

COMPARISON OF PROPRIETARY WITH PRESCRIPTION NUTRIENT SOLUTIONS
FOR ALBERTA WHITE SPRUCE AND LODGEPOLE PINE

by

DRAKE HOCKING

NORTHERN FOREST RESEARCH CENTRE
INFORMATION REPORT NOR-X-35
JUNE 1972

CANADIAN FORESTRY SERVICE
DEPARTMENT OF THE ENVIRONMENT
5320 - 122 STREET
EDMONTON, ALBERTA, CANADA
T6H 3S5

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	1
INTRODUCTION	2
METHODS	3
1. Comparison in sand cultures	5
2. Comparison in peat-filled Ontario-type tubes	5
3. Effects of peat source and nutrient dilution	6
4. Effect of large rooting volume	8
RESULTS	8
DISCUSSION AND CONCLUSIONS	10
REFERENCES	10
APPENDIX: Formula for Hocking's (1971) Solution	19
Table 1. Nutrient concentrations (ppm) in several solutions	4
Table 2. Saturation moisture contents and percentages of sieve fractions of two peat samples	7
Table 3. Growth of seedlings in sand cultures with different nutrient solutions	12
Table 4. Survival and growth of seedlings on peat in Ontario-type tubes with different nutrient solutions	14
Table 5. Effect of peat source and nutrient dilution upon growth of lodgepole pine with different nutrient solutions	16
Table 6. Influence of large rooting volume on response of lodgepole pine seedlings to different fertilizers	18

COMPARISON OF PROPRIETARY WITH PRESCRIPTION NUTRIENT SOLUTIONS
FOR ALBERTA WHITE SPRUCE AND LODGEPOLE PINE

by
Drake Hocking^{*}

ABSTRACT

Seedlings of Alberta white spruce (Picea glauca (Moench) Voss var. albertiana (S. Brown) Sarg.) and lodgepole pine (Pinus contorta Dougl. var. latifolia Engl.) were grown in sand cultures and on peat substrata of small and large rooting volumes. Three proprietary fertilizers and slight modifications of them were tested in comparison with a prescribed nutrient solution developed in earlier work.

For both species in sand cultures or on plot in restricted rooting volumes, the prescribed solution gave taller and heavier seedlings with lower shoot/root ratios than did the tested proprietary fertilizers. Only in the large peat volume did one fertilizer produce as large seedlings.

Other commercial formulations exist that are more similar to the prescribed solution than the ones tested. These might prove suitable for routine use.

* Research Scientist, Northern Forest Research Centre, Canadian Forestry Service, Environment Canada, 5320 - 122 Street, Edmonton, Alberta, Canada, T6H 3S5.

INTRODUCTION

Early trials of container seedlings in Alberta were performed with rather small seedlings. They were little more than germinants, although 4 or 5 weeks into autotrophic growth. Some of the stunting was a result of "hardening-off" treatments in cold frames at an early stage (4 weeks old), in which active growth was arrested by low temperature and moisture. Other growth retarding factors were inappropriate soil mixes, poor moisture control, and common incidence of pathogens. There was also a suspicion that some of the stunting in early pilot-scale production might be due to nutrient problems owing to use of proprietary fertilizers rather than prescription solutions as in the trials. With more recent trends towards older, larger seedlings, these suspicions became stronger.

This, and nutrient problems with conventional seedbed stock, led to a series of sand-culture experiments to determine optimum nutrient solutions. Full details will be published elsewhere, but one result was a recommended solution for Alberta white spruce and lodgepole pine (Hocking 1971; formula in Appendix) with characteristics rather similar to solutions used by other research workers. This could be termed a prescription nutrient solution, because it was developed specifically for the species concerned.

Certain commercially available, soluble, dry-powder, "complete" fertilizers were in general use for rearing container seedlings at that time. These may be termed proprietary because they can be purchased

"off-the-shelf" and are recommended by the manufacturers for many different species of plants.

Most proprietary fertilizers give no specific instructions for their use for container seedlings. More often, a general instruction suggests using one tablespoonful per gallon of water, but usually implies only infrequent application. For container seedlings, nutrients are usually applied weekly or twice weekly, enabling better control than less frequent application but requiring a lower concentration.

A number of tests were conducted under a variety of conditions, to compare growth using the prescribed nutrient solution with several proprietary fertilizers and some modifications of them. Mention of any product is for the convenience of the reader, and is not to be construed as recommendation or otherwise of that product.

METHODS

The compositions of nutrient solutions tested are listed in Table 1, along with another prescribed solution (Ingestad 1962) for comparison. Calculations for the proprietary fertilizers^{*} are based on a weight of 11.4 g. dry powder per tablespoon and an Imperial gallon (4.546 litres). All of the solutions are probably adequate in micro-nutrients, but there are quite large differences in proportions of the main elements.

Seedlings were grown in the greenhouse for periods of 10 to 16 weeks, at $70^{\circ}\text{F} \pm 5^{\circ}$ day and $50^{\circ}\text{F} \pm 5^{\circ}$ night. Relative humidity was

* Composition calculated from manufacturer's published data.

Table 1. Nutrient concentrations (ppm) in several solutions

Nutrient Element		Fertilizer solution											
Macro- nutrients	Hocking's Solution (1971)	Ingestad's Solution (1962)	RX-15 ****				RX-30****				21-21-21****		
			1 [*]	½	¼	¼ ^{**} ₊	1	½	¼	¼ ^{***} ₊	1	½	¼
N	112	100	375	187	93	155	750	375	187	187	560	280	140
P	31	13	325	162	81	81	100	50	25	49	240	120	60
K	156	65	300	150	75	278	200	100	50	156	450	225	112
Micro- nutrients													
Mg.	48	8.5	6.2				3.6				5.6		
Mn	0.2	0.4	2.1				1.8				0.6		
Fe	5.0	0.7	0.18				2.1				1.1		
Cu	0.02	0.03	0.7				0.7				0.6		
Zn	0.05	0.03	0.7				0.7				0.6		
B	0.4	0.2	0.5				0.5				0.2		
Mo	0.03	0.007	0.1				0.1				0.006		

*Concentrations in tablespoons (11.4 g.) per Imperial gallon (4.546 litres).

**RX-15, 1/4+ is modified by the addition of 2.27 g. KNO₃ per gallon.

***RX-30, 1/4+ is modified by the addition of 0.76 g. K₃PO₄ per gallon.

****Composition calculated from manufacturer's published data.

35-40% day and 65-80% night. Lighting was natural daylight supplemented at both ends with combined fluorescent and incandescent lighting to give a photoperiod of 18 hours.

Following the growth period, seedling survival was counted and heights and dry weight (of tops and roots separately) were measured.

Comparisons of growth on the different fertilizers were made on four types of substrata, as described below.

1. Comparison in sand cultures

For comparison on a basis of an inert root substratum, seedlings were grown on silica sand containing less than 0.01% N, 0.004% P, and 0.003% K. They were fed nutrient solutions by top irrigation drained to waste, at daily intervals.

The sand was 60-80 mesh. Pots were polyethylene, 8" in diameter and 6" deep. There were 50 seedlings per pot, and each species by nutrient combination was replicated 3 times in Latin squares.

The proprietary nutrient solutions tested were $\frac{1}{2}$ tbsp/gal concentrations of RX-30, RX-15, and 21-21-21p plus modifications of RX-30 and RX-15 to bring the nutrient proportions closer to those in the prescription solution (Table 1). The growing period was 16 weeks, at the end of which all seedlings were harvested for analysis.

2. Comparison in peat-filled Ontario-type tubes

Many factors can affect response to fertilizers and availability of nutrients. Growth on a relatively large volume of sand irrigated with nutrients daily, might not compare with growth on a small volume of peat irrigated infrequently.

This experiment compared growth on peat contained in $3/4"$ x $3\frac{1}{4}"$, Ontario-type tubes. There were 5 trays of 196 seedlings for each nutrient solution by species combination, completely randomized for treatment. The nutrient solutions tested were Hocking's prescribed solution and 1 tbsp. per gallon (as recommended) of the 3 proprietary fertilizers. Solutions were applied weekly at the rate of 1 gallon to 10 square feet of tubes. Additional irrigation was applied as required.

At the end of the 10-week growing period, survival was counted and one hundred healthy seedlings or all the survivors were sampled from each tray for analysis.

3. Effects of peat source and nutrient dilution

Two sources of peat that differed primarily in moisture-retaining capacity were tested. Peat 1 was raw and locally dug; peat 2 was dried, processed and packaged¹. The peats were separated into fractions by sieving and the saturation moisture contents of fractions were measured (Table 2). Peat 1 retained more water than did peat 2, overall and in each fraction. Neither peat contained significant amounts of nutrients, as determined by chemical analysis, prior to application of the nutrient solutions.

The nutrient solutions tested were $\frac{1}{4}$ tbsp. per gallon of the 3 proprietary fertilizers and $\frac{1}{2}$ and $\frac{1}{4}$ dilutions of the prescribed solution. They were applied only once weekly with no additional water, at the rate of 1 gallon per 10 square feet of tubes.

¹ "Sunshine" brand, Moss Spur, Manitoba. The product probably varies and specifications can only be taken as applying to the lot used.

Table 2. Saturation moisture contents and percentages
of sieve fractions of two peat samples

	<u>Fraction (retained by sieve size)</u>				Overall
	2 mm	1 mm	.5 mm	60 mesh	
Saturation moisture content, % of dry wt.					
Peat 1	650	574	454	241	530
Peat 2	477	333	333	157	316
Percent by weight in Fraction					
Peat 1	14	27	26	33	
Peat 2	6	37	34	23	

Basis: Each figure is a mean of 3 determinations.

Seedlings were grown in Ontario-type tubes. There were 3 trays of 196 seedlings completely randomized, for each treatment. Because of the number of treatments, only one species, lodgepole pine, was tested.

The growth period was 10 weeks. One hundred seedlings were sampled from each tray for measurements of height and weight.

4. Effect of large rooting volume

To test the influence of pot size on nutrient response, seedlings were grown on the moist peat (peat 1) in large pots (8" dia. x 6" deep), 20 seedlings per pot, 3 pots per treatment. All other conditions were the same as in the preceding experiment. All seedling were harvested for analysis.

RESULTS

In sand cultures and in Ontario-type tubes, for both white spruce and lodgepole pine, Hocking's solution gave significantly taller and heavier seedlings with lower shoot/root ratios. (Tables 3 and 4). In the Ontario-type tubes, all 3 proprietary fertilizers at this concentration (1 tbsp./gal.) resulted in significant mortality and chlorosis (yellowing) among the seedlings, especially in pine. Dead and chlorotic seedlings had rotted roots. Analysis of chlorotic foliage showed elevated levels of Na, K, and Ca. These observations indicate that decline and death were probably a result of excess nutrients and salinity.

In the study of the two peat sources and nutrient dilutions, survival (during rearing) in all treatments was uniformly high (over 98%).

An analysis of variance of the growth data (Table 5, Fig. 3) showed peats and nutrient treatments as main effects, with a significant interaction between them. All dilutions of the prescribed solution and RX-30, $\frac{1}{4}$ gave heavier seedlings on the moist peat than on the dry peat. There was no difference for RX-15 $\frac{1}{4}$ and 21-21-21, $\frac{1}{4}$. Moist peat gave taller seedlings for all nutrients except RX-30, $\frac{1}{4}$ and RX-15, $\frac{1}{4}$.

On the moist peat, the undiluted prescribed fertilizer gave seedlings that were significantly taller and heavier than any other treatment. On the dry peat, the differences were not as great, probably because moisture was limiting to growth or nearly so for all treatments.

Progressive dilution of the prescribed fertilizer gave progressive significant reductions in height, weight and shoot/root ratio for both moist and dry conditions. Shoot/root ratios for all nutrient treatments were reduced on dry peat.

In the large, "unrestricted", volume of peat, RX-15, $\frac{1}{4}$ gave the tallest and heaviest seedlings, followed by the prescribed solution. All treatments grew seedlings that were much heavier and had lower shoot/root ratios, than in the Ontario-type tubes.

The progressive dilutions of the prescribed solution had no effect on total weight, probably because the most dilute was not limiting owing to the larger available volume. However, dilution reduced height growth and shoot/root ratios.

DISCUSSION AND CONCLUSIONS

For growing container seedlings in restricted rooting volumes, Hocking's (1971) solution gave taller and heavier seedlings with lower shoot/root ratios than several proprietary fertilizers. Only in an "unrestricted" rooting volume did one proprietary fertilizer, RX-15 ($\frac{1}{4}$ tbsp. per gallon) produce as large seedlings.

Besides the proprietary fertilizers tested (which were in general use at the time) there exist other formulations, some of which approach Hocking's (1971) solution in composition and may prove suitable for routine use.

Many other factors can affect practical use and nutrient availability to small seedlings. For a detailed discussion, see Hocking (1971).

REFERENCES

- Hocking, D. 1971. Preparation and use of a nutrient solution for culturing seedlings of lodgepole pine and white spruce, with selected bibliography. Canada Dept. Environ. Can. For. Serv. Inf. Rept. NOR-X-1. Edmonton.
- Ingestad, T. 1962. Macro-element nutrition of pine, spruce and birch. Medd. Skogsforsku. Inst., Stockholm, 51(7): pp.150.

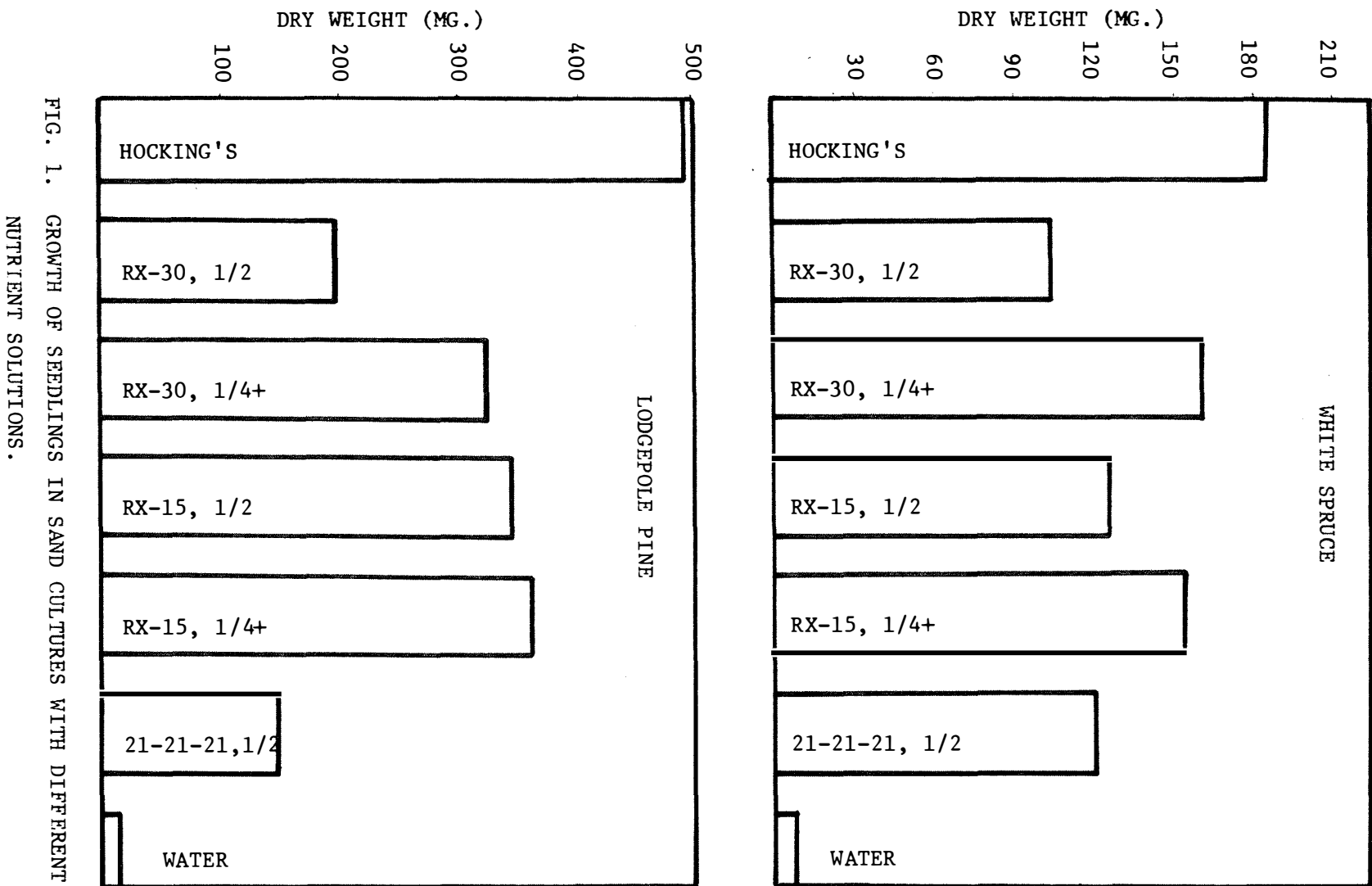


FIG. 1. GROWTH OF SEEDLINGS IN SAND CULTURES WITH DIFFERENT NUTRIENT SOLUTIONS.

Table 3. Growth of seedlings in sand cultures with different nutrient solutions.

Nutrient solution (See Table 1 for compositions)	White spruce			Lodgepole pine		
	Height (cm)	Total wt. (mg)	Shoot/root wt/wt	Height (cm)	Total wt. (mg)	Shoot/root (wt/wt)
Hocking's	7.9 a	183 a	3.00	15.0 a	496 a	2.12
RX-30, $\frac{1}{2}$	4.3 d	97 d	5.12	8.9 d	197 c	4.81
RX-30, $\frac{1}{4}$ +	6.6 b	164 ab	4.73	10.1 c	321 b	3.71
RX-15, $\frac{1}{2}$	5.8 bc	129 c	5.00	12.2 b	334 b	3.85
RX-15, $\frac{1}{4}$ +	7.1 ab	155 b	4.88	12.7 b	359 b	3.34
21-21-21, $\frac{1}{2}$	5.1 c	120 c	5.41	7.6 d	145 c	4.11
Distilled water	2.3 e	8 e	1.72	2.9 e	12 d	4.80

Basis: Means of 3 replicates of 50 seedlings each. Figures in the same column followed by the same letters do not differ significantly (P = 05) by Duncan's multiple range test.

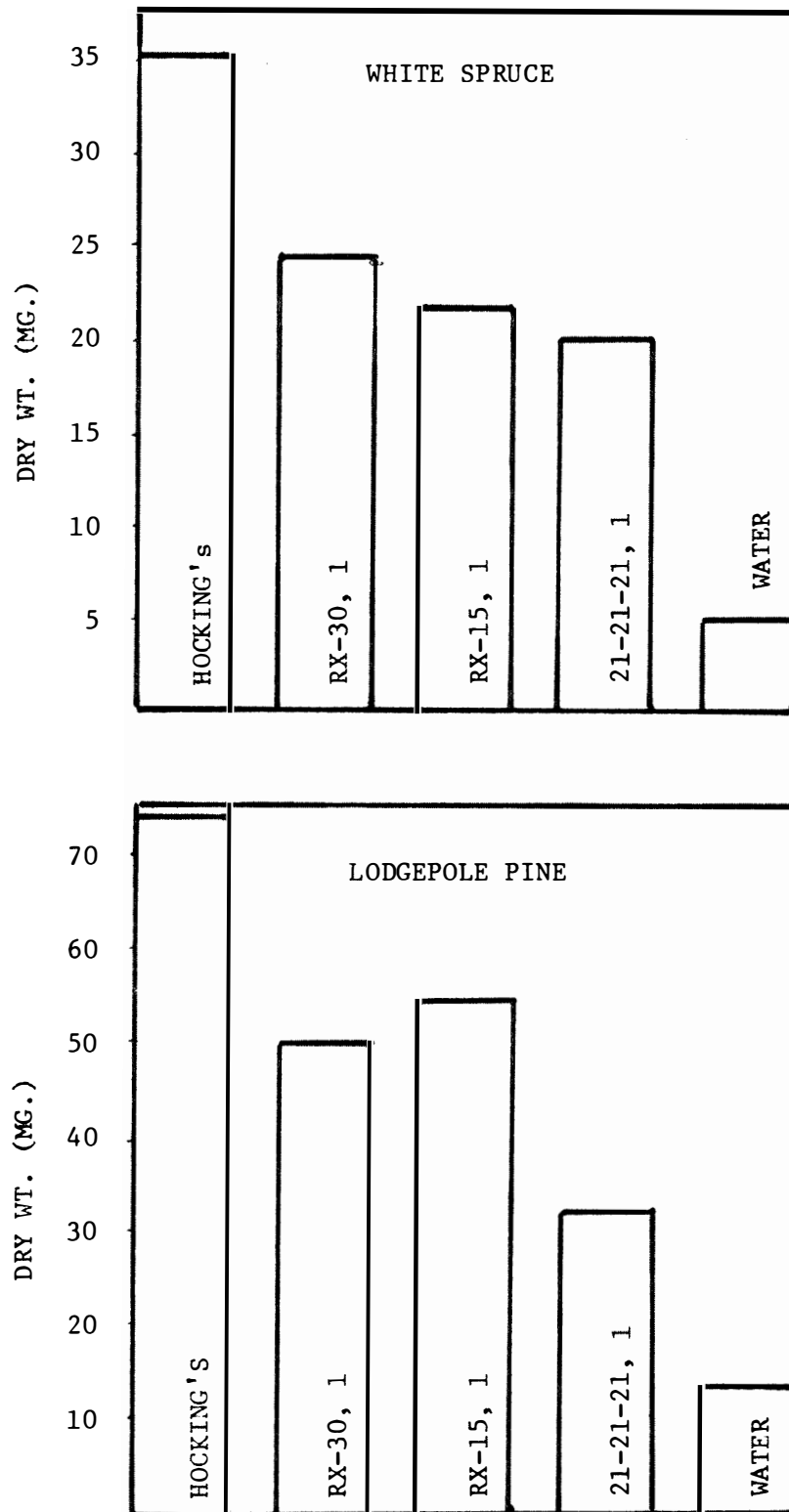


FIG. 2. GROWTH OF SEEDLINGS ON PEAT IN ONTARIO-TYPE TUBES, WITH DIFFERENT NUTRIENT SOLUTIONS.

Table 4. Survival and growth of seedlings on peat in Ontario-type tubes with different nutrient solutions

Nutrient solution (See Table 1)	White spruce				Lodgepole pine			
	Survival %	Height (cm)	Total wt. (mg)	Shoot/root (wt/wt)	Survival %	Height (cm)	Total wt. (mg)	Shoot/root (wt/wt)
Hocking's	99 a	5.3 a	35 a	6.55	99 a	6.3 a	73 a	4.03
RX-30, 1	5 d	4.1 b	24 b	8.64	31 c	5.4 b	50 b	5.70
RX-15, 1	84 b	3.8 b	22 b	8.25	86 b	5.0 b	54 b	5.97
21-21-21, 1	33 c	4.2 b	20 b	8.44	82 b	5.7 ab	32 c	5.00
Distilled water	9 a	2.4 c	5 c	1.91	93 a	3.2 c	13 d	4.85

Basis: Means of 3 replicates of 100 seedlings. Figures in the same columns followed by the same letters do not differ significantly ($P = 05$) by Duncan's multiple range test.

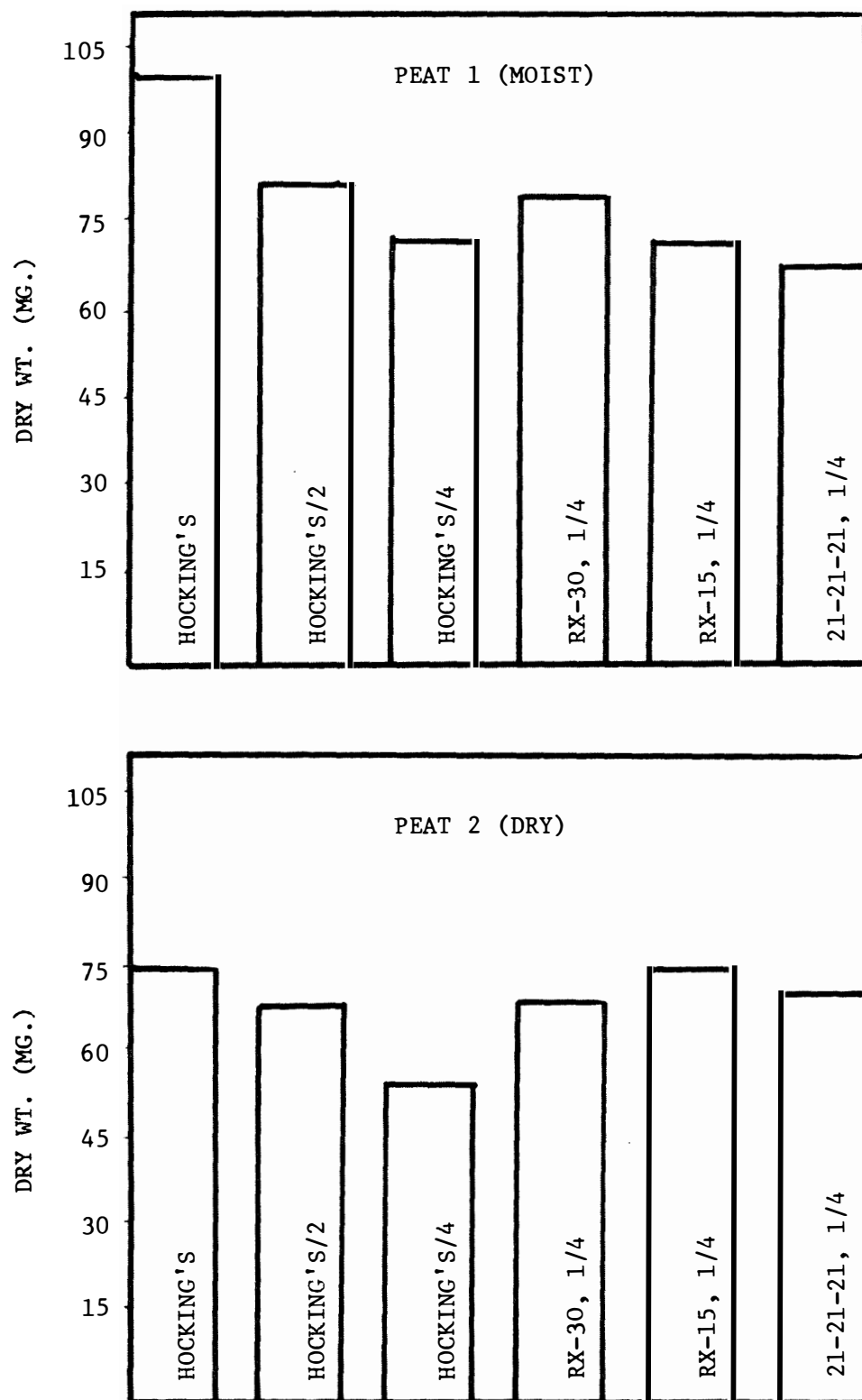


FIG. 3. EFFECT OF PEAT SOURCE AND NUTRIENT DILUTION UPON GROWTH OF LODGEPOLE PINE WITH DIFFERENT NUTRIENT SOLUTIONS.

Table 5. Effect of peat source and nutrient dilution upon growth of lodgepole pine with different nutrient solutions.

Nutrient Solution	Peat 1 (moist)			Peat 2 (dry)		
	Height (cm)	Total wt. (mg)	Shoot/root (wt/wt)	Height (cm)	Total wt. (mg)	Shoot/root (wt/wt)
Hocking's	6.8 a	102 a	3.88	5.6 a	75 a	3.18
Hocking's/2	5.4 b	82 b	3.12	4.5 b	68 b	2.47
Hocking's/4	5.1 bc	73 c	3.10	3.7 c	55 c	1.94
RX -30, $\frac{1}{4}$	5.7 b	81 b	4.79	5.8 a	70 ab	4.04
RX -15, $\frac{1}{4}$	4.9 c	73 c	3.64	4.7 b	75 a	2.95
21-21-21, $\frac{1}{4}$	5.2 bc	68 c	3.92	4.5 b	71 ab	2.85

Basis: Means of 3 replicates of 100 seedlings. Figures in the same column followed by the same letters do not differ significantly ($P = .05$) by Duncan's multiple range test.

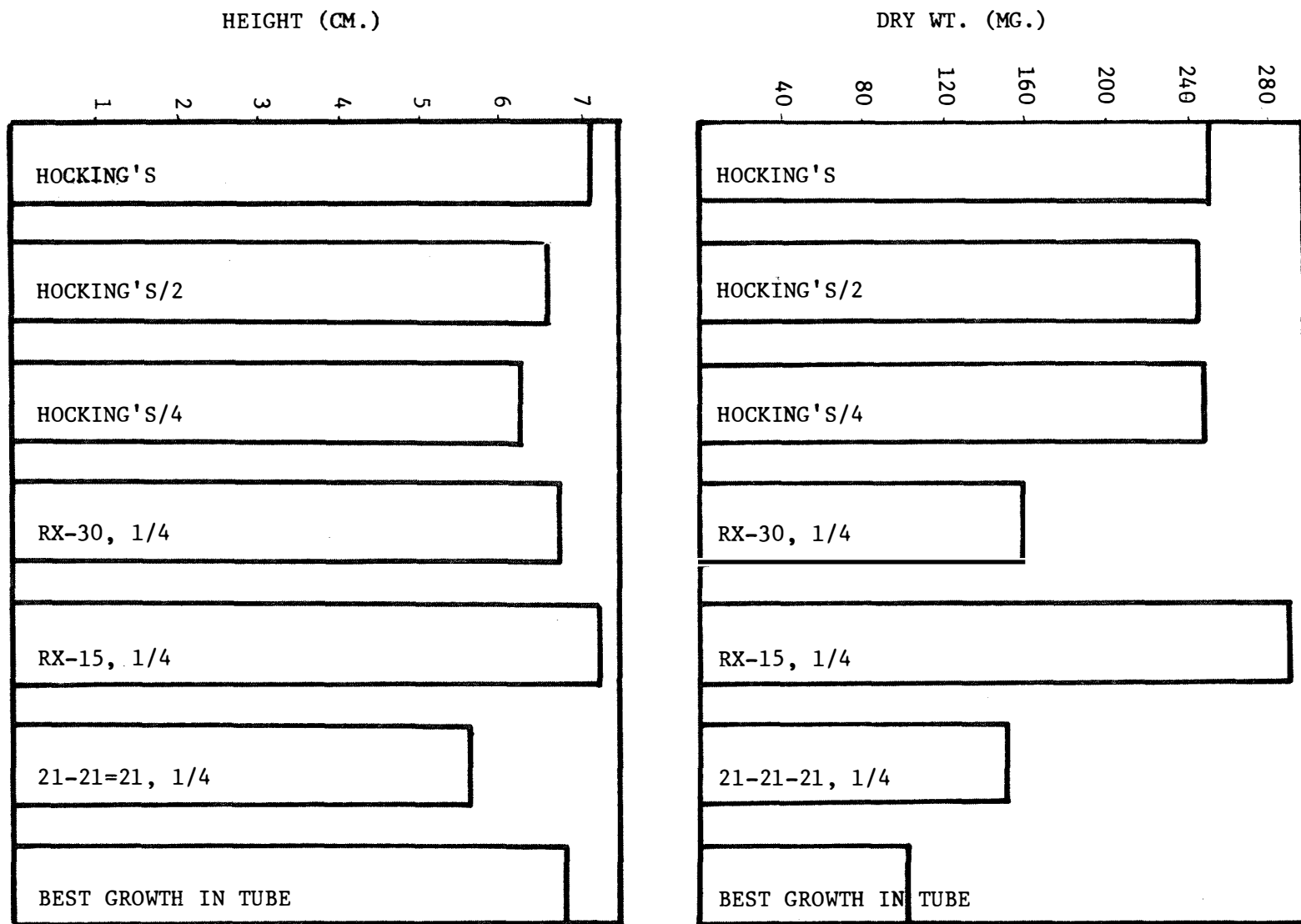


FIG. 4. INFLUENCE OF LARGE ROOTING VOLUME ON RESPONSE OF LODGEPOLE PINE SEEDLINGS TO DIFFERENT NUTRIENT SOLUTIONS.

Table 6 - Influence of large rooting volume on response of lodgepole pine seedlings to different fertilizers.

Nutrient Solution	Height (cm)	Total wt. (mg)	Shoot/root (wt/wt)
Hocking's	7.1 a	247 b	2.22
Hocking's/2	6.7 ab	243 b	2.17
Hocking's/4	6.3 b	245 b	1.90
RX-30, $\frac{1}{4}$	6.8 ab	160 c	2.73
RX-15, $\frac{1}{4}$	7.2 a	296 a	2.36
21-21-21, $\frac{1}{4}$	5.6 c	153 c	2.71
In Ontario-type tubes, best treatment	6.8	102	3.88

Basis: Means of 3 replicates of 20 seedlings. Figures in the same columns followed by the same figures do not differ significantly ($P = .05$) by Duncan's multiple range test.

APPENDIX: Formula for Hocking's (1971) solution.

Stock Solution 1:

<u>Chemical Name</u>	<u>Formula</u>	<u>Quantity</u>
Distilled water	H ₂ O	2 litres
Sulfuric acid (1%)	H ₂ SO ₄	5 ml
Ammonium chloride	NH ₄ Cl	107.0 grams
Potassium sulfate	K ₂ SO ₄	87.0 g
Potassium phosphate, dibasic	K ₂ HPO ₄	87.0 g
Boric acid	H ₃ BO ₃	1.126 g
Molybdenum trioxide	MoO ₃	0.007 g

Stock Solution 2:

<u>Chemical Name</u>	<u>Formula</u>	<u>Quantity</u>
Distilled water	H ₂ O	2 litres
Calcium nitrate	Ca(NO ₃) ₂ .4H ₂ O	236.0 grams
Magnesium chloride	MgCl ₂ .6H ₂ O	203.0 g
Manganous chloride	MnCl ₂	0.5 g
Zinc chloride	ZnCl ₂	0.05 g
Cupric chloride	CuCl ₂ .2H ₂ O	0.025 g
Ferric chloride [*]	FeCl ₃ .6H ₂ O	1.35 g

^{*} Or a chelated form of iron.

Mix 4 mls of each stock solution with 1 litre of soft water, adding the stock solutions to the water. For full details, see Hocking (1971).

Hocking, Drake

1972. Comparison of proprietary with
prescription nutrient solutions
for Alberta white spruce and
lodgepole pine.

Information Report NOR-X-35; 19 p.;
Northern Forest Research Centre,
Canadian Forestry Service,
5320 - 122nd Street,
Edmonton, Alberta.
T6H 3S5

Hocking, Drake

1972. Comparison of proprietary with
prescription nutrient solutions
for Alberta white spruce and
lodgepole pine.

Information Report NOR-X-35; 19 p.;
Northern Forest Research Centre,
Canadian Forestry Service,
5320 - 122nd Street,
Edmonton, Alberta.
T6H 3S5

Copies of this publication (if still in stock) may be obtained
from:

Information Officer
Northern Forest Research Centre
Canadian Forestry Service
Environment Canada
5320 - 122nd Street
Edmonton, Alberta
T6H 3S5