ISSN 0820-8107

MARITIMES FOREST RESEARCH CENTRE

TECHNICAL NOTE NO. 93

FERTILIZATION OF CONTAINERIZED TREE SEEDLINGS BY THE REPLACEMENT METHOD

Many of the greenhouse management practices currently in use in the Maritimes were developed for the Japanese Paperpot system. Although the paperpot was the first system used for large-scale production of containerized tree seedlings, many nurseries in the Region have changed in recent years to solid-wall container systems such as the BC/CFS Styroblock or the Can-Am Multipot. Management of soil water and fertility in these solid-wall systems is quite different from that used with paperpots. Problems may occur if practices developed earlier for irrigating and fertilizing paperpots are not modified.

In the paperpot system, the peat-filled set acts like a sponge since water can pass freely between adjacent cells. Poor aeration can result in the rooting medium if irrigation is excessive. However, solid-wall containers behave quite differently. Individual cells can dry excessively for several reasons: water can't move between cells; peat does not rewet readily; peat or peat-vermiculite media shrink upon drying, therefore air movement along the cell wall speeds drying and irrigation water runs between the cavity wall and medium rather than into the soil.

Most container nurseries use irrigation booms moved by motorized carts on tracks. Two problems occur: drying varies within the greenhouse - particularly along edges of benches, shaded portions, cold spots, or areas next to fans or heating equipment; and in spite of the appearance of uniformity, irrigation often isn't consistent because of less-than-ideal nozzle selection, alignment, spacing and height, nozzle wear, and pressure losses.

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Conventional vs. Replacement Fertilizing

Conventional In this technique, a once-weekly "shot" of concentrated fertilizer solution is applied with as little water as possible, followed by a brief irrigation to rinse the foliage and move the fertilizer into the soil. The actual volume of rinse water depends on the moisture content at the start of the operation.

Often fertilizers do not move as expected. Because leaching does not occur, fertilizer salts remain at the soil surface or accumulate excessively in the soil and fertilizer imbalances develop. Leaching has to be conducted periodically to remove excess salts.

Replacement With this technique the soil content of nutrients is returned to target levels after each fertilization. This occurs because at each fertilization, a large volume of nutrient solution is applied which saturates the soil and leaches excessive salts and root exudates. Since the solution is applied each time in excess, the concentration and balance of nutrients in the soil returns to an equilibrium with the concentration in the applied solution. All cavities are saturated and leached, so uniform soil moisture and nutrient content are achieved. This uniformity is illustrated in Figure 1 which compares conventional weekly addition of fertilizer by weight with the replacement technique.

The replacement technique can be used for periodic fertilization (e.g., once weekly) as described by Carlson (1979), or for constant fertilization with each irrigation.

Advantages of the Replacement Technique:

1. Regular flushing of rooting media prevents the buildup of salts and eliminates risk of burning.
2. Nutrients are evenly distributed throughout the plug so that root growth does not concentrate in one zone, while being burned in another.
3. Because there is no buildup of particular ions, there is little chance of an induced deficiency of one nutrient, caused by an excess of another.
4. Nutrient levels can be changed very quickly, to correct deficiencies or to harden-off seedlings.
5. Crops cannot be over-fertilized regardless of how much solution is applied or how often; this simplifies the actual fertilizing process and eliminates the major source of fertilizing problems.
6. Problems with uneven soil moisture content or individual cell drying are reduced.
7. Nutrient levels are returned to target specifications with each fertilization.

These advantages far outweigh the disadvantages. Large quantities of nutrient solution must be applied at regular intervals which can cause problems if water-logging is a problem, especially in winter. Under-the-bench heating and soil additives such as vermiculite can help alleviate this. There is some wastage of fertilizer materials where excess

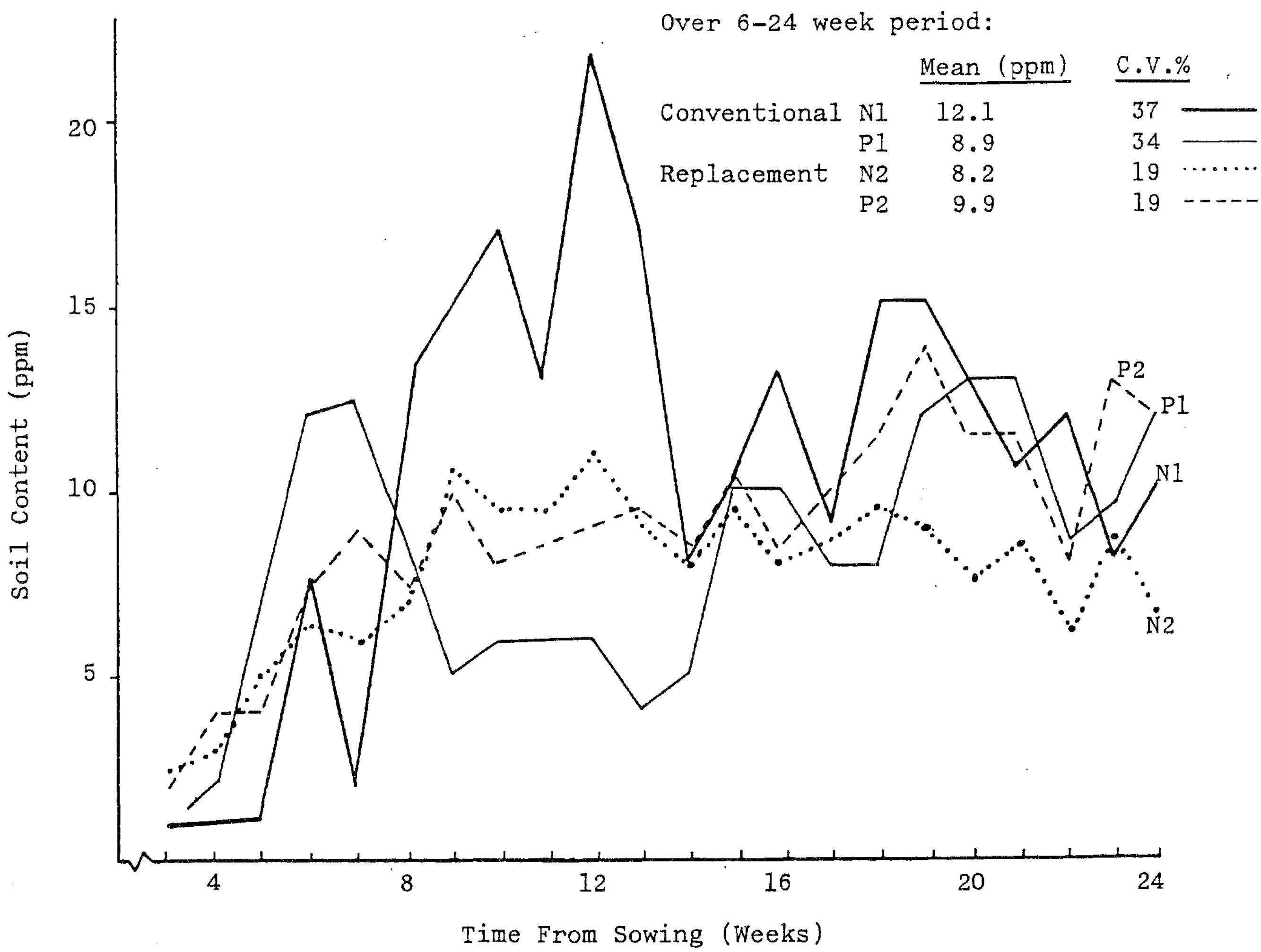

Fig. 1. Trends in soil content of nitrate nitrogen and extractable phosphorus as determined by lab analysis of greenhouse soil (peat-vermiculite): N_1P_1 - weekly addition of fertilizer by weight: N_2P_2 - weekly fertilization by "replacement" method.

solution is applied, although the actual cost is quite small and probably is cancelled by the reduced need for diagnosis and corrections and by improvements in crop quality.

Recommended Nutrient Levels for Greenhouse Soils

General guidelines for greenhouse soil nutrient content were developed for Maritime nurseries and reported by Hallett (1982). Recommendations are available for different species, season, and stage of growth. With replacement fertilizing, the fertilizer strength and balance should be adjusted until these target levels are achieved.

Fertilizer Materials

Most container nurseries use commercial soluble fertilizers which are injected into the irrigation water. Fertilizer management varies considerably from nursery to nursery and adjustments are made according to species, quality of irrigation water, time of year, or growth stage.

Target soil nutrient levels for the active growth period are

Soil salts mhos x 10^{-5}	pH	Available nutrients in ppm in soil extract				
		N	P	K	Ca	Mg
25-50	4-6	6-12	8-16	15-30	> 5	> 3

Optimum nutrient balance and concentrations have been formulated (Tinus and McDonald 1979; Carlson 1979). These formulations may involve on-site mixing of raw chemical materials or the blending of commercial mixes with elemental fertilizers. Recently, commercial formulations were developed for forest tree seedlings in different stages of growth.

At the Nova Scotia Tree Breeding Centre, replacement fertilizer solutions have been developed for multipot greenhouse crops (Table 1). The "growing" formulation used is 100-136-180 + chelated trace elements*. For winter crops, T.J. Mullin** found that nitrogen levels in excess of 100 ppm resulted in larger, greener spruce seedlings but with poorly developed root systems. Poor root growth could not be corrected by the addition of extra phosphorus. The 100 ppm nitrogen level produces a slightly smaller, but sturdier tree with better top:root balance and extractable root "plug". (Tree planters complain about poor root systems that make it difficult to extract seedlings.)

At the Tree Breeding Centre, concentrated stock solution (100x) is prepared in warm water. This is injected into the irrigation water by a Smith Measuremix injector at a ratio of 1:100. The volume of irrigation solution applied is about 1 L/4000 cm^3 of rooting volume. For Can-Am multipots, this is about 13 L/m^2. A foliage rinse is generally unnecessary. Monitoring the fertilizing operation includes measurement of irrigation water temperature, and salt content and pH of both the applied nutrient solution and leachate. Routine applications are made on Wednesday, and soil samples are collected on Monday for lab analysis. Because replacement fertilizing brings the soil into equilibrium with the applied solution during application, soil samples can be taken for nutrient analysis as soon as drip stops. Fertilizer solution is injected into the system whenever heavy watering is required.

The replacement fertilizing technique can be used with any soluble fertilizer. Table 2 shows how conventional "complete" soluble fertilizers, such as those from Peters®, may be blended to give a more suitable

*All fertilizer ratios in this paper are reported as concentrations of $N\text{-}P_2O_5\text{-}K_2O$. To convert to elemental concentrations, multiply $P_2O_5 \times 0.44 = P$, $K_2O \times 0.83 = K$

**T.J. Mullin, unpublished data.

nutrient balance for tree seedlings. Use of the new forestry fertilizers is described in Table 3 (e.g., Plant Prod®). Either of these may be a more attractive system for the production nursery, but do not offer the opportunity to adjust individual nutrient levels as readily as the "raw material" system described in Table 1.

Comparable instructions are given in the Plant Prod® or Peters® fertilizer guides under "constant feeding". The nurseryman can choose the fertilizer formulation and rate of nitrogen required, then apply the solution as described in this note.

Recommendation

The "replacement" technique described in this note should be used for fertilization of all solid-wall containers and for periodic and constant fertilization schedules. The fertilizer materials actually used and individual requirements will vary among nurseries depending on species, growing methods, available equipment, etc. The formulations and technique described in this paper provide a good starting point, but it may be necessary to tailor the system for each situation. Growers are encouraged to consult the references listed and to contact the authors for additional help.

The replacement technique is suited to solid-wall containers because the regular addition of large volumes of dilute nutrient solution results in leaching and control of soil salts which prevent individual cell drying, fertilizer imbalances, excess fertilizers which could burn roots or foliage, and nozzle patterns resulting from uneven fertilizing.

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August 1983

Table 1. Replacement fertilizer formulations using "raw" materials

Material	Quantity/1000 litres applied solution	Nutrients	ppm
"Starter" mix 50-205-90			
NH_4NO_3 (34-0-0)	65 g	NO_3 NH_4	11 11
H_3PO_4 (85% liquid)	199 mL	P	90
KNO_3 (13.75-0-44.5)	202 g	NO_3 K	28 75
"Growing" mix 100-135-180			
NH_4NO_3 (34-0-0)	130 g	NO_3 NH_4	22 22
H_3PO_4 (85% liquid)	132.5 mL		60
KNO_3 (13.75-0-44.5)	405 g	NO_3 K	56 150
"Hardening" mix 25-205-180			
H_3PO_4 (85% liquid)	199 mL	P	90
KNO_3 (13.75-0-44.5)	182 g	NO_3 K	25 67
K_2SO_4 (NFT grade 0-0-50)	198 g	K	82
Micro elements (used for all mixes)			
$MgSO_4 \cdot 7H_2O$ (epsom salts)	410 g	Mg	40
Fe chelate (10%)	40 g	Fe	4
Micro element chelate*	25 g	Fe Mn B Zn Cu Mo	1.75 0.5 0.325 0.1 0.025 0.015
Tracer dye (if desired for color)	1 g		

*Plant Products Co. Ltd., Bramalea, Ontario.

Table 2. Replacement fertilizer formulations using standard Peters ® "complete" fertilizers*

Material	Quantity, g/1000 L applied solution	Nutrients	ppm
"Starter" mix 50-205-90			
Peters ® 9-45-15	311	NH_4	28
		P	62
		K	39
Peters ® 10-30-20	220	NO_3	12
		NH_4	10
		P	29
		K	36
Peters ® Sequestrene 330	40	Fe	4
"Growing" mix 100-136-180			
Peters ® 9-45-15	290	NH_4	26
		P	57
		K	36
Peters ® 12-0-43	200	NO_3	24
		K	71
Peters ® 20-2-20	250	NO_3	15
		NH_4	35
		P	2
		K	41
Peters ® Sequestrene	40	Fe	4
"Hardening" mix 25-205-180			
Peters ® 5-50-17	410	NH_4	20.5
		P	90
		K	58
Peters ® 12-0-43	38	NO_3	4.5
		K	13.6
K_2SO_4 (NFT grade 0-0-50)	187	K	77
Peters ® Sequestrene 330	40	Fe	4

*Peters® Fertilizer Products, W.R. Grace and Co., Ajax, Ont. L1S 3C6

Table 3. Replacement fertilizer formulations based on Plant Prod® Forestry fertilizers*

Material	Quantity, g/1000 L applied solution	Nutrients	ppm
"Starter" mix 55-205-40**			
Plant-Prod Forestry Seedling Starter (11-41-8)	500	NO_3	8
		NH_4	47
		P	90
		K	33
"Growing" mix 100-40-100			
Plant-Prod Forestry Seedling Special (20-8-20)	500	NO_3	25
		NH_4	75
		P	18
		K	83
"Hardening" mix 40-100-150			
Plant-Prod Forestry Seedling Finisher (8-20-30)	500	NO_3	26
		NH_4	14
		P	44
		K	125

*Plant Products Co. Ltd., Bramalea, Ontario, L6T 1G1.

**Plant-Prod® Forestry fertilizers contain a microelement "package" amended for conifer tree seedling requirements when grown in peat or peat-vermiculite media. The formulations shown in the Table use the blended fertilizers without any additional materials, as recommended by the manufacturer.

These new formulations are being tested in many container nursery operations this year. The actual formulations to be marketed may be adjusted following testing as also were the new Peters® forestry fertilizers.