Recommendations and Alternative Growing Media for Use in Containerized Nursery Production of Conifers: Some Physical and Chemical Properties of Media and Amendments[1]

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Abstract.-- Physical and chemical properties of various nursery media were examined at the start of the crop cycle of containerized Englemann spruce. Preliminary results showed physical and chemical properties of the peat and amendments are highly variable. Combined, these ingredients produce variable media. The results highlight the need for monitoring the media physical and chemical properties and altering nursery culture to accommodate media properties.

INTRODUCTION

Nursery media contain solids, water, air, and eventually plant roots. The ideal growth medium for nursery culture should: permit healthy root development; be free of pathogens; offer physical stability; and supply water, nutrients, and air. This ideal medium should retain its properties throughout culture and be consistent from one crop to the next (Bunt 1976).

In the real world, peat-based growth media vary in their physical and chemical properties (Haynes and Goh 1978, Prasad 1979). Media also vary in their rate of decomposition (Langerud and Sandvik 1987). Ideal conditions for crop growth are also ideal for media decomposition. Decomposition reduces the aeration porosity of media. Poor media aeration alters root morphology and physiology (McKevlin et al. 1987) and is responsible for decreased seedling vigor and stature (Hocking 1972). Outplanting performance of seedlings grown in poorly aerated media is suspect (Hellum 1981).

Variable peat quality and failure to recognize this variability in crop management has been implicated in the increasing incidence of root diseases in container-grown conifer seedlings. Perlite, wood waste, and rockwool, have been suggested as alternatives to vermiculite in Cornell Peat-Lite mixes (Boodley and Sheldrake 1967) and may provide a means of altering peat properties. Different amendments appear to yield crops with different morphological attributes and plantation survival and growth (Phipps 1979). Amendments alter the porosity and nutritional regimes of nursery culture and, like peat, are variable. Species may respond deferentially to amendments.

STUDY OBJECTIVES

This study examines the physical and chemical properties of various media and amendments. The results report on the initial properties of a variety of media. Future results will report on the degradation of media and cultural consequences for seedling vigor. The preliminary results are presented to permit growers to make comparisons with their media.

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MATERIALS AND METHODS

Nurseries were canvassed to determine the range of operational and experimental media being used. Only Englemann spruce crops grown in PSB 313-sized containers were considered. Thirteen media and their amendments were sampled from both coastal and interior nurseries (Table 1) to include a wide range of nursery cultural conditions. Letters reference the media and numbers reference their amendments. Not all the amendments examined were incorporated into the media sampled.

Various physical and chemical properties were examined. Methods of analyses were selected that were used in forest nurseries or related industries. All analyses were carried out in triplicate.

Chemical properties

pH and electrical conductivity (EC) -- pH and EC were measured using a soil:distilled water solution (Day *et al*. 1979; McKeague 1981). These and other methods are used in the nursery industry.

Ash -- The ash content was determined using the Loss on Ignition method (McKeague 1981). Ash content is expressed on a % oven dry weight.

Table l.-- Nursery location, media, and amendments used. Media are identified by letters given parenthetically. Amendments are references by numbers.

Nursery	Location	(#)	Media	Amendments Used
1	Coast	(A)	6P:4V:1V	6, 11, 12
2	Interior	(B)	3P:1V	7, 11
	Interior	(C)	3P:1R-	7, 19
	Interior	(D)	1P:1S	7, 14
3	Coast	(E)	3P:2V	9, 11
	Coast	(F)	3P:1S	9, 15
	Coast	(G)	3P:1R+	9, 21
	Coast	(H)	3P:1R-	9, 17
4	Coast	(I)	3P:1V	8, 11
	Coast	(J)	1P:1S	8, 16
5	Interior	(K)	P	10
	Interior	(L)	3P:1R-	10, 17
	Interior	(M)	9P:1R-	10, 17

Media Symbols: P- Peat (1-10);
V- vermiculite (11); Pe - perlite (12);
S- Douglas-fir sawdust (13-16);
R+ - hydrophobic rockwool (17-19);
R- - hydrophilic rockwool (20,21)

Total carbon, nitrogen, sulphur -- Total carbon (TC) and total sulphur (TS) were determined using the Leco Analyzers (McKeague 1981). Total nitrogen (TN) was determined colorimetrically using the Auto Analyzer (Lavkulich 1981). All values are expressed as a % of oven dry weight.

Physical properties

Particle size -- Two methods were used to determine particle size distribution: dry and wet (rubbed fibre) sieve. The dry-sieve analysis is currently used in the British Columbia forest nursery industry to assess peat quality (Gates, pers. comm). The wet-sieve analysis (Day *et al*. 1979) is the method most often used in the peat industry (Farnham 1968). In both methods four sieve sizes were used: No. 5 (4mm), No. 10 (2mm), No. 20 (0.85mm), and No. 100 (0.15mm). Dry-sieve analyses are expressed as the percentage of air dry mass. Wet-sieve analysis is expressed as a percent of an oven dry mass. The coarse:fine ratio (C:F) is the ratio of weight of particles greater than 2mm ("coarse") to particles less than 2mm ("fine"; Carlson 1979).

Water retention -- Media water contents of 3cm-high, undisturbed container cells contents, were determined at soil water tensions of 0.03, 0.06, 0.10, and 0.33 bars using a Richardson pressure plate apparatus (McKeague 1981). The media water contents are expressed volumetrically (g H_2O/cm^3) and gravimetrically (g H_2O/ oven dry weight). Expressing results gravimetrically permits relating nursery gravimetric sampling results to lab results.

Watering regime -- During the early growing season each of the participating nurseries determined the gravimetric water contents of the media just before irrigation and 2 hours after irrigation. This sampling includes the extremes of irrigation. These water contents were then compared to the lab-determined gravimetric water retention curve to provide information on the water tensions experienced by the crop.

PRELIMINARY SURVEY RESULTS AND DISCUSSION

Media will be resampled at the end of the crop cycle to determine the degree of media degradation. Gravimetric sampling in the nurseries will be repeated later in the crop cycle. The effect of these media properties on seedling growth, particularly roots, will also be examined. Recommendations cannot be presented without data on the seedlings.

Peats. -- The unamended peats had variable chemical properties (Table 2), particularly total sulphur. All the peats sampled were within the chemical guidelines set out by Carlson (1979). The combination of chemical attributes varies.

Dry-sieve particle size analysis indicated that several peats had many fines (Table 3) and would be regarded as unacceptable by Carlson's (1979) standards. Wet-sieve analysis dispersed many of the aggregates yielding still lower coarse:fine (C:F) ratios. The ranking of the peats changed depending upon the method of sieving used. The C:F ratios may not be adequate to discriminate among peats - similar C:Fs can have very different particle size distributions within each of the broad size classes.

Table 2. Peat chemical properties. Peats have been arranged in order of decreasing pH. pH and EC from an distilled water solution. EC expressed as mS/cm.

Peat	pH	EC	%ASH	%TC	%TN	%TS	C/N
5	4.70	.39	9.8	47.1	1.43	.50	32.9
1	4.49	.32	6.4	41.5	.84	.68	49.4
9	4.40	.30	8.8	43.7	1.09	.72	40.1
3	4.38	.83	6.7	41.5	.87	.44	47.7
8	4.15	.29	7.3	50.8	1.11	.43	45.8
4	4.14	.31	5.2	44.1	1.05	.25	42.0
7	3.99	.14	4.6	96.1	1.06	.14	43.5
6	3.96	.23	7.4	45.9	.94	.12	48.8
2	3.89	.16	6.4	41.8	.81	.11	51.6
10	3.85	.16	5.9	46.4	.75	.10	61.9

Table 3. Peat particle size analysis. Peats have been arranged in decreasing C:F order.

	Mesh Size (% weight retained on sieve)					
Peat	No.5	No.10	No.20	No.100	No.100+	C:F
Dry-Sieve Analysis						
3	38.5	18.0	21.9	20.1	1.5	1.30
2	29.3	20.6	22.1	24.0	4.0	1.00
6	27.5	17.3	20.7	29.3	5.2	.81
10	19.9	20.1	25.1	34.2	.7	.67
8	18.8	14.1	22.2	36.2	8.7	.49
7	14.4	12.6	21.4	41.5	10.1	.37
1	.0	19.3	23.5	44.8	12.4	.24
9	4.2	10.8	24.3	48.7	12.0	.18
4	2.0	10.2	21.3	47.5	19.0	.14
5	3.0	4.6	16.6	58.8	17.0	.08
Wet-Sieve Analysis						
2	14.2	11.8	19.2	29.5	25.3	.35
4	6.2	10.9	18.2	35.9	28.8	.21
1	5.9	10.6	22.5	35.0	26.0	.20
5	5.4	6.8	18.2	44.1	25.5	.14
3	2.8	8.3	20.5	37.2	31.2	.12

Table 4. Peat water retention analysis. Results expressed on a volumetric basis. Peats arranged in order of decreasing aeration porosity (AIR).

	Water tension (bars)							
Peat	0.00	0.03	0.06	0.10	0.33	AIR	BD	PURE
5	86.1	32.3	27.8	24.4	20.2	53.8	.085	93.9
3	96.5	45.5	41.1	34.2	26.4	51.0	.085	94.1
1	82.6	37.4	30.6	27.0	19.6	45.2	.084	94.1
2	80.4	39.4	33.8	30.3	25.1	41.0	.085	94.0
4	71.7	32.0	27.4	23.6	20.0	39.7	.084	94.0

AIR - aeration porosity (% volume)
BD - bulk density (g/cc)
PORE - effective porosity (% volume)

Table 5. Media amendment chemical properties. Amendments have been arranged in order of decreasing pH. pH and EC from a distilled water solution. EC expressed as mS/ cm. Note: not all amendments examined were included in the media.

#	pH	EC	%ASH	%TC	%TN	%TS	C/N
Hydrophilic rockwool							
20	8.67	.23	99.1	1.20	.01	.59	120
Perlite							
12	7.61	.17					
Hydrophobic rockwool							
17	7.03	.11	99.2	.60	.004	.22	150
18	6.78	.02	99.7	.90	.02	.18	45
19	5.93	.11	97.9	4.50	.21	.01	21
Vermiculite							
11	6.85	.20					
Sawdust							
13	5.68	.07	.70	46.3	.07	.02	661
14	4.36	.22	.11	47.2	.09	.01	524
15	4.03	.44	.40	48.0	.07	.01	686

Other analyses (Table 4) indicated that the peats were very similar in their bulk densities (0.084 to 0.085 g/cc). Over 94% of the volume of the peats is occupied by air (i.e. 6% are solids). Water available between saturation and 0.33 bars ranged from 47 to 60% of the volume of the peat. The aeration porosity of the media did not relate well to the C:F ratio. The largest drop in water retention occurs between saturation and .03 bars. Peat physical properties appeared less variable than the chemical properties. Many of the physical properties (i.e. C:F ratio, air capacity) were outside the guidelines set out by Carlson (1979).

<u>Amendments</u> -- Like the peats, amendments were highly variable in their chemical properties (Table 5). Some of the rockwools had particularly high pH values and total sulphur. Predictably, the Douglas-fir sawdusts had very high carbon:nitrogen ratios and acid pH.

Particle size analysis of the sawdusts (Table 6) indicated that they could be as variable as the peat. One sawdust had a particularly small coarse:fine ratio.

Table 6. Sawdust particle size analysis. Sawdusts arranged in order of decreasing C:F ratio.

#	Mesh Size (% weight retained on sieve)					
	No.5	No.10	No.20	No.100	No.100+	C;F
13	22.6	39.9	31.1	6.0	.4	1.67
14	14.7	40.5	36.0	8.5	.3	1.23
15	2.9	25.0	43.3	27.7	1.1	.39

Table 7. Media chemical properties. Media have been arranged in order of decreasing pH. PH and EC from a distilled water solution. EC expressed as mS/cm.

#	pH	EC	%ASH	%TC	%TN	%TS	C/N
Hydrophilic rockwool-amended media							
G	5.78	2.41	65.7	16.0	.6	.36	26.7
Hydrophobic rockwool-amended media							
M	5.74	.69	29.4	31.4	.8	.13	39.3
L	5.64	.86	55.3	21.9	.5	.16	43.8
H	5.44	3.40	72.2	13.3	1.0	.40	13.3
C	5.18	1.09	27.7	32.9	1.2	.37	27.4
Vermiculite and perlite-amended media							
A	5.27	1.09	40.0	27.6	.9	.35	30.7
Vermiculite amended-media							
E	5.26	2.69	50.2	21.8	1.9	.55	11.5
B	4.82	1.13	24.4	33.4	1.3	.37	25.7
I	4.04	1.84	30.5	31.9	1.1	.44	29.0
Sawdust amended-media							
D	5.15	1.23	7.4	41.2	1	.24	41.2
F	4.44	2.87	5.5	40.4	1.3	.47	31.1
J	3.95	2.27	4.7	41.9	1.2	.37	34.9
Pure peat media							
K	4.45	.80	9.8	38.6	.8	.13	48.3

Table 8. Media wet sieve particle size analysis. Media have been arranged in decreasing C:F order.

#	Mesh Size (weighted retained on sieve)					
	No.5	No.10	No.20	No.100	No.100+	C:F
Sawdust-amended media						
1	11.7	30.6	21.3	24.2	12.2	.73
D	14.3	25.7	24.4	22.4	13.2	.67
F	3.6	21.1	27.6	28.2	19.5	.33
Vermiculite and perlite-amended media						
A	7.4	23.8	22.8	28.4	17.6	.45
Hydrophobic rockwool-amended media						
H	2.5	30.3	20.7	26.9	19.6	.49
M	9.8	15.9	20.8	31.7	21.8	.35
L	5.7	17.5	19.1	32.5	25.2	.30
C	11.7	10.6	21.2	35.1	21.4	.29
Pure peat media						
K	13.0	13.1	22.1	33.7	18.1	.35
Vermiculite-amended media						
I	7.3	19.3	24.7	33.1	15.6	.36
E	2.2	22.7	18.9	34.1	22.1	.33
B	5.9	16.7	21.7	37.7	18.0	.29
Hydrophilic rockwool-amended media						
G	1.6	19.0	18.1	34.4	26.9	.26

<u>Media</u>. -- Predictably, variable ingredients yield variable media. In many instances the physical and chemical effects of amendments on the media are confounded by peat and nursery differences. This confusion limits the ability to make critical comparisons among the media but allows an appreciation of the range of cultural conditions under which the same crop is being grown.

The chemical properties (Table 7) display a wide range of values. The EC values are particularly high reflecting the presence of slow-release fertilizers or recent irrigation with nutrient solution. The rockwool amended media had the highest pH. Media pH were ranked similar to ranking of the amendments.

On a wet-sieve basis, media particle size analysis displayed less variability than the unamended peats (Table 8). The C:F ratios from wet sieve analysis are consistently less than the dry sieve analysis. The sawdust-amended media had the largest coarse:fine ratios, with the medium prepared with the finer sawdust having a much smaller C:F ratio.

Water retention results (Table 9) indicate substantial differences in saturation water content. Values given for rockwool-amended media were difficult to obtain because the media did not wet readily. Bulk densities vary more than unamended peats as do the effective porosities. These differences reflect a nursery-effect in mixing and loading media.

On average the sawdust amended media have the largest aeration porosities. The vermiculite amended media had the lowest aeration porosities. There did not appear to be a relation between the C:F ratio of the media and the aeration porosity.

Watering regimes. -- It was assumed that media were maintained at low soil water tensions throughout the growing season. However, gravimetric sampling indicated a range of watering regimes. Some nurseries were irrigating media at soil water tensions less than 0.06 bars, others at tensions greater than 0.33 bars - outside the range for which water retention curves were developed.

Table 9.--Media water retention analysis. Results expressed on a volumetric basis. Media arrange in decreasing aeration porosity (AIR).

	Water tension (bars)							
#	0.00	0.03	0.06	0.10	0.33	AIR	BD	PORE
Sawdust-amended media								
F	84.6	45.9	38.0	31.7	25.4	38.7	.131	91.2
J	80.4	53.6	44.2	36.5	29.8	26.8	.121	91.1
D	78.6	57.6	45.6	36.8	29.5	21.0	.136	90.9
Hydrophobic rockwool-amended media								
C	81.9	49.0	39.3	32.6	27.8	32.9	.120	92.9
L	75.3	48.6	39.1	32.6	27.3	26.7	.183	90.5
M	82.3	55.7	46.2	39.3	32.6	26.6	.135	91.3
H	48.7	27.2	22.6	19.2	17.3	21.5	.202	90.8
Hydrophilic rockwool-amended media								
G	66.3	40.2	31.6	26.3	22.2	26.1	.223	89.6
Pure peat media								
K	85.7	61.6	53.3	44.5	35.9	24.1	.117	91.5
Vermiculite-amended media								
E	78.7	52.3	45.6	40.8	34.4	26.4	.126	93.3
B	79.1	56.0	46.8	39.7	32.3	23.1	.117	92.8
I	75.4	54.0	42.9	35.7	29.7	21.4	.111	92.7
Vermiculite and perlite-amended media								
A	75.9	57.7	48.5	40.0	30.1	18.2	.131	92.4

AIR - aeration porosity (% volume)
BD - bulk density (g/cc)
PORE - effective porosity (% volume)

SUMMARY

The physical and chemical properties of peat and amendments are highly variable. Combined, these ingredients produce a wide range of media. The variability of media must be recognized in cultural management.

There is are advantages and a freedom in mixing one's own growth media. Along with this freedom comes the responsibility to recognize and alter the crop culture to accommodate the properties of the media.

Alternative nursery media must be examined for physical and chemical properties. If mis-managed, even the ideal medium may not be capable of yielding a healthy, acceptable crop.

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