Vegetation Management Effects On The Nitrogen Nutrition of White Spruce Seedlings

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Abstract

Fertilization, site preparation, and vegetation management are the main methods used to improve soil nutrient availability in the forest environment. The study was conducted to examine the effect of managing naturally occurring vegetative species on plant stress and nitrogen nutrition of white spruce ***(Picea glauca*** [Moench} Voss) seedlings. Site preparation was achieved using the TTS Delta Powered Disc Trencher, and native vegetation was controlled by trimming at the ground surface with manual brush saws. Ammonium nitrate fertilizer (34-O-O) double labeled with ^{15}N was applied to a 1 m^2 plot at a rate of 100 kg N ha^{-1} (2.2923% enrichment). The white spruce seedlings and above-ground native vegetation were destructively sampled at the end of the next two growing seasons. Needles were also removed from white spruce seedlings to assess plant stress by measuring tissue ^{13}C concentrations. Site preparation and vegetation management doubled the fertilizer use efficiency (FUE) of the white spruce seedlings; however, total recovery of fertilizer nitrogen was quite low (2-6% of applied nitrogen fertilizer). The FUE of the major competitors (fireweed ***[Epilobium Angustifolium*** L.], grasses, and trembling aspen ***[Populus tremuloides Michx.]) was*** decreased by site preparation and vegetation management. Vegetation management increased the tissue ^{13}C concentration of the white spruce seedlings, indicating the seedlings were more stressed than the control and Delta disc trenched treatments. Vegetation management and site preparation increased the uptake of applied nitrogen fertilizer by limiting the fertilizer nitrogen uptake of native vegetation. However, vegetation management may cause greater stress to white spruce seedlings by increasing the light intensity through the removal of the native vegetation.

Introduction

The soil nutrient regime is one of the principle components of the forest environment over which some degree of control can be exercised. Forest fertilization is the main direct method used to improve soil nutrient availability. Other silvicultural operations, such as thinning, site preparation, and vegetation management, have an indirect effect upon the availability of and the competition for nutrients in the rooting environment. The effects of fertilization and vegetation management on forest growth have been studied extensively in British Columbia and the United States. However, there is little information available regarding the effects of nutrient amendments and vegetation management on forest growth in Saskatchewan and the Prairie Provinces. Therefore, the objective of this study was to examine the effect of managing naturally occurring vegetative species on plant stress and nitrogen nutrition of white spruce seedlings.

Materials and Methods

A randomized complete block field experiment was initiated 40 km south of Meadow Lake, Saskatchewan in May 1995. The soil in this area is dominantly Orthic Gray Luvisols of the Loon River soil association. The site was harvested in the winter of 1995 and silviculturally treated in May/June of the same year.

The treatment design consisted of four treatments: Control, Control + Vegetation Management, Site Prepared, and the Site Prepared + Vegetation Managed. Site preparation was achieved using the TTS Delta Powered Disc Trencher. Vegetation Management was achieved by trimming the native vegetation to the ground surface using manual brush saws. The control treatments were not site prepared. Each treatment was replicated three times.

Double ^{15}N-labeled NH_4NO_3 (2.2923% enrichment) was applied on July 5, 1995, at a rate of 100 kg $N \cdot ha^{-1}$. For each plot, the fertilii was evenly applied in 1 L of distilled H_2O by sprinkling evenly from a watering can on the soil surface in a 1 m^2 square around 4 trees in each of the Control, Delta, and Delta + Vegetation Management treatment plots. The area was then washed by sprinkling 1 L of distilled H_2O from a watering can over all vegetation in the plot so as to reduce 'contamination of the vegetation. One tree from each treatment plot was destructively sampled and analyzed for ^{15}N content by mass spectroscopy at the end of the second growing season. The fertilizer ^{15}N content of aboveground vegetation of competing species within the treatment plot was also analyzed by species.

Also, five needles were removed from the leader of two white spruce seedlings in all treatment plots and analyzed for ^{13}C content by mass spectroscopy. ^{13}C analysis was used to indirectly determine treatment effects on relative plant stress of the seedlings. The trees sampled for ^{13}C contents were not fertilized with ^{15}N.

Statistical analysis was completed using the general liner model procedure ANOVA (SAS Institute Inc. 1988) at the $p > 0.05$ significance level.

Results and Discussion

The total efficiency of fertilizer uptake (2.15-6.39% of total ^{15}N applied) was quite low compared to the 4-10% recovery reported by Chang et al. (1996). The low recovery of applied ^{15}N from white spruce is due to the young age of the seedlings and lack of root development throughout the treatment plot (Table I). Vegetation management and site preparation doubled the FUE of white spruce over the control plots; however, site preparation alone had no effect on the nitrogen uptake of the white spruce seedlings (Table 1). Results clearly showed that the white spruce seedlings competed poorly with the native vegetation for the applied fertilizer N.

Site preparation and vegetation management decreased the total uptake of nitrogen fertilizer by vegetation by reducing the plant biomass within the plots (Table 1). The FUE of the major competitors (Fire Weed Grasses, Trembling Aspen, and Yarrow) was decreased by combining site preparation and vegetation management. Site preparation alone had little impact on the fertilizer use of the native vegetation (Table 1).

Table 1: Influence of site preparation and vegetation management on fertilizer use efficiency and nitrogen derived from fertilizer at the end of the second growing season

Species	Fertilizer Use Efficiency (% of ^{15}N applied)*			Nitrogen Derived From Fertilizer (% of Total Nitrogen)**		
	Control	Delta	Delta + Weed Control	Control	Delta	Delta + Weed Control
Aster			0.03	50.87		4.54
Balsam Poplar					0.64	
Bedstraw	0.02					3.50
Bicknell's Geranium			0.36		3.24	18.72
Blueberry	0.04			13.06		
Bunchberry	0.02	0.03	0.03	13.77	12.42	16.45
Colt's Foot	0.25	0.14	0.13	40.85	35.50	9.53
Cranberry		0.04			11.02	
Dewberry	0.07	0.04	0.05	21.41	21.18	7.59
Fire Weed	1.23	1.52	0.19	37.55	15.58	10.47
Grasses	0.68	0.92	0.33	21.10	23.75	15.89
Narrow-leafed Hawk's Beard	0.64			39.30		
Salix	0.30			14.29	-	
Sarsaparilla	0.01		-	52.42	-	
Soap Berry				0.98		
Solomon's Seal				31.18		
Strawberry	0.17	0.03	0.12	25.63	5.00	27.64
Tall Lungwort	0.05			42.60		-
Trembling Aspen	1.17	0.47	0.04	11.71	11.09	27.23
Twinflower	0.02			28.15		-
Vetch			-		0.03	2.07
White Spruce	0.36	0.26	0.77	29.71	23.67	34.84
Wild Rose	0.13	0.29	0.08	26.09	9.54	17.97
Yarrow	1.25			29.08	3.72	
Total	6.39	3.73	2.15			-

* LSD (0.05) between treatments = 0.56%, between species = 0.68%

**LSD (0.05) between treatments = 28.96%; between species = 14.99%

Relative changes in the ^{13}C concentration fixed in plant tissue is an indirect measure of the stress resulting in decreased stomatal conductance. Most commonly, increases in ^{13}C concentration are a result of water stress. However, other sources of stress (e.g., nutritional stress, temperature stress) may result in decreased stomatal conductance, and increased ^{13}C tissue concentrations (O'Leary, 198 1).

Increased ^{13}C tissue concentrations in the Vegetation Management treatment plots suggest that those white spruce seedlings have undergone more stress than the Control and Delta treatment seedlings throughout the life of the tissue (Table 2). Soil moisture data indicates that the availability of water was not influenced by the vegetation management treatments. The increased ^{13}C concentrations may be due to high light intensity combined with high air temperatures reducing the growth of white spruce, while low light intensities protect white spruce from high air temperatures. The Canadian Forestry Service (1969) reported that white spruce growth was uninhibited by light intensities of only 45% of full light. However, when subjected to high light intensities and high air temperatures **(>25°C),** white spruce growth is significantly less than the growth of seedlings in 45% of full light at the same temperatures (Canadian Forestry Service, 1972).

Treatment	Mean $\delta^{13}C$ (‰)
Control + Vegetation Management	**-27.41a**
Delta + Vegetation Management	**-27.59ab**
Control	**-28.23abc**
Delta	**-28.42bc**

LSD (0.05) = 0.87%
Means with the same letter are not significantly different

Conclusions

Vegetation management and site preparation increased the uptake of applied nitrogen fertilizer by white spruce seedliigs by limiting the fertilizer nitrogen uptake of native vegetation. However, even when competition from native vegetation has been eliminated, the white spruce seedlings remain poor competitors for fertilizer N. Also, vegetation management appears to increase stress upon white spruce seedlings by increasing the light intensity through the removal of the native vegetation.

References

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