Transactions of the Illinois State Academy of Science
(2013) Volume 106, pp. 35-37

received 1/26/13
accepted 9/17/13

The Effects of the Herbicides Aminopyralid and Glyphosate on Growth and Survival of *Dipsacus laciniatus* (Dipsacaceae) Rosettes with Different Taproot Diameters

Rachel Damos and J.A.D. Parrish
Millikin University, Decatur, IL

ABSTRACT

Cutleaf teasel (*Dipsacus laciniatus*) is invasive to native flora in the northeastern United States. We compared the effectiveness of control by the herbicides aminopyralid (Milestone®) and glyphosate (Roundup®). We expected plants with smaller taproot diameters to be more susceptible to the herbicides, and aminopyralid to be more effective than the more general herbicide, glyphosate. We transplanted 228 plants into pots in the Millikin greenhouse and divided them into three groups according to taproot diameter. We randomly assigned plants of each size into three treatment groups to be sprayed with aminopyralid, glyphosate, or water only. Ten weeks after treatment, we dried and weighed all plants. All plants treated with aminopyralid died. Plants treated with glyphosate had higher survival with larger taproots. We conducted a second experiment to determine if aminopyralid was successful at half the concentration and again, all plants treated with aminopyralid died. Future studies could further decrease aminopyralid concentrations and test aminopyralid in the field.

INTRODUCTION

Dipsacus laciniatus, commonly referred to as cutleaf teasel, is an invasive monocarpic perennial in the Midwestern United States (Glass 2009) that has become a threat to native species (Solecki 1991, Huenneke and Thomson 1994) and is categorized as a noxious weed (USDA 2008). Teasel exists as a basal rosette for at least two years (Werner 1975) that reaches a diameter of approximately 30 cm which is effective in shading nearby growth. When conditions are optimal (Vitalis et al. 2004), a flowering stalk grows from the rosette and can produce 1,300 to 33,500 seeds (Bentivegna 2006). Between 28-86% of the seeds germinate, and 6% are still viable after three years (Bentivegna and Smeda 2011). Seeds are dispersed easily by means of mowing, bird feces (Werner 1979), and vehicular traffic (Solecki 1991). Its well-defined taproots reach depths of 75 cm with diameters of 5 cm (Werner 1975). As a common roadside plant, teasel has a competitive advantage because it can tolerate high levels of roadside contamination (Beaton and Dudley 2004).

As teasel abundance increases, development of an effective and inexpensive control method has become more essential. Methods include mowing, digging up the taproot, burning, and herbicides. The effectiveness of mowing is limited, as it must be completed mid-growing season, after the flowering stalk has bolted from the rosette, but before the seeds are viable (Dudley et al. 2009). Digging up the taproot is effective, but is unrealistic to use on large populations of teasel because it is too labor intensive (Glass 2009). Burning teasel is not an effective method because teasel rosettes resist fire (Solecki 1991). A prairie fire is actually beneficial to teasel because many other plants will die in the fire, decreasing the competition for teasel, which forms dense monocultures that are green early and late in the growing season. Natural control through insects, fungi, mites, viruses, and nematodes has been studied but further research is still necessary (Sforza 2004, Rector et al 2006). Further studies are also necessary on herbicide use as a control method for teasel, because results have been inconsistent (Werner 1979, Glass 1991, Dudley et al. 2009; Zimmerman et al. 2013).

We decided to further investigate herbicide use. We chose to study glyphosate, the active ingredient in widely used herbicides with low toxicity to mammals (Appleby 2005), such as Roundup®, because previous studies with glyphosate have shown inconsistent results of success (Werner 1979; Glass 1991; Zimmerman et al. 2013). We also included aminopyralid, the active ingredient in Milestone® in our study because of its specificity. Our first objective was to determine if there is a relationship between taproot diameter and ability of rosettes to survive herbicide treatment. We hypothesized that there would be a positive relationship between survival rates and increasing taproot diameter. Our other objective was to compare success of a general herbicide (glyphosate) and a specific herbicide (aminophyralid). As indicated on the herbicide labels, Milestone® is specifically formulated to target invasive broadleaf species, whereas Roundup® gives broad-spectrum control. Therefore, we hypothesized that aminopyralid would be more effective at killing teasel rosettes than glyphosate.

METHODS

From 15 September 2010 to 28 October of 2010, we collected and measured the diameter of 228 teasel rosettes from two collection sites in Illinois, the barrow pit on East Boyd Road, Macon County, and a field between Clinton Lake and 1700 East Road, DeWitt County. We transferred rosettes into 4L pots in the greenhouse of Leighty-Tabor Science Center on Millikin University's campus. All rosettes were given at least two weeks to recover from transplanting shock.

On 18 November 2010, we split the rosettes into three groups of 57 according to taproot diameter: small (0.1 cm - 1.0 cm), medium (1.5 cm – 2.5 cm) and large (≥ 3 cm). Within each size group, we randomly assigned rosettes to three treatments; sprayed with aminopyralid (n = 19), sprayed with glyphosate (n = 19), or sprayed with tapwater (n = 19). We calibrated two backpack sprayers and prepared the treatments by the recommended rate on the herbicide labels. We prepared one sprayer with 114 mL of glyphosate and 3.79 L of tapwater and the other sprayer with 3 mL of aminopyralid and 3.79 L of tapwater. We added 5 mL of Dawn® dishwashing liquid as a surfactant for each solution. We applied herbicide until the rosette leaves were covered, but not dripping. Then we randomly placed all rosettes on three benches in the greenhouse to prevent positional effects. After 12 days, we quantified the damage to each rosette using a five-point damage scale. Ten weeks after the treatments, we dried and weighed the above ground rosettes and the roots.

For a second experiment, beginning 28 January 2011, we split our remaining unused 57 rosettes into small (0.1 cm – 1.5 cm) and large (≥ 1.6 cm) according to taproot diameter. Our sample size would have been low had we used three groups, as in the first experiment. Within each size group, we randomly assigned rosettes to be sprayed with Milestone® or to serve as a control (no spray). We used a previously calibrated sprayer to apply half the recommended rate of aminopyralid. The protocol for the rest of the second experiment followed that of the first experiment.

We used the same methods for statistical analysis in both experiments. We used a 3(sizes) x 3(treatments) x 2(plant parts) on SPSS to compare the herbicide treatments among the sizes for both rosettes and roots and multiple t-tests to compare means within treatments or sizes. Since we used multiple t-tests, we used $P < 0.03$ for significance.

RESULTS

In the first experiment, a visual inspection at 12 days showed glyphosate appeared to be the more effective herbicide. Rosettes were green only in the center, while rosettes sprayed with aminopyralid were merely curled. However, after 10 weeks, many of the rosettes sprayed with glyphosate had recovered. There were significant differences in biomass of the rosettes (Fig. 1) and the roots (Fig. 2) among treatments at all sizes. The control group had the highest biomass for roots and rosettes whereas aminopyralid had the lowest. There were also significant differences among size groups in each of the treatments (Fig. 1 and 2). Roots and rosettes that started out largest had the highest ending biomass. There was not a significant difference between large roots treated with glyphosate and large roots in the control group. All other t-tests between treatment groups of the same size classes showed significant differences for both roots and rosettes at $P < 0.03$. All controls survived while none sprayed with aminopyralid survived. In rosettes sprayed with glyphosate, the survival rate increased as the taproot diameter increased (small 64.7%; medium 77.8%; large 82.4%).

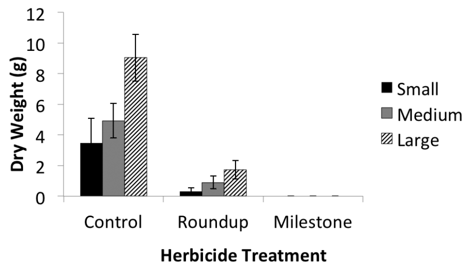

Figure 1. Dry weights ± 2 SE for *Dipsacus laciniatus* above ground rosettes 10 weeks after treatment. General Linear Model (3x3x2) on SPSS showed statistically significant differences among means for both herbicide treatments and taproot diameters ($P < 0.001$).

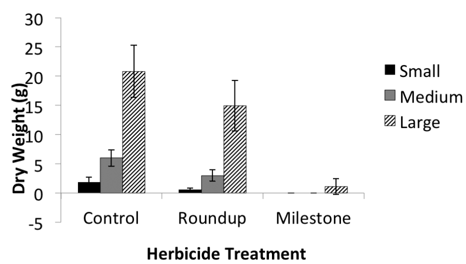

Figure 2. Dry weights ± 2 SE for *Dipsacus laciniatus* roots 10 weeks after treatment. General Linear Model (3x3x2) on SPSS showed statistically significant differences among means for both herbicide treatments and taproot diameter ($P < 0.001$).

In the second experiment with half the recommended concentration of aminopyralid, treatments were significantly different from controls for both roots and shoots at $P < 0.03$ (Fig. 3 and 4). Again, all controls survived and none sprayed with aminopyralid survived.

DISCUSSION

We expected plants with smaller taproot diameters to be more susceptible to the herbicides, and aminopyralid to be more effective than glyphosate in controlling teasel. Both hypotheses were supported. Glyphosate was not effective at killing rosettes,

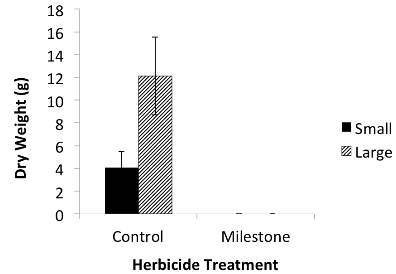

Figure 3. Dry weights ± 2 SE for *Dipsacus laciniatus* above ground rosettes from second experiment with half the recommended concentration of Milestone® (aminopyralid). General Linear Model (2x3x2) on SPSS showed statistically significant differences among means for both herbicide treatments and taproot diameters ($P < 0.03$).

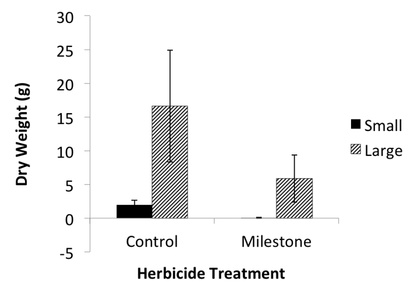

Figure 4. Dry weights ± 2 SE for *Dipsacus laciniatus* roots from second experiment with half the recommended concentration of Milestone® (aminopyralid). General Linear Model (2x3x2) on SPSS showed statistically significant differences among means for both herbicide treatments and taproot diameters ($P < 0.03$).

supporting results of an earlier field study (Zimmerman et al. 2013) and contradicting two earlier studies (Werner 1979; Glass 1991). There was a positive relationship between survival rates of rosettes sprayed with glyphosate and increasing diameter of taproot. Aminopyralid was effective at all taproot diameters at the recommended rate and at half the recommended rate.

We determined survival rates by dry weights of teasel rosettes. In each experiment, some of the large roots were still present even when rosettes were dead. Although we weighed these roots, we doubt they were capable of producing healthy new rosettes, because the roots showed signs of decay. The taproots were rubbery and the epithelial layer was gone or not secured to the root.

Herbicide labels suggested that effects of the herbicides would occur within two weeks. After 12 days, damage was more apparent in rosettes sprayed with glyphosate than rosettes sprayed with aminopyralid. However, over time, many of the rosettes sprayed with glyphosate recovered, while all the rosettes sprayed with aminopyralid died. Visual damage at 12 days was not predictive of survival rates. Many rosettes treated with glyphosate recovered, although in a deformed state. Further study over a longer duration is needed to determine whether those rosettes would be able to flower and produce seeds.

An effective teasel control strategy should cause little disturbance to the surrounding habitat. Herbicides often damage native, non-target species (Werner 1979; Glass 1991). Application of herbicides to rosettes in late fall or early spring may reduce effects on non-target species when most other plants are not photosynthetically active but teasel is (Bentivegna and Smeda 2008, Dudley et al. 2009). Since aminopyralid is effective on teasel at half the recommended rate, it may not be as harmful to native species, especially because it targets species such as teasel. With this specificity and low concentrations necessary for effective control, the treatments could be applied at any time of the year. When our teasel rosettes were transplanted, some of the surrounding vegetation was also transplanted, resulting in inadvertent inclusion of other species in the pots. In the second experiment, after rosettes in the treatment group died, other species in the pots continued to grow. Future studies should test lower concentrations of aminopyralid in the field and directly test its effects on non-target native vegetation. Our results provide support for aminopyralid use as an effective control agent for cutleaf teasel.

LITERATURE CITED

Appleby, A.P. 2005. A history of weed control in the United States and Canada – a sequel. Weed Science 53:762-768.

Beaton, L.L. and S.A. Dudley. 2004. Tolerance to salinity and manganese in three common roadside species. International Journal of Plant Sciences 165:36-51.

Bentivegna, D.J. 2006. Biology and management of cut-leaved teasel (*Dipsacus laciniatus* L.) in central Missouri. M.S. thesis. Columbia, MO: University of Missouri. p. 67.

Bentivegna, D.J. and R.J. Smeda. 2008. Chemical management of cut-leaved teasel (*Dipsacus laciniatus*) in Missouri. Weed Technology 22:502-506.

Bentivegna, D.J. and R.J. Smeda. 2011. Cutleaf teasel (*Dipsacus laciniatus*): Seed development and persistence. Invasive Plant Science and Management 4:31-37.

Dudley, M.P., J.A.D. Parrish, S. Post, C. Helm, and R.N. Wiedenmann. 2009. The effects of fertilization and time of cutting on regeneration and seed production of *Dipsacus laciniatus* (Dipsacacae). Natural Areas Journal 29:140-145.

Glass, W.D. 1991. Vegetation management guidelines: cut-leaved teasel (*Dipsacus laciniatus* L.) and common teasel (*Dipsacus sylvestris* Hubs.). Natural Areas Journal 11:213-214.

Glass, W.D. 2009. Vegetation management guideline cut-leaved teasel (*Dipsacus laciniatus* L.) common teasel (*Dipsacus sylvestris* Huds.) Available online <http:www.inhs.illinois.edu/research/VMG/teasel.html>.

Huenneke, L.F., and J.K. Thomson. 1994. Potential interference between a threatened endemic thistle and an invasive nonnative plant. Conservation Biology 9:416-426.

Rector, B.G., V. Harizanova, R. Sforza, T. Widmer, and R.N. Wiedenmann. 2006. Prospects for biological control of teasels, *Dipsacus* spp., new target in the United States. Biological Control 36:1-14.

Sforza, R. 2004. Candidates for the biological control of teasel, *Dipsacus* spp. In: J. M. Cullen, D. T. Kriticos, W. M. Lonsdale, L. Morin, and J. K. Scott editors. Proceeding of the XI international symposium of biological control of weeds. CSIRO Entomology, Canberra. Pp. 155-161.

Solecki M.K. 1991. Cut-leaved and common teasel (*Dipsacus laciniatus* L. and *D. sylvestris* Huds): profile of two invasive aliens. Pp. 85-92 in B.N. McKnight, ed., Biological Pollution: the Control and Impact of Invasive Exotic Species. Indiana Academy of Science, Indianapolis.

[USDA] U.S. Department of Agriculture. 2008. The PLANTS Database. Available online <http:plants.usda.gov>

Werner, P.A. 1975. Predictions of fate from rosette size in teasel (*Dipsacus fullonum* L.). Oecologia 20:197-201.

Werner, P.A. 1979. The biology of Canadian weeds: 12-*Dipsacus sylvestris* Huds. Pp. 134-145 in G. Mulligan, ed., The Biology of Canadian Weeds, Contributions 1-32. Information Services, Agriculture Canada, Ottawa, Ontario.

Vitalis, R., S. Glemin, and I. Olivieri. 2004. When genes go to sleep: the population genetic consequences of seed dormancy and monocarpic perenniality. American Naturalist 163:295-311.

Zimmerman, L.M., N.M. Mentzer, J.L. Forrest, and J.A.D. Parrish. 2013. The effects of herbicide treatment, life history stage, and application date on cut and uncut teasel, *Dipsacus laciniatus* (Dipsacacae). Natural Resources 4: 170-174.