forest management note

Note No. 31 **Northern Forestry Centre** **Edmonton, Alberta**

FERTILIZATION IMPROVES RED PINE SEED PRODUCTION

Past research has shown that red pine (*Pinus resinosa* Ait.) cone and seed production can be increased by either thinning or fertilizer application (Cayford and Jarvis 1967; Stiell 1971). The study described in this Note was initiated to determine if the application of fertilizer following thinning would further stimulate red pine cone and seed production.

The study site, selected in August 1978, was a 1.2-ha portion of a 23-year-old red pine plantation in the Cat Hills Provincial Forest of southeastern Manitoba, within the Rainy River (L.12) Section of the Great Lakes—St. Lawrence Forest Region (Rowe 1972). The site was abandoned farmland in 1955 and was furrowed and planted in September with 2 + 2 red pine seedlings at a density of 1415 seedlings per hectare. Survival after five growing seasons was 88%. In 1972 approximately one-half of the trees were removed, and about one-third of the crowns were pruned from the remaining stems in 1974. In 1977 the study portion of the plantation was thinned again to stimulate cone production, leaving a stand with the following characteristics:

Basal area	6.4 m^2/ha
Trees per hectare	368
Diameter at breast height (1.37 m)	15.0 cm
Spacing	5.2 m
Height	9.1 m

The topography of the area is flat, and the drainage of the Brunisolic soil belonging to the Sandilands-Vassar complex is excessive to good (Smith and Ehrlich 1964). The ground vegetation is sparse and consists mainly of roses (*Rosa* sp.), ericaceous shrubs (*Arctostaphylos uva-ursi* L.), grasses (*Oryzopis* sp. and *Poa* sp.), and lichens (*Cladina* spp. and *Cladonia* spp.).

METHODS

In 1978 eight pairs of trees similar in diameter and crown shape were chosen for study. One tree from each pair was randomly selected for the application of fertilizer; the other tree was the control. The minimum distance between treatment and control trees was 21 m to ensure an adequate buffer zone. Soil from sample sites was analyzed by the Manitoba Provincial Soil Testing Laboratory (Table 1). The fertilizer prescription[1] was based on these analyses: 225-449 kg/ha of elemental nitrogen (N), up to 200 kg/ha of phosphorus (P), and up to 300 kg/ha of potassium (K). The fertilizer applied in the study was within the recommended ranges.

	Application rate	
Fertilizer	kg/tree	kg/ha
34-0-0	4.5	535
16-20-0	5.0	597
0-0-62	2.0	238

This treatment provided a total of 277 kg of N, 119 kg of P, and 148 kg of K per hectare. The fertilizer was broadcast by hand within a radius of 5.2 m from each tree selected for treatment. Broadcasting was done on April 11, 1980, and again on March 20, 1981. Diameter measurements were made prior to fertilization in 1980 and then in the fall of 1982 and 1983. Tree heights were measured in the fall of 1983.

Because the study is in a seed production area, the trees could not be felled for cone collection, and the difficulty

[1] Provided by Dr. I.K. Edwards, soil scientist, Northern Forestry Centre.

Table 1. Manitoba Provincial Soil Testing Laboratory analysis of sample site soils

		Soil depth		
		0–30 cm	31–45 cm	46–60 cm
Texture		Sand	Sand	Sand
Carbonate content		Nil	Nil	Nil
pH		6.8	—[a]	—
Salinity (millimhos/cm)		0.1	0.1	0.1
Nitrate-nitrogen (kg/ha)		2.5	2.4	1.5
Available phosphorus (kg/ha)		66	—	0.1
Available potassium (kg/ha)		108	—	—
Sulfate-sulfur (kg/ha)		5.5	2.1	4.2
Micronutrients				
Copper (ppm)	1.1			
Zinc (ppm)	8.0			
Iron (ppm)	52.0			
Manganese (ppm)	6.6			

[a] Not determined.

involved in collecting all the cones produced on 12-m trees prevented the collection of the entire sample. To obtain an acceptable sample of cones, therefore, only those maturing in the collection year on the seventh whorl (from the top) of branches were collected. The seventh whorl was chosen because it is in the most prolific cone production zone of the tree (Godman 1962; Stiell 1971). Also, the main stem of the tree at this level is still capable of safely supporting the weight of the cone collector, and the branches are short enough to permit easy picking. This technique ensured picking of cones from branches undamaged by previous cone collections. Cones were collected in September 1981, 1982, and 1983.

Prior to seed extraction, the cones from treated and control trees were counted and separated into damaged and undamaged groups. The cones were first air-dried at room temperature until they began to open up and then oven-dried for 12 h at 60°C, after which they were placed in a plastic pail and vigorously shaken to remove the seed. This procedure resulted in the release of only a few seeds per cone. To rectify this, after being oven-dried the cones were soaked in cold water for approximately 1 min. and were oven-dried again for an additional 12 h. The cones were then shaken again to remove the seed. This procedure[2] greatly increased seed release. After being dewinged and cleaned, the seeds were electronically counted and weighed. Viability and soundness tests were made at the Pineland Forest Nursery. The hypothesis that fertilization significantly increases cone and seed production and growth was tested using paired one-tailed *t* tests. This test was used because it was assumed that the application of fertilizer according to the prescription might increase, and should not decrease, cone and seed production (Gagnon 1965).

RESULTS

Red pine cones require 2 years to mature; consequently, any increase in cone production due to the spring 1980 application of fertilizer should have become evident in the fall of 1981. That year, however, was a poor cone crop year, and the small number of cones collected precluded any attempt at data analysis. The following 2 years, 1982 and 1983, were good years, and the eight fertilized trees produced 610 and 477 cones, respectively, on the seventh whorl. The eight control trees produced a total of 264 and 290 cones in those years. Increases in the overall production of cones and seeds were significant at the 90% level (Figs. 1 and 2) despite the wide range in the number of cones produced per tree (control, 0–83; fertilized, 16–179). Although fertilization improves the overall production of cones, some trees are consistently good and others are consistently poor producers (Fowells 1965), as indicated by the cone production on individual trees, which was positively correlated between 1982 and 1983 ($R = 0.75$).

In this study, the most reliable method of assessing the effect of the fertilizer on seed production was examination of the data from insect-free cones, because the average number of seeds per cone between treatments and years was remarkably uniform (Table 2). Fertilization significantly increased total seed weight production by 160% in 1982 and 90% in 1983. Thus the fertilization resulted in an improvement in cone production that correspondingly increased total seed

[2] This procedure was suggested by Dr. J.I. Klein, tree improvement specialist, Northern Forestry Centre.

Table 2. The effect of fertilization on red pine cone and seed production

	1982				1983			
	Control	Fertilized	% increase	*t*	Control	Fertilized	% increase	*t*
Cones								
Total	264	610	131.1	1.901*[a]	290	477	64.5	1.756*
Insect free	242	557	130.2	1.854*	156	270	73.1	1.810*
Seeds (from insect-free cones)								
Total weight (g)	77.48	201.06	159.5	2.617*	42.36	80.37	89.7	2.271*
Seeds per cone	39.9	38.6	−3.3	—[b]	39.3	39.5	0.5	—
Weight per 1000 seeds (g)	8.01	9.35	16.7	1.877*	6.90	7.53	9.1	0.964[c]
Seed viability (%)	—	—	—	—	67.0	64.5	−3.7	—
Seed soundness (%)	—	—	—	—	83.9	75.7	−9.8	—
Total no. viable seed	—	—	—	—	4111	6886	167.5	—
Total no. sound seed	—	—	—	—	5148	8082	157.0	—

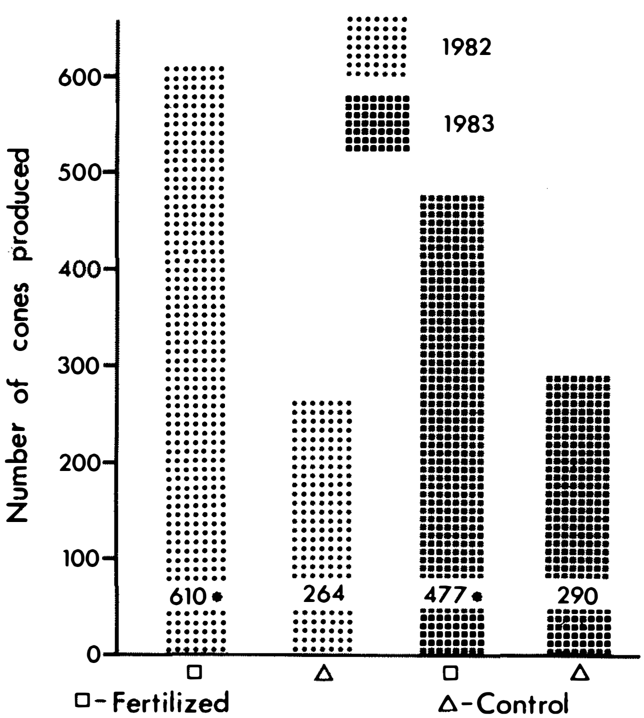
[a] Difference significant at the 90% level ($P = 0.10$).

[b] Not determined.

[c] Difference not significant.

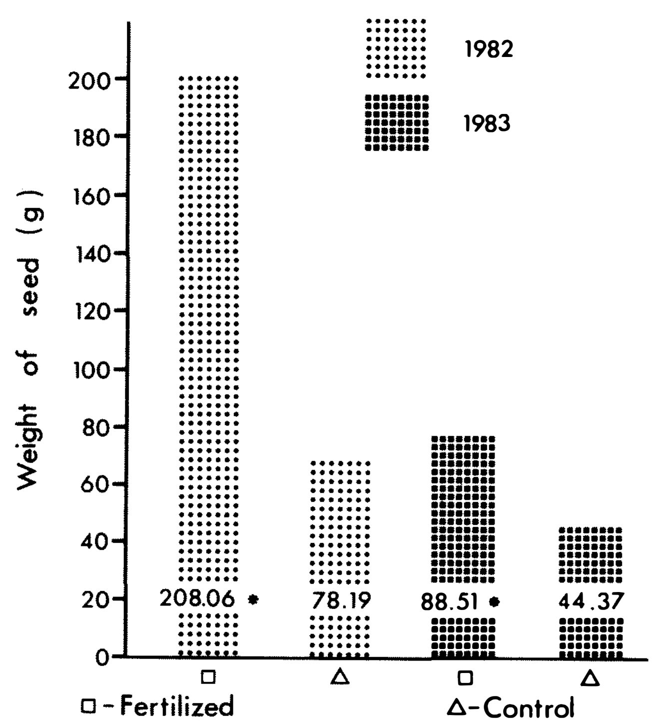
numbers and total seed weight. In 1982 the weight per 1000 seeds was 16.7% greater from the fertilized cones than from the controls. In 1983 it was 9.1% greater. Cayford and Jarvis (1967) found no difference in seed weight due to fertilization. This disparity might be due to the fact that they collected cones from the entire tree, while this study's sample came from the high production zone, where more good seeds are produced (Lyons 1956).

Cayford and Jarvis (1967) classified 43% of their cones



* Significantly different from control at 90% level ($P = 0.10$)

Figure 1. The effect of fertilizer on cone production (includes undamaged and damaged cones).



* Significantly different from control at 90% level ($P = 0.10$)

Figure 2. The effect of fertilizer on weight of seed produced (includes seed from damaged and insect-free cones).

as damaged. In this study the damage was 8.5% in 1982 and 44.5% in 1983. The 1983 crop was damaged more severely, resulting in more aborted cones than in 1982. This was reflected in fewer overall seeds per cone. Most insect damage in this study was due to the fir coneworm (*Dioryctria abietivorella* Grote).[3]

Seed viability and soundness tests conducted on the 1983 samples indicated no significant differences between treatment and control trees. The diameters of the fertilized trees increased significantly ($P = 0.10$) over the control trees by 1982 and 1983 (Table 3). The height difference in 1983 at 0.3 m was also significant ($P = 0.10$).

Table 3. The effect of fertilization on red pine diameter at breast height (dbh) and height

	1980	1982	1983
Mean dbh (cm)			
Control	18.22	20.39	21.11
Fertilized	19.40	22.29	23.24
t	1.367[a]	2.220*[b]	2.453*
Mean height (m)			
Control	—[c]	—	12.10
Fertilized	—	—	12.43
t	—	—	1.767*

[a] Difference not significant.

[b] Difference significant at the 90% level ($P = 0.10$).

[c] Not determined.

CONCLUSIONS

The results of this study indicate that red pine seed production areas on similar sites where thinning and pruning have taken place can realize a further increase in cone and seed production with fertilization. Based on visual examination of the total cone production of each of the 16 trees in this study and on the cone crop on the seventh whorl, it is recommended that the final thinning in a red pine seed production area should be carried out in good cone crop years and that the criteria used in selecting trees for removal should include nonproducing and poor cone-producing trees. This recommendation follows similar conclusions reached in other studies (Stiell 1971). The validity of using the cone crop of a single whorl of branches to represent the production of the entire tree, however, should be substantiated.

J.R. Dyck
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[3] Identified by Dr. H.R. Wong, insect taxonomist, Northern Forestry Centre.

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