Experimental Research Informs Control of Mexican Petunia (Ruellia simplex) in Natural Areas and Home-Gardens

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Mexican petunia (Ruellia simplex C. Wright), a common ornamental landscape plant, has invaded southeastern U.S. floodplain forests and is negatively impacting vegetation community structure and function. Control in invaded natural areas, coupled with control at the propagule source (home-gardens and landscapes), is recommended for management of this invasive species. We compiled results from recent Mexican petunia control studies to construct preliminary management recommendations. Mexican petunia can be controlled in both natural areas and home-gardens with 1 to 2 foliar glyphosate applications. Seasonal timing of glyphosate applications does not seem to impact effectiveness of Mexican petunia control, so we do not recommend specific timing of glyphosate application to home-gardeners. Seasonal timing of glyphosate applications did, however, impact post-control native species richness in natural areas, so we recommend that natural area managers apply glyphosate in the fall for the greatest post-control regeneration of native species. Reinvasion and/or occurrence of novel invaders can be an issue in both home-gardens and natural areas; therefore we recommend that glyphosate treatments be followed by replanting with appropriate material in both situations.

The ornamental horticulture industry is a source for invasive species (Barton et al., 2004; Dehnen-Schmutz et al., 2007; Peters et al., 2006) and invasive woody plant species in particular (Reichard and White, 2001). Invasion of non-native aggressive weedy species is costly in terms of lost ecosystem resources as a result of degraded natural areas and as a function of the costs of invasive species control (Pimentel et al., 2005). If control is postponed until a late stage of widespread infestation, it is on average 40 times more expensive than early removal (Harris and Timmins, 2009). Mexican petunia (Ruellia simplex C. Wright) is a commonly cultivated herbaceous plant species in the ornamental plant trade. It is a perennial species with a tolerance of a wide range of environmental conditions including: wet, dry, sun, shade, and nutrient-enriched soils. Colorful flowers and tolerance of varying environmental conditions make the species a popular choice with gardeners in the southeastern United States. Plants can bloom at all times of the year in Florida (Tobe et al., 1998), but peak flowering has been observed in the summer months. Unfortunately, the environmental tolerance of this species provides for consistent establishment that has allowed this species to spread from the urban environment into natural areas. Wunderlin and Hansen (2011) report that Mexican petunia is a common invader of wet habitats. Dense populations of Mexican petunia have been reported along stream banks and in floodplain forests (Hupp, 2007; Randall Stocker, pers. com, personal observations).

Consistent propagule source and environmental tolerance has allowed Mexican petunia to spread extensively into southeastern floodplain forests. Wunderlin and Hansen, (2011) report that it has been vouchered in 29 of 67 total counties within Florida. The most recent “Institute for Food and Agricultural Science (IFAS) Assessment of the Status of Non-Native Plants in Florida’s Natural Areas” recorded 16 significant invasions in large, monitored state parks, preserves and natural areas in Florida (Gantz and Avila, 2007). It has also been reported in parts of Texas, Louisiana, Georgia, Alabama, Mississippi, and South Carolina (USDA-NRCS 2012). Once established, it forms dense stands which suppress the native herbaceous plant community. Mexican petunia (R. simplex) should not be confused with the native, Ruellia caroliniensis. The native species is similar in appearance and is found throughout Florida (Wunderlin and Hansen, 2011). However, R. caroliniensis is smaller, less upright, and does not occur in the dense stands typical of the invasive Mexican petunia (Wilson et al., 2004).

The Florida Exotic Pest Plant Council denoted Mexican petunia as a Category 1 invasive species, indicating that it is: “altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives” (Florida Exotic Pest Plant Council 2011). Changes to species composition in Florida are of particular concern when they impact wetland habitats, as these changes can not only affect wildlife, but also water filtration and hydrologic health.

Case Studies: Selection

We used ISI Web of Science, AGRICOLA, and Digital Dissertations to search for relevant literature on Mexican petunia specifically with regard to control of this species. Additionally, we sought out researchers who had studied Mexican petunia control and had unpublished results. We then selected three case studies of previous research with clear experimental design and statistical analysis, including our own findings (case study three), to develop appropriate management plans for both natural areas and home-landscape situations.
Case Study One: Mexican petunia response to four herbicides at Lake Jesup, FL (Stocker et al., unpublished data)

METHODS. Field plots were located in the North Lake Jesup Tract of the Lake Jesup Conservation Area on the north bank of Lake Jesup, Seminole County, FL. Plots were randomly located in either shaded or unshaded areas. Thirty total 2 × 2 m (6.6 × 6.6 ft) plots separated with a 2-m (6.6 ft) buffer were sprayed with one of four ready-to-use herbicides (Table 1) until completely wet. Control plots were sprayed with an equal amount of water. Measurements of plant above ground percent cover were taken at 51, 90, 120, and 183 d after initial herbicide treatment and compared to a pre-treatment cover of at least 95% in all plots. A second herbicide application was applied at 120 d after initial herbicide treatment. Percent cover on non-Mexican petunia vegetation was recorded in all plots at 183 d after initial herbicide treatment.

OBJECTIVES. The objective of this work was to evaluate four ready-mixed herbicides for ability to control Mexican petunia.

RESULTS. At 90 d, there were no differences in effectiveness between herbicides in aboveground percent cover in the shaded plots. In the unshaded plots, Roundup and Weed-B-Gon provided greater Mexican petunia control than other products. At 120 DAT, Roundup provided greater Mexican petunia control than Brush-B-Gon Poison Ivy Killer, but not different than other products (Table 2). By 183 DAT, the completion of data collection, there were no differences in aboveground cover of Mexican petunia when treated with one herbicide product compared to another (Fig. 1). All herbicide treatments successfully reduced Mexican petunia cover to <0.5% after 183 d. Some regrowth of existing Mexican petunia plants was seen in all plots at 120 DAT before a second herbicide treatment was applied to plots (Fig. 1). However, no Mexican petunia seedlings were seen to establish in any plots after the initial herbicide treatment. At the completion of the experiment vegetation composition of treated plots had shifted to ≥ 50% non-target vegetation (non-Mexican petunia vegetation). Stocker et al. observed that while there was significant recolonization of non-Mexican petunia vegetation after herbicide treatments, this did not necessarily represent a fully functioning native plant community. Native species composition was not quantified in this experiment. Additionally, Stocker observed that the non-Mexican petunia vegetation appeared to be less damaged by herbicide applications in unshaded plots than in the shaded plots although this was also not quantified.

CONCLUSION. Results from the Stocker et al. research suggest that many ready-mixed and readily available herbicides can successfully reduce Mexican petunia cover as long as two herbicide treatments were applied, with the second application occurring at around 4 months after the initial application.

Table 1. Ready-to-use liquid (spray) herbicides tested for effectiveness in controlling Mexican petunia at Lake Jesup, FL (modified from Stocker, unpublished data).

<table>
<thead>
<tr>
<th>Product name</th>
<th>Chemical name</th>
<th>Concen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ortho Brush-B-Gon Poison Ivy Killer</td>
<td>Triclopyr triethylamine salt</td>
<td>0.7%</td>
</tr>
<tr>
<td>Ortho Weed B Gon Max</td>
<td>Mecoprop-p dimethylamine salt</td>
<td>0.22%</td>
</tr>
<tr>
<td></td>
<td>2,4-D Dimethyl amine</td>
<td>0.12%</td>
</tr>
<tr>
<td></td>
<td>Dicamba</td>
<td>0.05%</td>
</tr>
<tr>
<td>Ortho Basic Solutions Lawn Weed Killer</td>
<td>2,4-D Dimethylamine sal</td>
<td>0.326%</td>
</tr>
<tr>
<td></td>
<td>Mecoprop-p dimethylamine</td>
<td>0.163%</td>
</tr>
<tr>
<td></td>
<td>Dichloroprop-p dimethylamine</td>
<td>0.161%</td>
</tr>
<tr>
<td>Roundup</td>
<td>Glyphosate</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

Case Study Two: Characterization of Mexican petunia germination and survival at Paynes Prairie Preserve State Park, FL (Hupp, 2007)

METHODS. Studies in this case study were located in Paynes Prairie Preserve State Park, Alachua County, FL. Study sites were located along tributaries to Sweetwater Branch, a significant water source for the Paynes Prairie Basin watershed. Mexican petunia at these sites occurred in narrow bands (“Ruellia zone”) of 2–4 m (6.6–13.1 ft) on the upland edges of more frequently submerged areas. In order to evaluate Mexican petunia estab-

Table 2. Mean percent green Mexican petunia tissue remaining in aboveground cover after initial herbicide application (modified from Stocker, unpublished data).

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Days after initial herbicide treatment</th>
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<tbody>
<tr>
<td></td>
<td>51</td>
</tr>
<tr>
<td>Roundup</td>
<td>0.0 a</td>
</tr>
<tr>
<td>Weed-B-Gon</td>
<td>6.7 ab</td>
</tr>
<tr>
<td>Lawn Weed Killer</td>
<td>7.7 ab</td>
</tr>
<tr>
<td>Brush-B-Gon Poison Ivy Killer</td>
<td>10.0 b</td>
</tr>
</tbody>
</table>

*Letters represent significant differences in Tukey’s HSD means separation.

Fig. 1. Percent green Mexican petunia tissue remaining in aboveground cover after herbicide treatment (modified from Stocker, unpublished data).
lishment and competition with native vegetation. Hupp (2007) measured seed germination and seedling survival in pots buried in field plots either completely cleared of initial vegetation or not cleared of any vegetation in the “Ruellia zones” and in “upland zones”. “Upland zones” encompassed the areas immediately upland of the “Ruellia zones”. Mexican petunia was not found in the “upland zones”. An additional part of the study examined Mexican petunia seedling survival among 800 seedlings transplanted from pots into either cleared or not cleared field plots in both the Ruellia zone and the upland zone after 3.5 months. The seedling transplant experiment evaluated survival of both small [3-cm height (1.2 inches)] and large [15-cm height (5.9 inches)] seedlings under these treatment conditions.

**Objectives.** The objectives of this work were to:

- Examine whether Mexican petunia seed germination and seedling survival/establishment differs between the “Ruellia zone” and “upland zone” This will indicate whether there are differences when Mexican petunia is present.
- Examine whether Mexican petunia seed germination and seedling survival/establishment is impacted by competition between Mexican petunia and native vegetation.

**Results.** Germination of Mexican petunia seed was higher when seeded in the Ruellia zone than in the upland zone in both studies 1 (67.8% in Ruellia zone vs. 57.9% in upland zone) and 2 (35.4% in Ruellia zone vs. 21.2% in upland zone) of the field germination experiment (Fig. 2). Germination of Mexican petunia was also higher in the cleared plots (65.4%) compared to the not cleared plots (55.0%) (Fig. 3). Survival of Mexican petunia seedlings was much higher after 3 months in the cleared plots (85%) than in the not cleared plots (40%) (Fig. 3).

In the seedling transplant experiment, the interaction between cleared treatment and zone treatment was significant. Mexican petunia seedling survival was higher in the Ruellia zone when plots had been cleared, but was higher in the upland zone when plots were not cleared. Survival was similar for both large and small Mexican petunia seedlings when plots had been cleared, but when plots had not been cleared, survival was greater for large seedlings compared to small. Change in plant height and dry shoot biomass were greater in the Ruellia zone than in the upland zone when plots had been cleared. Light and soil temperature did not affect seedling survival in the transplant study.

**Conclusion.** Results from Hupp, 2007 research suggest that planting native species and/or retaining existing native species in Mexican petunia-invaded areas will likely reduce Mexican petunia germination and survival. This indicates that active native revegetation will be an important part of reestablishing a healthy native plant community in areas previously invaded with Mexican petunia.

**Case Study Three: Mexican petunia and native community response to glyphosate treatments at Paynes Prairie Preserve State Park, FL. (Wiese et al., 2012)**

**Methods.** Field plots were located on two sides of a tributary of Sweetwater Branch at Paynes Prairie Preserve State Park. Twelve 3 × 3 m (9.8 × 9.8 ft) plots were randomly located on each side of Sweetwater Branch tributary for a total of 24 plots. Each plot was divided into four 1.5 × 1.5 m (4.9 × 4.9 ft) subplots. One of four glyphosate repeated application treatments was randomly assigned to each of the four subplots: 0, 1, 2, or 3 glyphosate applications. Six plots were randomly selected on each side of the Sweetwater Branch tributary to receive glyphosate treatments beginning in either fall or spring. Percent cover of Mexican petunia, native species richness, total species richness, and quality (FAQWet index; Ervin et al., 2006) were assessed to measure the impact of glyphosate treatments.

**Objectives.** The objectives of this work were to:

- Evaluate effect of season of glyphosate application on Mexican petunia control.
- Evaluate effect of number of repeat glyphosate applications on Mexican petunia control.
- Evaluate effect of season of glyphosate applications and number of repeat applications on post-treatment vegetation quality.

**Results.** All glyphosate treated plots produced a significant reduction in percent cover of Mexican petunia compared to control plots (Fig. 4). There were no differences in percent cover of Mexican petunia between seasons of initial glyphosate treatment (Fig. 4). Total and native species richness were greater when glyphosate treatments were initiated in the fall and plots received two herbicide treatments than when any glyphosate treatments were initiated in the spring. There were few differences in overall

![Fig. 2. Percent germination of Mexican petunia seed planted in the Ruellia zone compared to planted in the Upland zone in two replicate studies (modified from Hupp, 2007).](image)

![Fig. 3. Seed germination and seedling survival of Mexican petunia after three months in field plots cleared of all vegetation compared to uncleared plots (modified from Hupp, 2007).](image)
resulting vegetation quality post-glyphosate treatment (Fig. 5). Quality of post-treatment aboveground vegetation measured by the FAQWet index was greater when glyphosate treatments were initiated in the fall and received two applications of glyphosate compared with plots that received fall-initiated treatments that were applied only once (Fig. 5). There were no other differences in post-treatment emergent vegetation quality (Fig. 5).

**Conclusion.** The research conducted by Wiese et al. (2012) indicates that Mexican petunia can be successfully controlled with glyphosate, applied at any time of year. However, this work suggests that the post-treatment native vegetation can be encouraged to a greater degree if the herbicide treatments are applied in the fall.

**Discussion**

Management of invasive plant species in natural areas is important for supporting fully functioning diverse vegetation communities. However, reducing the invasive plant propagule source of urban ornamental landscapes, specifically home gardens, is equally crucial for adequately managing invasive plant species. Ornamental invasive species are most likely to be a concern where urban sources of propagules border natural areas that can be invaded (Foxcroft et al., 2008). There is national pressure on growers to stop selling invasive ornamental plants, especially herbaceous perennials, shrubs, and trees (Coats et al., 2011; Wirth et al., 2004), but many of these species are already well established in the urban ornamental landscape. Foxcroft et al. (2008) note that there are formal agreements in place in many parts of the world including North America (Baskin, 2002; Reichard, 2004), New Zealand, Scotland, and South Africa for preventing new introductions of ornamental and horticultural species that are likely to be invasive, however, there are no formal agreements world-wide between the horticulture industry and conservation biologist regarding how to manage ornamental invasive plant species that have already established themselves in natural areas.

Most homeowners are not aware of invasive plant issues and are not actively seeking alternative species for their home landscape. For example, Connecticut home-gardeners surveyed, were able to identify regionally invasive ornamental species only 10-20% of the time (Gagliardo and Brand, 2007). A survey of 157 home gardeners from multiple regions of the country indicated that less than half were very familiar with the issue of ornamental invasive species (Reichard and White, 2001). However, 83% of total respondents and 92% of respondents who indicated familiarity with the ornamental invasive plant issue, indicated that it was important not to buy plants that were invasive (Reichard and White, 2001). Alberini and Segerson, (2002) suggest that a demand from consumers can result in businesses voluntarily offering “environmentally-friendly” products.

One method of reducing propagule source for ornamental invasive species has been to develop sterile cultivars (Tallent-Hasell and Watt, 2009; Trueblood et al., 2010). If the primary method of dispersal is seed then this can drastically reduce propagule source for ornamental invasive species while still allowing for the plant to be used in the landscape. This has been done successfully with lantana (*Lantana camara*) (Czarnecki and Deng, 2009), butterfly bush (*Buddleia davidii*) (Tallent-Hasell and Watt, 2009), and St. John’s wort (*Hypericum androsaemum*) (Trueblood et al., 2010).
However, butterfly bush is also easily propagated from vegetative material such as stem and root pieces, so release of sterile cultivars may not be sufficient to reduce to propagule source of this species (Tallent-Hasell and Watt, 2009). While research is being conducted to develop sterile cultivars of Mexican petunia, other research indicates that seed may not be the primary method of spread for Mexican petunia. Instead, Mexican petunia plants seem to spread by way of vegetative propagules as much or more than by seed (Reinhardt-Adams, personal communication). Therefore, installation of sterile cultivars of this species may not sufficiently reduce propagule source. In that case, removal of this species from the urban environment is key to limiting a continual source of propagules for invading natural areas.

Control of established invasive ornamental species frequently requires a multi-action approach to maintain control over the long-term. For example, management of butterfly bush required a similar multi-pronged approach to that of Mexican petunia. Plants in small invaded areas can be dug up; larger invasions require herbicide to kill the invading shrubs following by active revegetation by native species to prevent reinvasion or establishment of novel invaders (Tallent-Hasell and Watt, 2009). Similarly, treating invasive ornamental lantana (Lantana camara) with a single control effort resulted in only short-term control followed by reinvasion (Gooden et al., 2009). Gooden et al. (2009) note that follow-up control efforts will be needed to maintain control of this invasive species. Likewise, control of Chinese privet (Ligustrum sinense) reduced the population, but did not result in the desired native plant community post-control. Hanula et al. (2009) suggest that active revegetation, especially with regard to the understory plant community, will be needed to restore privet-invaded lands.

While growers can reduce invasive propagule supply by ending the sale of invasive ornamental plant species, it is up to homeowners to control already established invasive species in their home gardens. These gardens are a source of propagules that contribute to beginning and maintaining invasive species in natural areas. Examining case studies to direct management activities appropriately for control of Mexican petunia provides an example how other ornamental invasive species can be more adequately managed with a two-pronged approach: 1) control already invaded areas in natural areas and 2) control the urban source of propagules.

Management Recommendations: Natural Areas

Research conducted on herbicide control of Mexican petunia in the case studies described above suggests that Mexican petunia can be controlled with glyphosate as well as other herbicides in one or two applications. Natural areas often present the applicator with scenarios in which achieving complete spray coverage is difficult, such as downed trees or especially dense vegetation. Therefore managers will likely achieve the best control if they apply a follow-up herbicide application at approximately 3 months after the initial application to address any gaps in coverage from the first application.

While there does not appear to be an optimal season for herbicide application with regard to Mexican petunia control, total and native species richness in aboveground cover post-herbicide treatment, seem to be seasonal. A greater number of total species as well as native species were recorded in aboveground cover in the fall. This suggests that natural resource managers will likely have greater success with reestablishment of native cover if Mexican petunia is treated with herbicide in the fall. However, while the case studies indicate that the presence of native vegetation likely reduced reinvasion of Mexican petunia in the short-term, the post-herbicide treatment vegetation did not necessarily consist of a fully functioning plant community. Similarly, others have found that invasive species control with herbicide is not sufficient to stimulate a thriving post-treatment vegetation community (Kettenring and Reinhardt-Adams, 2011). Therefore we suggest that active revegetation, such as seeding with appropriate native species, be applied after herbicide treatments have achieved control of Mexican petunia.

Management Recommendations: Home-gardens

Based on the research summarized in these case studies, we can see that Mexican petunia must be removed or killed completely (mortality of above and belowground vegetation) or it will continue to resprout. Mowing or weed-eating the tops off Mexican petunia will not remove the plants entirely. Plants in a small area can be dug up with a shovel, but do aim to remove the entire root mass. If the area of Mexican petunia is larger, then a glyphosate treatment may be required. Glyphosate can be purchased by homeowners at most retail garden stores under the trade name Roundup. Ready-to-use solutions in small sizes come pre-mixed for convenient use by home-gardeners. If you are planning to use an herbicide, be aware that it is a pesticide and carefully read the instructions on the container and follow all safety precautions. Research summarized here suggests that a single application of glyphosate may control a small area of Mexican petunia. If the area of Mexican petunia vegetation is especially dense or difficult to achieve complete spray cover, a second follow-up application of glyphosate may be needed after 2–3 months.

It is important to follow up after removing or killing Mexican petunia by planting new and appropriate plant material into the bare area. Bare ground can quickly become invaded by weeds or different invasive species common to urban areas. Installing appropriate non-invasive or native ornamental species into newly bare ground right away provides sufficient plant competition to hold the space.

Literature Cited


