# Plant Nutrients Removed by Nursery Stock

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*Nutrient concentrations and biomass of roots, stems, and needles were determined for 2 + 0 seedlings of four conifer species: red pine (*Pinus resinosa *Ait.), eastern white pine (*Pinus strobus *L.), white spruce* (Picea glauca *(Moench) Voss), and Norway spruce* (Picea abies *(L.) Karst.). The pines consumed larger amounts of nitrogen, phosphorus, and potassium than did the spruces. Consumption of fertilizer equivalents per acre was in the order of red pine > eastern white pine > white spruce > Norway spruce.* Tree Planters' Notes 40(2):8-11; 1989.

Nurseries support one to two million seedlings per acre. Fertilizers must be added to produce nutritionally well balanced and high-quality seedlings that survive when outplanted. To gather data on the concentration of nutrients in coniferous tissue, 2-year-old seedlings were collected from the Wilson State Nursery, located near Boscobel, WI. The soil in this nursery is developed in quartsitic sandy river terrace of poor fertility.

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Improvement in soil fertility over the years was accomplished by the addition of peat, fermented sawdust compost, green manure, and N-P-K fertilizers applied broadcast, as top dressing, and as nutrient solutions. This has resulted in production of high-quality seedlings.

Coniferous seedlings of four different species grown at this nursery were analyzed for major, secondary, and micronutrients in the needles, stems, and roots. The amounts of the primary nutrients removed by the stock were then calculated. Analyses of soil samples from beds supporting the different species are used to indicate the adequacy of maintenance fertilizer applications applied in past years.

## Materials and Methods

Two composite soil samples consisting of fifteen 6-inch cores were collected from individual beds each of which supported four different species: 2 + 0 red pine, eastern white pine, white spruce and Norway spruce. One-hundred seedlings of each of the species were randomly sampled and analyzed for morphological and chemical characteristics (fig. 1).

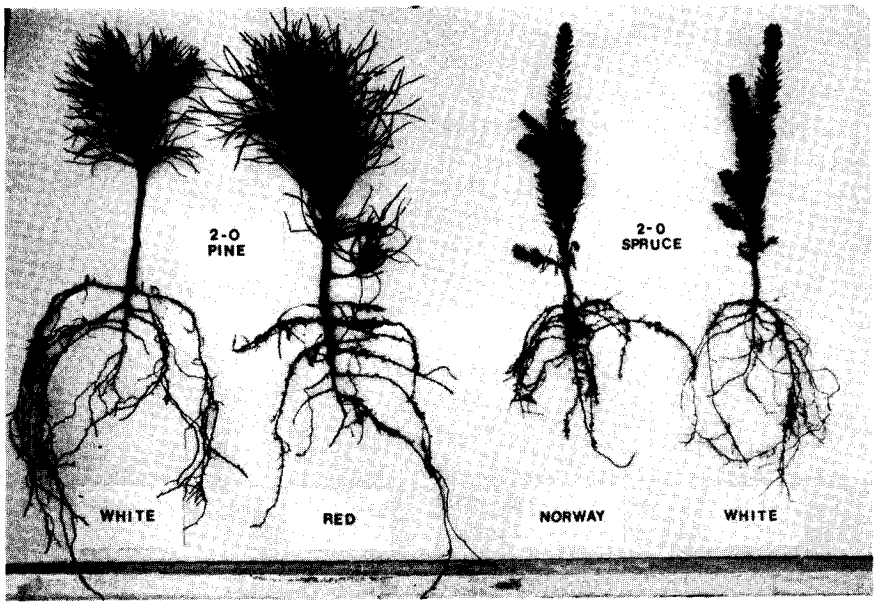


**Figure 1**—*Two-year-old coniferous stock (from left to right): eastern white pine, red pine, Norway spruce, white spruce* (Wilson State Nursery, WI).

The soil samples were dried in a forced-air oven at 70 °C and were then analyzed for fertility factors according to the methods outlined in Wilde et al. (4). The seedlings were first measured for morphological characteristics, then dried in a forced-air oven at 70 °C. Dry weights of tops and roots were measured and the samples were ground and analyzed for total mineral content by inductively coupled plasma emission spectroscopy (3). Total nitrogen was determined by the Kjeldahl method (2).

**Results and Discussion**

Soil analyses (table 1) revealed that most of the fertility factors in this area were ideal, with pH ranging from 5.5 to 5.6; silt plus clay at 9 to 11%; organic matter, 1.98 to 2.55%; available phosphorus, 153 to 168 pounds/acre $P_2O_5$; and exchangeable calcium and magnesium, 2.10 to 2.75 and 0.49 to 0.72 mE/100 g, respectively. Available potassium was 84 to 120 pounds/acre $K_2O$, which is lower than the optimum; this low level is attributed to uptake of potassium by seedlings as well as leaching losses that can occur in sandy soil.

The size of planting material is seldom correlated with its potential performance. More significant criteria are provided by the ratios of height of trees to stem diameters and of tops to roots. The height-diameter ratio in pines ranged from 4.05 to 4.58 and in spruces from 7.80 to 8.49. The top-root ratio in pines ranged from 2.12 to 2.76 and for spruces from 2.98 to 3.61. Both ratios are in acceptable ranges (table 2). The resistance of planting stock to adverse climatic influences and fungal diseases is also dependent on its concealed attributes, which include an adequate and well-balanced internal supply of macronutrients as well as micronutrients.

The nutrient concentrations of the roots, stems, and needles in four coniferous species are listed in table 3. No deficiencies or excesses of either major elements or microelements were apparent. Table 4 presents the uptake of N, P, and K per seedling, which varies with the biomass of each species as well as nutrient concentration. Uptake of N, and P followed the order of eastern white pine > red pine > Norway spruce > white spruce. Uptake of potassium followed the order of red pine > eastern white pine > Norway spruce = white spruce.

**Table 1**—*Fertility factors of soil supporting 2 + 0 conifers*

| Species | pH | Silt clay (%) | Organic matter (%) | Available nutrients (lb/ac) | | Exchangeable nutrients (mEq/100 g) | |
|---|---|---|---|---|---|---|---|
| | | | | P | K | Ca | Mg |
| Red pine | 5.5 | 11 | 2.38 | 163 | 120 | 2.50 | 0.55 |
| Eastern white pine | 5.6 | 9 | 2.55 | 158 | 120 | 2.75 | 0.49 |
| White spruce | 5.5 | 10 | 2.55 | 168 | 84 | 2.10 | 0.55 |
| Norway spruce | 5.6 | 10 | 1.98 | 153 | 108 | 2.10 | 0.72 |

**Table 2**—*Morphological characteristics of average 2 + 0 conifer seedlings*

| Properties of stock | Red pine | Eastern white pine | White spruce | Norway spruce |
|---|---|---|---|---|
| Height (cm) | 24 | 21 | 30.5 | 31 |
| Root length (cm) | 51.5 | 45 | 35.0 | 29.5 |
| Stem diameter (mm) | 5.93 | 4.59 | 3.91 | 3.65 |
| Weight of seedlings (g) | 8.81 | 7.68 | 5.03 | 5.03 |
| Weight of tops (g) | 6.47 | 5.22 | 3.94 | 4.08 |
| Weight of foliage (g) | 4.44 | 3.33 | 1.88 | 2.08 |
| Weight of roots (g) | 2.34 | 2.46 | 1.09 | 1.37 |
| Height/diameter ratio | 4.05 | 4.58 | 7.80 | 8.49 |
| Top/root ratio | 2.76 | 2.12 | 3.61 | 2.98 |

**Table 3**—*Concentration of nutrient elements in 2 + 0 coniferous seedlings*

| Plant part | Conc. (%) | | | | | | Conc. (ppm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | S | Zn | B | Mn | Fe | Cu | Al |
| Red pine | | | | | | | | | | | | |
| N | 1.44 | 0.22 | 0.85 | 0.31 | 0.15 | 0.11 | 81 | 7.9 | 434 | 70 | 3.1 | 86 |
| S | 0.78 | 0.14 | 0.44 | 0.25 | 0.14 | 0.06 | 67 | 6.9 | 232 | 131 | 4.3 | 169 |
| R | 0.50 | 0.10 | 0.29 | 0.15 | 0.08 | 0.06 | 47 | 5.5 | 113 | 595 | 3.0 | 877 |
| Eastern white pine | | | | | | | | | | | | |
| N | 1.98 | 0.25 | 0.73 | 0.50 | 0.19 | 0.17 | 94 | 9.4 | 262 | 90 | 3.6 | 75 |
| S | 0.92 | 0.22 | 0.81 | 0.24 | 0.18 | 0.13 | 90 | 9.1 | 145 | 145 | 7.2 | 168 |
| R | 0.62 | 0.14 | 0.28 | 0.21 | 0.09 | 0.07 | 72 | 6.2 | 78 | 782 | 3.2 | 1126 |
| White spruce | | | | | | | | | | | | |
| N | 1.68 | 0.28 | 0.69 | 0.95 | 0.18 | 0.14 | 109 | 8.5 | 457 | 163 | 3.3 | 148 |
| S | 0.77 | 0.16 | 0.54 | 0.45 | 0.12 | 0.06 | 88 | 7.8 | 166 | 182 | 4.8 | 143 |
| R | 0.68 | 0.14 | 0.32 | 0.31 | 0.09 | 0.06 | 71 | 7.1 | 84 | 777 | 2.9 | 1084 |
| Norway spruce | | | | | | | | | | | | |
| N | 1.84 | 0.26 | 0.70 | 0.83 | 0.20 | 0.12 | 55 | 6.8 | 221 | 125 | 3.5 | 89 |
| S | 0.67 | 0.16 | 0.47 | 0.40 | 0.14 | 0.06 | 74 | 8.1 | 100 | 95 | 4.6 | 93 |
| R | 0.74 | 0.09 | 0.26 | 0.29 | 0.09 | 0.06 | 45 | 6.6 | 62 | 982 | 2.8 | 1290 |

N = needles, S = stem, R = roots.

**Table 4**—*Total uptake per seedling of N, P, and K by average 2 + 0 coniferous seedlings*

| Species | Seedling weight (g) | Nutrient uptake (mg/seedling) | | |
|---|---|---|---|---|
| | | N | P | K |
| Red pine | 8.8 | 92 | 14.9 | 54 |
| Eastern white pine | 7.7 | 98 | 15.9 | 45.9 |
| White spruce | 5.0 | 55 | 10.1 | 27.5 |
| Norway spruce | 5.5 | 61 | 9.8 | 27.6 |

**Table 5**—*Uptake of N, P, and K per unit area at standard planting density of seedling beds*

| Species | Density/ft² | Nutrient uptake | | | | | |
|---|---|---|---|---|---|---|---|
| | | N | | P | | K | |
| | | lb/ac | kg/ha | lb/ac | kg/ha | lb/ac | kg/ha |
| Red pine | 29 | 256 | 286 | 42 | 46 | 150 | 168 |
| Eastern white pine | 26 | 245 | 274 | 39 | 44 | 115 | 128 |
| White spruce | 35 | 185 | 207 | 34 | 38 | 92 | 103 |
| Norway spruce | 26 | 152 | 170 | 24 | 27 | 69 | 77 |

Table 5 lists the uptake of N, P, and K by coniferous species per unit area at standard planting densities for the different species. Uptake of N, P, and K per unit area followed the order of red pine > eastern white pine > white spruce > Norway spruce. Table 6 presents the equivalent amounts of common commercial fertilizer materials consumed by 2 + 0 coniferous species over a 2-year period.

In conclusion, seedling analysis is an important tool in guiding fertilization practices. The results obtained from the analyses can be used to estimate maintenance fertilizer applications more accurately based on the amounts removed by different species and to design the most effective fertilizer program for the production of tree planting stock.

**Table 6**—*The equivalent amounts of N, P, and K fertilizers consumed by 2 + 0 coniferous species*

| Species | Fertilizer consumed (lb/ac) | | |
|---|---|---|---|
| | $(NH_4)_2SO_4$ (21 – 0 – 0) | $Na_3PO_4$ (0 – 45 – 0) | $K_2SO_4$ (0 – 0 – 50) |
| Red pine | 1219 | 215 | 360 |
| Eastern white pine | 1166 | 199 | 276 |
| White spruce | 880 | 174 | 221 |
| Norway spruce | 724 | 122 | 166 |

## Literature Cited


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