Raspberry *(Rubus idaeus* L.) Competition Effects on Balsam Fir *(Abies balsamea* (L.) Mill.) Seedlings in Northern Maine[1]

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The effects of competition from raspberries on the growth and nutrient quality of the foliage of balsam fir seedlings were evaluated. Seedlings overtopped by raspberries were smaller than open-grown seedlings. Root collar diameters averaged 5.5 and 8.2 millimeters in the overtopped and open-grown seedlings, respectively. Foliar analysis revealed higher P (0.18 versus 0.16 percent) and lower K (0.59 versus 0.80 percent) concentrations in the open-grown seedlings than in the overtopped seedlings. Nutrient proportions in both groups of seedlings deviated from proposed optimum levels. The foliar analyses indicated K deficiencies in the open-grown seedlings and possible luxury consumption of Ca in both groups.
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Clearcutting is common in the spruce-fir stands of northern Maine. A dense cover of raspberries frequently becomes established following clearcutting, and can suppress small spruce and fir seedlings (2, 6). This may increase the time required for these stands to reach merchantable size.

Foliar analysis is often used to evaluate the nutritional status of forest trees (22). Critical levels have been established for the essential elements in many species (15). However, examination of individual nutrient concentrations alone is inadequate to characterize the nutrient status of a tree. Maximum growth occurs only when the proper ratio among nutrients occurs in combination with optimum concentrations (20). Work with black spruce (*Picea Mariana* (Mill.) B.S.P.), white spruce (*P. glauca* (Moench) Voss), and Scotch pine (*Pinus sylvestris* L.) has led to the proposal of an optimum nutrient proportion (expressed as a weight relation to nitrogen) of: N = 100, P = 13, K = 65, Ca = 6, Mg = 8.5, S = 9, and Fe = 0.7 (8-10, 22, 23).

In this study, foliar analysis and growth data were used to investigate the impacts of raspberry competition on the growth and elemental composition of balsam fir seedlings.

Materials and Methods

This study was conducted in township T5R12, located between Chesuncook Lake and Baxter State Park at 46° N. and 69° W. in northern Maine. The climate in this region is continental. Total annual precipitation averages 92 centimeters, with snow falling between November and March (4). Soils of the Telos (coarse-loamy, mixed, frigid Aquic Haplorthod) and Monarda (coarse-loamy, mixed, nonacid, frigid Aeric Haplaquept) series were characteristic of the study area.

The uncut stands in the area were approximately 60 years old and originated following the spruce budworm outbreak of 1913-19 (19). Red spruce (*Picea rubens* Sarg.) and balsam fir were the principle components. Scattered eastern white pine (*Pinus strobus* L.), paper birch (*Betula papyrifera* Marsh.), and black spruce also were found. The stands were fully stocked, with the overstory basal area averaging about 28 square meters per hectare. Abundant advanced spruce and fir regeneration existed in the understory.

Five adjacent clearcut strips were located in 1979. The strips had been harvested with mechanical feller-bunchers during the winter of 1974-75. The strips were approximately 30 meters wide, oriented northeast-southwest, and were separated by strips of uncut timber 45 to 60 meters wide.

Two groups of 10 balsam fir seedlings were selected in each clearcut strip in October 1979. Half the seedlings were overtopped by raspberries, whereas the remainder were free to grow.

The total height and the root collar diameter of each seedling were measured. Seedlings were then severed at the root collar, and seedling age was determined by

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counting the annual rings. The current year's foliage was collected from each seedling and put together with the foliage from all other seedlings within each group.

These composite foliage samples were dried at 70 °C and ground in a Wiley mill to pass a 0.84-millimeter screen. Nitrogen was determined by a micro-Kjeldahl procedure (14). Phosphorus was determined by the vanadomolybdate-HNO_3 procedure following dry ashing at 500 °C (5). Ten milliliters of 0.33 M magnesium acetate was added to the ground sample and evaporated prior to dry ashing to prevent volatilization of P. Cations were determined following dry ashing at 550 °C. Calcium and magnesium were determined by atomic absorption, and potassium was determined by flame emission spectrophotometry. Sulfur was determined colorimetrically following a nitric-perchloric acid digest (5).

The student's *t*-test was used to determine differences in age, height, root collar diameter, and foliar nutrient concentrations between open-grown and overtopped seedlings (11).

Table 1—*Age, height, and root collar diameter and nutrient concentrations in the foliage of balsam fir seedlings growing in clearcuts in northern Maine*[1]

Seedling condition	Age (yr)	Height (cm)	Root collar diam. (mm)	Nutrient conc. (%)					
				N	P	K	Ca	Mg	S
Overtopped	6.2 a	36.2 a	5.5 a	1.30 a	0.16 a	0.80 a	0.51 a	0.11 a	0.12 a
Open-grown	6.4 a	47.9 a	8.2 b	1.27 a	0.18 b	0.59 b	0.57 a	0.10 a	0.11 a

[1]Values in a column with the same letter are not significantly different (Alpha = 0.05).

Results and Discussion

The average age of both the overtopped and the open-grown seedlings was 6 years (table 1). Thus, the regeneration present in these 5year-old clearcuts originated from seedlings that existed in the understory at the time of harvest. Such advanced regeneration is a common feature in spruce-fir stands in eastern North America (1), and is the principle source of regeneration following clearcut harvesting (3).

The open-grown seedlings in this study were larger than those overtopped by raspberries (table 1). Competition from raspberries appears to have retarded the growth of these seedlings, particularly with respect to diameter. Similar results have been reported by Holt and coworkers (7).

Nutrient concentrations in the foliage of the sampled seedlings are presented in table 1. Significant differences were found in P and K concentrations between overtopped and open-grown seedlings. Nutrient proportions in the two groups of seedlings and comparisons with proposed optimum values are presented in table 2. The nutrient ratios in both groups of seedlings deviated from the proposed optimum proportions.

Although statistically significant, differences in P concentrations were relatively small. Lowry and Avard (12) found no difference in f concentrations among crown classes in black spruce. However, van den Driessche (21) reported higher P concentrations in suppressed trees. It is doubtful that the differences found in the present study are biologically significant. Phosphorus concentrations were above critical levels (15), and the ratio of P to N is very close to the optimum value in both groups of seedlings (table 2).

Table 2—*Nutrient proportions in the foliage of balsam fir seedlings growing in clearcuts in northern Maine compared with optimum values (N set at 100)*

Nutrient	Overtopped	Open-grown	Optimum value[1]
N	100	100	100
P	12.3	14.5	13
K	61.5	46.5	65
Ca	39.2	42.3	6
Mg	8.3	7.7	8.5
S	9.1	8.6	9

[1]van den Driessche (1976).

Large and statistically significant differences in foliar K concentrations existed between the overtopped and open-grown seedlings, with higher K concentrations in the overtopped seedlings. Similar results have been reported with black spruce (12) and red pine (*Pinus resinosa* Ait.) (13). In addition, the K to N ratio in the open-grown seedlings was the only nutrient proportion that deviated below the optimum by more than 10 percent, thus indicating a severe K deficiency. Growth dilution in the open-grown seedlings may be responsible for these differences.

An extremely high Ca to N ratio was found in both the open-grown and the overtopped seedlings. The values were between 6 and 7 times greater than the suggested optimum value. When data from other studies of balsam fir are used to construct nutrient proportions, high values for the Ca to N ratio are also obtained (16, 17, 24).

Because of an imbalance in the age structure of the spruce-fir forests in the Northeast, attributed to the cyclic nature of outbreaks of the spruce budworm, *Choristoneura fumiferana* (Clemens), a softwood timber shortage has been predicted for this region (18). Regeneration delays induced by raspberry competition would exacerbate this shortage. The research presented in this paper has shown that competition from raspberry plants reduces growth and affects tree nutrition of balsam fir seedlings, which could contribute to the timber shortfall problem. Additional work is needed in this area. In particular, the optimum nutrient proportions in balsam fir foliage need to be identified.

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