Mechanical and chemical control of Tessaria dodoneifolia (Hook. Et Arn.) Cabrera (sweet chilca)

TOLOZANO, B.; PISANI, J.M.; PURICELLI, E.C.

ABSTRACT

The encroachment of native or exotic woody species in rangelands results not only in cover changes of some species, but also in changes of the amount and availability of forages for livestock. Tessaria dodoneifolia (Hook. et Arn.) Cabrera (sweet chilca) is a native shrub species in Argentina, which in recent years has been mentioned as an invader of north-eastern Argentinean rangelands. The objectives of this research were to study in sweet chilca: 1) the efficacy of mechanical (shoot cutting up to 30 cm high) and chemical control treatments (picloram+triclopyr and picloram+2,4D) and the combination of both types of control, 2) the optimal control timing (onset or end of the weed season growth), 3) the optimum dose of picloram+2,4D on plants of different sizes, and 4) the emergence of new seedlings of sweet chilca one year after herbicide application. Chemical treatments alone or in combination with mechanical control showed a very good control. Picloram+2,4D was the most effective treatment at applied at the beginning of active growth, while other treatments did not differ between application times. Sweet chilca plants did not survive the recommended dose for other shrub species. No differences in control on seedling establishment one year after herbicide application was observed.

Keywords: herbicides, optimal dose, rangelands, Argentina.

INTRODUCTION

Natural grasslands account for nearly 60% of the Argentine area (160 million hectares) (Fernandez and Busso, 1999) and are basic forage resource used by livestock during most of the year. With the increase in the coverage of native and exotic woody species in these natural systems there is a replacement of grasses and a reduction in accessibility and forage supply for cattle (Graz, 2008; Archer, 1990; Moleele et al., 2002; Tighe et al., 2009).

Woody species can be controlled in natural grasslands using controlled fire (Willard, 1973; Vitelli and Pitt, 2006; Kunst et al., 2015), biologic, chemical and mechanical control; and the combination of chemical and mechanical controls (Masters and Sheley, 2001; Van Wilgen et al., 2001; Vitelli and Pitt, 2006).

Among them, mechanical and chemical controls are the most effective and selective. Mechanical control allows the elimination of the unwanted species by cutting the aerial part or extracting the plant from the root. However, in places where the species has occupied large areas or is forming large patches, mechanical control can be costly and laborious (Van Wilgen et al., 2001).
Selective herbicides can control the undesired species without negatively affecting the other species, that are part of the natural pasture community (Van Wilgen et al., 2001). The herbicide efficacy can be conditioned by the phenological momentum (DiTomaso, 2000), the height and the number of stems (Jacoby et al., 1990) and the stage of growth of the plants (Agbakoba and Goodin, 1969). While herbicide application can effectively control woody species, it may also have medium- and long-term side effects on grassland communities, which should be taken into account when evaluating control techniques.

In Argentina there are several examples of increased coverage of woody species on natural grasslands and abandoned fields such as Prosopis ruscifolia (vinal) (Cabral et al., 2003), Acacia sp. (Cozzo, 1995), Geoffroea decorticans (chañar) (Echeverría and Giulietti, 2002).

Tessaria dodoneaefolia (Asteraceae) (sweet chilca) is a native woody species that in recent years has been reported as an invader of pastures in the northeastern Argentina. It is commonly associated with saline soils of northern Argentina, Paraguay, Uruguay and Bolivia. It reaches a height of up to 3 m. Its leaves are not eaten by cattle, except in times of extreme droughts when some tender basal shoots may be eaten. It flowers from October to March, and its flowers produce large numbers of small fruits with seeds of anemocoric dispersion (Burkart, 1974).

To know the control methods that lead to a reduction in the coverage of sweet chilca would provide effective tools for the producers of weed-encroached areas.

The aims of this work were to study in sweet chilca: 1) the effectiveness of mechanical control treatments (cutting of shoots at 30 cm in height), chemical control treatments (herbicide application) and the combination of both; 2) the optimum moment to apply control methods (onset or end of active growth); 3) the optimal dose of the most efficient chemical treatment among those previously studied in plants of different sizes and 4) the emergence of new seedlings per year after the application of the treatments.

**MATERIALS AND METHODS**

The tests were conducted at the Cattle Rearing Demonstration Unit [Unidad Demostrativa de Cria Bovina] La Palmira of the EEA INTA Rafaela (29° 46' 40.19" S; 61° 13' 53.21" W) in the district of Las Avispas, province of Santa Fe, Argentina. This unit has 600 hectares affected to a large extent by sweet chilca. The soil is natric (natracualf or natracuol), and distributed in random blocks. The main plot consisted of plowed plots with an arrangement of the subunits in stripes parallel to the strips. The subunits were divided into plots with an arrangement of the subunits in stripes parallel to the strips. The subunits were divided into plots 50 m long and 5 m wide with 1 m sowing distance. Each strip was 6 m wide and 5 m long. A repeated split-plot design was used, with two experimental factors: herbicides and control methods. The herbicides were applied on individual plants to the point of runoff. The control methods were applied to the strips: 1) Mechanical control; 2) Chemical control; 3) Combination of both (herbicide with cutting) and a control without application of control methods.

In the mechanical control treatment, herbicide application started one week after the cut of the plants. We used a 16 liter compression backpack with a flat fan type Lumark tip. Herbicides were applied on individual plants to the point of runoff. The experimental units were plots of 56 m². Treatments were application of the herbicides was the treatment: picloram + triclopyr (4.4 + 8.35%), 5 l p.c./100 l diesel; and picloram + 2.4D (24 + 6.415%), 5 l p.c./ha (chemical control); shoot cutting at 30 cm of height with grass trimmer (mechanical control); combinations of both (herbicide with cutting) and a control without application of control methods.

The crown of sweet chilca has stems with basal buds and is located on the ground, almost at the surface level. The diameter of the crown is defined as the average of the length of two perpendicular lines that join the outermost stems of the plant at ground level. The optimum dose was evaluated by counting the dead plants one year after the application of the herbicide.

The live biomass of the treated plants and mortality were analyzed by ANOVA and the means were compared with a Tukey test (Infostat, 2008) with a significance level of 5%. The normality of the variables was tested using the Shapiro-Wilks test and the homogeneity of variances using the Levenne test. The variables that did not comply with the ANOVA assumptions were transformed by square root.

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A comparison of the two application times for herbicides (picloram + triclopyr and picloram + 2,4D) (Infostat, 2008) was performed using a t-test.

The number of young sweet chilca plants that settled a year after the application of the control treatments was analyzed by ANOVA with a Tukey mean comparison test (Infostat, 2008). The data were transformed by square root.

RESULTS

We report an interaction between the treatments performed at the beginning of the active growth and in the tolerance to them (Figure 1a and b). Adequate control of the biomass with every treatment - except for mechanical control - was obtained at 30 DAA, and at 90 DAA in every treatment except mechanical control and the combination of mechanical control and picloram + triclopyr.

The biomass of the remaining plants was greater at 90 DAA than at 30 DAA. In the remaining treatments the biomass was the same in both dates. At 30 DAA biomass was greater for mechanical control, while at 90 DAA the maximum biomass was observed in mechanical control followed by mechanical control combined with picloram + triclopyr.

One year after application of treatments at the beginning of active growth plant mortality was not the same in all treatments (p <0.05) (Figure 2).

No dead plants were found under mechanical control. Mortality was higher (p <0.05) in plants treated with mechanical control in combination with picloram + 2,4D, and individually with picloram + 2,4D.

As a consequence of successive frosts, in the treatments applied at the end of the active growth it was only possible to harvest the biomass at 30 DAA (Figure 3). The greatest biomass was reported under mechanical control, which sig-

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Height (m)</th>
<th>Number of stems</th>
<th>Diameter of the crown (cm)</th>
<th>Diameter of the canopy (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1 (0.05)</td>
<td>1.4 (0.13)</td>
<td>0.0 (0.00)</td>
<td>15 (0.03)</td>
</tr>
<tr>
<td>2</td>
<td>1.3 (0.12)</td>
<td>2.8 (0.64)</td>
<td>19 (0.04)</td>
<td>38 (0.06)</td>
</tr>
<tr>
<td>3</td>
<td>2.3 (0.06)</td>
<td>23.6 (1.66)</td>
<td>27 (0.01)</td>
<td>90 (0.03)</td>
</tr>
</tbody>
</table>

Table 1. Age, height, number of stems, crown and canopy diameter (mean + SE) of the plants of Tessaria dodoneifolia before being exposed to 7 doses of picloram + 2,4D.

![Figure 1. Biomass of plants of Tessaria dodoneifolia at a) 30 and b) 90 days after the application of treatments at the beginning of the growth season. The bars on the columns correspond to the standard error. Different letters indicate significant differences (p <0.05; Tukey’s test) among the treatments for each harvest date. Asterisks on the columns indicate significant differences (p <0.05; t Test) between the means of each treatment at 30 and 90 days after the application of the treatments. CM= mechanical control; CM + pic + tric= mechanical control + picloram + triclopyr; CM + pic + 2,4D= mechanical control + picloram + 2,4D; pic + tric= picloram + triclopyr; pic + 2,4D= picloram + 2,4D.](image-url)
significantly differed from the rest of the treatments, except for the combination of mechanical control and picloram + triclopyr. Plants were less tolerant to the combination of mechanical control and picloram + 2,4D, and picloram + 2,4D individually.

One year after the application of the control treatments at the end of the growth cycle, no dead plants were recorded in mechanical control (Figure 4). The highest mortality occurred with picloram + triclopyr and picloram + 2,4D without mechanical cutting.

When we compared the mortality caused by the treatments applied at the beginning and at the end of the active growth, mortality was higher at the beginning of the growing season for the combination of mechanical control and picloram + 2,4D and did not differ between seasons for the rest of the treatments.

At the beginning of active growth, the combination of mechanical control and picloram + 2,4D resulted in a mortality rate of 90%. The same occurred for the application of this herbicide individually (control: 88%). The mechanical control without the application of herbicides did not resulted in
All control plants (0X) of different ages survived. One-year plants did not survive any of the remaining doses. Survival was observed in plants two years old to 1/4X, and three years old to 1/4X and 1/2X. At higher doses, no plants survived.

**DISCUSSION**

At the end of the active growth, plant mortality under picloram + 2,4D and picloram + triclopyr was above 90%. As at the beginning of active growth, no mortality was observed in plants under mechanical control alone, and the plants presented the highest remnant live biomass. This indicates that the cutting of individuals at 30 cm does not reduce the sweet chilca cover at any time. The plants have the stocks stored in the roots which allows the regrowth after the mechanical control. In another study, mechanical control over other Asteraceae species proved laborious and costly, and spawned regrowth after cutting.

However, it was possible to control the species by cutting them twice a year when regrowth reached 0.5 meters in height. Results were obtained after approximately three years of successive cuttings (Marchesini, 2003).

Under chemical control the mortality was high both at the beginning and at the end of the active growth of sweet chilca. Although these treatments were not more effective in relation to the time of application, there was a trend towards greater control for by the end of active growth (early autumn) (Figures 2 and 4). This was also reported in the control of Rubus ulmifolius, where the application of herbicides at the end of summer-early autumn resulted in a greater control of the species when compared with spring applications (Mazzolari et al., 2011).

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**Figure 4.** Mortality of Tessaria dodoneifolia plants a year after the application of the treatments at the end of the growth season. Bars on the columns correspond to the standard error. Different letters indicate significant differences (p<0.05, Tukey’s test). CM= mechanical control; CM + pic + tric= mechanical control + picloram + triclopyr; CM + pic + 2,4D= mechanical control + picloram + 2,4D; pic + tric= picloram + triclopyr; pic + 2,4D= picloram + 2,4D.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Seedlings density ± (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>0.1 (0.09)</td>
</tr>
<tr>
<td>CM</td>
<td>0.0 (0.03)</td>
</tr>
<tr>
<td>CM+Pic+Tric</td>
<td>0.3 (0.25)</td>
</tr>
<tr>
<td>CM+Pic+2,4D</td>
<td>0.2 (0.07)</td>
</tr>
<tr>
<td>Pic+Tric</td>
<td>0.3 (0.13)</td>
</tr>
<tr>
<td>Pic+2,4D</td>
<td>0.2 (0.13)</td>
</tr>
</tbody>
</table>

Table 2. Density of Tessaria dodoneifolia seedlings (plants/m2) a year after the application of treatments ± standard error (SE). T = control; CM= mechanical control; CM+ Pic + Tric= mechanical control + picloram + triclopyr; CM + Pic + 2,4D= mechanical control + picloram + 2,4D; Pic + Tric= picloram + triclopyr; Pic + 2,4D= picloram + 2,4D.
This could be due to the fact that at that moment the plant starts a translocation of the assimilates towards the roots and along with them it would also be transporting the herbicides. In this way, more herbicide would arrive to the roots, resulting in a greater mortality. Similar results were obtained by Harrington and Miller (2005) when studying the control of Ligustrum sinense. These authors reported a lower control of the species during the spring because the plants are actively growing and the translocation of assimilates would flow to the aerial parts of the plant and not towards the roots.

Mechanical treatments allow reducing the height and coverage of sweet chilca and thus facilitate a more uniform application of the herbicides. Usually the combination of the mechanical treatment and the subsequent application of herbicides resulted in a lower mortality (<50%) than the individual application of herbicides. This could be attributed to the lesser remnant foliage remaining in the pruned plants when compared to those unpruned. Nevertheless, this does not explain why the mechanical cut and picloram + 2,4D treatment at the beginning of the growing season was so effective.

On the one hand, in Solanum glaucophyllum the cutting of the plants favors the action of systemic herbicides because the leaf/stem ratio is increased and this results in a greater receptivity and penetration of the herbicide in the plant (Bertin and Cepeda, 2007). On the other hand, the cutting of the plants could induce the mobilization of the reserves to recover the lost biomass, thus generating a translocation towards the aerial part and not towards the roots.

Gonzaga (1998) suggests that the combination of mechanical and chemical control is more efficient than the application of herbicides without mechanical control. In this study, at the beginning of the growing season the efficacy of the combination of mechanical control and picloram + 2,4D was not different from the one achieved by applying the two herbicides without mechanical control.

The cutting of sweet chilca plants prior to application of herbicides may be less effective because there is a reduction in the herbicide absorption surface. The combination of mechanical control and glyphosate on Eupatorium bonifoliun, E. buniifolium, Baccharis spicata, B. dracundifolia, B. pingraea, B. punctulata and E. laevigatum plants, with a regrowth of 0.5 m, reduced the coverage by almost 100% 5 months after the cutting (Marchesini, 2003).

After annual applications of picloram (0.56 kg/ha) for five years Lym and Messersmith (1987) did not find accumulation at the soil surface and the persistence of the herbicide would be related to the rainfall occurred after the application and to the type of soil. In this way, greater amounts of picloram persisted in the soil in the driest years. On this basis, this herbicide would not have an effect on the establishment of new seedlings in the pasture community.

In this study, rainfall in 2008 was 339 mm, while in 2009 it was 886 mm. The greatest rainfall occurred during 2009 favored the establishment of new weed seedlings. In a study by Harrington and Miller (2005), it was shown that triclopyr would have no activity in the soil and would present little risk to the associated vegetation.

One to five years old plants of Rubus fruticosus did not survive the recommended dose of 2,4,5 T and to picloram or higher doses (Amor, 1974). Older plants were more tolerant than younger plants. Similarly, the translocation of 2,4D and picloram in Convolvulus arvensis plants at 3, 7 and 16 weeks was higher in the seedling stage (Agbakoba and Goodin, 1969).

These results are in agreement with those reported by Jacoby et al. (1990) and Jacoby et al. (1990) in Prosopis glandulosa var. Glandulosa, who observed that the plants with the highest number of stems were less controlled by the herbicides. In this study, three-year-old plants were higher and had a greater number of stems, and consequently a larger diameter of crown and canopy.

The larger diameter of the canopy could reduce the penetration of the herbicide in the plant (Jacoby et al., 1990a and b). In this way, the greater tolerance to herbicide doses could be explained by the larger size.

CONCLUSIONS

There was no mortality in plants under mechanical control either at the beginning or at the end of the growth season.

Chemical treatments were the most effective, both at the beginning and at the end of the growth season.

No differential effect of control treatments on the subsequent establishment of sweet chilca seedlings was observed.

There was no plant survival at the recommended dose for shrubs of picloram + 2,4D. One-year-old plants did not survive any of the tested doses, while 2-year and 3-year-old plants survived at lower doses than the ones recommended.

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BIBLIOGRAPHY


