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Evaluation of Composted Rice Hulls and a Lightweight Clay Aggregate as Components of Container-Plant Growth Media[1]

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Abstract

Four experiments were conducted with selected woody landscape plants in containers to compare container media consisting of composted rice hulls and a lightweight clay aggregate (Arkalite) to pine bark and sand. Plant growth in the inorganic components of sand and Arkalite was generally similar. Plant growth in organic components of 100% composted rice hulls or 50% composted rice hulls and 50% pine bark compared favorably with the growth obtained with 100% pine bark as the organic component. Excellent growth was obtained with composted rice hulls only when not amended or amended with small amounts of dolomitic limestone. Use of composted rice hulls should be based on costs and availability.

Index words: artificial media, fertilization, azalea

Significance to the Nursery Industry

Use of composted rice hulls as the organic component of growth media is a viable alternative to pine bark. Excellent growth, comparable to the growth obtained with pine bark, was obtained with composted rice hulls in these studies. Excellent plant growth was obtained only when little or no dolomitic limestone was added to composted rice hulls. Growers should use composted rice hulls on a trial basis first to determine the usefulness of this material for their production program. The use of composted rice hulls should also be based on costs and availability.

Introduction

Organic materials such as pine bark or peat and inorganic materials such as builder's sand, calcined clay, perlite and vermiculite are used to formulate growth media to produce woody landscape plants in containers. The selection of media components in which container-grown plants can be successfully grown is usually based on freedom from soil pests and harmful chemicals, cost, shipping weight and local availability (2, 7, 8, 9, 10).

Composted rice hulls may have potential as an organic component of artificial growth media. Two to three million acres of land are planted in rice in the U. S. each year. The major production areas are in Mississippi, Louisiana, Texas, Arkansas, and Missouri (1). Large quantities of rice hulls are readily available as a by-product from the milling process. Work by Einert and Guidry (6) indicated that composted rice hulls may serve as a practical soil substitute for plants grown in containers. Fresh rice hulls are composted for use as a growth medium by first storing them in pits for several months where anaerobic decomposition occurs. The hulls are then removed from the pits and piled in windows for aerobic decomposition. In a few days during the composting process the temperature of the hulls generally reaches 55 to 66°C (130 to 150°F). Several weeks later the compost cools and is ready for marketing (3).

The addition of fresh (not composted) rice hulls to growth media resulted in poorer growth of 5 woody landscape species (11). Parboiled rice hulls in growth media resisted decomposition and were intact after a 6 month growing period, but were successfully used as one third or less of the organic component of greenhouse potting media to force flower bulb crops (4, 5).

Arkalite is a lightweight clay aggregate used to manufacture lightweight concrete masonry units and is also marketed as a ground covering material for use by the landscape industry.

The objective of these studies were to compare combinations of composted rice hulls and Arkalite to pine bark and sand as components of media to grow plants in containers.

Materials and Methods

Factorial experiments utilizing randomized complete block designs were conducted in 1982, 1984, and 1985. Fresh milled pine bark or composted rice hulls were mixed with builders sand or Arkalite in 3 particle sizes [screened, crushed, and blended (Arkansas Lightweight Aggregate Corp., West Memphis, AK)] in a 4:1 ratio, amended or not amended with dolomitic limestone, in 1982 (Table 1). All media blends were amended with slow release 18N-2.6P-10K (18-6-12) (Sierra Chemical Co., Milpitas, CA), 0N-8.6P-0K (0-20-0) and fritted trace elements, FTE 555 (W. R. Grace & Co., Allentown, PA), at 4.46 kg/m^3 (7.5 lb/yd^3), 0.59 kg/m^3 (1lb/yd^3) and 74 g/m^3 (2 oz/yd^3). Treatments were replicated 6, 6 and 5 times with *Rhododendron indicum* (L.) Sweet 'Formosa' (Formosa azalea), *Ilex crenata* Thunb. 'Compacta' (Compact Japanese holly) and *Juniperus horizontalis* Moench. 'Plumosa' (Andorra juniper). Liners of Rhododendron, Ilex and Juniper were planted in 6 1 (#2), 3 1 (#1) and 3 1 (#1) containers on April 15, 1982, respectively. Additional slow release fertilizer was surface applied at 6.7 g (0.24 oz)/container plant on July 23 to Ilex and Juniper and on August 2, 1982 to Rhododendron. The study was terminated on October 29, 1982.

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Table 1. Chemical analyses of water extract (2 water: 1 media volume ratio) of growth media containing pine bark (PB) composted rice hulls (CRH) sand and Arkalite.

Growth media[z] Organic : Inorganic	Dolomitic lime	K	Ca	Mg	Na	pH	EC	SAR
	-(kg/m³)-	(ppm)					(umhos/cm)	
PB : Sand	0.0	122	0	28	25	3.80	920	1.01
PB : Sand	4.7	104	127	71	52	4.74	620	0.91
PB : Arkalite (screened)	0.0	93	122	11	23	3.97	600	0.53
PB : Arkalite (screened)	4.7	111	144	55	17	5.21	820	0.30
PB : Arkalite (crushed)	0.0	122	97	14	41	3.93	760	1.02
PB : Arkalite (crushed)	4.7	95	146	59	22	5.13	880	0.39
PB : Arkalite (blended)	0.0	89	89	15	14	3.90	640	0.36
PB : Arkalite (blended)	4.7	101	166	64	41	4.99	760	0.68
CRH : Sand	0.0	84	82	12	31	3.63	740	0.22
CRH : Sand	4.7	131	162	84	36	5.77	860	0.57
CRH : Arkalite (screened)	0.0	62	139	21	7	4.89	620	0.14
CRH : Arkalite (screened)	4.7	108	208	53	35	6.25	800	0.56
CRH : Arkalite (crushed)	0.0	115	231	31	68	4.02	1000	1.11
CRH : Arkalite (crushed)	4.7	117	177	70	15	5.64	1100	0.24
CRH : Arkalite (blended)	0.0	131	203	25	36	4.12	1000	0.63
CRH : Arkalite (blended)	4.7	77	53	24	3	6.24	520	0.09

[z]growth media components–4 organic:1 inorganic ratio, (by vol).

Two experiments were conducted with *Rhododendron indicum* 'Formosa' in a 45% shadehouse in 1984. Experiment I (Table 4) consisted of three media treatments of pine bark : composted rice hulls : sand [4:0:1, 2:2:1, and 0:4:1, (by vol)]; three of pine bark : composted rice hulls : Arkalite [4:0:1, 2:2:1 and 0:4:1, (by vol)]. Two rates of 17N-3P-10K (17-7-12) fertilizer, 5.3 and 8.9 kg/m³ (9 and 15 lb/yd³), (Sierra Chemical Co., Milpitas, CA) were added to the 6 media blends. Experiment II consisted of pine bark or composted rice hulls, both mixed with sand in a 4:1 ratio (by vol), 2 rates of dolomitic limestone, 0 and 1.2 kg/m³ (0 and 2 lb/yd³), and 2 rates of 17N-3P-10K (17-7-12) fertilizer, 5.3 and 8.9 kg/m³ (9 and 15 lb/yd³).

All media treatments in 1984 were amended with 12N-2.6P-5K (12-6-6), (Sta-Green Plant Food Co., Sylacauga, AL), 0N-8.6P-0K (0-20-0) and fitted trace elements (FTE 555) at 0.59 kg/m³ (1 lb/yd³), 0.59 kg/m³) and 74 g/m³ (2 oz/yd³). All media treatments in Experiment I were amended with 1.2 kg/m³ (2 lb/yd³) of dolomitic limestone. Liners of Rhododendron in both experiments were planted in 6 l (#2) containers on April 17, 1984. A surface application of 12N-2.6P-5K (12-6-6) was made to all container plants at 4.7 g (0.17 oz) on June 12, 1984. Slow release 17N-3P-10K (17-7-12) was surface applied, according to treatment, on June 14, 1984.

Growth media treatments consisted of pine bark : composted rice hulls : sand in ratios of 4:0:1, 2:2:1 and 0:4:1, (by vol); dolomitic lime rates of 0, 1.2 and 4.7 kg/m³ (0,2, and 8 lb/yd³); and 17-7-12 fertilizer rates of 25 and 42 g (0.9 and 1.5 oz) /container in 1985 (Table 5). All media treatments were amended with 0N-8.6P-0K (0-20-0) and fritted trace elements (FTE 555) at 0.59 kg/m³ (1 lb/yd³) and 74 g/m³ (2 oz/yd³). Dolomitic lime rates and amendments were mixed with the growth media and the slow release fertilizer rates were surface applied in 2 equal applications on April 23 and July 17, 1985. Liners of *Juniperus conferta* Parl. 'Emerald Sea' (Emerald Sea Shore juniper), *Rhododendron* × 'Herbert' [*Rhododendron yedoense* var. *poukhyanense* (Lev) Nakai × *R. kaempferi* Planch. 'Herbert'] and *Raphiolepis indica* (L.) Lindl. 'Elizabeth' were planted in the media treatments in 3 l (#1) containers in 4 replications on April 10, 1985. The study was terminated on October 10, 1985.

Growth data were taken at the end of each experiment. One container-plant was an experimental unit in all studies, with the exception of Ilex in 1982, where 2 container plants were used per experimental unit. Plants were severed at the growth media surface to obtain shoot fresh weight. Root ratings were a mean of ratings by 2 observers. The containers were removed and the root-ball was shaken lightly to expose the roots for evaluation with a rating of 10-excellent and 0-poor.

Growth media samples were taken from container plants of Ilex at the initiation and at the termination of the study conducted in 1982. Media samples of each treatment for testing were composites of 12 container plants of Ilex, 2 containers/plot with 6 replications. Saturated hydraulic conductivity was determined by measuring the rate of water passing through a cylindrical core of media, 5 cm (2 in) high and 7.2 cm (2.8 in) in diameter. A hydraulic head of 10 cm (3.9 in) was used. Particle size analyses were accomplished by manually shaking a nest of standard sieves for 10 minutes (Table 2). Chemical analyses were made on 2:1 water to media (by vol) extract. The metallic cations Ca, Mg, K and Na were determined using a IL 457 Atomic Absorption Spectrophotometer.

Results and Discussion

Some of the chemical and physical properties of the media components and media mixtures are shown in Tables 1 and 2. These data were based on media samples taken prior to growing plants. In general, these materials contained very small amounts of fine particles. These coarse materials permit the rapid transport of air and water. Only the crushed and blended Arkalite had more than 10% material less than 0.25 mm (.01 in) in diameter. Hydraulic conductivity of

Table 2. Particle size distribution of growth media components.

Particle size	Organic components: Pine bark	Composted rice hulls	Inorganic components: Sand	Arkalite screened	Arkalite crushed	Arkalite blended
(mm)	(Percent by weight)					
>6.4	19.5					
2–6.4	39.3	4.7	13.1	64.5	23.9	22.7
1–2.0	19.9	23.6	10.7	26.7	20.2	17.6
0.5–1	11.3	43.3	22.8	7.1	14.5	11.1
0.25–.5	6.7	19.7	46.8	1.5	11.4	7.8
0.125–.25	2.6	5.2	6.4	0.1	9.4	6.0
0.050–.125	0.4	1.8	0.1	0.1	9.2	5.1
<0.050	0.3	1.1	0.1	0.0	11.5	6.8

the mixtures (data not shown) was rapid with initial values varying from 2-11 cm/min (.79-4.3 in/min). These values decreased during the season, but the minimum value was still greater than 1 cm/min (.4 in/min) in October. The 2:1 (by vol) distilled water equilibrium extract pH value given in Table 1 were very acid (pH < 4) for all cases where lime was not applied to media with the organic component pine bark or the inorganic component sand. The pH of all blends of composted rice hull and Arkalite were less acid (pH > 4). These data suggest that calcium and magnesium are contained in rice hulls and Arkalite and are released to the media solution. Bark contains magnesium but not calcium. Electrical conductivity (EC) and SAR was low for these materials and should cause no salt injury. Therefore plant requirements for nutrients such as N, P, and K would have to be supplied by applied fertilizer. The water used for irrigation was slightly alkaline (pH 8.1) and caused a small increase in pH during the growing season.

1982 Experiment. The addition of dolomitic limestone reduced the growth of Rhododendron, Juniper, and Ilex in composted rice hulls (Table 3). A growth reduction was observed, but not as extreme for Rhododendron and Ilex in pine bark, while the Juniper increase in growth was not significant. Pine bark was superior to rice hulls on root growth and the addition of dolomitic lime caused a deteriation of root growth for all plants. The reason for the deleterious effect of dolomitic limestone on the growth of these plants was not obvious. While the pH of the solution was over 6 in some cases, this would not be expected to be harmful to Juniper or Ilex. Also the Ca, Mg, and K ratios in the solution extract were in the acceptable range for good growth. We were not able to identify the cause of the unfavorable interaction between dolomitic limestone and rice hulls.

Few differences in fresh weight and root rating were observed due to the inorganic component of the media for all genera tested. Fresh weight of Rhododendron was greatest for blended Arkalite (142 g) compared to screened Arkalite (118 g). Fresh weight of Rhododendron grown in the inorganic components sand (128 g) and crushed Arkalite (129 g) were similar and between screened and blended Arkalite. Fresh weights of Ilex were greatest with a mixture of sand (125 g) with composted rice hulls and intermediate with crushed Arkalite with pine bark (116 g) and composted rice hulls (116 g). Lowest fresh weights were obtained with sand (104 g) and Arkalite blend (110 g) with pinebark, and screened (108 g) and Arkalite blend (109 g) with composted rice hulls. The screened Arkalite contained the greatest amount of large particles (Table 2) and provided the least desirable physical environment for growth.

1984 Experiment I. Shoot fresh weight of *Rhododendron* 'Formosa' was higher with pine bark alone, as the organic component, compared to composted rice hulls alone or both sand and Arkalite at both fertility levels (Table 4). Replacing one-half of the bark with composted rice hulls yielded growth similar to pinebark or composted rice hulls alone (Table 4). Rhododendron grown in media blended with sand and at the high fertility rate had the greatest fresh weight compared to the other inorganic component and fertilizer combinations (Table 4). Fresh weights of Rhododendron plants were similar between inorganic components at the low fertility level. All pine bark, composted rice hulls, sand and Arkalite com-

Table 3. Effect of organic amendment and dolomitic limestone rate on the growth of three landscape plants, 1982.

Organic amendment	Dolomitic limestone	Juniperus 'Plumosa' Fresh weight	Juniperus 'Plumosa' Root rating	Ilex 'Compacta' Fresh weight	Ilex 'Compacta' Root rating	Rhododendron 'Formosa' Fresh weight	Rhododendron 'Formosa' Root rating[z]
	(kg/m^3)	(g)		(g)		(g)	
Pine Bark	0	105	4.5	115	7.4	142	7.1
	4.7	131	4.0	103	7.2	128	5.4
Composted Rice Hulls	0	147	4.1	135	7.4	142	5.9
	4.7	117	3.0	95	5.8	104	3.6
LSD = 0.05		27.9	.79	7.4	1.03	13.6	.60

[z]Root rating: 10 = excellent, 0 = very poor.

Table 4. **Effects of organic amendment ratio, inorganic amendment and fertilizer rate on the growth of Rhododendron 'Formosa' Experiment I, 1984.**

Organic amendment ratio			Fresh weight		Root rating[z]	
			Fertilizer		Fertilizer	
Pine bark	Composted rice hulls	Inorganic amendment	5.3	8.9	5.3	8.9
(v/v)		(1 volume)	(g)	(g)		
4	0	Sand	394	264	8.5	8.1
2	2	Sand	271	346	8.3	8.2
0	4	Sand	269	337	7.9	7.8
4	0	Arkalite	299	313	8.1	7.6
2	2	Arkalite	281	332	8.6	7.8
0	4	Arkalite	253	307	6.6	6.6
LSD = 0.05			36.2		.74	

[z]Root rating: 10 = excellent, 0 = very poor.

binations resulted in good root growth with the exception of Arkalite with composted rice hulls, (Table 4).

1984 Experiment II. Fresh weight of *Rhododendron* 'Formosa' was increased at the higher rate of fertilizer (8.9 kg/m^3) compared to the low rate (5.3 kg/m^3), 348 and 289 g, respectively. Including dolomitic limestone at 1.2 kg/m^3 improved root quality from a rating of 7.7 to 8.3, where 1 being the poorest rating and 10 the highest or best. No differences between organic components for either fresh weight or root rating were detected (data not shown). Fresh weight of Rhododendron was not affected by application of

Table 5. **Effects of growth media, dolomitic limestone and fertilizer rate on the growth of three woody landscape cultivars, 1985.**

Growth media Pinebark:rice hulls:sand	Dolomitic limestone	Fresh weight Fertilizer 25	Fresh weight Fertilizer 42	Root rating[z] Fertilizer 25	Root rating[z] Fertilizer 42
(v/v/v)	(kg/m^3)	(g)	(g)	(g)	(g)
		Raphiolepis 'Elizabeth'			
4:0:1	0.0	109	154	7.7	8.2
	1.2	109	177	7.5	8.2
	4.7	120	161	7.0	7.7
2:2:1	0.0	125	164	8.7	9.5
	1.2	153	192	8.7	9.2
	4.7	122	160	7.7	8.0
0:4:1	0.0	149	184	8.5	8.5
	1.2	124	186	8.0	8.7
	4.7	121	164	7.7	8.0
LSD = 0.05		29.2		.97	
		Rhododendron 'Herbert'			
4:0:1	0.0	63	24	6.2	5.5
	1.2	67	62	6.2	6.0
	4.7	71	90	6.2	4.5
2:2:1	0.0	83	52	7.7	7.0
	1.2	64	90	7.0	6.2
	4.7	62	77	5.0	5.2
0:4:1	0.0	73	87	7.2	6.0
	1.2	57	73	5.5	5.2
	4.7	47	48	4.5	4.7
LSD = 0.05		33.3		1.06	
		Juniperus 'Emerald Sea'			
4:0:1	0.0	110	145	5.5	6.2
	1.2	124	168	5.2	6.2
	4.7	135	144	5.0	5.5
2:2:1	0.0	138	176	6.5	6.2
	1.2	134	176	6.0	6.5
	4.7	111	141	6.2	6.2
0:4:1	0.0	121	177	5.0	6.2
	1.2	129	164	6.0	6.0
	4.7	102	151	5.7	5.5
LSD = 0.05		22.1		1.10	

[z]Root rating: 10 = excellent, 0 = very poor.

1.2 kg/m^3 dolomitic limestone and root rating was not affected by fertility rate.

1985 Experiment. Raphiolepis 'Elizabeth' did not respond to small applications (1.2 kg/m^3) of lime and growth was retarded at high applications (4.7 kg/m^3). Growth was superior in the media containing rice hulls when measured either by fresh weight or root evaluation.

The effect of adding composted rice hulls to the mixture in the absence of lime was beneficial for fresh weight of both *Rhododendron* 'Herbert' and *Juniperus* 'Emerald Sea' (Table 5). However, when lime was applied, particularly at high rates (4.7 kg/m^3), to media composed predominantly of rice hulls, growth and root ratings were reduced. This again suggests an unfavorable interaction between dolomitic lime and rice hulls.

The effect of application of slow release fertilizer (17-7-12) to these plants is inconclusive (Table 5). The root rating of Rhododendron was diminished at the higher rate of fertilizer. On the other hand, Juniper and Raphiolepis responded to fertilizer application when measured by either fresh weight gain or root rating.

Growth data obtained in these studies indicate that composted rice hulls is a good substitute for pine bark as an organic component of container plant growth media. The addition of dolomitic limestone at 4.7 kg/m^3 was detrimental to the shoot growth of *Rhododendron* 'Formosa', *Juniperus* 'Plumosa' and *Ilex 'Compacta'* in 1982 and *Rhododendron* × 'Herbert', *Raphiolepis indica* 'Elizabeth' and *Juniperus* Emerald Sea' in 1985 indicating that this rate of dolomitic limestone should not be added to growth media containing 50 or 100% composted rice hulls. Best growth was obtained using 0 or 1.2 kg/m^3 of dolomitic limestone with composted rice hulls as the primary organic component. Use of 4.7 kg/m^3 of dolomitic limestone with pine bark resulted in decreased shoot fresh weight of 2 of 3 test plants in 1982 and increased shoot fresh weight of 2 of 3 test plants in 1985. Poorer root systems were obtained with 4.7 kg/m^3 of dolomitic lime regardless of the growth medium.

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