Fertilizer Trials on Containerized Red Pine[1]

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Abstract.--Nitrate (N03), ammonium (NH4), and urea forms of nitrogen fertilizers were tested on containerized red pine (*Pinus resinosa,* Ait.) at four locations in Michigan, Wisconsin, and Minnesota. Height, stem caliper, shoot and root dry weight, were all significantly different between treatments. Formulations with both high NO_3 and NH_4 produced larger seedlings at all locations at 14 weeks from sowing. Formulations with just high NH4 Produced larger seedlings at three locations at 14 weeks old.

INTRODUCTION

Nearly 15 million containerized red pine, *Pinus resinosa* Ait. seedlings are planted annually on 18 to 20 thousand acres in Minnesota, Wisconsin, and Michigan. The success of these planting efforts depends greatly upon the ability of seedling growers to provide a seedling that will withstand the rigors of the environment.

Seedling growers from forest industry, government, and the private sector gathered in Escanaba, Michigan December 11-12, 1984 to explore ways to improve container stock quality[4]. All agreed that it would be beneficial to produce larger red pine container stock by either maximizing growth during the first 15 weeks in the greenhouse or by culturally controlling shoot height growth.

Red pine exhibits determinate height growth. Generally, 13 to 15 weeks after sowing, red pine seedlings stop shoot height growth and set bud even if environmental conditions are optimum for stem elongation. It is considered beneficial if taller, well balanced containerized seedlings could be produced during the 15-week growth period. Each greenhouse manager attending the Escanaba meeting gave a description of their cultural practices and stock specifications. All locations were similar in operation with only minor cultural practice differences except for one major difference; no two locations used the same fertilizers. A key question discussed was whether nitrate (N03), ammonium (NH4), or urea nitrogen plays a more important role in promoting shoot height growth.

The results of a cooperative study started by growers attending the Escanaba meeting are reported here. The objective of the study was to determine the effects of different nitrogen formulations on the development of containerized red pine seedlings grown under each cooperator's growing conditions. This study was also a pioneering effort to establish a pattern for future cooperative growers trials.

MATERIALS AND METHODS

Cooperators

The cooperating greenhouse facilities included two paper companies, one Federal facility, and one county government contracting with a private facility. The four cooperators and their greenhouse locations were Mead Paper Company, Escanaba, Michigan; Consolidated Paper Company, Monico, Wisconsin; Forestry Sciences Laboratory (FSL), Rhinelander, Wisconsin; and Cass County Land Department, Carlson's Greenhouse in Cass Lake, Minnesota (figure 1).

Container

The seedlings were grown in Styroblock 2-A containers at all locations. This container is a rectangular block of expanded polystyrene containing 240 cone-shaped cavities with a cell density of 103 cavities per square foot. Each cavity is 2.5 cubic inches with a top diameter of 1 inch and a depth of 4.5 inches.

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[4]Scholtes, John R. Container Grower's Meeting minutes, December 11-12, 1984 in Escanaba, MI. Minutes being assembled at State and Private Forestry, Broomall, Penn.

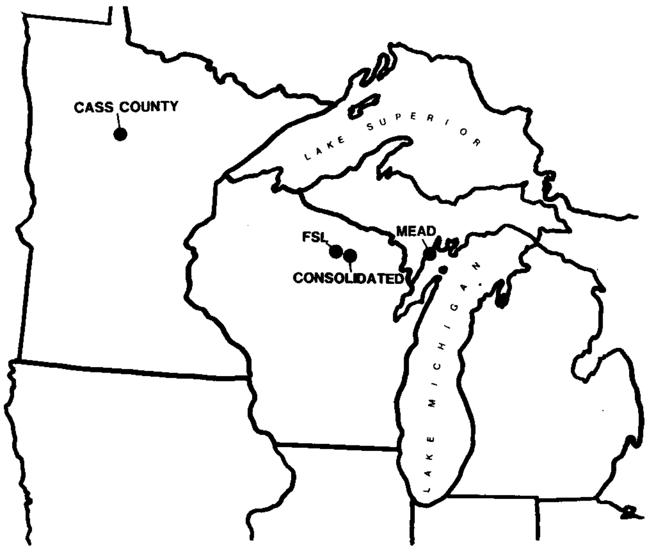

Figure 1.--Map of Cooperator locations.

Treatment Procedure

Cultural practices for red pine production were identical for all locations except for fertilizer treatments. There were five fertilizer treatments: three standard fertilizers supplied to all locations, and a fertilizer selected by each grower was applied both by hand, and by the grower's production method. The four participating Nurserymen received the same three standard fertilizers, sampling diagrams, mailing bags, and instructions to standardize the three treatments and sampling procedures. The standard fertilizers were measured, mixed in watering cans, and hand applied at all locations. These standards were 20-10-20 (12% N03-N, 8% NH4-N) referred to hereafter as N03 (Nitrate), 17-6-6 (17% NH_4-N) referred to hereafter as NH_4 (Ammonium), and 20-19-18 (5.2% NO_3-N, 3.75% NH_4-N, 11.75% urea) referred hereafter as urea (table 1).

In addition, each grower also applied his own in-house fertilizer mix to selected container blocks by hand (treatment designated T-1) and also to the rest of the greenhouse, including three more selected blocks through the production injector-irrigation system (treatment designated T-2). T-1 and T-2 application rates were determined by each grower to simplify his particular stock nutrition needs. growers were encouraged to keep the total N of their selected treatments close to that used for the three standard fertilizers to achieve the best comparison.

When the production stock, including the three selected T-2 treatment blocks, were being fertilized the other treatment blocks were either removed from the area or shielded. After fertilizing all seedlings were rinsed during the water-only portion of the fertilization-irrigation routine.

Each grower determined when to water and fertilize. Some used every-other-day fertilizer schedules. Others established their schedules by monitoring seedling needs and applying when necessary, usually during the exponential growth stage which was from approximately 6 weeks to 14 weeks after sowing. During the first 6-week juvenile growth period, the fertilizer rates were half those shown in Table 1.

Table 1.--Nitrogen constituents in treatments at various locations.

Treatments (by location)	NPK	NO_3	NH_4	Urea	Total N
		ppm			
NO_3[1])	20-10-20	182	122	0	304
NH_4)-all locations	17-6-6	0	258	0	258
urea)	20-19-18	80	57	168	305
FSL T-1, T-2[2]	20-7-19	176	106	21	303
Mead T-1	20-10-20	182	122	0	304
T-2	20-10-20	158	106	0	264
Cass Co. T-1, T-2	10-20-30[3]	77	19	0	96
Combined -------	34-0-0	23	7	0	30
Consol. T-1, T-2	20-20-20	51	36	95	183

[1] NO_3, NH_4, and urea are the standard fertilizer mixes used at all locations.
[2] T-1 and T-2 are the local greenhouse fertilizer treatment applied by hand (T-1) and through the irrigation system (T-2).
[3] 10-20-30 is a nutriculture product, produced by Plant Marvel Laboratories, Chicago, IL. The remaining 5 formulations are Peters soluble fertilizer produced by Grace Horticultural Products Technical Group, Fogelsville, PA.

(Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.)

Experimental Design

At each location, experiment consisted of a randomized block design with three replications. All replications were in the same greenhouse. The T-1, N03, NH4, and urea treatments were each randomly assigned to one styroblock per replication. The three T-2 sample styroblocks were selected from production stock that typified the average stock type of the crop.

Sampling and Data Analysis

A standard sampling design was supplied to each grower for selecting seedling samples biweekly beginning 4 weeks after sowing. Seedlings from each location were kept separate by treatment and replication. Each location sent the seedlings in the supplied mailers to the Rhinelander FSL to be measured, oven dried, weighed, and recorded. Data from all locations were contained and analyzed by ANOVA. Variables analyzed were height, stem caliper, shoot dry weight, root dry weight, and shoot/root dry weight ratio. Included in the model were effects of location, treatment, time, and three two-way interactions. Effects due to replications and replication interactions were combined into a pooled error term. Significance was tested assuming all effects fixed which allowed using the error mean square as the denominator in all F-tests.

RESULTS

In general, main effects were stronger than interactions although interactions were themselves highly significant. Effects due to treatments were stronger than effects due to location for all variables. The fact that interactions were significant suggests that treatments need to be selected on a site-by-site basis in order to maximize growth. No one treatment at 14 weeks old was best at all locations (figure 2).

All seedling/characteristics showed similar responses to fertilizer treatment (figure 3). For example, the urea treatment at the Cass County location produced the poorest seedlings, in terms of characteristics, measured; the T-2 treatment tended to produce the best seedlings.

Responses at the other locations showed similar patterns for 14-week-old seedlings (table 2).

Comparing the standard treatments at the four locations revealed several patterns (figure 4). urea produced the shortest shoots and smallest stem calipers (except for the FSL location). The NH_4 ammonium treatment unexpectedly produced the best seedlings (again, except for shoot height at the FSL location). At three locations, the NH4 treatment did better than the growers' preferred production treatment, T-2.

DISCUSSION

Some growers learned that other available commercial fertilizers may produce better

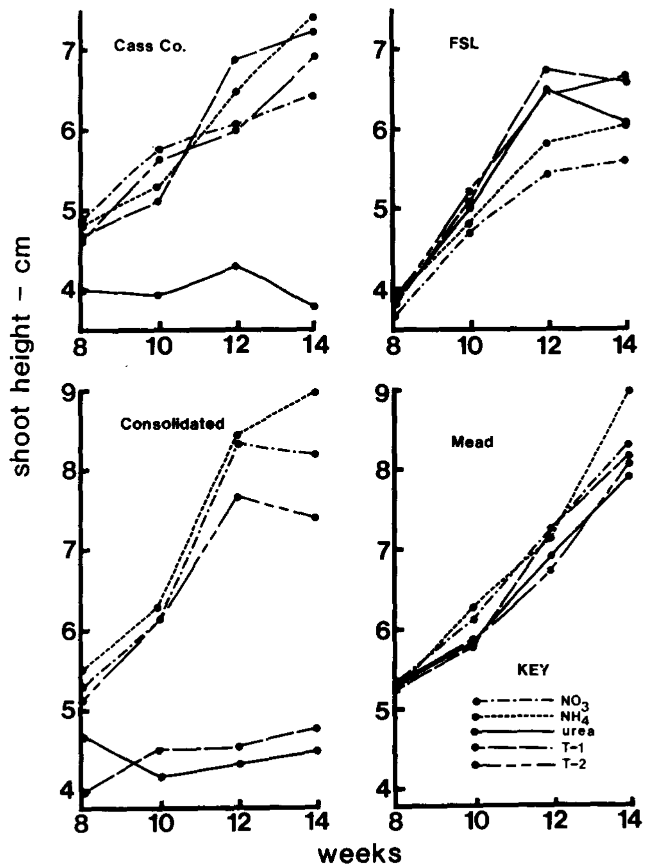

Figure 2.--Containerized red pine shoot height response to fertilizer treatments at various greenhouse locations.

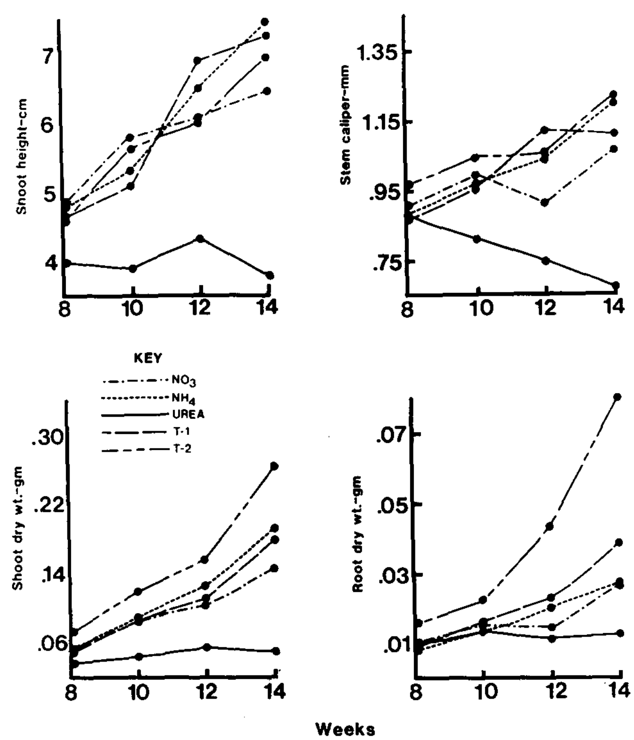

Figure 3.--Containerized red pine physical characteristics by fertilizer treatments at Cass County greenhouse location.

Table 2.--Seedling characteristics at 14 weeks by each location and fertilizer treatment.

	FSL	Mead	Cass County	Consolidated
Stem Height (cm)				
NO_3	5.56	8.28	6.48	8.21
NH_4	6.03	8.90	7.40	9.00
urea	6.06	7.87	3.80	4.50
T-1[1]	6.56	8.08	7.22	4.79
T-2	6.60	8.10	6.90	7.42
Stem Caliper (mm)				
NO_3	1.02	1.30	1.06	1.40
NH_4	1.25	1.37	1.19	1.60
urea	1.19	1.32	0.67	1.02
T-1	1.24	1.38	1.11	0.96
T-2	1.26	1.10	1.21	1.30
Shoot Dry Weight (gm)				
NO_3	.173	.194	.145	.281
NH_4	.295	.206	.188	.356
urea	.252	.180	.048	.106
T-1	.289	.193	.177	.105
T-2	.289	.134	.262	.250
Root Dry Weight (gm)				
NO_3	.046	.058	.026	.101
NH_4	.065	.053	.027	.138
urea	.071	.054	.012	.051
T-1	.074	.057	.038	.044
T-2	.095	.059	.080	.108
Shoot/Root Dry Wt. Ratio				
NO_3	3.8/1	3.3/1	5.6/1	3/1
NH_4	4.5/1	3.9/1	7/1	2.6/1
urea	3.5/1	3.3/1	4/1	2/1
T-1	3.9/1	3.4/1	4.7/1	2.4/1
T-2	3/1	2.3/1	3.3/1	2.3/1

[1]T-1 and T-2 are the local greenhouse fertilizer treatments, hand applied (T-1) and applied same as for greenhouse production (T-2).

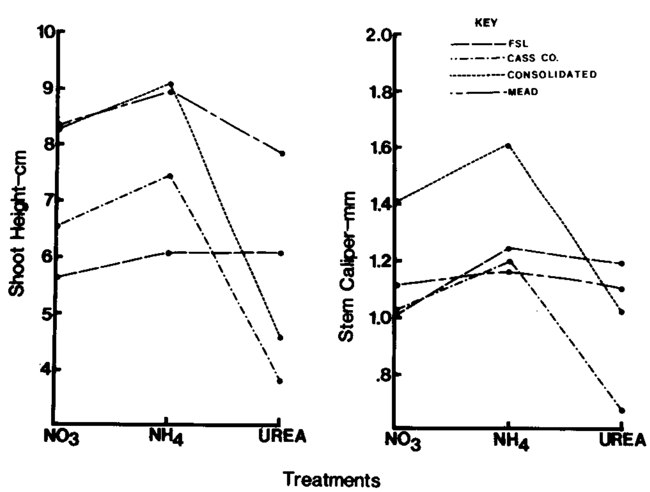

Figure 4.--Fertilizer treatment effects at various greenhouse locations at 14 weeks from sowing.

seedlings than their currently preferred ones. Since three treatments were standard across locations but the treatment responses differed by location, it is clear that fertilizer response depends upon environmental conditioning. To maximize seedling growth, each grower should conduct fertilizer trials periodically to test performance against changes in cultural practices, or to test new fertilizer mixes; an observation worth noting as a grower with multispecie production; the fertilizer treatments that produced better red pine seedlings did not produce better jack pine seedlings. There appears to be specie specific responses to fertilizer that require testing to maximize seedling performances. Results from other growers' trials may not necessarily apply.

The plan for this study, which involved several growers providing data from standard tests with overall coordination provided by a research organization, worked satisfactorily. Thus, the second goal, to develop a pattern for future cooperative trials with area container growers, was achieved.

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