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The Use of COIR as a Containerized Growing Medium for Douglas-fir Seedlings

Robin Rose and Diane L Haase

Abstract

In response to environmental concerns and the need for peatland conservation, alternative growing media for conifer seedling production must be investigated. We grew Douglas-fir seedlings in 6 media; components included peat moss, peat moss amended with sawdust, and 2 sources of coir (coconut fiber) mixed with and without peat moss. Coir had higher pH, P, K, and Na and lower Ca and N than peat moss and a peat moss-sawdust mixture. Bulk densities of coir and coir-based media were lower than those in peat moss and a peat moss-sawdust mixture. After 21 wk, seedlings grown in coir-based media were significantly smaller and had lower foliar N and Ca than those grown in peat moss. Because of coir's many favorable qualities, we suggest further research using culturing regimes specific to the substrate's nutrient properties.

KEYWORDS: *Cocos nucifera, Pseudotsuga menziesii,* substrates, coconut

NOMENCLATURE: ITIS (1998)

To meet consumers' environmental concerns and increased regulation of peatland exploitation, alternatives to sphagnum peat moss (*Sphagnum* spp. L. [Sphagnaceae])-based media need to be developed for container nurseries. Coconut (*Cocos nucifera* L.[Arecaceae]) coir, the fibrous material derived from the mesocarp, is a promising resource in this endeavor. Coir is plentiful in many Pacific countries such as Sri Lanka, Indonesia, Malaysia, Phillippines, and Thailand. Long fibers of the coir husk have traditionally been extracted and used in manufacturing ropes, matting, brushes, automobile seats, and drainage pipe filters. The short fibers and dust have been considered a waste product, but now this product can be processed into dehydrated, easily-handled, expandable, compressed bricks or bulk bales (Svenson 1995).

Short coir fiber is very high in carbon, degrades slowly, and is similar to peat moss in look and texture (Verdonck and others 1983). Other characteristics that suggest coir as a peat moss substitute include excellent drainage, physical resilience, wetability, absence of weeds and pathogens, and it is readily renewable (Cresswell 1992). Coir has been shown to be a viable growing medium for plants (Reynolds 1974; Handreck 1993; Dyke 1994; Meerow 1994; Smith 1995; Evans 1996; Evans and Stamps 1996; Noguera and others 1997; Offord and others 1998) and may prove to be a suitable substitute or amendment for peat moss-based media. Few reports exist regarding performance of coir as a growing medium for conifer seedling production. Our objective was to evaluate the use of coir as a component in growing media on Douglas-fir (*Pseudotsuga menziesii* var. *menziesii* (Mirb.) Franco. [Pinaceae]) growth and nutritional status.

TABLE 1

The 6 media used in this study

Medium	Components (by volume)
Peat moss (control)	2:1:1 sphagnum peat moss:vermiculite:perlite (operational nursery medium)
Ecotech	2:1:1 Ecotech coir:vermiculite:perlite
Ecotech + peat moss	1:1:1:1 Ecotech coir:sphagnum peat moss: vermiculite: perlite
Lignocell	2:1:1 Lignocell coir:vermiculite:perlite
Lignocell + peat moss	1:1:1:1 Lignocell coir:sphagnum peat moss: vermiculite:perlite
Forestry Mix #3	7:3 sphagnum peat moss:Douglas-fir sawdust

Materials and Methods

Our media components included single-screened Canadian sphagnum peat moss, Douglas-fir sawdust, Ecotech® coir, Lignocell® coir, #2 coarse vermiculite, and horticultural grade perlite combined in 6 mixtures used in our study (Table 1). Lignocell (distributed by Farm Wholesale Greenhouse, Salem, Oregon) is imported from Sri Lanka as highly compressed bricks (20 x 10 x 5 cm, ≈ 650 g [8 x 4 x 2 in, ≈ 1.4 lb]). Following manufacturer instructions, we re-wetted Lignocell by adding 4 l (1.1 gal) of water to each brick. Each brick yielded about 6 l (1.6 gal) of coir. Ecotech (distributed by Farm Wholesale Greenhouse, Salem, Oregon) is imported from the Phillippines as a large bale (40 x 32 x 24 cm, ≈ 7.5 kg [16 x 13 x 9 in, ≈ 16.5 lb]). Again, following manufacturer instructions, we re-wetted the bale by adding a 5:1 ratio of water:coir (30 l or 8 gal water) resulting in about 70 l (18.5 gal) of coir. Forestry Mix #3 is a commercial 7:3 peat moss:Douglas-fir sawdust commercial mix (Pacific Soil, Hubbard, Oregon) amended with Nitroform® (manufactured by Nu-Gro Technologies, Inc, Grand Rapids, Michigan) (38N:$0P_2O_5$:$0K_2O$) at a rate of 450 g/m^3 (0.75 lb/yd^3) and a wetting agent. With the exception of vermiculite and perlite, a sample of each component (Forestry Mix was treated as a single component) was analyzed for chemical properties. In addition, a sample from each medium was analyzed for physical properties.

Seedlings were grown at Hood Canal Container Nursery (Port Gamble, Washington) in styro-4 containers (66 cm^3 (4 in^3) cavities, 160 cavities per styroblock container). For each medium we filled 5 styroblocks. Our experimental design was a randomized complete block with 5 replications (styroblocks). After filling styroblocks with the respective medium, stratified Douglas-fir seeds were sown and covered with grit on 1 April 1997. Styroblocks were clearly labeled and placed randomly in the study area. Seedlings were cultured under standard nursery regimes including weekly fertilization with a combination of Peters Conifer Grower® (20N:$7P_2O_5$:$19K_2O$) and calcium nitrate (15N:$0P_2O_5$:$0K_2O$) at a rate or 150 ppm N.

On 25 August 1997 after seedlings set bud, we randomly selected 20 seedlings from each medium replication for morphological evaluation. After seedlings were washed free of medium, we measured height, stem diameter, and root and shoot dry weights. Needles from the 20 sampled seedlings were combined, dried 48 h at 68 °C (154 °F), and weighed. Composite foliar samples were analyzed for macro and micronutrients using standard laboratory techniques. Nutrient concentrations and contents were examined using vector analysis (Haase and Rose 1995).

Tests for normality, linearity, and constant variance of the residuals were performed and transformations were not deemed necessary to ensure validity of these assumptions. Data were analyzed using analysis of variance. To determine significant differences in data among media treatments Fisher's Protected Least

TABLE 2

Chemical properties of the media components

Component	pH	Total Kjeldahl nitrogen	P	K	Ca	Mg	Na	Cation exchange capacity	Soluble salts
		%	ppm					meq/100 g	mmhos/cm
Peat moss	4.4	0.87	20	99	127	29	2	130	2.6
Ecotech	5.5	0.33	628	19,929	9	8	13	73	3.1
Lignocell	5.3	0.50	46	4446	16	15	15	89	0.4
Forestry Mix #3 [a]	4.7	0.68	4	246	46	9	1	53	0.2

[a] We treated this mixture as a single component.

TABLE 3

Physical properties of the media

Medium	Bulk density (g/cm^3)	Gravimetric water content (%)					Volumetric water content (%)				
		saturation	0.1 bar	0.8 bar	2.0 bar	15.0 bar	saturation	0.3 bar	0.8 bar	2.0 bar	15.0 bar
Peat moss	0.13	840	285	205	154	79	105	36	26	19	9
Ecotech + peat moss	0.11	1019	310	232	168	86	117	36	27	19	7
Ecotech	0.10	1138	349	270	235	86	110	34	26	23	9
Lignocell + peat moss	0.12	970	361	235	n/a	102	120	45	29	n/a	11
Lignocell	0.11	1038	357	276	209	181	116	40	31	23	18
Forestry Mix #3	0.15	784	300	179	155	129	120	36	27	24	14

Significant Difference procedure was used at the ∝ ≤ 0.05 level. We used Statistical Analysis Software (SAS Institute Inc 1989) for all analyses.

Results

Coir was more basic and had higher levels of P, K, and Na and lower levels of Ca and N than the peat moss-based media at the onset of the study (Table 2). Peat moss and Forestry Mix media had the highest bulk densities and lowest gravimetric water contents (Table 3). Ecotech and Lignocell (100% coir) had 10% to 20% higher gravimetric water contents than the peat moss and Forestry Mix media while both 1:1 peat:coir media were intermediate. Volumetric water contents showed less variability (Table 3).

Twenty-one wk after sowing, seedling height, stem diameter, root dry weight, and shoot dry weight differed among media ($P = 0.0001$) (Figure 1). Seedlings grown in either Ecotech, Ecotech+peat moss, or Lignocell were significantly smaller than those grown in the control peat moss medium. Seedlings grown in Lignocell+peat moss or Forestry Mix were similar to the control peat moss medium.

Foliar dry weight and N, K, Ca, Mn, Fe, and Mo concentrations differed significantly by medium (Table 4). Seedlings grown in Ecotech or Lignocell (100% coir) media or Lignocell+peat medium had the lowest N concentrations and contents (Table 4, Figure 2a). Seedlings grown in the control peat moss medium had the highest Ca concentrations and contents while those grown in the 100% coir had the lowest (Table 4, Figure 2b). Seedlings grown in the Forestry Mix tended to have the highest K, Mn, and Mo concentrations. The 4 coir-based media had the lowest Fe concentrations.

Discussion

Chemical and physical properties of our peat moss and coir materials were similar to those reported elsewhere (Handreck 1993; Miller and Jones 1995; Smith 1995; Offord and others 1998) although coir K levels, espe-

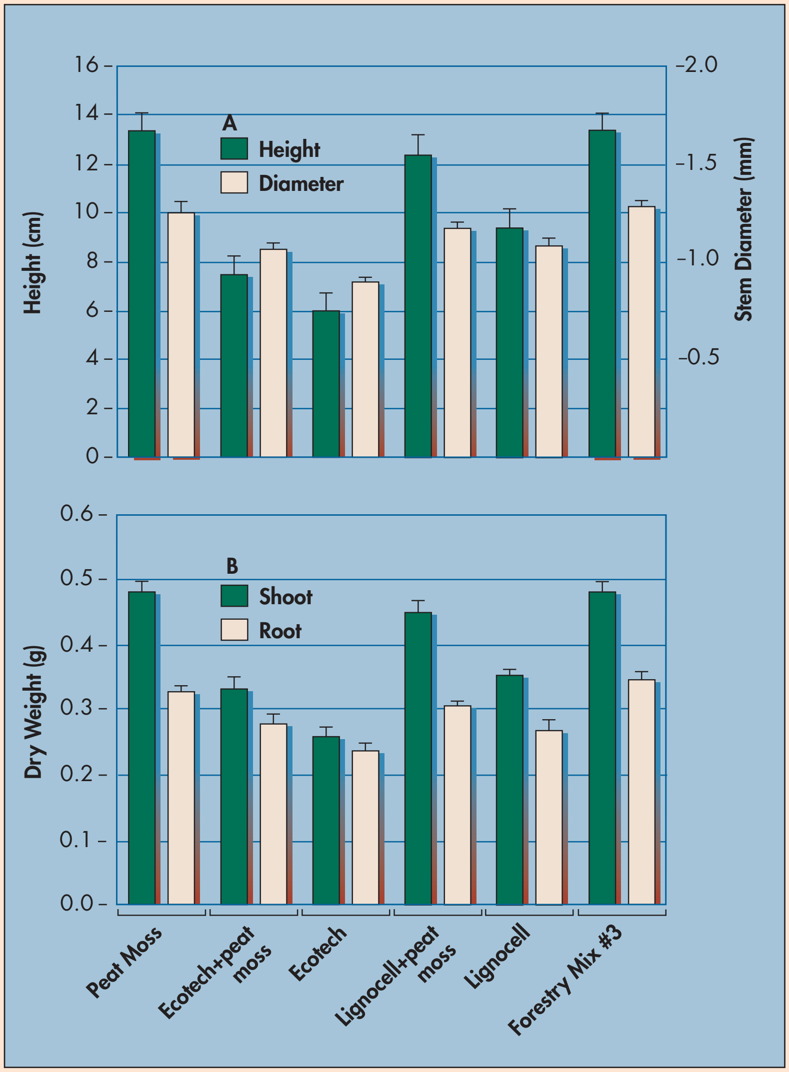

Figure 1 • *Seedling morphology 21 wk after sowing in various media: (A) height and stem diameter and (B) shoot and root dry weights. Bars represent 1 standard error.*

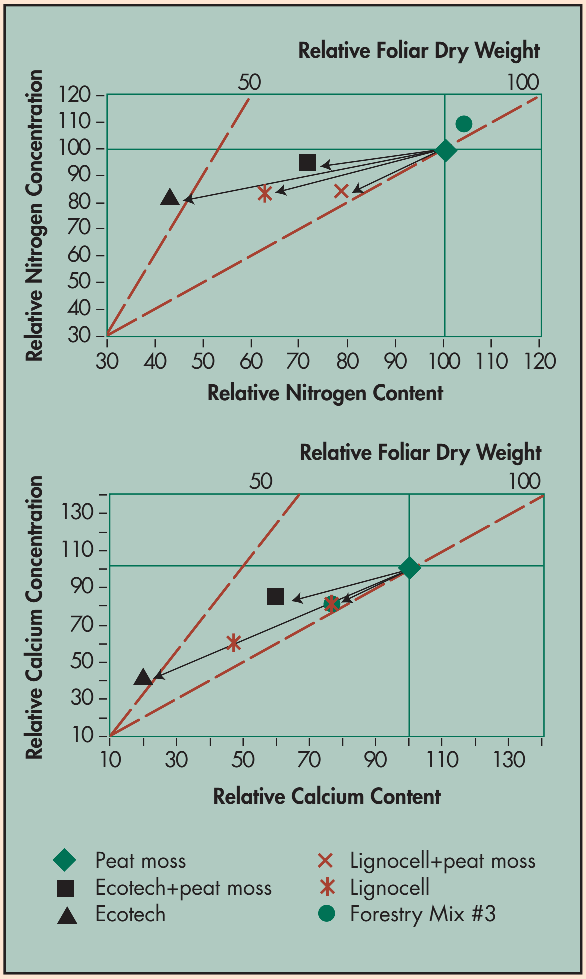

Figure 2 • Foliar nitrogen and calcium concentrations and contents of each medium relative to control peat moss.

cially for Ecotech, were very high. Research has shown potentially unfavorable characteristics of coir compared to peat moss: higher pH and higher K, Cl, and Na concentrations (Handreck 1993; Smith 1995; Konduru and others 1999). Coir salt content can be high since coconut palms grow near seas and coconut husks can sometimes be processed in brackish waters (Martinez 1995; Smith 1995; Offord and others 1998). Also, because coconut is a semi-halophyte and thought to require salt application for optimal growth, some growers fertilize with salts such as NaCl and KCl (Konduru and others 1999). As a result, coir quality can vary considerably and growers using it for growing media must be familiar with the source. The high water-holding capacity is comparable or superior to peat moss (Miller and Jones 1994; Smith 1995; Evans and Stamps 1996). Dyke (1994) and Smith (1995) noted that although coir appears to dry out on the surface it still has sufficient moisture in the root zone.

Seedlings grown in coir-based media tended to have lower Ca, N, and Mn foliar concentrations compared to the control peat moss medium. Nutrient losses in coir may occur as a result of leaching since it can have lower CEC values than peat moss (Handreck 1993; Offord and others 1998). Growers have found that coir-based media need supplemental N (Handreck 1993; Martinez 1995; Noguera and others 1997) and may also benefit from liming (Noguera and others 1997). Surprisingly, foliar K concentrations were not elevated despite the extremely high K levels found in both coir sources. Handreck (1993) noted that the high K content of coir suggests that fertilizers need not contain as much K as is normally used and the relative concentrations of Ca, Mg, and K are such that Ca deficiency is inevitable in plants grown in unamended coir materials.

Researchers have observed improved growth of plants in coir mixes compared with peat moss mixes (Verdonck and others 1983; Cresswell 1992; Meerow 1994), yet others have found no significant differences (Evans and Stamps 1994; Offord and others 1998) or poorer growth (Radjagukguk and others 1983). In our study, Douglas-fir seedlings grew less in media containing coir than they did in control peat moss medium or Forestry Mix. This may be a result of nutrient deficiencies as evidenced by the lower N and Ca concentrations of plants grown in coir.

We expected a N deficiency in seedlings growing in the Forestry Mix but nutrient analyses revealed N and other nutrient concentrations were similar to those grown in the control peat moss medium. Sawan and Eissa (1996) found cucumber growth in sawdust was as good as, or better than, growth in peat moss. Douglas-fir

TABLE 4

Mean foliar dry weight and nutrient concentration for each medium. Within a column, means not followed by a letter did not differ among media; means followed by the same letter are not significantly different at ∝ ≤ 0.05

Medium	Dry wt. (g)	N	P	K	Ca	Mg	Na	Mn	Fe	Zn	Al	B	Cu	Mo
		%					ppm							
Peat moss	7.0 c	0.83 b	0.32	1.13 bc	0.15 d	0.11	72	68 b	40 c	30	22	18	2.5	0.34 bc
Ecotech + peat moss	5.5 b	0.77 ab	0.30	1.02 ab	0.12 c	0.11	64	106 c	27 ab	24	14	17	2.3	0.27 ab
Ecotech	3.9 a	0.66 a	0.30	1.15 bc	0.06 a	0.10	76	39 a	23 a	28	12	16	2.2	0.21 a
Lignocell + peat moss	6.9 c	0.68 a	0.29	1.04 ab	0.12 c	0.10	101	71 b	35 bc	24	25	17	2.7	0.25 a
Lignocell	5.4 b	0.69 a	0.29	0.98 a	0.09 b	0.12	77	44 a	30 b	27	16	17	2.6	0.30 abc
Forestry Mix #3	6.9 c	0.86 b	0.32	1.20 c	0.12 c	0.11	68	127 d	40 c	31	17	17	2.8	0.36 c

sawdust is low in N but is also low in available carbon compared to sawdust from other species (Bollen and Lu 1957). Therefore, it is less likely to cause stunting even without added nitrogen and may increase growth in some crops (Bollen and Lu 1957). Coir is also reportedly high in carbon. Although we did not measure carbon levels in either coir source, we speculate that the lower foliar N concentrations may have resulted in part from high C:N.

Practical Implications

Although our study suggests that coir is a less favorable substrate for growing containerized Douglas-fir seedlings than conventional peat moss-based media, we believe that an adjusted nutrient and irrigation regime tailored to coir's physical and chemical attributes should result in satisfactory conifer seedling development.

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Author Information

Robin Rose
Director
Robin.Rose@orst.edu

Diane L Haase
Associate Director
Diane.Haase@orst.edu

Nursery Technology Cooperative
Department of Forest Science
Oregon State University
321 Richardson Hall
Corvallis, OR 97331