Growth of Hibiscus in Media Amended with a Ceramic Diatomaceous Earth Granule and Treated with a Kelp Extract

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Summary. Growth of *Hibiscus rosa-sinensis* L. 'President' under daily irrigation and decreasing irrigation frequency was compared in a 5 pine bark : 4 sedge peat : 1 sand (by volume) medium amended further with 0%, 10%, 20%, or 30% (by volume) Axis, a kiln-fired diatomaceous earth granule. Half of each substrate treatment also was drenched three times with Agroroots, a kelp extract. Shoot and root dry weights were compared after 4.5 months of growth. Container media amended with Axis at 10% volume yielded hibiscus plants with higher shoot dry weights than nonamended media. Root-zone drenches with Agroroots increased shoot dry weights of plants subjected to decreasing irrigation frequency and grown without Axis, but did not significantly affect plants receiving daily irrigation. Shelf-life effects of Axis treatment revealed that all plants reached the permanent wilting point 5 days after cessation of daily irrigation. Both products may allow container plant production with less irrigation. Further tests should be conducted with a broader range of species.

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Water use and quality will remain a concern of the horticultural industry in the next century (Mezitt, 1992; Yeager, 1992). Container media amendments that reduce irrigation inputs for plant production and are biological sources of essential nutrients and growth regulators will be an important part of an integrated approach addressing these concerns.

Axis (AgroTech 2000, Plainsboro, N.J.) is a kiln-fired diatomaceous earth aggregate produced from diatomite deposits. It is inert and has a pH of 7. Because of its porous nature, Axis reportedly absorbs > 100% of its own weight in water, then releases the water to the surrounding soil as the soil's water content drops below field capacity. Used as a container media amendment, Axis might allow plant production using less water without loss of quality.

Kelp by-products stimulate plant growth in various ways (Aldworth and Van Staden, 1987; Crouch and Van Staden, 1991; Featonby-Smith and Van Staden, 1983, 1984, 1987; Finnie and Van Staden, 1985; Nelson and Van Staden, 1984a, 1984b; Temple and Bomke, 1989). The beneficial effects usually have been attributed to the presence of cytokinins in the extracts (Blunden and Wildgoose, 1977; Kingman and Moore, 1982; Tay et al. 1985), but ethylene-producing compounds (Nelson and Van Staden 1985) and auxins (Augier, 1976; Sumera and Cajipe, 1981; Williams et al., 1976) have been isolated from marine algal extracts as well. The extracts also typically contain variable but significant quantities of essential plant nutrients, vitamins, and amino acids.

In this study we tested the effects of amending the container medium with Axis in conjunction with root-zone applications of a kelp by-product, Agroroots, on growth of *Hibiscus rosa-sinensis* L. 'President' under daily irrigation and with decreasing irrigation frequency.

Materials and methods

One hundred-sixty liners of hibiscus were potted on 23 Sept. 1993 in 1-gal (2.7-liter) containers of a mix of 5 aged pine bark : 4 sedge peat : 1 sand (by volume) further amended with 0%, 10%, 20%, and 30% (by volume) Axis and 16 lb (7.3 kg) of Osmocote 17-7-12 (Scotts, Milpitas, Calif.), 8 lb (3.6

kg) dolomite, and 1.5 lb (0.7 kg) Micromax (Scotts) per cubic yard (0.73 m³). Half of each substrate treatment received a root drench of 8 oz (237 ml) Agroroots at label rate (1:200 dilution) 1 week after transplanting, a second drench 7 weeks after transplanting and a third drench 13 weeks after transplanting. The other half received no Agroroots. The plants were placed under low-volume irrigation (spitters) in a greenhouse (max PPF = 1200 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) and irrigated daily [15 min, delivering 0.4 gal (1.7 liters)] until 21 Oct. 1993. After the initial month, 10 plants of each substrate–Agroroots treatment were grown with daily irrigation and 10 with irrigation applied every third day (22 Oct. 3 to 2 Dec. 1993), then every fourth day (3 Dec. 1993 to 3 Jan. 1994), and finally every fifth day (4 Jan. to 1 Feb. 1994). The experiment was a 4 × 2 × 2 factorial with 10 plants per treatment completely randomized in two split-split irrigation plots. The experiment was terminated on 1 Feb. 1994 and shoot and root dry weights were determined. Data were analyzed for significance and interactive effects using covariant analysis (Snedecor and Cochran, 1980), with rate of Axis the covariant factor. Overall effects were tested for significance, as were effects of Axis and Agroroots within each irrigation treatment. Physical parameters of the amended media were determined in 5-inch (12.5-cm) columns at inception and termination of the experiment for three replicate samples using protocols from Ingram et al. (1990). Six additional plants of each Axis treatment were grown under daily irrigation, but without Agroroots treatment. At the end of the production period, these plants were maintained without irrigation to assess shelf-life effects of varying Axis amendment rates. Days to the permanent wilting point were recorded.

Results and discussion

Decreasing irrigation frequency had the greatest effect on shoot dry weight of hibiscus. Plants grown with decreasing irrigation frequency had higher shoot dry weights than plants grown with daily irrigation (Table 1), but not higher root dry weights. This may have been due to greater leaching of nutrients from the root zones of the plants receiving daily irrigation. Visible water stress symptoms were not ob-

served on plants receiving decreasing irrigation until the longest interval of 5 days was instituted.

In the overall model, Axis had significant linear and quadratic effects on shoot and root dry weights of hibis-

Table 1. *Effects of irrigation, substrate amendment with Axis (ceramic diatomaceous earth granule), and root drench with Agroroots (kelp extract) on growth of Hibiscus rosa-sinensis 'President'*

No.	Treatment		Shoot dry wt ² (g)	Root dry wt ² (g)
	% Axis	Agroroots		
<i>Daily irrigation (I)^y</i>				
1	0	No	27.6 (2.3) ^y	4.7 (0.6)
2	10	No	37.3 (3.2)	8.0 (1.3)
3	20	No	33.6 (1.9)	7.8 (0.7)
4	30	No	29.4 (2.1)	7.8 (1.1)
5	0	Yes	30.1 (1.2)	6.8 (0.8)
6	10	Yes	34.3 (2.2)	7.2 (0.6)
7	20	Yes	35.5 (1.8)	8.8 (0.9)
8	30	Yes	32.3 (2.0)	8.0 (0.6)
<i>Decreasing irrigation frequency (IF)^x</i>				
9	0	No	44.3 (6.2)	5.8 (1.1)
10	10	No	54.9 (7.3)	7.8 (1.7)
11	20	No	37.1 (4.2)	5.5 (1.0)
12	30	No	42.6 (5.3)	6.3 (1.2)
13	0	Yes	60.7 (3.6)	8.8 (1.1)
14	10	Yes	66.7 (5.0)	10.9 (1.5)
15	20	Yes	48.4 (4.1)	6.7 (0.8)
16	30	Yes	39.4 (4.5)	5.5 (1.0)
Overall effects (P)			$R^2 = 0.467^w$	$R^2 = 0.188^v$
IF	0.0001	NS		
Agroroots	0.018	0.0174		
Axis	0.0017	0.0161		
Axis × Agroroots	NS	NS		
Axis × IF	0.002	NS		
Agroroots × IF	NS	NS		
Axis × Agroroots × IF	NS	NS		
Axis × Axis	0.002	0.040		
Axis × Axis × IF	0.042	NS		
Axis × Axis × Agroroots	NS	NS		
Axis × Axis × Agroroots × IF	NS	NS		
Effects w/in I (P)—Daily I			$R^2 = 0.184^u$	$R^2 = 0.172^t$
Agroroots	NS	NS		
Axis	0.0305	NS		
Axis × Agroroots	NS	NS		
Axis × Axis	NS	NS		
Axis × Axis × Agroroots	NS	NS		
Decreasing IF			$R^2 = 0.289^s$	$R^2 = 0.194^r$
Agroroots	0.0281	NS		
Axis	0.0132	0.0255		
Axis × Agroroots	NS	NS		
Axis × Axis	0.0070	0.0210		
Axis × Axis × Agroroots	NS	NS		

²Mean of 10 replicates (SE).

^yDaily irrigation: 0.4 gal (1.7 liters).

^xDecreasing irrigation frequency: irrigation applied every third day (22 Oct. to 2 Dec. 1993), every fourth day (3 Dec. 1993 to 3 Jan. 1994), then every fifth day (4 Jan. to 1 Feb. 1994).

^wdf = 15, P = 0.0001.

^vdf = 15, P = 0.0086.

^udf = 7, P = 0.0341.

^tdf = 7, P = 0.0530.

^sdf = 7, P = 0.0007.

^rdf = 7, P = 0.0248.

cus (Table 1). However, significant interactions occurred between irrigation frequency and Axis. With daily

irrigation, amending the substrate with Axis increased shoot dry weights of hibiscus (Table 1, Fig. 1) when

Agroroots was not used. Substrate amended to 10% volume with Axis (treatment 2) had the highest shoot dry weights compared to the control.

In the overall model, Agroroots had significant effect on shoot and root dry weights of hibiscus. However, when the model was restricted within irrigation treatment, Agroroots had no significant effect on root dry weights. This suggests that the effects of Agroroots on root growth were marginal, at best. With daily irrigation, Agroroots had no significant effects on either shoot or root dry weights.

Under decreasing irrigation frequency (Table 1, Fig. 2), Axis and Agroroots had significant effects on shoot dry weight of hibiscus. Axis significantly affected root dry weight, but Agroroots had no significant effect. Agroroots resulted in greatest increase in shoot dry weights compared to the control at the 10% Axis amendment (treatment 14) and without Axis (treatment 13). Amending the medium with 10% Axis by volume

Fig. 1. Growth of Hibiscus rosa-sinensis 'President' under daily irrigation in substrate amended with Axis (ceramic diatomaceous earth granule) and treated with kelp extract Agroroots $n = 10$.

Fig. 2. Growth of Hibiscus rosa-sinensis 'President' with decreasing irrigation frequency in substrate amended with Axis (ceramic diatomaceous earth granule) and treated with kelp extract Agroroots, $n = 10$.

without Agroroots treatment (treatment 101 also increased shoot dry weights compared to the control. Increasing the volume of Axis amendment from 10% to 20% lowered shoot dry weights whether or not Agroroots was used.

Amending the container medium with Axis had no affect on the shelf life of hibiscus. Six plants each of the 0%, 10%, 20%, and 30% amendment treatments all reached permanent wilting point 5 days after cessation of irrigation.

Compared to 0% Axis amendment, various amounts of Axis resulted in different substrate water-holding capacities and percentage air porosities (Table 2). These differences were largely unnoticeable after 4.5 months except for water holding capacity of the 20% rate of Axis.

Table 2. Physical parameters of 5 pine bark : 4 sedge peat : 1 sand (by volume) container substrate amended with Axis, a ceramic diatomaceous earth granule [mean (SD) of three samples].

Axis	Inception		4.5 Months ²	
	Air space (%)	Water holding capacity (%)	Air space (%)	Water holding capacity (%)
0%	27.3 (3.7)	24.2 (4.3)	25.7 (4.2)	27.9 (2.9)
10%	24.6 (4.1)	29.8 (1.3)	24.6 (4.2)	29.4 (0.1)
20%	24.0 (1.0)	32.3 (0.9)	25.4 (0.5)	33.7 (2.5)
30%	25.9 (0.9)	31.7 (0.7)	29.1 (4.8)	29.2 (5.5)

²Placed under irrigation for the duration of the experiment.

With daily irrigation, container media amended with Axis at 10% volume produced hibiscus plants with higher shoot and root dry weights than nonamended media. Root-zone drenches with Agroroots increased shoot dry weights of plants subjected to decreasing irrigation frequency and grown without Axis, but had no effect on plants receiving daily irrigation. Both products may have value for producing container plants when irrigation is applied every 3 to 5 days. Based on our results with hibiscus, 10% amendment with Axis is the most effective rate of this diatomaceous earth product to use with container plant substrates. Further tests with both products should be conducted with a broader range of species.

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