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A COMPARISON OF PHYSICAL, CHEMICAL, AND GENETIC CONTROLS TO REDUCE DEER BROWSE DAMAGE TO HYBRID POPLAR SEEDLINGS

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ABSTRACT: Deer browsing on commercially-grown hybrid poplar seedlings can inflict heavy damage to trees and reduce economic returns by deforming and/or stunting the growth of trees. A field trial was initiated on a 7,050 ha hybrid poplar plantation to evaluate the effectiveness of a physical barrier (Vexar tubing), a topical repellent (Plantskydd), a systemic repellent (SeO_2), and a less-palatable clone in reducing deer browse damage. The trial was conducted during the 1999 growing season in a recently harvested and replanted 6 ha unit. The four treatments were arranged along with a control in a randomized block design, with five blocks randomly arranged near the edge of the harvest unit where deer activity was concentrated. Terminal browse damage was assessed at two week intervals over a ten week period. Relatively little browsing occurred in any of the treatments during the first four weeks following planting. Vexar tubing provided superior protection ($P<0.05$) for seedlings at 6, 8, and 10 weeks following planting compared to all other treatments. The clonal treatment was browsed less ($P<0.05$) than the Plantskydd, selenium, and control treatments over the ten week evaluation period. However, overall growth rates for this clone were lower ($P<0.05$) than all other treatments, suggesting that this particular clone would not be beneficial from a fiber production standpoint. The results of this study suggest that Vexar tubing is an effective method of controlling deer browse damage to hybrid poplar seedlings. Use of genetically-resistant clones may provide some browse protection. However, growth rates of the clone tested did not perform well enough to consider using this clone on an operational basis.

KEY WORDS: deer browsing, genetic control, hybrid poplar, *Odocoileus hemionus*, physical barrier, *Populus*, repellent, wildlife damage

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INTRODUCTION

The potential for hybrid poplars (*Populus* spp.) to produce large amounts of biomass in a relatively short rotation period has resulted in efforts by several companies to establish large industrial plantations in the Pacific Northwest (Heilman et al. 1995). Unfortunately, some plantations have been established in either areas of high deer densities, or have created favorable habitat, thus resulting in increased deer densities. The effects of high deer densities on tree plantation establishment and forest regeneration has been thoroughly documented (Crouch 1976; Anderson and Loucks 1979; Marquis and Brenneman 1981; Alverson et al. 1988; Tilghman 1989; Witmer and deCalesta 1992). Deer densities as low as 4 deer/km^2 can inhibit regeneration of some tree species (Alverson et al. 1988). Deer browse damage to poplar plantations has resulted in stem deformation, stunted growth, and even plantation failure (Krinard 1973; Netzer 1984). This type of damage can have a substantial impact on site productivity, resulting in an economic loss in some cases (Weigand et al. 1993).

Lethal methods of control are not always necessary nor acceptable in today's "new era of vertebrate pest control" (Fall and Jackson 1998). Wildlife managers must continue to search for effective non-lethal approaches to wildlife damage management, such as repellents, physical barriers, and cultural methods. The objective of this study was to examine the efficacy of various chemical, physical, and genetic controls in reducing deer browse damage to hybrid poplar seedlings. Plantskydd was chosen as a topical repellent because it has been shown to reduce deer browsing on conifer seedlings (Nolte 1998). Selenium (SeO_2, 99%) was used as a systemic, soil drench treatment because it has been shown to effectively reduce deer browsing on Douglas-fir seedlings when applied in this manner (Rediske and Lawrence 1962; Allan et al. 1984). Likewise, the use of Vexar tubing to reduce deer browsing damage to conifer seedlings has been well documented (Anthony 1982; DeYoe and Schaap 1984). Clone 15-029 (Univ. of Wash./Wash. St. Univ.) was chosen for use as a genetic control because anecdotal evidence collected by the author has suggested that this clone receives less deer browse damage relative to other clones in adjacent plantations.

METHODS

Study Site

The study was located on a 7,050 ha commercial hybrid poplar plantation in the Columbia Basin of eastern Oregon. Elevations on the plantation ranged from 120 to 250 m, and average annual precipitation was 22 cm. The predominant land use in the region surrounding the plantation was irrigated agriculture. Parts of the plantation were also bordered by shrub-steppe vegetation. Mule deer (*Odocoileus hemionus*) densities in and around the study site were estimated by winter aerial counts previous to the study to be over 40 deer/km^2 (B. W. Moser, unpublished data).

The trial was conducted on a recently harvested 6 ha unit, bordered on the north, west, and east sides by six-year old plantations, and on the south side by shrub-steppe vegetation and irrigated farmland. Tree rows were oriented north-south, and spaced 3.05 m apart. The entire unit was hand-planted with 20 cm cuttings (clone OP-367) on 11 to 13 May 1999. Cuttings were planted 18 to 19 cm into the soil so that the terminal bud was flush with the soil surface. Cuttings were planted 2.3 m apart in rows, interspaced with the stumps from the previous tree crop. Stump resprouts were sprayed with glyphosate on 24 June 1999 in order to reduce competition for the new plantings. The unit was drip-irrigated from 11 May through 15 October 1999. Approximately 75 cm of water/ha were applied over the season, and a total of 100 kg/ha of nitrogen fertilizer were applied incrementally as an aqueous solution through the drip system during the growing season.

Procedures

The study was a randomized block design, with five blocks placed along the western edge and located randomly within the first ten rows of the harvested unit. Experimental plots within each block consisted of three rows of three seedlings (nine seedlings/plot), and were arranged adjacent to one another within the blocks. Five treatments (Plantskydd, selenium, Vexar, clonal, and control) were randomly assigned among each of the five experimental plots located within each block.

Plantskydd was prepared according to label instructions and applied to trees with backpack sprayers on 28 May 1999 and 24 June 1999. It was applied twice due to rapid growth of unprotected shoots. Selenium (SeO_2) was applied as an aqueous solution (100 mg SeO_2/100 ml water) to the soil around the base of each seedling. This treatment was applied on 28 May 1999 and 24 June 1999 in order to minimize the potential of phytotoxic effects of one large dose of selenium. A total of 200 mg of SeO_2 was applied to each tree in this treatment. Vexar tubing was applied to seedlings on 28 May 1999. A roll of 100 cm tall Vexar fencing was used to create tubes by cutting 61 cm sections and rolling them into 19 cm tubes. The ends of each tube were weaved together with a bamboo stake, and along with another stake were secured to the ground around the seedling. The genetic treatment, clone 15-029, was planted in place of clone OP-367, using the planting procedures described above.

Cumulative seedling damage was assessed at two-week intervals by determining the percentage of terminal leaders in each plot that were browsed by deer. Browsing on lateral branches was not measured because hybrid poplars normally grow out of this type of damage with relatively no effects on form, growth or diameter (B.W. Moser, unpublished data). On the other hand, terminal damage leads to deformities and stunted growth, both of which are unacceptable from a management standpoint. Therefore, only damage that would lead to a reduced economic value was considered (Reimoser et al. 1999).

Phytotoxic effects of repellents were evaluated qualitatively by examining leaf color and form immediately following application and every two weeks for the following ten weeks. In addition, tree heights were measured at 10 weeks and 20 weeks following planting to assess both phytoxicity as well as to aid in assessing the efficacy of the various treatments on tree health.

Data Analyses

A randomized block ANOVA with repeated measures was initially used to determine the potential effects of treatments and evaluation period on terminal damage to seedlings. There was a significant interaction ($P<0.0001$) between treatment and evaluation period. Therefore, a randomized block ANOVA was used to analyze differences among treatments at 2, 4, 6, 8, and 10 weeks following planting. A randomized block ANOVA was also used to assess differences in tree height among treatments at 10 and 20 weeks following planting. Tukey's multiple comparisons tests were used to isolate significant differences ($P<0.05$) among treatment means for all analyses. All percent data were arcsine-squareroot transformed prior to analyses (Steel et al. 1997)

RESULTS

Terminal Damage

Little browsing (<5%) was observed during the 2 weeks following planting and no differences ($P>0.05$) were observed among treatment means. Browsing of seedlings began to increase by 4 weeks (Figure 1). However, no differences ($P>0.05$) were observed among treatment means. Browse damage to terminal leaders at 6 weeks was lower ($P<0.05$) for the Vexar treatment, compared to all other treatment means (Figure 2). In fact, the Vexar treatment was the only treatment in which no browsing occurred. In addition, browse damage was lower ($P<0.05$) for the genetic treatment compared to the Plantskydd treatment and control (Figure 2). Similar patterns were observed during the next two observation periods. The first sign of browsing damage to Vexar-treated seedlings was observed at 8 weeks. Nevertheless, Vexar still reduced ($P<0.05$) browsing damage at 8 weeks compared to all other treatment means (Figure 3). Browsing on the genetic treatment was reduced ($P<0.05$) in comparison to the Plantskydd, selenium, and control treatments (Figure 3). Mean percentage of terminals browsed at 10 weeks was again lower ($P<0.05$) for the Vexar treatment compared to all other treatment means (Figure 4). Mean percentage of terminals browsed in the genetic treatment was lower ($P<0.05$) than the Plantskydd and selenium treatments, but not the control (Figure 4). The cumulative mean percentage of terminals browsed at 10 weeks following planting was 60.2% for Vexar, 84.4% for genetic, 97.6% for control, and 100% for both selenium and Plantskydd (Figure 4).

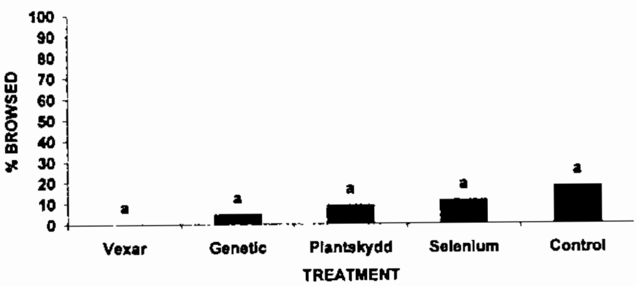

Figure 1. Mean percentage of hybrid poplar terminal leaders browsed by mule deer four weeks following planting. Means followed by the same letter are not different ($P<0.05$).

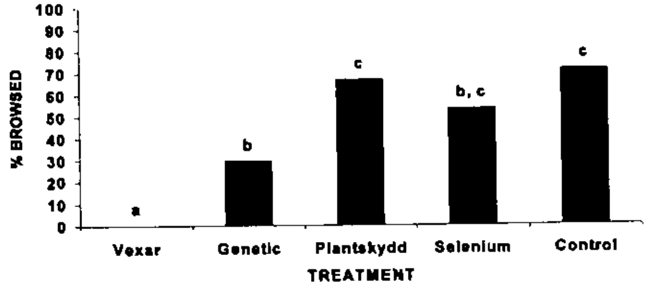

Figure 2. Mean percentage of hybrid poplar terminal leaders browsed by mule deer six weeks following planting. Means followed by the same letter are not different ($P<0.05$).

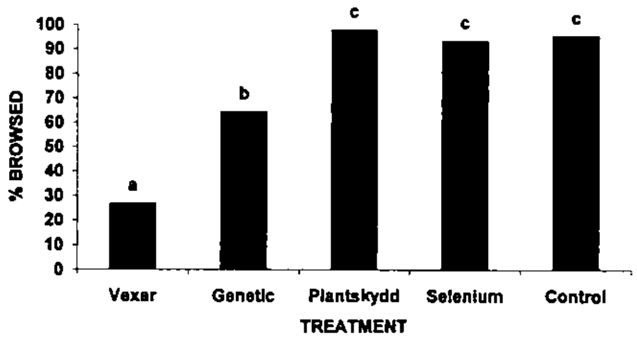

Figure 3. Mean percentage of hybrid poplar terminal leaders browsed by mule deer eight weeks following planting. Means followed by the same letter are not different ($P<0.05$).

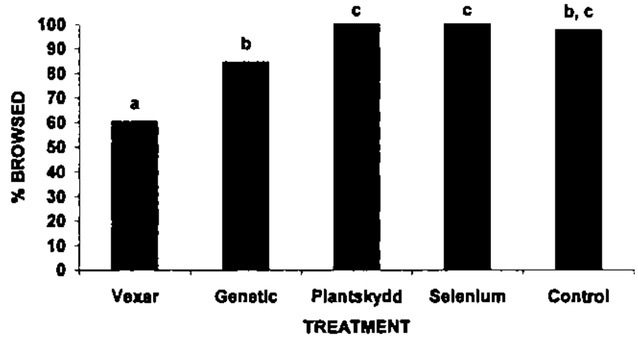

Figure 4. Mean percentage of hybrid poplar terminal leaders browsed by mule deer ten weeks following planting. Means followed by the same letter are not different ($P<0.05$).

Tree Heights and Phytotoxic Effects

Mean height (m) of trees 10 weeks following planting was greater ($P<0.05$) for Vexar compared to all other treatment means (Figure 5). In addition, mean height for the Plantskydd treatment was higher ($P<0.05$) than for the genetic treatment (Figure 5). Mean height at 20 weeks (end of growing season) was once again higher ($P<0.05$) for Vexar compared to all other treatment means (Figure 6). Mean height was lower ($P<0.05$) for the genetic treatment when compared to the Vexar, Plantskydd, selenium, and control treatments (Figure 6). End-of-season mean tree height for the Vexar treatment was nearly twice as great as any of the other four treatments (Figure 6).

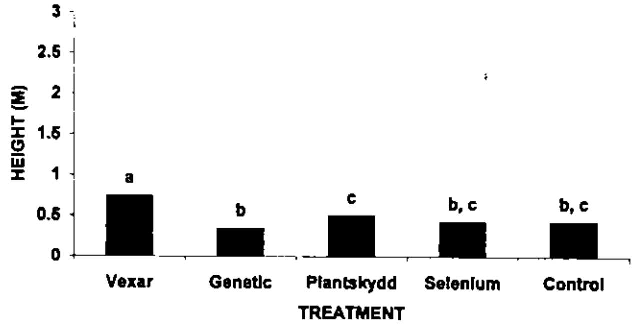

Figure 5. Mean height (m) of hybrid poplar seedlings ten weeks following planting (28 July 1999). Means followed by the same letter are not different ($P<0.05$).

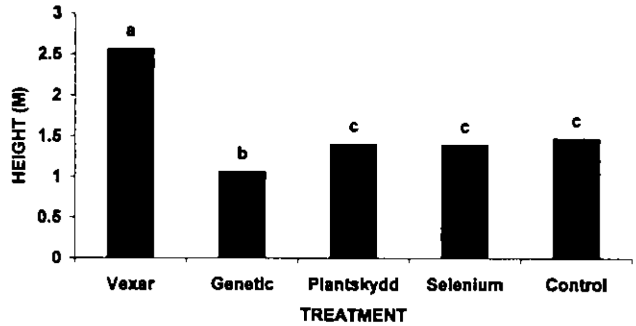

Figure 6. Mean height (m) of hybrid poplar seedlings 20 weeks following planting (28 September 1999). Means followed by the same letter are not different ($P<0.05$).

The leaves of trees treated with Plantskydd began to curl immediately following application. Trees were inspected 24 hours later and were found to have recovered completely. According to tree height data, this phytotoxic effect apparently had no impact on overall tree growth, at least when compared to the control. No other phytotoxic effects were observed for either the Plantskydd or selenium treatments.

DISCUSSION

Relatively little browsing occurred on any of the treatments during the first four weeks following planting. A probable explanation for this lack of browsing is that seedlings were relatively small during this time period, and difficult for deer to detect among the competing vegetation and stump resprouts. Furthermore, treatments were not applied to the seedlings until two weeks following planting, therefore no treatment effects would have been observable until the next observation period at four weeks. Stump resprouts and competing vegetation were sprayed with glyphosate at 4 weeks, effectively reducing vegetation around the test plots, and increasing visibility of the seedlings within the test plots. The results of this herbicide application on browsing of seedlings were readily apparent at the next observation period (Figure 2).

The Vexar treatment provided significantly greater protection for seedlings compared to all other treatments for the entire ten-week period. These results are consistent with other studies involving the use of Vexar to protect conifer seedlings (Anthony 1982; DeYoe and Schaap 1984). Seedlings in the Vexar tubing remained completely inaccessible to deer until eight weeks after planting, when some of the seedlings began to emerge from the tubes and became vulnerable to browsing. Nevertheless, even those seedlings that were browsed were vigorous enough to quickly grow beyond the reach of deer, which appeared to be around 1.5 m in this study. Anthony (1982) found that Vexar tubes frequently caused contorted leaders and stunted growth of ponderosa pine seedlings. However, no deformities on hybrid poplar seedlings were observed in this study.

The genetic treatment, clone 15-029, sustained less overall browse damage than the Plantskydd and selenium treatments. It is possible that this clone is less palatable to deer than the standard clone used in this study. However, the reduced rate of growth of this clone compared to the seedlings in the other treatments may have affected the level of browse damage sustained. The shorter form of these seedlings may have effectively hidden the trees among debris and competing vegetation, thus reducing browse damage. Nevertheless, cumulative browse damage was not different ($P > 0.05$) from that of the control during the ten-week period. In addition, the low growth rate of this clone may exclude it from consideration as an operational planting for fiber production.

The Plantskydd treatment appeared to have no impact on deer browsing of hybrid poplar seedlings, even though it has been shown to reduce deer browsing on conifer species (Nolte 1998). The lack of efficacy in this study was probably due to the rapid emergence of unprotected shoot growth from the terminal leaders. Howery et al. (1999) recognized this potential problem when applying Plantskydd to grape vines, and attempted to remediate it by applying the repellent every two weeks during the damage period. This frequency of application was not attempted in this study due to the high cost of actually treating operational plantings in this manner. As a result, browse damage was considerable to these seedlings. The rapid rate of growth of hybrid poplars would probably require a minimum application frequency of once per week in order to effectively reduce deer browsing, given that average growth of trees on this plantation is around 1.7 cm/day. This application frequency would inevitably be cost-prohibitive in most commercial plantations.

The selenium treatment did not reduce deer browsing on hybrid poplar seedlings in this study. Selenium has been shown to reduce browsing by deer on conifer seedlings at concentrations as low as 1 to 2 ppm (Allan et al. 1984). Seedlings in this study treated with selenium all exuded a noticeable garlic-like odor, indicating absorption of the selenium from the soil (Lewis et al. 1974; Vokal-Borek 1979). In addition, a composite sample of terminal leaves was taken from both the selenium-treated trees as well as the control trees on 28 September 1999 and analyzed for selenium content. Leaves of selenized trees had an average of 2.00 ppm selenium, while control trees averaged 0.17 ppm, indicating that the selenium had been absorbed into the seedlings. However, it appears that this level of selenium was not high enough to reduce browsing of hybrid poplars by mule deer in this study.

Perhaps the chemical treatments would have been more effective if the browsing pressure had been low to moderate. However, browsing pressure was relatively high in the study area, and as a result the repellent treatments were unable to reduce browse damage to an acceptable level.

The results of this study suggest that physical barriers are the most effective means of reducing the effects of deer browsing to hybrid poplar seedlings. Although expensive, physical barriers such as fences and Vexar tubing provide ample protection for seedlings during a critical period of development. Lack of protection during seedling development could result in plantation failure in some instances.

Further research should be done in the area of genetic development of resistant clones. It is possible that deer-resistant hybrid poplar clones exist that also provide the rates of growth needed to be considered for use in a commercial plantation.

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