WETTING AGENTS USED IN CONTAINER SUBSTRATES ARE THEY BMP'S ?

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Abstract

Commercial grower mixes containing sphagnum peat routinely contain wetting agents. Studies report that coarse dry potting components such as pine bark can be more thoroughly moistened if wetting agents are used. Under frequent leaching irrigations, wetting agents have been reported to enhance nutrient leaching from substrates. Effective longevity of previously tested wetting agents was considered to be only 3 to 4 weeks. New products claim greater longevity and advertise that less water volume is required for optimum plant growth. One such product is Saturaid (Debco Pty, Ltd. Victoria, Australia). The objective of this study was to evaluate the effect of Saturaid on air and water properties of a course substrate, nutrient levels and the effect on growth under decreasing irrigation volume. The granular wetting agent was incorporated into a pine bark substrate at 0,1.0 and 2.0 g/l substrate volume. *Cotoneaster dammeri* 'Skogholm' plants were potted into 2.8 l pots and irrigated with 500 ml of water per container for 22 days after which 1/3 of the containers received 425 ml (15% reduction) and another 1/3 were irrigated with 350 ml (30% reduction) daily. Saturaid had little effect on moisture and air characteristics compared to the control, no effect on foliar nutrients or on nutrients in leachates collected at 43, 64 or 84 days after potting. When irrigation volume was decreased there was a linear increase in shoot dry weight. Wetting agent rate had no effect on shoot or root dry weight at the highest irrigation volume. At the 2 g/l wetting agent rate, shoot dry weight exhibited a quadratic growth response, with the plants receiving the largest volume of water having the least shoot dry weight. Root dry weight at the lowest (350 ml) irrigation volume increased with increasing wetting agent rate, but no effect was observed at greater irrigation volume. It was concluded that the product continued to be effective after 22 days when irrigation was decreased in 2/3 of the test plants, however the exact longevity of the product was not evaluated. At low irrigation volumes or under conditions of irrigation conservation, this wetting agent has potential to enhance plant growth.

1. Introduction

Wetting agents have been reported in many studies to increase moisture retention in potting substrates and improve plant survival and development (Bhat *et al.* 1992, Regulski, 1984). Most brands of sphagnum peat moss and commercial peat based bagged mixes marketed in the U.S. contain wetting agents which attests to the recognition that wetting agents are useful in initial wetting of organic potting components. Effective longevity of previously tested wetting agents in pine bark substrates was considered to be only 3 to 4 weeks (Bilderback 1989; 1993). However, the longevity of most wetting agents is not expected to be over 3 to 4 weeks after potting and frequent irrigation. New products claim greater longevity and advertise that less water volume is required for optimum plant growth. One such product is Saturaid (Debco Pty, Ltd., Victoria, Australia).

Increased irrigation efficiency to conserve irrigation water and reduce runoff from container nurseries is currently of great interest to nurserymen and would be considered as a Best Management Practice (BMP). Many nurserymen are evaluating the use of cycled irrigation as a BMP. Cycled irrigation has been reported to reduce water application by as much as 25% when compared to standard single irrigation application (Fare, *et al.* 96, Tyler *et al.*, 96a; 96b). However, cycled irrigation requires considerable automation of irrigation systems and very intensive irrigation management. Considerable research is also being conducted at universities related to interval applications of water and decreasing or eliminating water leached from containers.

Since wetting agents enhance the surface wetting and absorption of irrigation water into substrate component organic particles, they may also provide a means to reduce the amount of irrigation volume required and consequently reduce irrigation runoff from nursery production areas under low irrigation conditions.

The objective of this study was to evaluate the effects of a wetting agent recently introduced to the nursery industry in the United States on air, water and nutritional characteristics of a pine bark substrate and on plant nutrient uptake and growth. An objective of this study was also to evaluate Saturaid wetting agent as a BMP that would increase irrigation efficacy by reducing irrigation volume required to grow an ornamental crop in a pine bark substrate

2. Materials and methods

Cotoneaster dammeri Schneid 'Skolghom' cotoneaster liners were potted into 2.78 liter containers and placed on a gravel nursery production area. The study was initiated June 26 and terminated on September 18, 1995: a duration of 12 weeks. Irrigation treatments were begun July 18, 3 weeks after initiation of the study. Cotoneaster was chosen for the study since previous studies have indicated that growth is very dependent on water and nutrient resources in container substrates (Tyler, *et al.* 1993a; 1993b; 1996a and 1996b).

2.1. Nutritional amendments

Pine bark was amended with 3.6 kg/m^3 of dolomitic limestone using a spiral agitator type 0.8 m^3 mixer. Nutricote 18-6-8 / 180 with minors and magnesium sulphate were incorporated individually into each container at the rate of 5.4 kg/m^3 and 1.8 kg/m^3 respectively. Each container received 17.8 g Nutricote 18-6-8 / 180 (3.2 g N / container) and 6.0 g $MgSO_4$ per container.

2.2. Substrates and Wetting Agent Rates

1. Pine Bark Control- used as a single component potting substrate incorporated with dolomitic limestone, minor elements and Controlled Release Fertilizer at rates described above.
2. Saturaid 1.0 g/l incorporation rate- 2.78 g Saturaid granules were weighed and incorporated into each 2.78 l pot. All other amendments and procedures were as described above.
3. Saturaid 2.0 g/l incorporation rate- 5.56 g Saturaid granules were weighed and incorporated into each 2.78 l pot. All other amendments and procedures were as described above.

2.3. Irrigation Volumes Applied

1. Minimal Leaching Fraction: Substrate irrigation volume applied was based upon the volume of water required to irrigate the Pine Bark Control Substrate to produce zero

or minimal irrigation leaching. Approximately 500 ml of water per container were required to irrigate the Pine Bark Control for thorough wetting with minimal leaching. Each of the three substrates were irrigated with 500 ml in this irrigation treatment.

2. Fifteen percent reduction: Each substrate received 15% less volume of irrigation than in Irrigation Treatment 1: therefore Treatment 2 received approximately 425 ml of water per irrigation.
3. Thirty percent reduction: Each substrate received 30% less volume of irrigation than in Treatment 1: therefore Treatment 3 received 350 ml. of water per irrigation. All containers were irrigated using an irrigation controller allowing variable irrigation periods. Each container was irrigated by a Tornado Orchid Mist Spray nozzle equipped with a "Dor Non-Drip Device". This system allowed low velocity irrigation application at a precise and uniform volume. Volumes applied were monitored weekly and adjusted to maintain uniformity.

2.4. Statistical design

A split plot design with irrigation as main plots and substrates as sub-plots in each irrigation zone was used. A total of nine (9) treatment combinations with eight (8) blocks of single container replicates of each treatment combination resulted in 72 containers in the study. All variables were tested for differences using analysis of variance and regression analysis. All reported correlations were significant at $p \leq 0.05$.

2.5. Data collected

2.5.1. Physical properties

To determine air and water retention characteristics, cylindrical aluminum rings, 347.5 cm^3 in volume (7.6 cm dia, 7.6 cm ht) were placed in 5 containers of each substrate and left fallow without plants. These containers were placed adjacent to the plants in the research study. After approximately 3 weeks, the cores were extracted and physical properties determined. Total porosity, water holding capacity and air space for each substrate, were determined by procedures of Fonteno and Bilderback (1993) using aluminum cylinders attached to a porous plate base. Each unit (cylinder with attached base plate) was placed in a Buchner funnel, saturated and allowed to drain. Wet weights of the samples were recorded. Samples were placed in a forced-air drying oven at 110 °C for 24 hours and dry weight recorded. Container capacity (CC) (% volume) was defined as (wet weight - dry weight) / volume. Air space (AS) was the volume of water drained from the sample/ volume of sample. Total porosity (TP) was CC + AS. An estimate of unavailable water (UW) was defined as the amount of water held at 1.5 MPa. Available water was determined for each sample as CC - UW using pressure plate extraction and procedures according to Klute (1986) and Milks *et al.* (1989)

2.5.2. Container nutritional levels

The effect of Saturaid on nutrient retention or leaching was evaluated using VTEM Leachate Extraction Procedure (Wright, 1986). Approximately 120 ml of water was applied to the top of 4 designated blocks 1 to 2 hours after irrigation. Leachates obtained were analyzed for electrical conductivity, pH, NO_3N, NH_4N, and P. Leachates were collected 1 week after initiation of the study and once every 4 weeks throughout the duration of the study. Leachate samples were frozen until analyzed for NO_3N (Calaldo *et al.*, 1975), NH_4N (Chaney and Marbach, 1962) and P (Murphy and Riley, 1962) using a spectrophotometer (Spectronic 1001 Plus, Milton Roy Co. s Rochester, N.Y.)

2.5.3. Plant response

Plant response was determined by measuring shoot and root dry weight as compared to wetting agent rates and irrigation volume effects. Nine weeks after initiation of the study foliar nutrient concentration including nitrogen, phosphorus, potassium, calcium, and magnesium were determined by inductively coupled plasma emission spectroscopy.

3. Results and discussion

3.1. Physical Properties

The values measured can be seen from Table 1. The wetting agent had only a small effect on substrate moisture and air characteristics. Total porosity decreased 1% (by vol.) at the 1 g/l rate and 2% at 2 g/l, however 83% to 85% total porosity volumes are the highest expected for pine bark substrates. Air space volume which is variable depending upon the height of the sampling column decreased 1 to 3% in the 7.6 cm height rings with addition of the wetting agent, but still remained in the mid-range of air space volumes expected for pine bark substrates in the sampling cores. Container capacity was increased 2% and available water content increased 4% at the 1 g/l rate of application. Bulk density was unaffected.

Decreases in total porosity and air space may indicate that the wetting agent increased penetration of water through pine bark surfaces and into the particles and apparently some of the increased moisture retained was available and some was held tightly to internal surfaces and was not available. Converse to soils, organic potting components such a pine bark contain pores within particles (Airhart and Pokorny, 1978) which hold air and can retain moisture once water penetrates the particle. Some of this internal water is available to plants when roots penetrate the pine bark particle. Greater available water capacity in the 1 g/l rate may indicate both greater penetration of water into the bark particles but also greater moisture retention between particles because particle surfaces were more thoroughly wet using the wetting agent.

3.2. Container nutrition levels

Nutrient solution levels sampled at 43, 64 or 84 days after potting were not statistically different for wetting agent rates or irrigation volumes applied, thus it can be concluded that Saturaid did not enhance leaching at these irrigation application volumes (data not shown).

In previous studies with a non-ionic wetting agent, leaching of NO_3N, P and cations were increased from pine bark and pine bark and sand substrates under high irrigation volumes exceeding 800 ml per 3.78 l containers (Bilderback 1989).

3.3. Plant response

No statistical differences were found for any foliar tissue nutrient concentrations for wetting agent rates or irrigation volumes applied. Tissue levels were generally within acceptable concentration as follows: 2.4- 2.6 % for N; 0.13-0.14 % for P; 0.9- 1.0 % for K; 1.4-1.5 % for Ca; and 0.4-0.5 % for Mg; by dry weight at mid-season (Jones *et al.*, 1991).

Shoot dry weight had a quadratic increase in relation to irrigation volume (Table 2). No response was detected with increasing wetting agent rates when shoot growth data was analyzed for all irrigation volumes. These results indicate that there was no shoot growth benefit unless irrigation volume was decreased. No relationship was detected between irrigation volume or wetting agent rates for root dry weights when analyzed over all levels. There were no significant interactions for irrigation volume and wetting agent rate for growth data or any parameter measured.

When irrigation volume was decreased there was a linear increase in shoot dry weight (Table 3). Wetting agent rate had no effect on shoot or root dry weight at the highest irrigation volume. At the 2 g/l wetting agent rate, shoot dry weight exhibited a quadratic growth response, with the plants receiving the largest volume of water having the least shoot dry weight. Root dry weight at the lowest (350 ml) irrigation volume increased with increasing wetting agent rate, but no effect was observed at greater irrigation volume.

Shoot growth in substrates containing the wetting agent were larger when irrigation volume was reduced from the 500 ml control. Plants in the 500 ml irrigation treatment were smaller (approximately 20 g / treatment) than those grown at reduced irrigation rates with wetting agents which ranged from 24 to 30 g dry weight. Perhaps, under reduced irrigation volumes plants were forced to become more efficient in water use as they grew. The 500 ml irrigation volume appeared to limit growth in comparisons to dry weights obtained in previous studies (Tyler, *et al.* 1993b, Tyler, 1996b) where 900 ml daily irrigation was found to produce plants as large as 1000 to 1400 ml volumes. Plants in those studies had dry weights of approximately 85 g top dry weight and 16 g root dry weight compared to 31 g shoot and 5 g root dry weight in this study. However, those studies were conducted over longer growing periods, up to 104 days and this study was terminated after 84 days.

The longevity of this wetting agent was not determined in this study, however it can be concluded that the product continued to be effective after 22 days and apparently affected growth through the 84 day duration of the study.

Regardless, Saturaid wetting agent may be a BMP that could enhance growth of nursery crops under conditions when a nurseryman anticipates irrigation resource shortages due to drought conditions or water restrictions.

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Table 1. Physical properties of Pine Bark and Pine Bark + Saturaid Wetting Agent substrates.

Substrate	Total Porosity	Air Space	Container Capacity (% Volume)	Available Water	Unavailable Water	Bulk Density (g/cc)
PB Control	84.8	22.7	62.1	33.9	28.2	0.22
PB+ 2.78 g	83.6	19.9	63.7	37.6	26.1	0.22
PB+ 5.56g	82.5	21.0	61.5	33.4	28.1	0.22
Normal Ranges	50.0-85.0	10.0-30.0	45.0-65.0 (% volume)	25.0-35.0	25.0-35.0	0.2-0.5 (g/cc)

Table 2. Irrigation volume effects on cotoneaster shoot and root dry weights, 84 days after initiation of the study.

Irrigation Volume (ml)	Shoot Dry Weight (g)	Root Dry Weight (g)
350	23.8	4.3
425	26.6	4.2
500	19.5	3.7
Significance		
L	*	NS
Q	**	NS

Table 3. Irrigation volume (IV) and wetting agent rate (WAR) effects of cotoneaster shoot and root dry weights, 84 days after initiation of the study.

Irrigation Volume	WAR (g/l) 0	1	2	*Significance* L	Q	WAR (g/l) 0	1	2	*Significance* L	Q
	Shoot Dry Weight (g)					Root Dry Weight (g)				
350	19.5	24.0	28.0	*	NS	3.5	4.1	5.0	*	NS
425	22.7	25.9	30.7	**	NS	4.2	3.5	5.1	NS	NS
500	17.7	20.8	20.5	NS	NS	4.0	3.1	4.1	NS	NS
Significance (IV)										
L	NS	NS	NS			NS	NS	NS		
Q	NS	NS	*			NS	NS	NS		