Current Trends in Nutrition of Container Stock

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Introduction

The container tree nurseries in Western Canada have been going through a constant adjustment of their seedling nutrition programs to meet the challenges imposed by the increasing demand for bigger stock types, early delivery dates for summer planting, increased requests for seedlings grown in copper-treated containers and, ultimately the demand for excellence in field performance. This presentation will mainly focus on the experiences of Pelton Reforestation Limited in its efforts to adjust the seedling nutrition program for the production of quality stock that meets customers' expectations.

Bigger Stock Types

The use of bigger stock types by field foresters is resulting in more successful plantations, especially in sites with high brush competition and snow press occurrences or with high light/high drought conditions. Bigger stock increases survival rate and helps achieve free-growing status at the least cost, at the earliest date, and with the least difficulty (Sears, 1997).

In British Columbia the preference of field foresters for bigger stock types started in the late 80's with the increasing use of the 160/65 ml and 112/105 ml (Styroblock, Format 600) containers (Brazier, 1990). In 1988 Sutherland and Day (1988) suggested that to maintain optimal survival and growth for whit(spruce, black spruce and jack pine the container volume should range from 90 to 120 ml. In 1989 Pelton Reforestation LTD (PRL) in collaboration with Beaver Plastics introduced the 77/170 ml stock type for 2+0 spruces. In the last 3 years in British Columbia the most popular stock type has been the "112's" (105 and 80 ml) with a significant increase in the use of 77/120 ml and 77/170 ml stock types (Table 1).

Table 1. Stock types used in British Columbia for spruce Douglas-fir, lodgepole pine and western red cedar

#Cavity / volume (ml)	Plant density (#/ft^2)	#seedlings (000)'s 1995	1996	1997
240/40	105	5,582.2	4,158.2	2,386.3
160/60	87	1,814.9	1,964.2	1,809.4
160/65	87	78,037.6	68,168.5	59,048.6
112/80	49	23,615.1	34,794.5	44,023.7
112/105	49	64,730.9	47,377.6	42,286.3
77/120	34	984.4	2,148.6	7,325.3
77/170	34	11,160.7	13,727.9	14,606.2
60/250	26	0	76.0	838.8
45/340	20	608.7	997.8	1,681.8
15/1000	6.6	0	0	18.4

At Pelton Reforestation the demand for 160/65 ml stock type has dramatically decreased in 1997 whereas that for the 112/80 ml has increased by 50 %. The 77s (170 ml and 120 ml) and 45s (340 ml) stock types

Table 2. Stock types grown at Pelton Reforestation Ltd.

#Cavity / volume (ml)	Plant density (#/ft^2)	#seedlings (000)'s 1995	1996	1997
240/40	105	540.0	0	576.0
160/60	87	548.3	1,740.0	535.2
160/65	87	8,187.2	8,488.8	3,347.7
112/80	49	12,206.8	13,915.3	18,216.8
112/105	49	18,176.6	19,364.3	18,431.2
77/120	34	294.5	1,061.5	5,705.8
77/170	34	4,870.1	6,406.7	6,630.9
60/250	26	36.3	21.2	547.9
45/340	20	418.5	577.1	1,135.4
15/1000	6.6	0	0	1.6

requests almost doubled the previous year's (Table 2), especially for 2+0 stock.

Bigger container sizes with lower plant densities allow for the production of well-balanced seedlings with greater number of branches and lateral buds. It also allows for greater sun light exposure of the foliage improving the hardening-off process and consequently, seedling establishment in the plantations. Well developed branches with sun-conditioned foliage provide better self-shading and increase stem protection from sun scald and promote root development.

The different rate of growth and development of seedlings grown in bigger cavities requires adjustments in the nutrition program to ensure a good bud development and optimal level of mineral nutrient reserve at lifting time.

Summer Planting

Summer planting of hot-lifted stock has become a very important alternative to reforest sites where soil temperature and moisture conditions compromise survival and field performance of frozen-stored stock traditionally planted in spring.

Summer planting allows for rapid seedling establishment and improved second-year growth due to warmer soil temperatures and optimal soil moisture conditions encountered at planting time. Hot-lifted stock also increases the planting window beyond the availability of cold-stored stock, especially for high elevation sites where frost events occur throughout the growing season

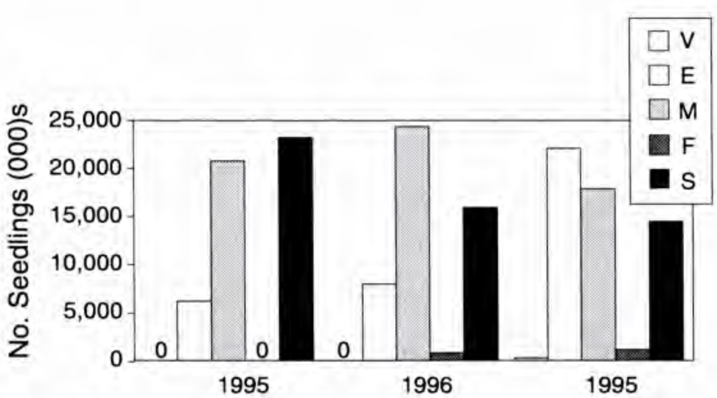

Figure 1. Annual seedling production at pelton reforestation LTD according to delivery time. (V=very early summer, E=early summer, M=Mid-summer, F=fall, and S=spring.

At PRL the request for early summer delivery has increased dramatically in the last 3 years. In 1995, 10.4 % of the annual seedling production was delivered in early summer (June 15 -July 15), increasing to 12.5 % for 1996 and to 41.2 % for 1997 (Figure 1).

Seedlings grown for summer planting are usually lifted 26-28 weeks after sowing. At lifting, seedlings should meet specifications of height and caliper and should be in optimal physiological conditions to grow roots in the field for the rest of the growing season. The mineral nutrition of seedlings, therefore, becomes one of the crucial factors for the production of bigger stock in a short growing season. As suggested by Ingestad

(1982), to optimize growth, seedlings should be grown with constant internal nutrient concentrations free from nutrient stress.

At PRL all efforts are made to follow the steady-state nutrition concept, by using controlled-release fertilizer as the base of the fertilization program, supplemented by constant applications of soluble fertilizer solutions with a complete nutrient formulation. Mineral nutrient status of seedlings is closely monitored with weekly tissue analysis during exponential growth and bi-weekly later in the season.

The use of controlled-release fertilizer is an integral part of PRL seedling nutrition program. It is estimated the 60-70 % of the nutrient requirement to produce target seedlings is supplied by controlled-release fertilizer incorporated in the growing medium. It has been observed that when seedlings do not contain controlled-release fertilizer due to equipment malfunction or operator error, growth and development fall behind and do not catch up with the rest despite top dressing or increased applications of soluble fertilizers.

The amount of rainfall experienced at the PRL location is a contributing factor for the preference for controlled-release fertilizer. At PRL all 2+0 stocks are grown in outside compounds whereas the 1+0 stocks are started in greenhouses and hardened-off in the outside compounds. The incorporation of controlled-release fertilizers in the growing media reduces the excessive leaching of nutrients and allows the maintenance of optimal nutrient levels even under wet weather conditions when the application of soluble fertilizers is not effective.

The increasing availability of controlled-release fertilizer with small particle or prill size (i.e. Osmocote mini-prill, Nutricote midi-prill) together with the increase in container cavity size have helped overcome the prill distribution problem encountered in past years. Nowadays several manufactures offer a variety of controlled-release fertilizers with different release time and formulations allowing nursery managers to have a better control of the nutrient levels through the different phases of seedling development. There are fertilizers with different forms of nitrogen, with or without micronutrients, and a variety in release time that ranges from 40 to 360 days. Manufacturers are also offering customized blends that will meet any particular requirements.

The use of short-day or "blackout" treatment has replaced the need for nutrient stress and drought as a means for regulating height growth and inducing dormancy. Seedlings treated with short days are more uniformed in height and bud development and in better physiological conditions to overcome transplanting shock (Eastham 1990). Short-day treatment also allows for the buildup of optimal mineral nutrient reserve in hot-lifted stock in spite of the short growing season in the nursery. Optimal level of mineral nutrients will promote outplanting performance of container stock (Timmer et. al 1991).

The use of blackout treatment has become an integral part of Pelton Reforestation seedling production. It allows a precise scheduling of delivery dates of hot-lifted stock on its optimal physiological stage for outplanting. Blackout also is instrumental in height growth control and dormancy induction on all coastal species, except for Western red cedar, for fall and spring planting. Pelton Reforestation has been using blackout treatment for dormancy induction since 1980.

Copper-Treated Containers

Copper-treated containers are used to promote root systems with short and abundant laterals. After planting, copper-treated seedlings are expected to produce a well distributed root system to improve establishment and stability. Roots tips are pruned when coming in contact with the copper compound applied to the cavity walls. Root tips resume growth when seedlings are outplanted, producing more roots in the top section of the plug improving seedlings establishment, and its long term stability (Struve et. al., 1994 in Watt and Smith, 1996).

In British Columbia copper-treated containers have been extensively used on lodgepole pine. At PRL, even though the majority of the requests for copper-treated stocks are for lodgepole pine seedlings, others species such as interior spruce, interior Douglas-fir, western red cedar, western larch and ponderosa pine have also been grown in copper-treated containers. These species, however, have shown variable degrees of susceptibility to copper toxicity which require adjustment of cultural practices and nutrition programs for the production of target seedlings.

Copper-induced iron deficiency (chlorosis) is the most common effect of copper-treated containers on species such as Douglas fir, western red cedar, western larch and on some provenance of interior spruce and lodgepole pine. Table 3 shows an example of the copper effect on tissue iron concentration on lodgepole pine over a one month period. Copper interferes with iron absorption by strongly competing for absorption sites. Copper also interferes with the upward movement of iron in the plant (Rey and Tsujita, 1984). Correction of copper-induced iron deficiency is commonly alleviated by the application of iron chelate.

Table 3. Mineral nutrient concentrations of lodgepole pine seedlings (PSB=regular container, PCT=Cu-treated container)

	N %	P %	Ca %	Mg %	K %	S %	Cu ppm	Fe ppm	Zn ppm	Mn ppm	B ppm
May 1											
PL-PSB	2.52	.32	.39	.16	1.36	.35	12	116	126	452	35
PL-PCT	2.34	.33	.26	.16	1.56	.32	22	67	119	332	28
June 1											
PL-PSB	2.45	.29	.41	.15	1.56	.38	6	61	164	261	29
PL-PCT	2.65	.35	.36	.14	1.54	.36	19	31	189	430	29

Some other considerations have to be taken into account to ensure an effective root pruning in seedling grown in copper-treated containers (van Steenis 1994). Seeds should be placed in the middle of the cavity to avoid premature root pruning which could affect seedling growth. pH of irrigation water, fertilizer and "soil" solutions should be monitored and adjusted to obtain an effective root pruning. Water management should include a wet/dry cycle with over-drain irrigation to prevent copper accumulation in the growing medium and promote root growth through the whole length of the plug.

;rowing Media and Amendments

Although container tree nurseries in Western Canada utilize peat moss as the base of their growing media, other components, organic and inorganic, have been incorporated to improve the physical and chemical properties of the growing media. Vermiculite, perlite, "styrolite" and sawdust are used to improved flowability during container filling and to offset the variability in peat quality. The selection of growing media components will determine the degree of nutrition program adjustment necessary for the production of target seedlings. These components will affect CEC, water holding capacity, air porosity, shrinkage and rewetability of the growing media.

PRL has being using Douglas-fir sawdust as part of its growing medium since the early Eighties to improve its air porosity and drainage, especially during the rainy season. This practice has brought about the production of a more fibrous root system and less incidence of root diseases. The utilization of fresh sawdust with a high C/N ratio, however, has required an increase in nitrogen supply at the beginning of the season to offset the nitrogen required for decomposting. Controlled-release fertilizers incorporated in the growing media supply the initial N required for sawdust decomposition. Table 5 shows some property differences between peat moss and sawdust.

Table 4. Composition of peat moss and sawdust and nitrogen required for composting (Modified from Amass and Adamson, 1972).

Material	Nitrogen %	Carbon %	C/N Ratio	N (kg/m^2)
Douglas-fir sawdust	0.12	48.1	400	0.04
Sphagnum peat moss	0.80	49.4	62	0.44

Other Factors Affecting Nutrition of Container Stock

Mycorrhizae Inoculation

An increased interest in artificial mycorrhizae inoculation of container stock has been experienced in the last 3 years by field foresters and nursery managers. Mycorrhizae colonization in container stock promotes root branching and improves root plug integrity and handling (Hunt, 1989). Yield of extractable plugs could be increased in species with slow root development, especially on hot-lifted stocks. The main benefit of mychorrizae colonization, however, is in the outplanting stage, improving survival and seedling establishment, especially in poor fertility sites (Zukas, 1997).

To promote the colonization of mycorrhizae from natural or artificial inoculations in container stock, modest reductions in fertility are recommended (Hunt, 1989), with preference for nitrates as form of nitrogen fertilizer. The reduction in fertility, however, may delay shoot development and the achievement of height and root collar diameter targets.

Genetically Improved Material

The use of genetically improved seeds is increasing in British Columbia. Seed orchard seedlots have a more vigorous growth than wild collection seedlots do, requiring some adjustment of the nutrition program for the production of well-balanced seedlings, especially when grown in small container sizes. Genetically improved seedlots should be grown in big container sizes to maximize their growth potential

Concluding Remarks

Nutrition of container stock has evolved considerably in the last 10 years. Increasing demand for bigger stock types and early delivery dates of hot-lifted stock has brought about changes in the philosophy and execution of seedling nutrition. Bigger stock produced in a shorter growing season requires a steady-state nutrient supply to optimize growth and field performance. Short-day treatment has become an excellent alternative to nutrient stress and drought for height growth control and dormancy induction. It has also helped achieve optimal mineral nutrient reserve levels in the seedlings to improve their field performance.

Seedling nutrition programs will continue to evolve as other variables are introduced in the production systems. The used of copper-treated containers, mychorrizae inoculations, genetically improved seed, and different growing media will require a constant adjustment of the mineral nutrient program for the production of quality stock.

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