Macro and Micronutrient Programmes in B.C. Bareroot Nurseries[1]

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Abstract.--In 1986 an intensive foliar analysis programme was introduced, subsequently, boron, copper, iron and zinc were often found to be low or deficient during the growing season and lift. The programme combined the introduction of micronutrient soil amendments and foliar sprays and has significantly improved stock quality.

INTRODUCTION

In British Columbia, there are eight bareroot nurseries; six ministry, one company and one private, located in various climatic zones. Over the years, the nutrient programmes and stock standards have changed quite dramatically with increased demands for larger and more suitable stock types. In 1986, frequent foliar nutrient analysis programmes were introduced. This has helped in modifying fertilizer schedules to suit the different stock standards.

SOIL NUTRIENT LEVELS

Soil types on the nurseries vary from coarse sands to clay loams. Fortunately, most of the nurseries with the heavier soils are no longer in bareroot production. The ministry bareroot nurseries are on a three year crop rotation, with two years of crops and one of fallow. No green manure or cover crops are grown, which results in good disease control but is a poor soil management practice. As a result, organic matter levels must be maintained by adding peat prior to seeding and transplanting. The addition of sawdust in the fall, to reduce frost heaving, also helps. Although these practices maintain the level of organic matter and keeps the cation exchange capacity (O.M.) (C.E.C.) at a satisfactory level, they do not improve the soil tilth in the same way that humus does.

Soil analysis was only done during the summer of the fallow year. The nutrient levels that were used (table 1) were a modification of those established for Douglas fir by van de Driesche (1969), and further adjustments were made for the various nurseries as and when required.

Table 1.--1988 Soil nutrient levels[1] used on B.C. Forest Service nurseries.

ph	% OM	%N Kjeldahl	P pm Bray 1	K m.e.q./100g	Ca	Mg dry	CEC soil
5.2 -5.8	3-8	0.20	100 -0.25	0.20 - 250	5.0 - 0.30	<1.4 -8.0	15 -20

[1]These levels were required prior to sowing or transplanting.

Macronutrient plant-analysis was only carried out at the end of the growing season on specific 1-0 and the occasional 2-0 seedlots. The 2-0 fertilizer programmes were determined using the mineral nutrient ratios for seedling tissue established by Ingestad (1979).

The pH was maintained at a high level for forest nurseries, because the fertilizers used tended to be acidic. During the growing season, a pH of 4.4 was often found in the soils, which does effect the availability of some nutrients.

The nitrogen (N) levels, although of major importance, were disregarded when preparing the fertilizer programmes because of the numerous processes which affect N in the soils. This results in too much variation over short periods. Ammonium sulphate was the main N source, with ammonium nitrate being applied occasionally on 2-0 and transplants. The latter

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caused a considerable amount of damping off in 1-0 stock.

Phosphorus (P) was maintained at a very high level because a slight reduction at the time of seeding considerably reduced the size of the 1-0 and 2-0 stock. There were also indications that under certain conditions high P was essential for the success of some plug transplants. These levels were of concern, as they do reduce the availability of zinc (Zn), copper (Cu) and iron (Fe) (Chapman 1966). Superphosphate, triple superphosphate, diammonium phosphate and monoammonium phosphate were the P fertilizers used. The amount of monoammonium phosphate applied prior to sowing was reduced by injecting or banding it below the seed drill, which also resulted in a considerably improved 1-0 stock quality.

Despite potassium (K) levels being satisfactory or high in some nursery soils, there was often some difficulty maintaining acceptable levels in the seedlings and transplants (van den Driessche 1977). This became more pronounced during root wrenching and undercutting. It appears that these two cultural practices, combined with frequent irrigation, reduce the plants' ability to take up K. This may be due to the soil pH, the reduced root area in contact with the soil, root form (Mengel and Kirby 1982) and leaching (Duryea and Landis 1984). Frequent applications of potassium sulphate are now being made at these stages of root culture. High K soil levels also tend to depress the uptake of magnesium (Mg).

Though calcium (Ca) is essential for good root and apical meristem development, there was always some concern about the effect it had on the soil pH. When necessary, Ca was applied as either limestone or dolomite, and the rates used depended on the pH.

In spite of applications of dolomite, potassium-magnesium sulphate and magnesium sulphate, magnesium tended to be low. High K and Ca soil levels may induce Mg deficiency symptoms. The increase in the K supply may reduce the Mg content in the foliage. It does not, however, affect the levels in the roots or fruit to the same extent, because high K promotes the translocation of Mg towards fruits and storage tissues (Mengel and Kirby 1982). The calcium-magnesium and potassium-magnesium relationships are very important nutrient interactions in the production of seedlings.

Sulphur (S) was not a problem in bareroot production because of the large amounts applied in the fertilizers.

All the macronutrients were broadcast and worked into the soil prior to bed shaping. Some P was also injected or banded under the seed drill at the time of sowing, in the spring. Top dressings of the fertilizers were carried out on all stock types when necessary during the spring, summer and fall.

FOLIAR ANALYSIS FOR MACRO AND MICRONUTRIENTS

Until recently, little attention was paid to the micronutrients because the analysis service was not readily available. Over the years, visual identification of deficiencies was made and later confirmed by an analysis; but there was no micronutrient analysis programme in place. The importance of complete foliar analysis programmes in forest nurseries are demonstrated by the example of boron (B) increasing the resistance of forest plants to frost, drought and disease (Baule and Fricker 1970).

In 1986, a new programme was established allowing the nurseries to carry out foliar analysis for macro and micronutrients during the growing season. This was a tremendous step forward, although acceptable levels had not yet been clearly defined. The nutrient requirements and levels in plants vary with the species (Ballard and Carter 1986) and type of culture (Landis 1985). The levels that are used for bareroot are not necessarily suitable for containers. This is because the nutrient availability varies considerably between mineral soils and organic mediums, and is also affected by soil temperatures. There were difficulties in deciding on acceptable levels for all species and stock types, because they vary throughout the plant at different stages of growth. The levels used are based on trials conducted at the test nursery near Victoria, and research carried out to determine the best seedlings based on morphological and nutritional standards. The currently recommended nutrient levels (table 2) are used Tor all species and stock types.

Table 2.--1988 Nutrient Levels

Element	Target %	Accepted Range %
Nitrogen	2.0	1.50-3.50
Phosphorus	0.25	0.20-0.40
Potassium	1.0	0.80-2.00
Calcium	0.35	0.20-1.00
Magnesium	0.15	0.12-0.30
Sulphur	10% of N level	Minimum 0.15
	ppm	ppm
Iron	100	80-600
Copper	8	4-20
Zinc	30	25-80
Manganese	100	80 and up
Boron	30	20-50

When necessary, large macronutrient applications were made during the late fall and early spring. In order to accommodate various climatic conditions, the late fall top dressings were carried out at just about freeze up in the interior. The early spring ones were carried out in late February or early March at the coast (Mengel and Kirby 1982). Micronutrients were sometimes applied as soil amendments with the macronutrients.

During the growing season, foliar applications of P, K, Ca, and Mg, and micronutrients were made when necessary. The rates that were used (table 3) are the lowest ones that have been used successfully in the vegetable industry (Knott 1966) and the bareroot forest nurseries in British Columbia.

Table 3.-- Nutrient Application Rates

Nutrient	Material and approx. analysis	Soil Applic. (k0/ha)	Foliar Applic. (kg/1100 L water/ha)
Boron	Solubor ($NS_2B_4O_75H_2O$) 20.5% B.	5	1
Calcium	Limestone, dolomite, gypsum, superphosphate	-	-
	Calcium nitrate ($Ca[NO_3]_2,2H_2$) 20% Ca.	-	5-10
Copper	Copper sulphate ($CuSO_4,5H_2O$) 25.5% Cu.	25	2
Iron	Ferrous sulphate ($FeSO_4,7H_2O$) 20% Fe.	10	2
Magnesium	Dolomite 20-45% Mg.	-	-
	Magnesium sulphate ($MgSO_4,7H_2O$) 9.8% Mg.	150-200	10-15
Manganese	Manganese sulphate ($MnSO_4,4H_2O$) 24.6% Mn.	20	20
Sulphur	Agricultural Sulphur	100-200	-
	Ammonium Sulphur	-	-
	Potassium	-	-
	sulphate and	-	-
	superphosphate.	-	-
Zinc	Zinc sulphate ($ZnSO_4,7H_2O$) 22.7% Zn.	10	2

Nutrient deficiency symptoms were considerably reduced following the implementation of the foliar analysis programme. Samples were collected in the early spring and during the growing seasons at 4-6 week intervals until the fall. During that period, some variability existed due to the translocation of nutrients to various organs; however, appropriate adjustments were usually made during the current growing season.

Enough top material was collected to provide at least 5 grams dried weight of small seedlings or needles. The tissue was air or oven dried at 60° C prior to shipping to the laboratory, and the results were usually available within three or four days. This allowed remedial action to be taken immediately.

Analysis indicated that P, K, Ca and Mg were sometimes low. While P tended to be deficient in 2-0 coastal Douglas fir and sometimes in lodgepole pine, 1.5-1.5 interior spruce and 2-0 coastal Douglas fir often suffered from K deficiency and occasionally there were problems at some nurseries with Ca and Mg.

Among micronutrients B, Cu, Fe, and Zn, were the main concerns. B and Zn deficiencies appeared to be involved in the multi bud and leader, rosette, and dominant bud failure in interior spruce (Ballard and Carter 1986). These problems were eliminated or considerably reduced following the introduction of the micronutrient analysis and spray programme. Normally, a single application was necessary, but sometimes additional treatments were required. In the past, many of these problems were blamed on stock type, weather and/or chemical damage.

Intensive production of bareroot is still dependent on sound management. This is done by using all available resources including foliar and soil analysis, because the climate, environment and other factors all have considerable effect on a crop.

CONCLUSION

In British Columbia, the bareroot nursery stock types have improved considerably in the past few years. One of the major reasons for this has been the approach to plant nutrition. The new plant analysis programme has helped to optimize the plant nutrient status of forest seedlings.

When necessary, the nutrient target levels for the various species and stock types will be updated so that the programme will achieve its potential.

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