

Title: **Evaluating Additional Conifer Seedlings Grown in a Gravel Bed for Fall Transplanting**

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FINAL STATUS OF THE PROJECT

Experimental technique:

The experiment, using a gravel bed or field soil to grow conifer seedlings before transplanting to the field, was started on May 29, 2002. Seedlings (2-0 age) were planted in a gravel bed, 10 ft. by 12 ft. by 1.25 ft. or in field soil in a bed 10 ft. by 12 ft. Three conifer species, Austrian pine (*Pinus nigra*), Serbian spruce (*Picea omorika*), and white fir (*Abies concolor*), were planted with five plants of each species for the three transplant months (August, September, and October) in four blocks. Therefore, a total of sixty plants were used from each type of planting bed (gravel vs. field soil) for each species. To minimize root damage when transplanting, guard rows of seedlings were planted between the rows of experimental plants. The gravel bed and field bed were fertilized with Scott's Osmocote® Exact® the previous year (2002). Most of the white fir seedlings died in both the field and gravel beds, and this species was excluded from the transplant part of the experiment. A number of the Austrian pine and Serbian spruce seedlings also failed to survive after being transplanted to the gravel bed or field, so only two transplant months (September and October) were used in this study. On September 13 and 17 and then October 11, 2002, pine and spruce seedlings were dug from the gravel bed or field bed and transplanted to field soil. Transplanted seedlings became established and were grown for one season. On August 6, 2003, seedling heights were measured before the plants were cut off at ground level. Their stem diameters were measured at 3 cm from the cut at their bases. The stems were measure once and turned 90 degrees to get a second measurement. The measurements were averaged to obtain an average stem diameter for each plant. After completing the stem diameter measurements, the entire shoot for each plant was placed in a bag, which was placed in a drying oven for one week so that shoot dry weights could be determined. Shoot dry weights, average stem diameters, and plant heights were analyzed for differences in plant growth by using analysis of variance. Differences between treatment means were determined by using Least Squares Means at the 5% level.

Results and Discussion:

Pine and spruce seedlings differed in their abilities to survive fall transplanting (Table 1). For the most part, Austrian pine seedlings survived with minimal losses due to transplanting during different months. The type of growing bed (gravel versus soil) also appeared to have little influence in seedling mortality. In contrast, the type of growing bed made a strong impact

on the survival of Serbian spruce seedlings transplanted in fall (Table 1). Only half of the field-grown seedlings transplanted during September and October survived after transplanting to the field. All gravel bed-grown spruce seedlings transplanted in September survived, and only 16.7% (2 out of 12 plants) moved in October died. These results clearly show that the Serbian spruce were less tolerant of transplanting than the Austrian pines. In addition, the gravel bed growing system appears to have helped the Serbian spruce seedlings be better prepared for the transplant process in fall. The improved survival of gravel bed-grown Serbian spruce seedlings was probably due to the much larger root systems on these seedlings compared to those grown in the field (Figure 1).

Table 1. Percentage of Austrian pine and Serbian spruce seedlings that died after being transplanted from a field bed or gravel bed during early fall. Each percentage was based on 12 plants transplanted per treatment during each month unless noted.

Species	Treatment	Month	Percent Dead
Pine	Field	September	16.7
		October	8.3
	Gravel bed	September	8.3
		October	8.3
Spruce	Field	September	50 ^z
		October	50 ^z
	Gravel bed	September	0
		October	16.7

^zPercentage based on 6 plants.

The mean plant heights, average stem diameters, and mean shoot dry weights of Austrian pine seedlings were unaffected by the type of planting bed (gravel or field soil) the seedlings grew in before transplanting (Table 2). The lack of growth differences between the seedlings grown in either the gravel bed or field soil before transplanting was somewhat expected since ponderosa pine and Colorado spruce seedling grown in the two systems the year before also grew similarly after transplanting to the field. The root systems on the Austrian pine seedlings grown in the gravel bed were usually larger, based on visual observations (Figure 2), but the larger root systems apparently failed to result in increased shoot growth of these plants during the first year after transplanting. Perhaps the larger root systems would have had an impact on shoot growth if the study were continued a second year after transplanting.

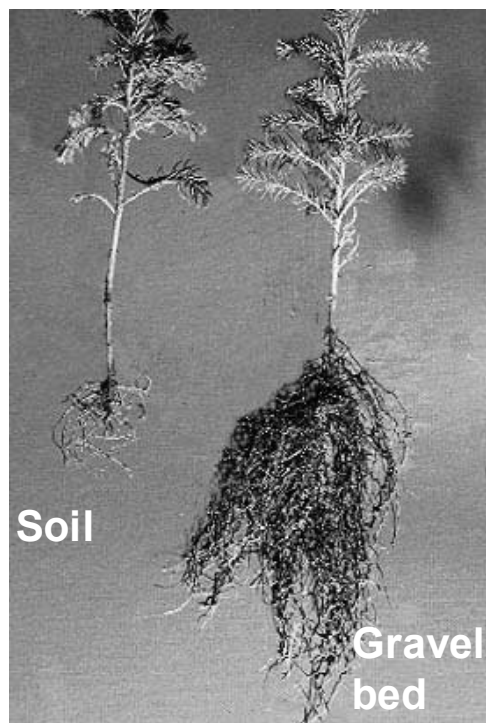


Figure 1. Root systems on 2-0 Serbian spruce seedlings grown for 19 weeks in field soil (left) or a gravel bed (right) before lifting. Plants with a “representative” (neither largest or smallest) root system for each treatment were used for this picture.

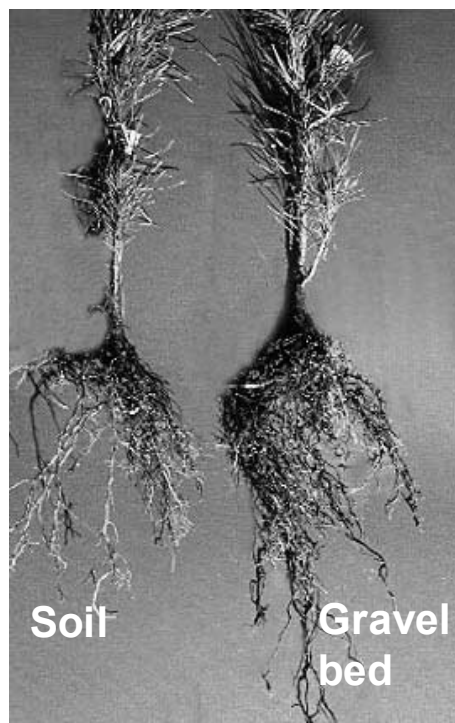


Figure 2. Root systems on 2-0 Austrian pine seedlings grown for 19 weeks in field soil (left) or a gravel bed (right) before lifting. Plants with a “representative” (neither largest or smallest) root system for each treatment were used for this picture.

Only the plant heights of the Serbian spruce seedlings were significantly affected by the growing system used before transplanting (Table 2). Statistical differences among the analyzed growth parameters for the plants grown in the different systems may have been more readily seen if more field soil-grown seedlings survived during the study. Based on the plants that survived, however, seedlings grown in the field and transplanted in October were about 14% shorter than those grown in the gravel bed and transplanted in either September or October. Interestingly, field-grown spruce seedlings transplanted in September were similar in height to those grown in the gravel bed. Although the statistical models for average stem diameter and shoot dry weight ($P = 0.1081$ and $P = 0.0668$, respectively) indicated that the transplant months and growing systems failed to influence these growth parameters on the spruce seedlings, the data indicated differences in plant growth. For instance, gravel bed-grown spruce seedlings tended to have slightly larger (about 1 mm) stem diameters and had close to double the amount of foliage, as indicated by shoot dry weights. These data for the spruce plants also indicated that field soil-grown seedlings were tall but had less foliage since they were close in height to gravel bed-grown seedlings but averaged about half of their shoot dry weights (Table 2). These differences in growth of the gravel bed-grown and field soil-grown seedlings after transplanting were probably due to the large differences in the sizes of the root systems between the two types of plants (Figure 1).

Table 2. Effects of pre-transplant treatment and transplanting month on plant height, average stem diameter, and shoot dry weight of Austrian pine and Serbian spruce seedlings. All data within a column and within a species were statistically similar, except for the plant heights of the spruce seedlings, which varied significantly among the treatments. All data were means based on 12 plants transplanted per treatment during each month unless noted.

Species	Treatment	Month	Plant height (cm)	Avg. Stem diameter (mm)	Shoot dry weight (g)
Pine	Field	September	34.5	7.9	18.0
		October	39.6	8.5	21.1
	Gravel bed	September	38.5	8.2	21.1
		October	36.6	8.0	18.6
Spruce	Field	September ^z	35.1 ab	4.5	6.7
		October ^z	30.8 a	4.1	4.8
	Gravel bed	September	36.2 b	5.7	12.0
		October	35.6 b	5.4	11.5

^zData based on 3 plants.

These results demonstrated that Austrian pine seedlings grew equally whether planted in field soil or a gravel bed as a pre-transplant treatment. In addition, these seedlings could be transplanted during either September or October with similar success. These results for Austrian pine were similar to those for ponderosa pine and Colorado spruce (completed in the first transplanting study), indicating that growing these species in a gravel bed before transplanting to the field in fall yields few, if any, advantages in improved field growth during the next growing season. In contrast, Serbian spruce seedlings grown in a gravel bed as a pre-transplant treatment survived much better after transplanting, having at most only one-third the mortality of plants grown first in field soil. In addition, gravel bed-grown Serbian spruce seedlings grew significantly taller and tended to have almost twice as much foliage. These results are interesting especially because the root system on gravel bed-grown seedlings was usually larger (based on visual observations) for both species, particularly for the Serbian spruce (Figure 1), compared to plants grown in field soil. Perhaps the growth of gravel bed-grown Austrian pine seedlings would have increased compared to soil-grown plant two years after transplanting. The gravel bed appeared to facilitate improved root growth for the Serbian spruce seedlings resulting in increased survival and shoot growth. Therefore, the gravel bed growing system may be useful as a pre-transplant treatment only for seedlings of species that are somewhat difficult to transplant.

Significance to the Nursery Industry:

Based on this research, 2-0 Austrian pine seedlings grown in a gravel bed or field soil grew similarly after they were transplanted to the field for growing to larger stock. Therefore, the gravel bed provided few readily apparent advantages over soil with regard to plant growth for Austrian pine. On the other hand, the gravel bed improved survival and growth of Serbian spruce seedlings after transplanting. Serbian spruce mortality, at least in our study, indicated that this species may be difficult to transplant, yet seedlings receiving the gravel bed pre-transplant treatment survived much better than those grown in the field first. Therefore, the gravel bed may provide an advantage for difficult-to-transplant species.

Growing seedlings in a gravel bed will most likely cost more than just transplanting seedlings into field soil, due to the cost of buying gravel and sand along with constructing a raised bed to hold the gravel. Even with these added costs, the gravel bed has some important advantages over field soil. First, the seedlings were very easy to lift out of the gravel with few roots lost. Second, the roots systems were larger in size; although larger root systems apparently failed to result in larger shoot growth after one growing season in the field (Table 2). The final advantage of using a gravel bed is that the root systems of harvested seedlings can be easily cleaned and prepared for shipment overseas or to quarantined areas. Since the sand and gravel can be completely and easily removed from root systems, seedlings grown in a gravel bed can be used for export to foreign markets. Root systems can be effortlessly washed and inspected. Fumigation treatments can be readily applied to lifted seedlings. Furthermore, seedlings lifted from the gravel bed grew at least as well as those grown in soil, so buyers of gravel bed-grown conifers can expect to purchase quality seedlings that will grow well when transplanted into their growing regimes. The bottom line is that growing 2-0 Austrian pine seedlings in a gravel bed would be worthwhile only if a grower needed to transplant seedlings in early fall or if the grower is shipping these conifers to quarantined areas or overseas markets. For difficult-to-transplant conifers, however, the gravel bed growing system may improve transplant survival and subsequent growth by promoting root growth on young seedlings.