A Weed Compaction Roller System for Use with Mechanical Herbicide Application

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ABSTRACT: *We designed, constructed, and field-tested a versatile and unique weed compaction roller system that can be used with mechanical herbicide application for invasive weed control in tree plantations, agronomic settings, and areas where localized flora and fauna are in danger of elimination from the landscape. The weed compaction roller system combined with herbicide application generally had greater vegetation control compared with using only herbicide treatments or the unsprayed control. The roller system-herbicide treatment combination showed substantial total vegetation control two growing seasons after application without impacting diameter growth of the crop trees, which supports the need for less frequent entries into the field. The cost of the roller system was approximately $300.00. North. J. Appl. For. 23(1):66–69.*

Key Words: Vegetation management, invasive weed control, *Agropyron repens*, *Cirsium arvense*.

Intensively cultured plantations of cottonwoods and their hybrids (*Populus* species, excluding the aspens and colloquially known as poplars) can augment the industrial fiber supplies in many regions of North America and have gained attention in the north-central United States (Husain et al. 1998). Interest in growing poplars like agronomic crops arose in the north-central region because the area contains substantial acreages of marginal farmland, where poplars grow approximately six to eight times faster than native quaking aspen and bigtooth aspen (*Populus tremuloides* Michx. and *P. grandidentata* Michx., respectively) (Riemenschneider et al. 2001, Netzer et al. 2002). In addition, there is a predicted shortage of native aspen in this region within 10–20 years due to a lack of aspen stumpage within harvestable diameter classes (Piva 2003).

Improper site management of poplar plantations can cause tree death, ensuing plantation failure, and substantial economic loss (Buhler et al. 1998). Thus, we view it essential to assess the effects of alternative site management strategies, including the use of mechanical and chemical techniques, if the inherent growth potential of the crop trees is to be realized (Hansen et al. 1994, Heilman and Norby 1998). Buhler et al. (1998) noted effective weed control can potentially double productivity. Marino and Gross (1998) reported highly significant growth reductions with increased levels of weed competition.

Common problems associated with the use of traditional, mechanical herbicide application systems are stripping, chemical waste, field accessibility, and cost. Mechanical between-row application systems require nozzles to be set high enough to obtain complete weed coverage. However, high nozzle settings often result in drift and spray contact with tree foliage, which ultimately causes damage to the crop trees. Stripping occurs when the spray booms are not set high enough to obtain full spray coverage or the height of the weeds exceeds the height of the spray boom, which shields much of the remaining weeds from receiving herbicide treatment. Excessive weed heights often render traditional spray equipment incapable of obtaining full weed coverage. Chemical waste, which is a major contributor to groundwater pollution in the north-central United States (Barbash et al. 2001), is attributed to factors such as overspray, the lack of immediate on-off switches or valves, and setting the spray boom to heights that make the spray more susceptible to drift. In addition, field accessibility for large equipment is cumbersome and may be restricted to the drier times of the year. Limited accessibility and inadequate weed control often lead to proliferation of invasive weed species. The combination of the aforementioned problems increases cost due to repeated application, misapplication, or both.

In an effort to address existing problems, we have developed and tested a weed compaction roller system for use with a four-wheeled all-terrain vehicle (ATV) to flatten and

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crimp invasive weeds prior to herbicide application (Wiese et al. 2001). The use of the roller system along with mechanical herbicide application reduces stripping, chemical waste, and problems of field accessibility. The roller system increases cost effectiveness by improving contact between the herbicide spray and targeted weeds while reducing drift, compared with current systems. We tested our weed compaction roller system along with numerous herbicide treatments to evaluate the efficacy of using the roller system in tree plantations and similar agronomic settings. The objectives of our field testing were to: (1) compare the effectiveness of vegetation management between our weed compaction roller system combined with mechanical herbicide application with using herbicide treatments alone and (2) evaluate whether our system combining roller and herbicide treatments reduced unintentional impact on crop trees as measured by their diameter growth.

Materials and Methods

Equipment Design and Use

The major equipment needed for our weed control strategy consisted of a standard four-wheeled ATV, spray boom with accessories, and our newly developed weed compaction roller system (Figure 1). The spray boom and roller system are attached to the ATV such that the roller assembly flattens and crimps the weeds immediately before the spray boom passes over the weeds, while releasing the herbicide treatment and providing full-spray coverage of the weeds with the chemical application.

Our recommended specifications of the ATV include the capability of four-wheel drive and a minimum of a 240-cc (15-horsepower) engine. The ATV is used to pull the spray boom and roller system over the target area prior to herbicide application. The spray boom should have adjustable height settings, flat-fan spray nozzles, a holding tank with an electric pump (or a carbon dioxide (CO_2)-pressurized system), and chemical-resistant hose. The height-adjustable spray boom is positioned to obtain full coverage while being located close enough to the ground to reduce the amount of spray drift. The spray nozzles, available in numerous fluid-dispersant angles, are used to meet specific needs. We recommend using flat-fan spray nozzles because of their inherent accuracy during herbicide application. Our rear-mounted CO_2-pressurized system (Bellspray, Inc., Opelousas, LA) is able to apply a variety of herbicide mixtures by opening a valve specific to the canister positioned across the back of the ATV. The roller system consists of square tubing to provide strength and rigidity, high-travel gas shock absorbers that force the roller system to maintain continual contact with the ground while traversing uneven terrain, and a 10.2-cm diameter × 1.2-m long roller with crimping bars to flatten the weeds (Figure 2). In addition, roller extensions may be used for wider coverage applications.

Other components used for greater efficiency include an on-off control switch that regulates the transfer of chemicals through the hoses to the nozzles and an electric winch, rated at 907 kg, for lowering and raising the roller system before and after use. The winch is helpful for transport between plantings and rows within plantings.

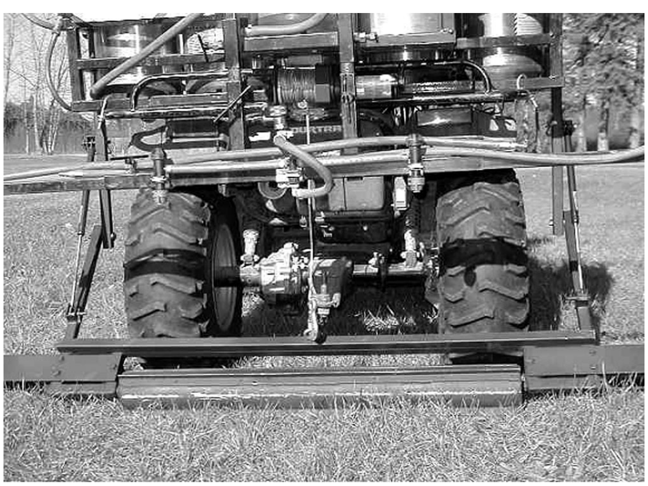

Figure 1. Complete weed control system consisting of a standard four-wheeled all-terrain vehicle, spray boom with accessories, and newly developed weed compaction roller system.

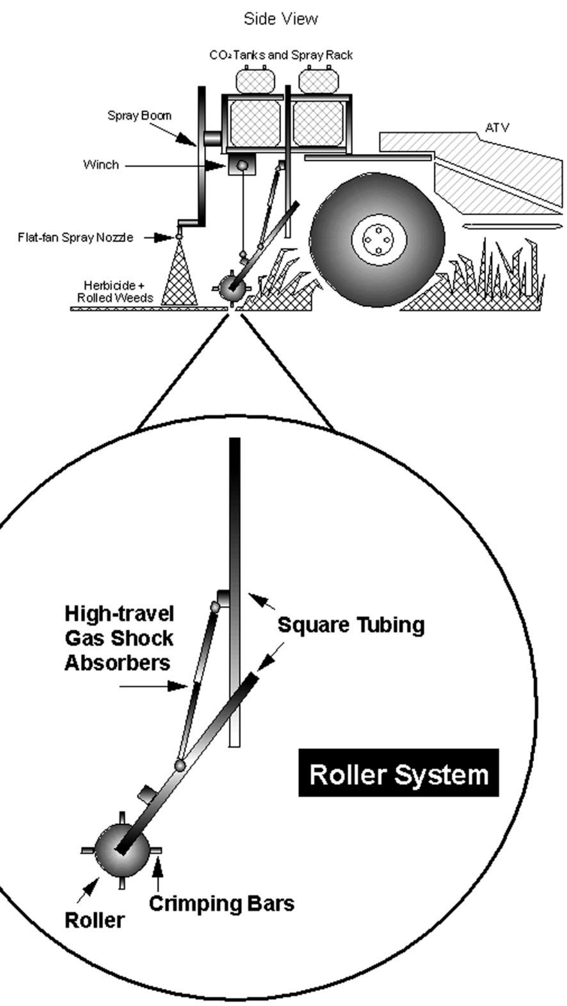

Figure 2. Diagram of the weed compaction roller system used along with mechanical herbicide application for greater coverage and weed control than herbicide application alone.

Field Testing

The study site was located in a 3-year-old poplar plantation, having a spacing at planting of 2.4 × 2.4 m, near Birchdale, Minnesota (48.6° N, 94.1° W). Limited accessibility and inadequate weed control supported intensive invasion of quackgrass (*Agropyron repens* (L.) Beauv.) and Canada thistle (*Cirsium arvense* (L.) Scop.) that measured well above 1 m in height. The plantation consisted of commercial clones NM6 (*Populus nigra* L. × *P. maximowiczii* A. Henry) and DN34 (*P. deltoides* Bartr. ex Marsh × *P. nigra* 'Eugenei'). The experimental design consisted of two blocks and 18 treatments per block. Herbicide treatments, applied with and without the use of our weed compaction roller system, consisted of Accord (glyphosate) at two rates and tank-mixed Accord with various combinations of Milestone (azafeniden), Scepter (imazaquin), and Squadron (imazaquin + pendimethalin). An unsprayed control also was tested (Figure 3).

The percent of total, broadleaf, and grass vegetation controlled was estimated in July of 2001 and 2002 to test the effectiveness of the treatments. The vegetation data were subjected to analyses of variance according to SAS (PROC GLM; SAS Institute 2000) assuming a model with a random block effect and fixed effects for year and treatment. Furthermore, diameter at breast height (dbh; 1.4 m above the ground) was measured twice during the 2002 growing season and once after the 2003 growing season on 20 trees per block and treatment. Interior trees were measured to avoid edge effects (Hansen 1981, Zavitkovski 1981). The diameter data were subjected to analyses of variance according to SAS (PROC GLM; SAS Institute 2000) assuming a split-plot-repeated-measures design and a model with a random block effect and fixed effects for treatment (whole plot) and sampling date (sub plot), which was the repeated measure. Fisher's protected least significant difference (LSD) was used to separate means of main effects when no higher-order interactions were present (Carmer and Walker 1982).

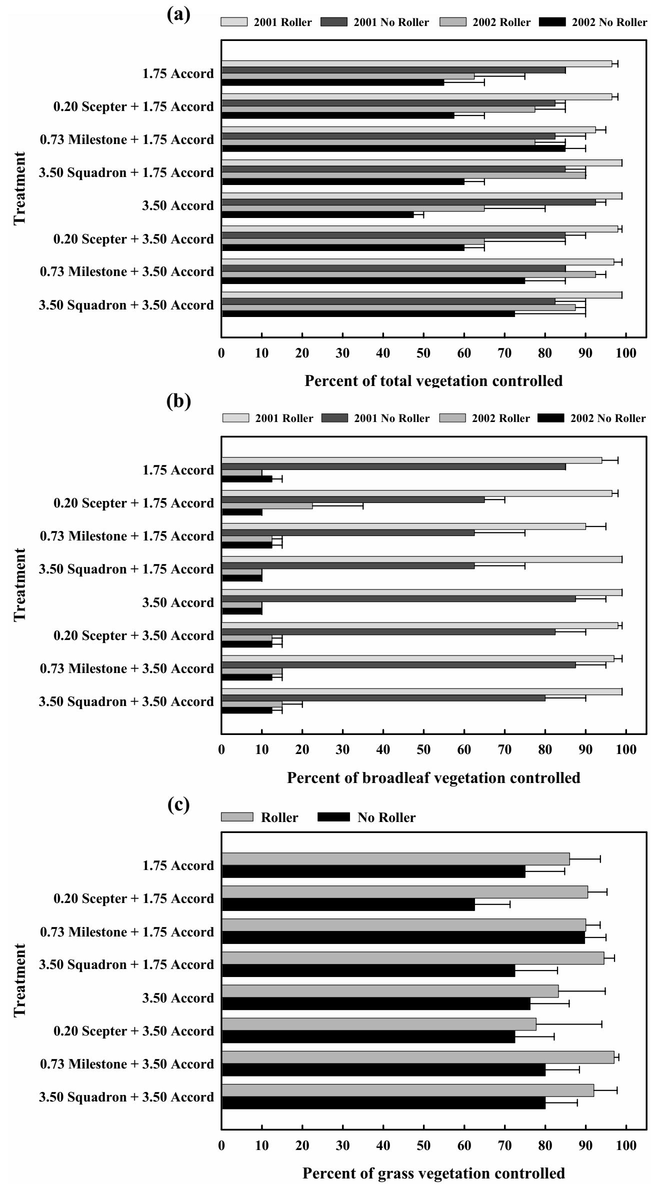

Figure 3. Percent of total vegetation (a), broadleaf vegetation (b), and grass vegetation (c) controlled in 2001 and 2002 following application of eight herbicide treatments with and without the use of a weed compaction roller system in a 3-year-old poplar plantation near Birchdale, Minnesota, during 2001. An unsprayed control treatment with and without the roller exhibited no vegetation control. Herbicide rates are expressed as L·ha^{-1}. Each bar represents the mean of two blocks (a and b) and four blocks (c) with one standard error. Generic names for the herbicides are as follows: Accord concentrate, glyphosate; Milestone, azafeniden; Scepter, imazaquin; and Squadron, imazaquin + pendimethalin.

Results

Vegetation Control

The interaction between year and treatment was significant for the percent of total vegetation controlled ($P = 0.0336$) and the percent of broadleaf vegetation controlled ($P < 0.0001$), but negligible for the percent of grass controlled ($P = 0.1037$). Therefore, the data for the grass variable were pooled across years. All treatments utilizing the roller in 2001 exhibited greater total vegetation control than those without the roller (Figure 3a). Similar results existed for 2002, except for one treatment (0.73 Milestone + 1.75 Accord) where the roller (78 ± 8) was less effective than not using the roller (85 ± 5) for the percent of total vegetation controlled. The percent of broadleaf vegetation controlled showed similar trends of greater control with the roller than without the roller in 2001, but the effectiveness of the roller diminished following the second growing season (2002) after herbicide and roller application (Figure 3b). In addition, all treatments utilizing the roller exhibited greater grass vegetation control than those without the roller, across years (Figure 3c).

Tree Diameter Growth

The main effect of treatment and the interaction between treatment and sampling date were negligible for dbh ($P = 0.3270$ and $P = 0.9999$, respectively). However, the main effect of sampling date was significant for dbh ($P < 0.0001$). Thus, despite an initial hypothesis that the effectiveness of the roller may cause increased herbicide damage to the trees and a subsequent decrease in diameter growth, the diameter across treatments increased with later sampling dates. Diameter at breast height was 3.6 ± 0.1, 5.6 ± 0.1, and 7.3 ± 0.1 cm for the first, second, and third sampling date, respectively ($LSD_{0.05} = 0.2$, $n = 360$).

Discussion

The effectiveness of vegetation management was greater with the use of the weed compaction roller system along with mechanical herbicide application compared with using herbicide alone or the unsprayed control, with the exception of one treatment. Similar results were reported for pussy willow (*Salix discolor* Muhl.) and common osier (*S. viminalis* L.), where plots that were mechanically and chemically treated exhibited less weed biomass than those that only were treated chemically or not treated at all (Labrecque et al. 1994). The roller system-herbicide treatment combination showed substantial total weed control two growing seasons after application. Therefore, we believe deployment of this new technology with known herbicide practices supports better opportunities for increased weed control with fewer overall entries into the field. Also, given the similar nature of the culture of poplars and many agronomic crops, we believe our system shows promise for agronomic settings. In addition, we believe our system can greatly increase the effectiveness of weed control along roadside ditches and other areas where native, localized flora and fauna are in danger of elimination from the landscape due to competition from invasive species (Yahner et al. 2001).

A reduction in dbh of the crop trees was a concern due to the increased weed control with the use of the roller system. We hypothesized such increased weed control may cause the herbicides to penetrate the soil and come into contact with the tree root systems, ultimately reducing dbh. In contrast, our results showed no effect of residual herbicide on the diameter growth of the trees. Nevertheless, future studies should be conducted to test for potential impacts of the chemicals on the root systems and diameter growth over extended periods of use because of greater weed control effectiveness. Studies conducted to identify comparable weed control effectiveness at reduced herbicide application rates will be beneficial to decrease the potential harm of residual chemicals to aboveground and belowground tree components, along with reducing overall costs of vegetation management associated with frequency of entries into the field and amount of chemical waste.

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