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EFFECT OF CELL SIZE AND FERTILIZATION RATE ON SEEDLING SURVIVAL AND GROWTH

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Problem

The Alaska Division of Forestry has shown an increased interest over the past three years in the contract planting of containerized white spruce seedlings. This method of forest regeneration provides the greatest guarantee of achieving adequate spruce establishment in the shortest possible time. Unfortunately, it is also the most expensive, due in large part to the high cost of the planting stock required. At the present time all of the seedling stock which is planted during the summer is produced by the Divsion of Forestry's Eagle River Nursery. The container presently being used to produce an 18 month old seedling is the the 4 in^3 Ray Leach Cell. Although this cell size and container system are widely used, it is not the only system available. In Canada, several different types of systems and cell sizes are currently being used, ranging from the 2 in^3 Styroblock cells to the 10 in^3 Spencer-Lemaire cells.

The wide range of cell sizes available for growing containerized seedlings brings up some important questions which need answering. What effect does the container cell size have on the size of the seedlings produced? Can good sized seedlings be produced in small cell sizes by increases in fertilization rates? Do seedlings need to be 18 months old before they can be planted successfully, or can they be planted at six months? What cell size and fertilization rate is optimum for growing six month seedlings? If the present cell size can produce an acceptable seedling in six months instead to 18, then a significant savings in nursery costs may be achieved. This would help to make seedling planting a more economically viable regeneration option in Alaska.

Objectives

A two-phased study of the effect of cell size and fertilization rate on the growth of white spruce and lodgepole pine seedlings was initiated in February, 1985. The Spencer-Lemaire container system's 4 in^3 and 10 in^3 cell sizes were selected for examination. Each species and cell size was

fertilized at four different rates: no fertilizer, 100 ppm N, 150 ppm N and 200 ppm N. Half of the seedlings in each treatment were outplanted after 6 months and the other half were held in containers for 18 months before outplanting. There were three major objectives of this study:

1. Measure and compare seedling height growth in the greenhouse for the different cell sizes and fertilization rates.

2. Measure and compare root and shoot dry weights before out planting at 6 months and 18 months.

3. Measure and compare seedling height growth in the field for the different cell sizes and fertilization rates.

Methods

White spruce seed from the Bonanza Creek Experimental Forest and lodgepole pine from the Yukon Territory, Canada were sown in the Spencer-Lemaire cells on February 5, 1985. The growing media was a 3:1 mix of local peat and vermiculite. After sowing, the cells were covered with 1/4" diameter gravel to a depth of one half inch. The containers were checked daily to insure that they remained moist, and were watered as necessary. All of the cells were covered with a sheet of clear plastic, until the first germinants appeared.

The number of germinants for the different species and cell sizes were recorded on a daily basis. The cells with multiple germinants were thinned to one seedling each, beginning two weeks after initial germination. Extra seedlings were transplanted to empty cells to insure 100% cell establishment. Cells with transplants were marked so that germinant counts could continue.

Fertilization with a liquid fertilizer (Peter's 18-18-18) began four weeks after sowing. A stock solution of the fertilizer was diluted to 100 ppm N, 150 ppm N and 200 ppm N and applied once a week. The breakdown of the cell counts for each species and fertilization rate was as follows:

	White Spruce		Lodgepole Pine	
Fertilizer Rate	4 in^3	10 in^3	4 in^3	10 in^3
Control	130	128	130	128
100 ppm N	130	128	130	128
150 ppm N	130	128	130	128
200 ppm N	130	128	130	128
Total	520	512	520	512

The difference in cell counts between the two cell sizes was the result of cell arrangement in growing trays. The 4 in^3 trays held 65 cells, while the 10 in^3 trays held 32. In order to eliminate handling problems, only whole trays of cells were sown.

The first growth measurements were made 4 weeks after the fertilization began. A random selection was made of 16 seedlings from each treatment which were marked and remeasured every four weeks until July 22, 1985. Calipers were used to take height measurements from the primary needles to the base of the needles at the tip to the leader. This provided a measure of relative height growth for the mainstem rather than total height. By measuring in this way, variability in total height resulting from differences in seed size was eliminated.

The seedlings were moved from the West Ridge Greenhouse to Experimental Farm during the first week in June to begin a hardening-off period prior to outplanting and overwintering. Fertilization was discontinued after July 22. A random selection of ten seedlings from each treatment was made for root-shoot dry weight analysis. Half of the seedlings in each treatment replication, with the exception of the unfertilized seedlings, were taken to Rosie Creek for outplanting. The planting area, 20 miles west of Fairbanks, had been mechanically scarified in June in preparation for a contract planting by the Divison of Forestry. The scarification process was performed to expose mineral soil which is the preferred growing site for white spruce. The equipment used to scarify the soil consisted of a TTS-35 disc trencher pulled behind a D-6. The scarification treatment cut two paralell furrows through the organic layer and provided fairly uniform planting conditions. This allowed each treatment replication to be planted in a different, randomly selected furrow within the experimental plantation area. A total of 50 seedlings from each treatment were planted.

The remaining seedlings were overwintered under snow at the Farm. After break-up in 1986, watering and fertilization were begun again and continued until July 23. No measurements were taken during this time. Before planting a random selection of ten seedlings from each treatment was made for root-shoot analysis. The seedlings were then taken to Rosie Creek and planted in between the seedlings planted the previous year. The seedlings which were planted at 6 months were marked with potting stakes so that they could be distinguished in the future from those planted at 18 months.

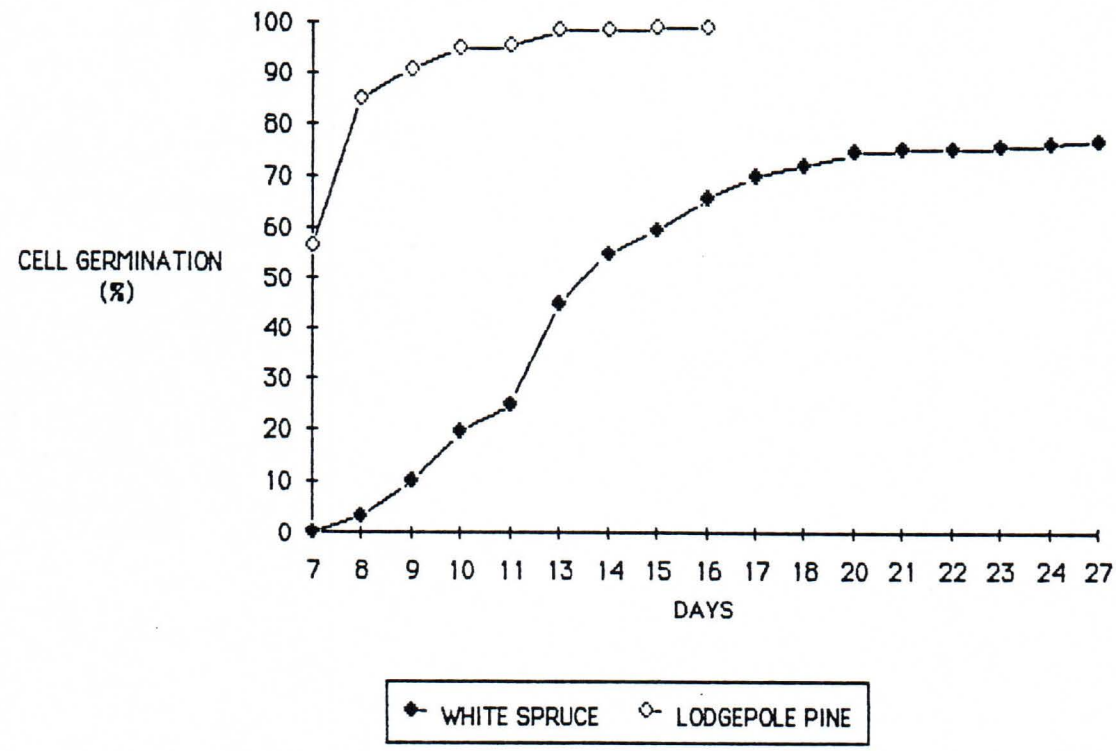
The first field measurements of seedling heights were made in September, 1986. Annual remeasurements will be made and a growth comparison report prepared after 5 years. At that time a decision will be made whether or not to continue remeasurements on an annual basis or go to a five year growth measurement period.

Results

Germination Rates

The final cell germination rates for white spruce and lodgepole pine were 76% and 99.5%, respectively (Figure 1). The lodgepole pine seed germinated much more rapidly than the white spruce seed. The germination rates for both species did not appear to be effected by cell size. When the study was set up, there was interest in determining whether germination rates would be influenced by changes in soil temperature caused by cell size. White spruce, in particular, germinates more rapidly at temperatures above 20° C.

Figure 1. Cell germination percentages for white spruce and lodgepole pine.



Growth Rates

As can be seen in Figures 2, 3, 4 and 5, there were some obvious effects of the three fertilization rates on the relative height growth of both seedling species. Although some of these differences appeared to be quite large, they were not always statistically significant. There was a lot of variation in the size of the seedlings included in some of the samples which influenced the results of a statistical comparison of the averages.

The seedlings all showed a definite decrease in growth rates after being placed outside. This response was most pronounced for the seedlings treated with the two lower fertilization rates. The growth rate decrease for the seedlings which received the 200 ppm treatment was always less than for the other two. Also, the seedlings with the higher fertilization rate showed a more complete return to previous growth rates during the next measurement period.

White spruce and lodgepole pine showed different early responses to the fertilization rates. Lodgepole always showed the greatest height growth at the highest fertilization rate. White spruce, on the other hand, always grew more slowly during the first two measurement period under the 200 ppm rate, than it did under the two lower rates. However, height growth under the higher fertilization rate always equaled or surpassed the growth at the lower rates by the third measurement period.

4 in^3 cells

White spruce showed the best growth results with the 200 ppm N fertilizer treatment. The 8.19 cm (3.2 in) average height growth under this treatment was significantly greater, both numerically and statistically, than in the other treatments. The 6.14 cm (2.4 in) average for the 150 ppm N seedlings was statically greater than the 4.39 cm (1.73 in) average for the 100 ppm N seedlings.

For lodgepole pine, the best growth results also occurred in the 200 ppm N treatment. The 7.32 cm (2.9 in) average height growth under this treatment was statistically greater than in the other treatments. Unlike the white spruce treatments, there was no statistical difference between the seedling heights of the 150 ppm N and 100 ppm N treatments. These heights were 5.51 cm (2.2 in) and 5.42 cm (2.1 in), respectively.

10 in^3 cells

The growth response of white spruce in this cell size was substantially different than was the case in the 4 in^3 cells. There was no statistical difference between the 12.0 cm (4.7 in) average height growth of the 200 ppm N treatment and the 10.6 cm (4.2 in) of the 150 ppm N treatment. However, both of these treatments were significantly different from the 8.6 cm (3.4 in) average height of the 100 ppm N treatment.

Figure 2. Height growth responses for white spruce seedlings grown in 4 in^3 cells at three fertilization rates.

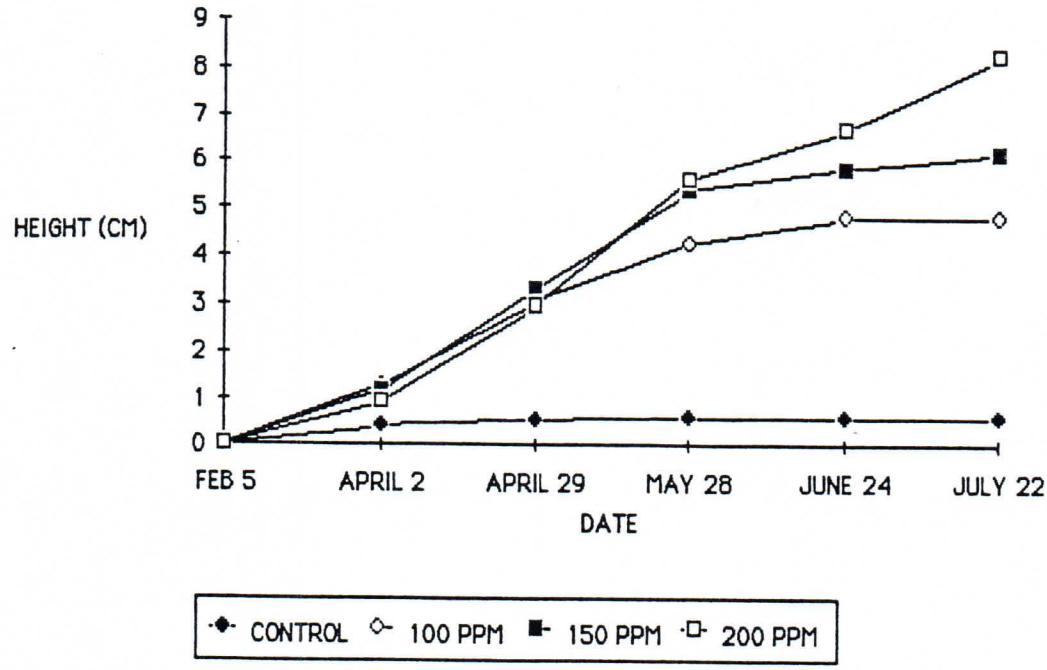


Figure 3. Height growth responses for lodgepole pine seedlings grown in 4 in^3 cells at three fertilization rates.

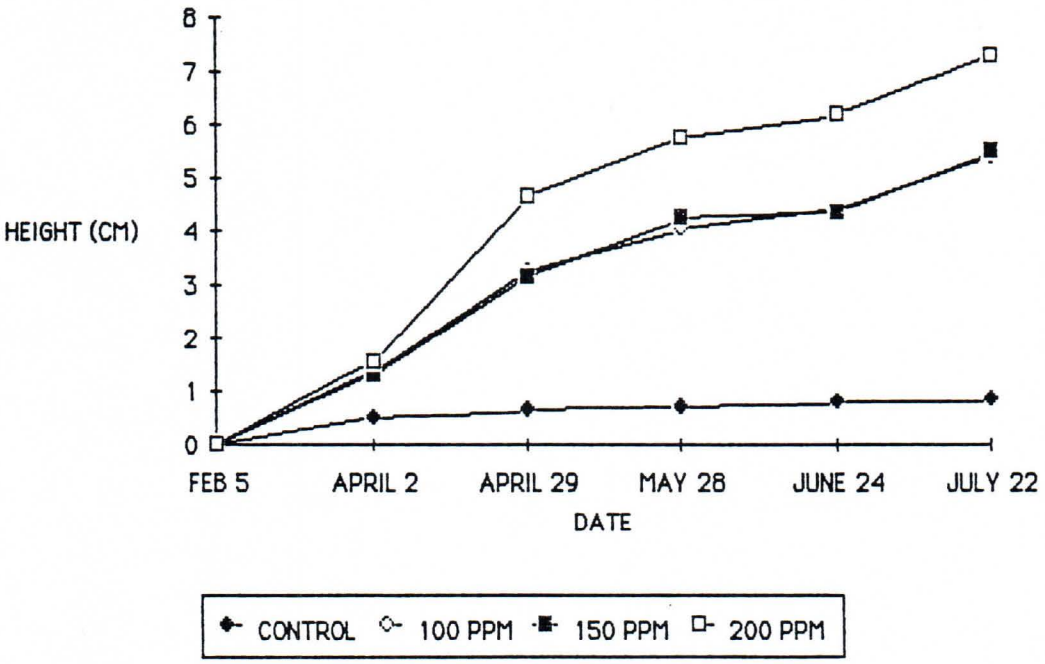


Figure 4. Height growth responses for white spruce seedlings grown in 10 in^3 cells at three fertilization rates.

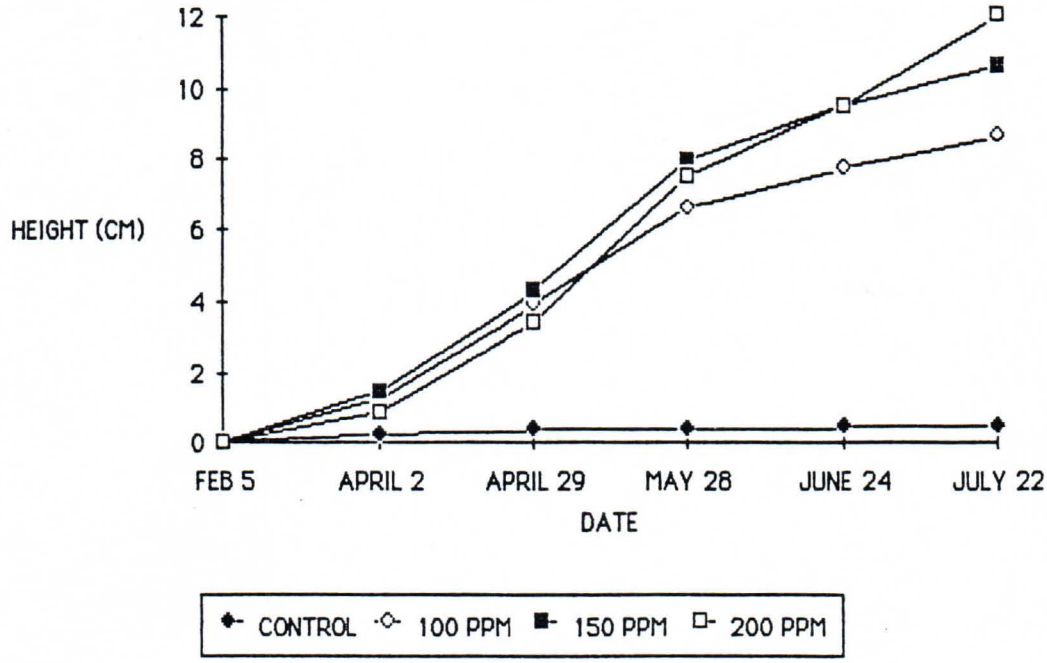
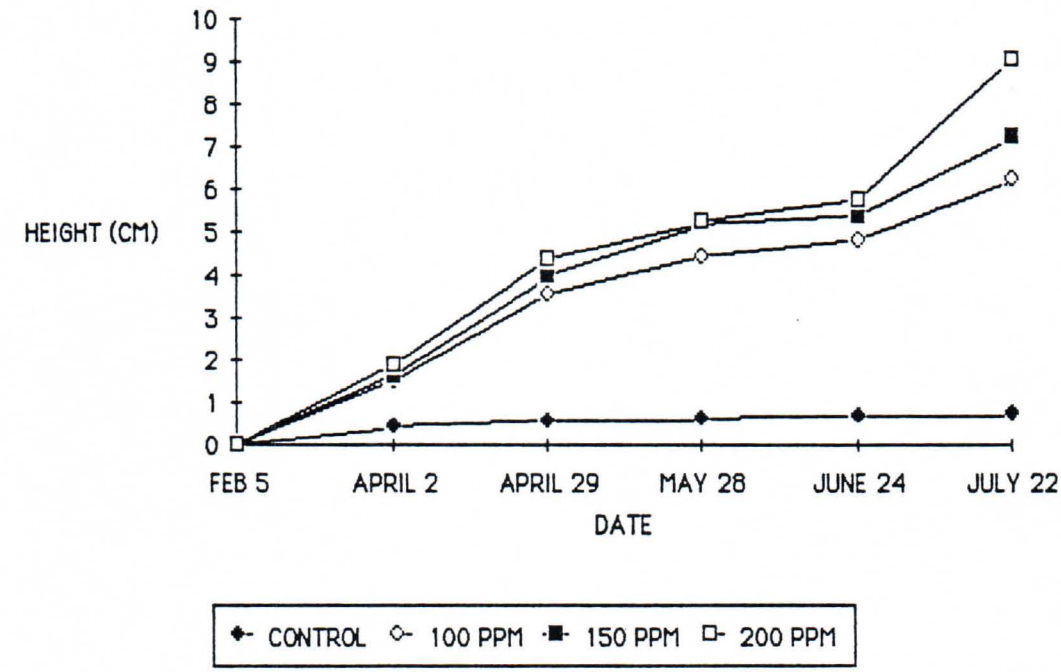


Figure 5. Height growth responses for lodgepole pine seedlings grown in 10 in^3 cells at three fertilization rates.



The final height growth responses for lodgepole pine showed both similarities and differences from the responses found in the 4 in^3 cell treatments. The 9.04 cm (3.6 in) average height growth under the 200 ppm N treatment was statistically greater than in the lower fertilization rates. However, unlike the growth response in the smaller cells, there was a significant difference between the 7.26 cm (2.8 in) average for the 150 ppm N rate and the 6.23 cm (2.5 in) average for the 100 ppm N rate. Also, the difference between the three rates were not as great during the early measurement periods as they were with the smaller cells.

Root/Shoot Dry Weights

The dry weights of roots and shoots were obtained to determine the effect fertilization has on the root mass in relation to stem mass. The size of the root system has an influence on how fast the seedling can begin to take up nutrients from the soil once it is outplanted. The effect that the different root and shoot weights have on the performance of the seedlings is being examined in the field portion of this study. The weights reported here are only for the 6 month old seedlings, as the analysis of the 18 month root and shoot weights has not been completed.

Both white spruce and lodgepole pine exhibited similar responses in root and shoot growth. Increasing fertilization rates caused the above ground shoot to produce mass at a faster rate than the roots (Figures 6 and 7). This was the case for all cell sizes. There were, however, significant differences between the root and shoot weights for the different cell sizes. The shoot weight differences in particular were greater than was indicated by the differences in height growth. An explanation for this difference in magnitude is the fact that the 10 in^3 cells produced seedlings with lateral branches, while the 4 in^3 cells did not. The lateral branches did not add to total height but did increase weights significantly. The root weights for all the fertilizer treatments in a given cell size were not found to be significantly different from one another. Increasing fertilizer rates had much less effect on root weights than on shoot weights.

Figure 6. Root and shoot dry weights for white spruce seedlings grown in two cell sizes at three fertilization rates.

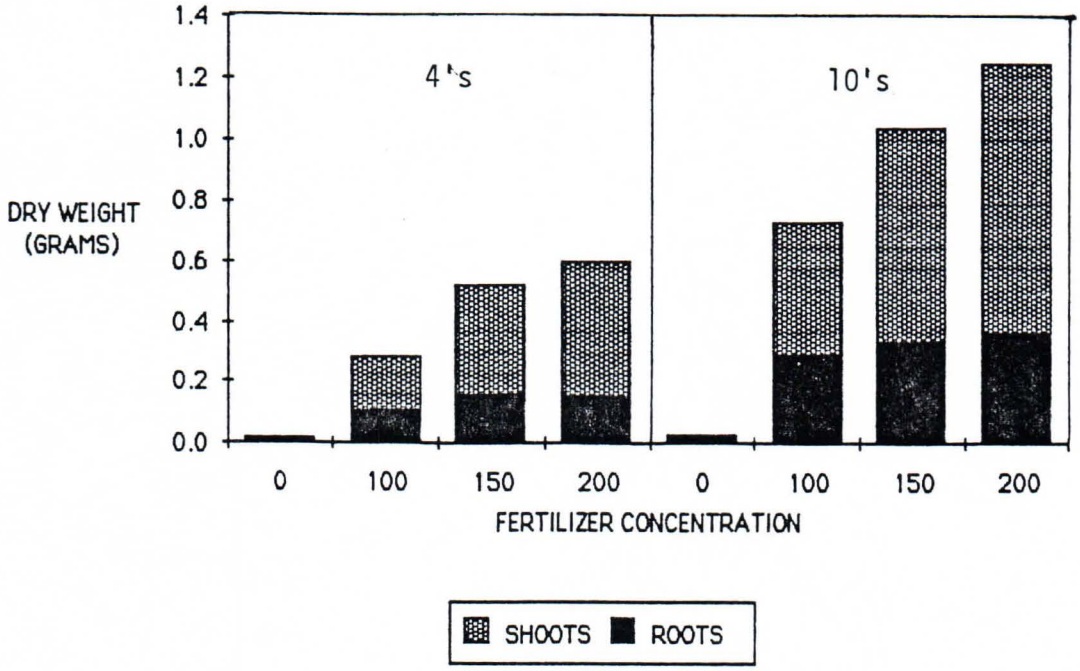
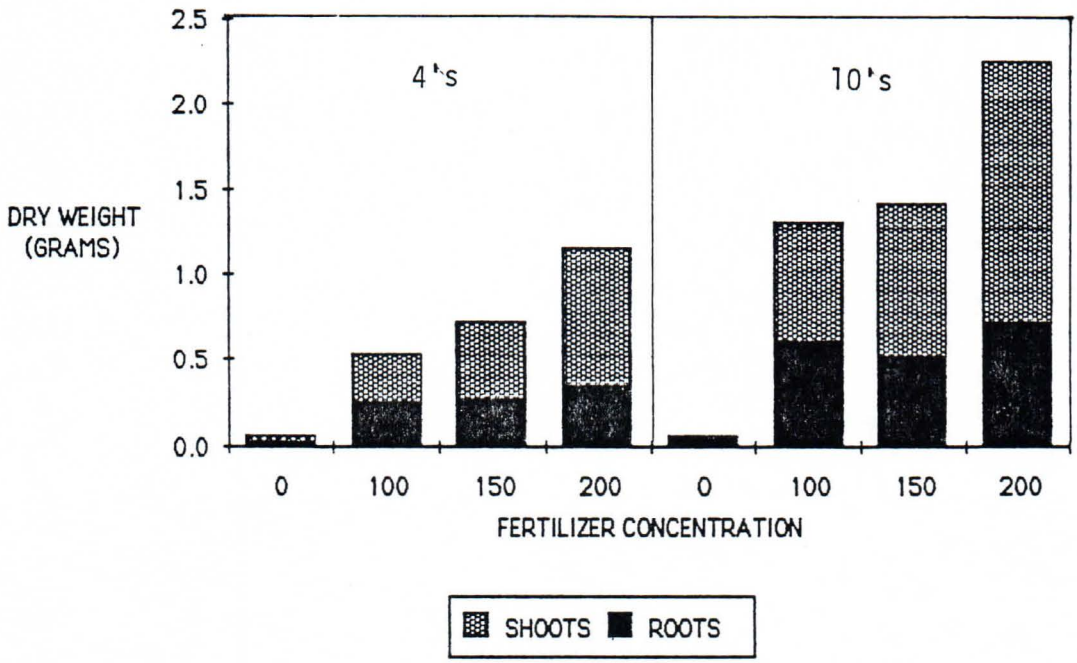


Figure 7. Root and shoot dry weights for lodgepole pine seedlings grown in two cell sizes at three fertilization rates.



Conclusions

Due to the longterm nature of the field study on the effects of the different fertilization rates, it is not possible to make a definitive statement on which rate and cell size is best. It will be at lease five years before any reliabel information will be available for analysis. However, some simple conclusions can be made concerning the growth results from the greenhouse portion of this study:

1. The 200 ppm N fertilization rate produced in almost all cases a significantly larger seedling than the lower rates.

2. The larger cell size produced a significantly taller and more massive seedling than the smaller cell.

3. The root-shoot ratio decreased as fertilization rates increased.

In applying the results of this study to the greenhouse production of white spruce and lodgepole pine seedlings, economics will have to be considered. Production costs for using a 200 ppm N fertilization rate and 10 in^3 cells will be increased. This will be caused by increased fertilizer costs, as well as by a reduction in the number of seedlings which can be produced. The large cells take up twice as much space as the small ones. On the other hand, costs may be decreased if a 6 month old seedling proves to be an acceptable alternative to 18 month old seedlings.

The willingness of the Division of Forestry to pay more money per seedling will depend a lot on the results of the field plantings. Growth responses which may be statistically significant in the greenhouse may not be of any practical significance in the field. An increase in height growth at the end of a 120 year rotation period for white spruce and lodgepole may not be worth the additional costs. With less money available to the state, benefits and costs will be closely examined from now on.