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Effect of a Medium-Incorporated Hydrogel on Plant Growth and Water Use of Two Foliage Species[1]

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Abstract

A fully expanded hydrogel, Agrosoke, was used to replace 5% (1 ×) or 10% (2 ×) of the volume of a potting medium to determine its effect on plant growth and water use. Although irrigation frequency was unaffected by Agrosoke, spider plants (*Chlorophytum comosum* (Thunb.) Jacques 'Vittatum') grown in the 2× medium were 50% larger and had more lateral shoots and better root systems than the control, demonstrating improved water use efficiency. Agrosoke had no effect on either irrigation frequency or on fresh weight of Boston fern (*Nephrolepis exaltata* (L.) Schott. 'Rooseveltii'). Leachates from hydrogel-amended media had higher electrical conductivity indicating that more nutrients and other salts were held by these media.

Index words: *Nephrolepis exaltata* 'Rooseveltii,' *Chlorophytum comosum*, irrigation, evapotranspiration, transpiration, hydrogel

Introduction

Plants grown in containers with limited soil require frequent irrigation to maintain adequate medium moisture, particularly during the periods when evapotranspiration (ET) rates are high. Tropical foliage plants generally require high temperatures which are associated with high water demand for maximum growth. Previous research on increasing water-holding capacity of soilless media has been conducted using hydrophilic polymers. Hydrogels absorb various amounts of water during expansion and have been found to increase water retention in potting media, thus reducing irrigation frequency and delaying the onset of wilting (2, 3, 7, 13). Marigold (*Tagetes erecta* L.) grown in a peat-lite medium amended with hydrogel had less internal moisture tension (3), while cineraria (*Senecio cruentus* (Masson) DC.) grown in a similar medium had less water loss only when an antitranspirant was used at the same time (15). Top growth of chrysanthemum was unaffected by hydrogel when used at moderate rates (13). however, high rates of hydrogels in the medium have been found to cause phytotoxicity in some cases (13, 14). Hydrogel did not affect growth or shelf life of weeping fig (10).

Agrosoke (Grosoke International, Texas) is a polyacrylamide hydrogel recently introduced to the U.S. market.

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Water absorption in distilled water was below 40 g of water per g of dry material, in contrast to many other hydrogels capable of absorbing several hundred g of water per g of dry material. It is also recommended that Agrosoke be added to the medium in its fully expanded form for best results, whereas the other hydrogels are mixed directly into the medium.

The objectives of this study were to determine the effect of Agrosoke on plant growth during the summer production period and on water use by 2 foliage plant species.

Materials and Methods

On June 6, 1986, 33 single-shoot liners each of spider plant and Boston fern were planted singly in 15 cm (6 in) containers in a medium of sphagnum peat moss and pine bark (equal parts by vol) amended with 6 kg/m^3 (10 lb/yd^3) Nutricote (14N-6P-11.6K, type 180), 2 kg (3.4 lb/yd^3) Micromax, and 3 kg/m1^3 (5 lb/yd^3) dolomite. Two hundred g (7 oz) of agrosoke was placed in 8 l (2 gal) of water for 16 hr to reach full expansion. Treatments included replacing 5% (1×, the recommended rate) and 10% (2×, twice the recommended rate) of the base medium volume with the fully expanded gel, which was thoroughly mixed into the medium. Initial pot weights were 550, 615, and 680 g (1.21, 1.35, and 1.50 lb) for the control, 1×, and 2× media, respectively.

Pots were thoroughly watered immediately after planting and placed on benches in a shade house covered with one layer each of black polypropylene shade fabric and polyethylene plastic (6 mil) providing 520 umol.s^{-1}m^{-2} (approximately 3600 ft-c) maximum photosynthetic photon flux (PPF). A white paint was applied to the polyethylene on July 17, reducing maximum PPF to 280 umol.s^{-1}m^{-2}. Temperatures in the production house ranged from 24° to 40°C (75° to 104°F).

Pots were checked daily and water with an electrical conductivity (EC) of 1.35 to 1.50 mS cm^{-1} (approximately 950 to 1050 ppm total salts) was used to irrigate plants as needed. Number of irrigations was recorded for each pot. Water containing 200 mg l^{-1} (200 ppm) N from a 20N-8.6P-16.6K fertilizer (20-20-20, W.R. Grace & Co.) was used for all irrigations after August 22. There was a single plant in each pot as an experimental unit replicated 11 times in a randomized complete block design.

On September 22, all plants and root systems of spider plants were evaluated for visual quality using a scale of 1 to 5 (see Table 1), and pots were thoroughly watered at 1600 HR. At 0830 HR the following morning, water was added to each pot so as to collect approximately 30 ml (1 oz) of leachate for EC and pH measurements. Pots were weighed 1 hr after leachates were collected and weighed at the same time of day during the next several days (5 days for spider plant and 2 days for Boston fern) to determine water loss due to ET. Plants were irrigated immediately after completion of ET determinations. Fresh weight of the shoots and roots, and number of shoots per pot in spider plant and top fresh weight of Boston fern were recorded 2 days after irrigation.

Results and Discussion

Spider plant. Visual grade of the spider plants was substantially better in the 2× treatment due to the 50% larger canopy and greater number of lateral shoots (Table 1). However, Agrosoke at the recommended rate (1×) did not promote plant growth. Distribution of plant fresh weight between the shoots and root systems (shoot:root ratio) was unaffected by Agrosoke. Root systems of the 2× plants were also 50% larger (Table 1) and occupied a larger volume of the medium, providing a better means of water and nutrient uptake.

Since plants were given only plain water during most of the experimental period, nutrients in the media were likely at suboptimal levels (Table 2) before supplemental fertilization was initiated. Increased growth in the 2× plants may have been the result of improved nutrient levels in the medium. Previous studies have shown that incorporation of hydrogel in a potting medium increased its ability to retain nutrients for plant use (5) and enhanced the growth of *Ligustrum lucidum* 'Compactum' at low fertility levels (14).

High initial ET rates declined as the amount of available water in the media decreased (Table 3), which agrees with other research (1), since the day-to-day climate remained fairly constant. An analysis of pot weights revealed that pots amended with Agrosoke at both rates were 40 g (1.4 oz) heavier than the control (Table 1). This amount of extra water was a very small fraction of the total water held by the base medium in a 15 cm (6 in) pot. It is not clear why the 2× pots retained the same amount of extra water as the 1× pots. Although, it may be possible that Agrosoke in the 2× medium deteriorated faster due to the higher salt level in this medium (Table 2).

The higher initial ET rates observed in the 2× plants were not proportional to their increased size (Table 3). Incorporation of Agrosoke into the potting medium did not affect evaporational water loss from the medium surface without foliage coverage. Consequently, either leaf transpiration rate in the 2× plants was substantially lower than the others,

Table 1. Effect of Agrosoke hydrogel on growth, pot weight and irrigation of spider plants.

Agrosoke rate	Plant grade	Root quality	Plant fresh wt (g)		Shoot:root ratio	Pot weight (g)		No. of irrigations	No of lateral shoots
			Shoot	Root		With plant	Without plant		
Control	2.6[z]b[y]	2.9[x]b	110 b	36 b	3.05 a	1269 c	1123 b	21.8 ab	5.0 a
1×	2.7 b	2.8 b	117 b	39 b	3.00 a	1318 b	1162 a	20.5 b	5.6 ab
2×	4.1 a	3.6 a	161 a	56 a	2.88 a	1381 a	1164 a	23.5 a	6.4 b

[z]Based on a scale of 1 to 5, where 1 = unsalable, 3 = good, and 5 = excellent.

[y]Means within a column followed by the same letter or letters are not significant at the 5% level as measured by Duncan's new multiple range test.

[x]Based on a scale of 1 to 5, where 1 = less than 5 roots at the bottom of the soil mass, 3 = abundant roots, and 5 = bottom of the soil mass covered by roots.

Table 2. Initial and final electrical conductance and pH of medium leachates as affected by Agrosoke hydrogel in the medium.

	Initial		Final			
			Spider Plant		Boston fern	
Agrosoke rate	Electrical conductance (mS m^{-1})	pH	Electrical conductance (mS m^{-1})	pH	Electrical conductance (mS m^{-1})	pH
Control	092 c[z]	663 a	304 b	501 a	331 b	528 a
1×	106 b	645 b	412 a	500 a	379 a	513 a
2×	125 a	650 b	412 a	511 a	411 a	495 b

[z]Means within a column followed by the same letter or letters are not significant at the 5% level as measured by Duncan's new multiple range test.

or water evaporation rate in the 2× pots was reduced due to greater coverage of the medium surface by the foliage. In either case, water had been used more efficiently by the 2× plants because these larger, faster growing plants had similar requirements as controls. Other studies (3, 15) did not find hydrogels to improve water use efficiency, possibly due to the small pot size (10 cm/4 in) and high transpiration rates of those plants being studied. Pine bark used in this study may have reduced evaporational and transpirational water loss (1) compared to the peat-lite media used in other studies.

Boston fern. Agrosoke had no significant effect on the fresh weight or visual grade of Boston fern, although the control plants tended to have greater fresh weights (Table 4). Irrigation frequency increased proportionally with greater fresh weight, which may have been a function of higher transpiration rates due to the greater total leaf area. It was reported previously that the leaf area of Boston fern varied even when there was no significant difference in dry weights (9). Because of the extremely high ET rates in Boston ferns, the limited additional water in 2× pots did not reduce irrigation frequency (Tables 3 and 4).

Addition of Agrosoke to the medium increased the initial EC of leachates, with the highest EC in the 2× treatment (Table 2). Because of the constant fertilization near the end of this experiment, final EC of both plant species was high. Since more soluble salts are held in the media containing the hydrogel (5), fertilization rate or frequency would be reduced to avoid any possible damage to plants which are sensitive to high salt level in the medium. Initial leachate pH was decreased by the hydrogel, probably due to its release of free acids to the medium (14). The lower final leachate pH was likely a result of constant fertilization toward the end of the production period (11, 12). Although the final pH was lower than that for the optimum growth of most foliage plants, it was within the range for optimum growth of Boston fern (4).

In this experiment, fully expanded Agrosoke was mixed into a medium to replace given portions (5% and 10%) of the base medium as recommended by the manufacturer. This may have reduced the efficiency of Agrosoke to increase

Table 3. Evapotranspiration of spider plant and Boston fern and water evaporation as affected by Agrosoke hydrogel in the medium.

	Evapotranspiration (g water/pot/day)							Evaporation (g water/pot/day)		
	Spider plant					Boston Fern				
Agrosoke rate	1	2	3	4	5	1	2	1	2	3
Control	141 b[z]	135 ab	98 a	89 a	77 a	262 a	226 a	48 a	29 a	31 a
1×	135 b	130 b	97 a	88 a	77 a	231 a	200 b	47 a	29 a	29 a
2×	160 a	148 a	105 a	92 a	77 a	242 a	220 a	48 a	29 a	30 a

[z]Means within a column followed by the same letter or letters are not significant at the 5% level as measured by Duncan's new multiple range test.

Table 4. Effect of Agrosoke hydrogel on growth, irrigation and postharvest quality of Boston fern.

			Pot weight (g)		
Agrosoke rate	Plant grade	Plant fresh weight (g)	with shoots	without shoots	No. of Irrigations
Control	4.6[z]a[y]	105 a	1320 b	1215 b	37.6 a
1×	4.1 a	88 a	1354 a	1267 a	28.7 b
2×	4.3 a	93 a	1357 a	1265 a	32.3 ab

[z]Based on a scale of 1 to 5, where 1 = unsalable, 3 = salable, and 5 = excellent.
[y]Means within a column followed by the same letter or letters are not sigificant at the 5% level as measured by Duncan's new multiple range test.

water holding capacity of the medium on a per pot basis because part of the water in the hydrogel was offset by the amount of water which could be held by the replaced medium. The amount of extra water in hydrogel-amended medium could have been reduced by the end of production period due to deterioration of the gel structure (14), or the destructive interactions between soil amendments and the gel (6, 7, 8). Binding tension of absorbed moisture in the gel may make part of the extra water unavailable to plant roots (7). Mixing the dry Agrosoke directly into a medium would reduce labor and storage costs associated with using the expanded gel.

Significance to the Nursery Industry

This study demonstrates that the addition of Agrosoke to potting medium at twice (2×) the recommended rate enhanced plant growth, improved quality, and increased water use efficiency in spider plant. Spider plants grown in the 2× Agrosoke amended medium may be finished earlier than controls. Growth of Boston fern was not affected by the use of Agrosoke at either rates in the medium. Plant growth as affected by different ways of mixing Agrosoke into medium needs to be studied in order to use this hydrogel most efficiently.

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