Effects of Site Preparation Treatments on Seedling Survival and Growth in the ESSF Biogeoclimatic Zone – Project 3.02

SUMMARY

Four site preparation treatments — herbicide, herbicide plus shade cards, scalping, and scalping plus ripping — were compared with a control to test their effects on seedling survival and growth in the ESSF zone. Experimental plots of Engelmann spruce and lodgepole pine were established following site preparation.

In the control, mortality was found to be high for both species after three growing seasons: 60% for spruce and 68% for pine. The scalping and ripping treatments greatly reduced mortality (to less than 10%); the herbicide and shade cards treatments were less successful, experiencing high second and third season losses. Differences in the frequency and intensity of frost resulting from the various treatments appear to account for the differences in mortality. In the mechanical treatments, for example, frost occurred less frequently and with less severity than in the control.

All the treatments increased seedling diameter growth and soil water content. Reduced growth in the control was likely due to short periods of moisture stress in the surface organic layer, as well as to chilling during low night-time air temperatures.

INTRODUCTION

Over a 4-year period (1986–1989), this study investigated the effects of site preparation treatments on seedling survival and growth in the Very Dry Cold Engelmann Spruce Subalpine Fir (ESSFx) biogeoclimatic subzone. The research, part of Southern Interior FRDA Project 3.02, was carried out in a large cutblock at an elevation of 1670 m near Tsintuskw Lake (43 km NNW of Kamloops). The site is mainly level with a few minor drainage ways. The dominant vegetation is pinegrass and bluejoint reed grass. The block was cleared in 1981, but has since received no silvicultural treatment.

TREATMENTS

Four treatments were compared with a control (CTL, no site preparation): herbicide (HRB), herbicide plus shade cards (SHD), scalping (SCP), and scalping plus ripping (RIP). The treatments were applied uniformly to strips 12 m long by 3 m wide. Herbicide (30 mL glyphosate [Roundup®] per 100 m²) was applied to the herbicide treatments 2 or 3 times during the growing season to eliminate competing vegetation. This was done during the first 2 years following planting; after this no attempt was made to control competing vegetation. Shade cards 30 cm wide and 50 cm high were placed to the south of each seedling. The cards were positioned with the base at ground level and the top leaning to the north. The distance between the seedling and base of the card was approximately 15 cm. Scalloping with a front-mounted blade removed the surface organic layer. Ripping to a depth of 30–50 cm was done using two rear-mounted ripper shanks, with paths 30–40 cm apart.

In 1988, research on the ripped trenches was started and some of the results are included here. The trenches were made using a ripper shank with a heavy steel drag. The trenches were 20–30 cm deep and 40–60 cm wide at the top in both the scalping and control strips, with two trenches per strip. Trenches were finished by hand to ensure uniform geometry, and are narrower and deeper than nearby operational disk trenching treatments.

The experimental plots were located in a fenced area to prevent damage from livestock. Engelmann spruce (Se) and lodgepole pine (PI) 1+0 containerized (plug) stock was used in all the plantings. In spring 1986, site preparation was completed and Se seedlings were planted in a randomized complete-block design. In spring 1987, Se seedlings (plus PI seedlings in a control) were planted in an experiment identical to that in the previous year, except that the site preparation had been done in fall 1986. In spring 1988, Se and PI seedlings were planted in a single-block experiment. The site had been prepared in fall 1987.

RESULTS

Seedling Environment

Volumetric water content in the layer from 12 to 26 cm in the control and all treatments was usually around 28%, and never less than 22%. Significant reductions in seedling growth as a result of water stress are not expected until soil moisture content drops below 15% (-0.2 MPa) (see FRDA Memo 152). However, these measurements were made with a neutron probe centred at 19 cm and indicate only a mean water content in the 12–26 cm layer. Since volumetric water content usually increases with increasing depth, this method therefore overestimates the volumetric water content in the layer near the surface. If seedlings preferentially root in the upper layers, especially in the control and herbicide treatments where an organic layer remains, periods of water stress may occur.
Frost events (air temperature less than 0°C at 15 cm) were common throughout all the growing seasons, but were less frequent and less severe in the mechanical site preparation treatments than in the control. For example, from June to August 1988 there were two severe frosts (air temperature less than -4°C 15 cm above the ground) in the scalping treatment compared to 17 in the control. Air temperatures below -4°C have been found to cause frost injury in many actively growing conifers. It is assumed that the most critical period for frost injury is during bud-break and elongation, which occurs in late June and early July at this site. Severe frosts occur during this period in most years.

Average daily soil temperatures at the 5 cm depth were 2-3°C higher in mechanical treatments than in the control. The mean soil temperature at 5 cm in the control was 10°C. Further details on the occurrence of frost and its effects on seedlings is reported in FRDA Memo 181.

Seedling Mortality

Figure 1 shows the mortality of the Se and PI seedlings planted in 1987, measured at the end of the first, second, and third growing seasons since planting. Mortality occurring during the first and second winters have been included in the measurements at the end of the second and third growing seasons, respectively.

Mortality of the Se seedlings planted in the mechanical site preparation treatments (SCP and RIP) was much less than that of the seedlings in the control. The herbicide and shade card treatments both reduced mortality — the shade card treatment in particular. The scalping and ripping treatments resulted in no mortality until the second winter and third growing season; the shade card and herbicide treatments and the control resulted in significant mortality during the first winter and second growing season.

These results were very different to those obtained for the seedlings planted in 1986 and 1988. The 1986 seedlings were abandoned in the third growing season because of very high mortality in the control and herbicide treatments, and because of frost heave damage in the scalping treatments. However, mortality of all seedlings planted in 1988 (including the trenched seedlings) remained very low after two growing seasons.

As with the Se control seedlings, the PI seedlings planted in 1987 underwent significant mortality after three growing seasons, but, much of the PI mortality occurred during the first growing season.

Seedling Growth

Figures 2 and 3 show diameter and height growth of the Se and PI seedlings during the first 3 years following planting in 1987. The diameter of seedlings in all treatments after three growing seasons was significantly greater than that of seedlings in the control.

However, the growth of Se seedlings in the treatments was lower than that at the FRDA 3.02 MSXk site where a similar planting is being studied (FRDA Memo 167). Height growth at the two sites showed similar trends, except that at the ESSF site the height growth in the herbicide treatment was closer to that in the control rather than to that of the other treatments. The low growth rates and heavy leader damage caused by frost make it difficult to interpret this anomalous height growth in the herbicide treatment.

Frost damage to leaders caused a decrease in mean seedling height in the control after the second growing season. According to the results of the 1988 planting, both height and diameter growth in the trenched treatments compared favourably with the ripping treatment. Growth of seedlings planted in the 1988 scalping and ripping treatments was similar to that in the 1987 treatments. Herbicide and shade card treatments were not included in the 1988 planting.

The height and diameter growth of the control PI seedlings planted in 1987 was similar to that of PI seedlings planted at the MSXk site.

INTERPRETATIONS

In the control, mortality is high for both Se and PI after three growing seasons, 60 and 68% respectively. This mortality is much higher than that observed for these two species at the FRDA 3.02 site in the MSXk subzone, 14 and 5% respectively. Mortality in the shade card treatment was less than that in the herbicide treatment, but it was similar for these two treatments at the other two dry sites in the FRDA 3.02 study (FRDA Memos 166 and 167).
FIGURE 2. Height of Engelmann spruce and control lodgepole pine seedlings planted in 1987 at the ESSFxc site.

It is unlikely that moisture stress at this site was high enough to cause mortality. Furthermore, the trend in mortality is not similar to that of soil water content (FRDA Memo 162). Neither has winter damage been observed at this site. Seedlings in all treatments are usually covered by snow, so differences in mortality are not likely due to winter environmental conditions. Frost heaving and saturation of the soil in early spring do occur at this site, but they happen most often in the mechanical site preparation treatments and do not explain this trend in mortality. Measurements have shown that frost is less frequent and less severe in the mechanical treatments than in the control. In the herbicide and shade card treatments, frost occurrence would likely be intermediate. This trend is similar to that in mortality. Frost injury or chronic effects due to frequent chilling are probably a major cause of mortality at this site.

As all treatments increased seedling diameter growth and soil water content, it is likely that short periods of moisture stress in the surface organic layer and soil in the control reduced growth. However, as frost intensity and frequency are known to be less in the mechanical treatments and are probably less in the herbicide and shade card treatments than in the control, it is likely that frost or chilling due to low nighttime air temperatures are also involved.

FIGURE 3. Diameter of Engelmann spruce and control lodgepole pine seedlings planted in 1987 at the ESSFxc site.

CONCLUSIONS

- Mortality of both Se and PI seedlings is high in the control after three growing seasons.
- Little difference in mortality, height or diameter of Se seedlings is evident until after the second growing season.
- Ripping, scalping and trenching greatly reduce mortality.
- Differences in mortality appear to be due to differences in frost frequency and intensity produced by the treatments.
- Although soil water content is high at the 19 cm depth, it appears that soil water deficiency near the surface limits growth.
- The trenching treatment appears to result in increases in growth that are similar to those observed in the ripping treatment.

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