coleus (*Solenostemon scutellarioides* 'Kong Salmon Pink') grown in substrates containing 3 parts peat moss: 1 part vermiculite: 1 part perlite, with no hydrogels incorporated (control) or with 34 g/ft^3 of two different particle sizes (small: 0.2mm – 0.8mm, and large: 0.8mm – 2.0mm) of hydrogel.

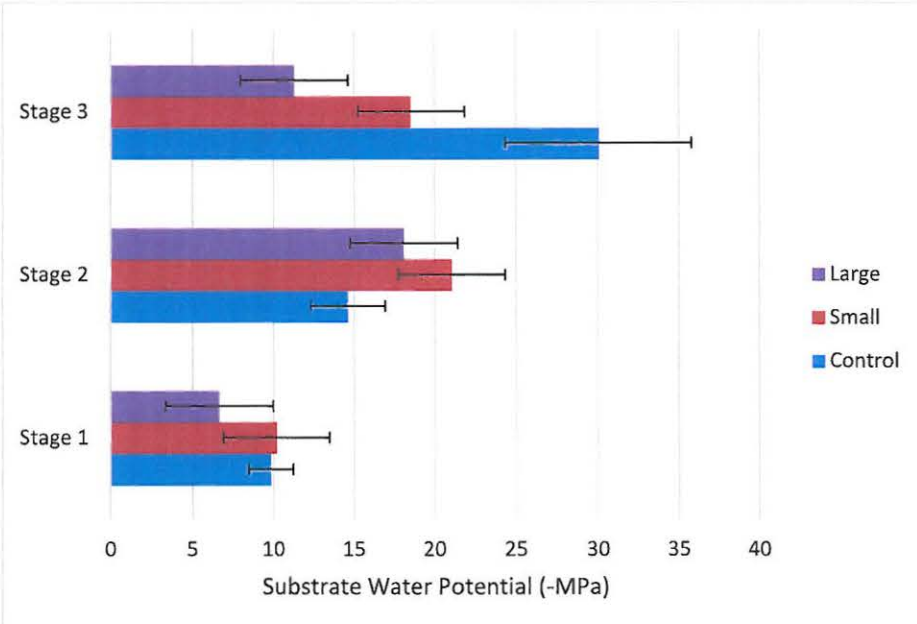

Figure 6. Substrate water potential for vinca (*Catharanthus roseus* 'Cora Apricot') grown in substrates containing 3 parts peat moss: 1 part vermiculite: 1 part perlite, with no hydrogels incorporated (control) or with 34 g/ft^3 of two different particle sizes (small: 0.2mm – 0.8mm, and large: 0.8mm – 2.0mm) of hydrogel.

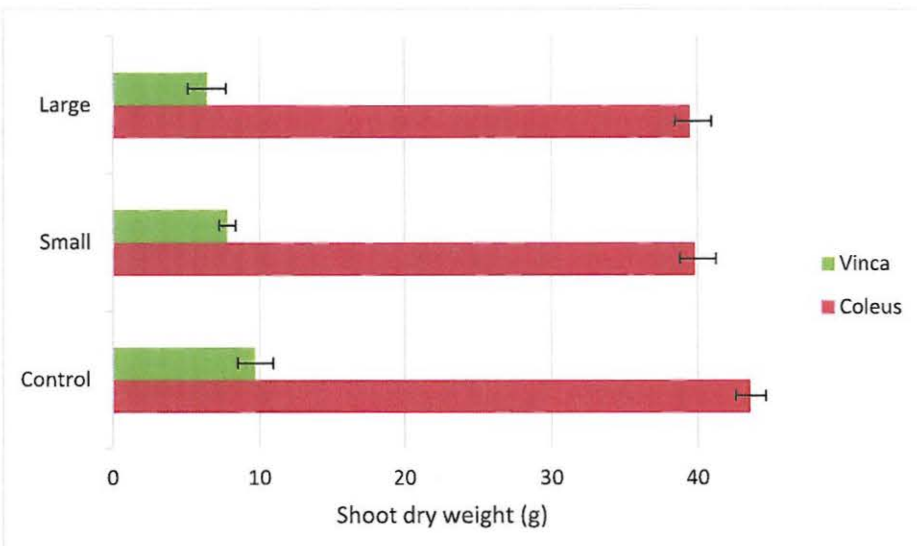

Figure 7. Shoot dry weight of coleus (*Solenostemon scutellarioides* 'Kong Salmon Pink') and vinca (*Catharanthus roseus* 'Cora Apricot') grown in substrates containing 3 parts peat moss: 1 part vermiculite: 1 part perlite, with no hydrogels incorporated (control) or with 34 g/ft^3 of two different particle sizes (small: 0.2mm – 0.8mm, and large: 0.8mm – 2.0mm) of hydrogel.