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Optimizing nitrogen loading of *Picea mariana* seedlings during nursery culture

K.F. Salifu and V.R. Timmer

Abstract: Plant growth and nutrient uptake response to increased fertilization can be conceptually described by curvilinear relationships depicting phases of nutrient deficiency, sufficiency, luxury consumption, and toxicity to rationalize fertilizer prescriptions and improve nutrient diagnosis. We validated this model to determine optimum nitrogen storage of young black spruce (*Picea mariana* (Mill.) BSP). Container seedlings were supplied with a mixed nitrogen–phosphorus–potassium (N–P–K) fertilizer at rates ranging from 0 to 80 mg N/seedling and reared in a greenhouse for one growing season. Plant growth and nutritional parameters of the plants exhibited classic responses of N deficiency, luxury consumption, and toxicity that were corroborated by vector diagnosis and appeared consistent with the conceptual model. Seedling biomass production was maximized at sufficiency (30 mg N/seedling), whereas N content of tissues peaked at the optimum loading rate (64 mg N/seedling). Toxicity occurred at the 80 mg N/seedling dose rate that increased plant N concentration (5%) but reduced growth (17%) and N content (14%) relative to the optimum level. Plant N content was raised 150% by optimum loading, exemplifying the effectiveness of this practice for building internal N reserves prior to planting. The newly validated model will help refine fertilizer recommendations and nutrient diagnosis for other species or cultural systems.

Résumé : L'effet d'une fertilisation accrue sur la croissance et le prélèvement de nutriments par les plantes peut être conceptuellement décrit par une relation curviligne qui représente les phases de déficience, de suffisance, de consommation de luxe et de toxicité afin de rationaliser les prescriptions de fertilisation et d'améliorer le diagnostic nutritionnel. Nous avons validé ce modèle afin de déterminer le stockage optimal d'azote (N) de jeunes plants d'épinette noire (*Picea mariana* (Mill.) BSP). Des semis en contenants ont été traités avec un fertilisant mixte N–P–K à des taux variant de 0 à 80 mg N par semis et cultivés dans une serre durant une saison de croissance. La croissance et les paramètres nutritionnels des plants ont montré les réponses classiques de déficience en N, de consommation de luxe et de toxicité, lesquelles ont été corroborées par le diagnostic vectoriel et apparaissent consistantes avec le modèle conceptuel. La production de biomasse des semis était maximisée à la phase de suffisance (30 mg N par semis) tandis que le contenu en N des tissus a atteint un sommet au taux optimal de charge (64 mg N par semis). La toxicité est apparue à la dose de 80 mg N par semis, laquelle a augmenté la concentration de N dans le plant (5 %) mais a réduit la croissance (17 %) et le contenu en azote (14 %), relativement au niveau optimal. Le contenu en N de la plante a été accru de 150 % par une charge optimale, ce qui démontre bien l'efficacité de cette pratique afin de mettre en place des réserves de N avant la plantation. Le modèle nouvellement validé aidera à raffiner les recommandations de fertilisation et le diagnostic nutritionnel d'autres espèces ou d'autres systèmes culturaux.

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Introduction

Nitrogen (N) accumulation or luxury consumption can occur in nature during pulses of N availability or when supply exceeds the capacity of plants to utilize N for growth (Millard 1988; Lambers et al. 1998). Under such conditions, N acquired in excess of demand for growth and maintenance is invested in storage that can be depleted later to support new growth during times of N limitation (Chapin 1980). New nursery cultural techniques, such as nutrient loading (Timmer 1997), were designed specifically to simulate this natural phenomenon, where fertilizer is supplied in excess of demands for current growth to induce luxury uptake characterized by increased internal concentration without significant change in total dry mass.

When nutrient-loaded seedlings were outplanted, they depleted these reserves, but also took up more nutrients from external soil sources, significantly stimulating new growth development (Malik and Timmer 1998). Nutrient-loaded trees consistently outperformed conventionally cultured stock planted on a variety of ecological site types (Timmer and Munson 1991; Quoreshi and Timmer 2000*b*) and on simulated N availability gradients of soils (Munson and Timmer 1989; Xu and Timmer 1999; Salifu and Timmer 2001). The benefits of vigorous growth and early dominance by loaded seedlings (Malik and Timmer 1996; McAlister and Timmer 1998) show promise for improving early plantation establishment, particularly on weed-prone sites. These preliminary results have stimulated interest in nutrient loading, but more insight into optimizing fertilizer prescriptions

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