Title: **Evaluating a Gravel Bed Growing System to Produce Conifer Seedlings 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 in before transplanting to the field, was started on May 11, 2001. Seedlings 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, ponderosa pine (*Pinus ponderosa*), Colorado spruce (*Picea pungens*), and white fir (*Abies concolor*), were planted with five plants of each species for the three transplant months (August, September, and October) planted 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® on June 28, 2002 and fertilized with Peter's (liquid) 30-10-10 at 100 mg/Liter N on August 1, 2002. Since most of the white fir seedlings died in the field and gravel bed, they were excluded from the transplant part of the experiment. On August 17, September 17, and October 16, 2001, 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 1, 2002, seedling heights were measured before the plants were cut off at ground level. Their stem diameters were measured at the base, and 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, stem diameters, and plant heights were analyzed for differences in plant growth by using analysis of variance.

Results and Discussion:

Pine and spruce seedlings survived fall transplanting equally well. In other words, survival results were similar for both treatments, gravel versus soil, but seedlings transplanted in August were most vulnerable to being moved during the hot weather (Table 1). For September, a few more pine seedlings originally grown in field soil died compared to those grown in the gravel bed, but these results were statistically similar. The same number of spruce seedlings transplanted in August died regardless of the original planting bed (soil versus gravel bed), but all spruce seedlings transplanted in September and October survived transplanting regardless of

Table 1. Percentage of ponderosa pine and Colorado spruce seedlings that died after being transplanted from a field bed or gravel bed during late summer and early fall. Each percentage was based on 20 plants transplanted per treatment during each month unless noted.

Species	Treatment	Month	Percent Dead
Pine	Field	August	22.2[z]
		September	15
		October	0
	Gravel bed	August	20
		September	5
		October	0
Spruce	Field	August	15
		September	0
		October	0
	Gravel bed	August	15
		September	0
		October	0

[z] Percentage based on 18 plants.

the original planting bed, indicating Colorado spruce seedlings generally tolerate September transplanting better than ponderosa pine seedlings.

The heights, stem diameters, and shoot dry weights of ponderosa pine seedlings and Colorado spruce seedlings were unaffected by the type of planting bed (gravel or field soil) the seedlings grew in before transplanting (Table 2). Although pine and spruce seedlings grown in the gravel bed tended to be taller after one growing season in the field compared to those first grown in field soil, their heights were statistically similar. For example, the mean height of the pine seedlings grown in the gravel bed before transplanting was 31.6 cm by the end of the growing season, but those grown in field soil before transplanting were 28.7 cm tall (mean height) by August 2002, regardless of the month the seedlings were transplanted. The difference in height between these means was slightly over one inch. Likewise for spruce seedlings grown in the gravel bed or field soil before transplanting, the mean difference in height between them was only about one inch (compare 28.4 to 26.0 cm, respectively) for plant heights averaged over months. Neither growing treatment (field or gravel bed) nor transplanting month affected stem diameters or shoot dry weights of the pine and spruce seedlings. Mean stem diameters and mean shoot dry weights were statistically similar for pine seedlings or spruce seedlings regardless of treatment and transplanting month (Table 2).

Table 2. Effects of pre-transplant treatment and transplanting month on plant height, stem diameter, and shoot dry weight of ponderosa pine and Colorado spruce seedlings. All data within a column and within a species were statistically similar. All data were based on 20 plants transplanted per treatment during each month unless noted.

Species	Treatment	Month	Plant height (cm)	Stem diameter (mm)	Shoot dry weight (g)
Pine	Field	August[z]	29.6	8.9	19.5
		September	28.3	9.0	19.3
		October	28.3	9.7	25.5
	Gravel bed	August	31.4	9.1	22.6
		September	33.8	9.8	24.4
		October	29.6	9.3	22.9
Spruce	Field	August	24.6	7.4	17.6
		September	27.2	7.3	15.8
		October	26.3	7.3	16.7
	Gravel bed	August	27.8	7.6	17.7
		September	30.0	8.1	17.2
		October	27.6	7.2	15.8

[z] August data based on 18 plants.

These results demonstrated that seedlings grew equally whether planted in field soil or a gravel bed as a pre-transplant treatment. In addition, August was the most difficult month for transplanting the pine and spruce seedlings since the highest numbers of seedlings died during this month, regardless of being grown in soil or gravel before transplanting (Table 1). Overall, this research has shown that growing ponderosa pine and Colorado spruce seedlings 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. Although gravel bed-grown seedlings of both species were roughly one inch taller by the end of one growing season after transplanting, these differences are probably of little biological significance. These results are interesting especially because the root system on gravel bed-grown seedlings was usually larger (based on visual observations) for both species compared to plants grown in field soil. Based on these results, an interesting question to ask is, what would the differences be in plant growth after two years of growing in the field (post-transplanting)? Perhaps growing the seedlings for one or two additional growing seasons after transplanting will enable gravel bed-grown seedlings to grow larger more quickly compared to those planted first in field soil. Unfortunately, this type of experiment would be impossible to complete under the current grant program (funding for only one year with work to be completed in one year).

Significance to the Nursery Industry:

Based on this research, 2-0 ponderosa pine and Colorado spruce seedlings grown in a gravel bed or field soil grew similarly after they were transplanted to a field for growing to larger stock. Therefore, the gravel bed provided few readily apparent advantages over soil with regard to plant growth. In fact, growing seedlings of these two species 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; however larger root systems apparently failed to result in better transplant survival (Table 1) or 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 ponderosa pine or Colorado spruce seedlings in a gravel bed would be worthwhile only if a grower needed to transplant seedlings in late summer or if the grower is shipping these conifers to quarantined areas or overseas markets.