Comparison of Torching and Glyphosate Applications for Japanese Stiltgrass (*Microstegium vimineum*) Control

Geoffrey Payne[1], Jim Evans[1], Ethan Murdock[2], and Jeffrey Derr*[3]

Abstract

Trials were conducted over three years to evaluate two torchings, torching followed by glyphosate application, raking followed by glyphosate application, and one or two yearly applications of glyphosate for control of Japanese stiltgrass. A single glyphosate application in fall reduced Japanese stiltgrass cover but the percent cover increased during the following growing season. Either two torchings or two applications of glyphosate per season for three years gave excellent Japanese stiltgrass control but plants recovered the year after treatments ended. Raking away leaf litter in spring increased Japanese stiltgrass cover. Torching followed by a glyphosate application was less effective than 2 applications of glyphosate. Treatments would need to be repeated for over three years to eradicate Japanese stiltgrass from a site.

Species used in this study: Japanese stiltgrass, *Microstegium vimineum* (Trin.) A Camus.

Index words: fire, herbicide application, invasive plants, weed control.

Significance to the Horticulture Industry

Japanese stiltgrass is an invasive species that invades shady, moist sites. Torching plots in April followed by a glyphosate application in August for two years reduced Japanese stiltgrass stand in spring and summer but this weed recovered completely two years later. Applying glyphosate twice per year, in May and September, or torching in May and August, gave excellent Japanese stiltgrass control during the growing season, but it recovered the year after treatments ended. Treatments will needed to be maintained for over three years if eradication of Japanese stiltgrass is the goal.

Introduction

Japanese stiltgrass (*Microstegium vimineum* (Trin.) A. Camus (Poaceae)), also known as Asian stiltgrass, Nepalese browntop, annual jewgrass, bamboograss, or flexible sesagrass, is a summer annual C4 grass (Barden 1987, Tu 2000, Winter 1982). Shade resistant and invasive in the United States, *M. vimineum* is native to China, Korea, Japan, Malaysia, and India) (Fryer 2011). *M. vimineum*'s earliest recorded appearance in the United States was in Knoxville, Tennessee in 1919 (Fairbrothers 1972). Its movement is likely due to its use in the early 1900s as a packing material for Chinese porcelain and for basket weaving. Growing conditions for *M. vimineum* include shaded, low-elevated, mesic soils with outside disturbance stimulating germination.

The 3,200-acre Piney Grove Nature Preserve, owned by the Nature Conservancy, is located in Isle of Wight County of Virginia. Located within a longleaf pine ecosystem, the native community in this preserve has many species of varying degrees of rarity (Connor and Rudolph 1991, Jackson 1990, Macey et al. 2016). These species are accustomed to frequent ground fire treatments every 1-10 years to maintain an open, savanna-like groundcover necessary for the native ecosystem (Drew 1998). Many of these species are perennial and will resprout if the plant is burned to ground level (Van Lear et al. 2005). The preserve is the most northerly U.S. nesting ground for the protected red-cockaded woodpecker (*Leuconotopicus borealis* Vieilot 1809, syn. *Picoides borealis)*, a ground feeder. The Nature Preserve management has concerns about how the spread of Japanese stiltgrass could impact its feeding grounds. Ground subjected to controlled burning could provide an opportunity for Japanese stiltgrass to spread into these areas after competing plants and leaf matter are burned, leaving exposed soil. There was concern that the prescribed fire treatments were also helping germinate *M. vimineum* through removal of leaf litter. Emery et al. (2011) reported that of the native and non-native species burned in their trials (including *M. vimineum*), none of the non-native species' germination were stimulated by the prescribed fires. Mowing and fall fires just before seed set were shown to be effective controls for Japanese stiltgrass (Flory and Lewis 2009). Spring fires did not reduce Japanese stiltgrass biomass.

Judge et al. (2005a, 2005b) showed that certain preemergence and postemergence herbicides, including single applications of glyphosate, were effective for Japanese stiltgrass control. Payne et al. (2019) showed that a single application of glyphosate was effective for Japanese stiltgrass control if applications were made in June after new germination had ceased, Redwood et al. (2018) showed that Japanese stiltgrass seed rarely maintained viability in soil for 24 months, suggesting the species could be eliminated over a two to four year period.

The Piney Grove Nature Preserve is bisected by a public gravel roadway which is subjected to mechanical grading several times a year. The contractor equipment used for this may have caused the initial introduction of Japanese stiltgrass to the site many years prior. Since 2013, the

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[1]Master Naturalist.

[2]Research Assistant, Virginia Tech, Hampton Roads AREC, Virginia Beach, VA 23455.

[3]Professor, Virginia Tech, Hampton Roads AREC, Virginia Beach, VA 23455.

*Corresponding author: jderr@vt.edu.

Table 1. Timing of torching, raking, and glyphosate (Glyph) applications in the field trials.

Trial	Treatment	4/9/14	5/7/14	8/27/14	4/11/15	5/16/15	9/4/15	5/7/16	9/7/16
1	Torch/Glyph	Torch		Glyph	Torch		Glyph		
2	Glyph			Glyph			Glyph		Glyph
2	Glyph/Glyph		Glyph	Glyph		Glyph	Glyph	Glyph	Glyph
2	Rake/Glyph	Rake		Glyph	Rake		Glyph		Glyph
3	Glyph/Glyph		Glyph	Glyph		Glyph	Glyph	Glyph	Glyph
3	Torch/Glyph	Torch		Glyph	Torch		Glyph		
4	Glyph/Glyph		Glyph	Glyph		Glyph	Glyph	Glyph	
4	Torch/Torch		Torch	Torch		Torch	Torch	Torch	

grading practices may have caused the spread of the once isolated occurrences of Japanese stiltgrass, which in 2018 was now widespread along the approximately 6 km (4) mile roadway in the preserve. While inundation has been rapid along the roadway, the spread of Japanese stiltgrass away from the road has been slow but persistent (personal observation by G. Payne).

Following an initiative from the National Science Foundation (NSF) and the Virginia Master Naturalists (VMN) program to promote the training of citizen scientists, a meeting with the Nature Conservancy lead to the development of a proposal to set up test plots within the Piney Grove Preserve to assess the best practices for control of Japanese stiltgrass. In the fall of 2013, master naturalists surveyed the preserve and determined the best location for test plots. This study is unique in that the test plots in the preserve were monitored for several years after treatment to assess the effectiveness of the control options. The objectives of this research were to: 1) to determine if raking leaf litter is effective at stimulating Japanese stiltgrass germination, therefore making later applications of glyphosate more effective, 2) to compare the effectiveness of fall versus spring plus fall glyphosate applications, 3) to compare two burnings to two glyphosate applications, and 4) to compare burning followed by glyphosate applications to two glyphosate applications.

Materials and Methods

Experiments were initiated in Piney Grove Nature Preserve in 2014. Percent ground cover for Japanese stiltgrass and other plant species was determined visually in all plots. Japanese stiltgrass cover during the summer in the various trials generally ranged from 60 to 70%. Observations were made on approximately a monthly basis during the growing season (April to October) in 2014, 2015, 2016, and 2017. Japanese stiltgrass plants heights were also recorded. Burning was achieved using a propane torch. The plot was torched until all plant matter was burned. Glyphosate (18%) was applied at 23 $ml \cdot L^{-1}$ (3 fl $oz \cdot gal^{-1}$). Treatment timings for the torching and glyphosate applications are listed in Table 1. On June 28, 2017, glyphosate was applied to all plots as part of park maintenance. A randomized complete block with four replications was used for all trials. Plot size was either 1.8 m by 1.8 m (6 ft by 6 ft) or 1.2 m by 1.2 m (4 ft by 4 ft) with at least 0.3 m (1 ft) between pots. Data was subjected to analysis of variance. Standard deviation was plotted in conjunction with treatment means.

Trial 1: Effectiveness of burning followed by glyphosate. This study was conducted to evaluate the effectiveness of spring torching followed by fall glyphosate application. Treatments were applied in 2014 and 2015 (Table 1). The area was dry and shaded by trees. Torching would remove leaf litter, thus potentially increasing Japanese stiltgrass germination, therefore making the glyphosate application more effective.

Trial 2: Hand raking for delittering. This plot is located in a full-sun, dry location. Hand rake delittering was achieved by extensive raking of the plot area to remove dead leaf matter to leave essentially bare soil. The test were conducted to determine if removing leaf litter would promote the germination of Japanese stiltgrass, thus leading to a faster elimination of the residual seed bank. Delittering was performed in April. The delittering treatment was compared to fall and spring plus fall applications of glyphosate (Table 1).

Trial 3: Burning versus glyphosate. This study compared torching in spring followed by fall glyphosate application to two applications of glyphosate (Table 1). The test plots were immediately adjacent to a permanent wetland, part of a larger swampland, a well shaded area.

Trial 4: Two burnings versus two glyphosate applications. This study compared torching in spring and fall to spring and fall applications of glyphosate (Table 1). The shaded plot was burned until all plant matter was charred. The initial burning in spring 2014 had the advantage of residual leaf matter in situ acting as fuel. Subsequent burnings relied more on the torch alone. Although large scale burning on an annual basis is not practical (insufficient detritus to sustain fire), this practice was continued each year to be able to compare results with other methods. Torching was also evaluated in different test areas in April to compare with rake delittering and in May to compare with May glyphosate treatment.

Results and Discussion

Torching in April followed by a glyphosate application in fall reduced the Japanese stiltgrass cover during the spring and fall of the following two years but did not eradicate this invasive weed (Fig. 1). By the following fall (2016), Japanese stiltgrass had recovered to close to the level seen in nontreated plots, probably due to seed produced in previous years. Japanese stiltgrass cover was

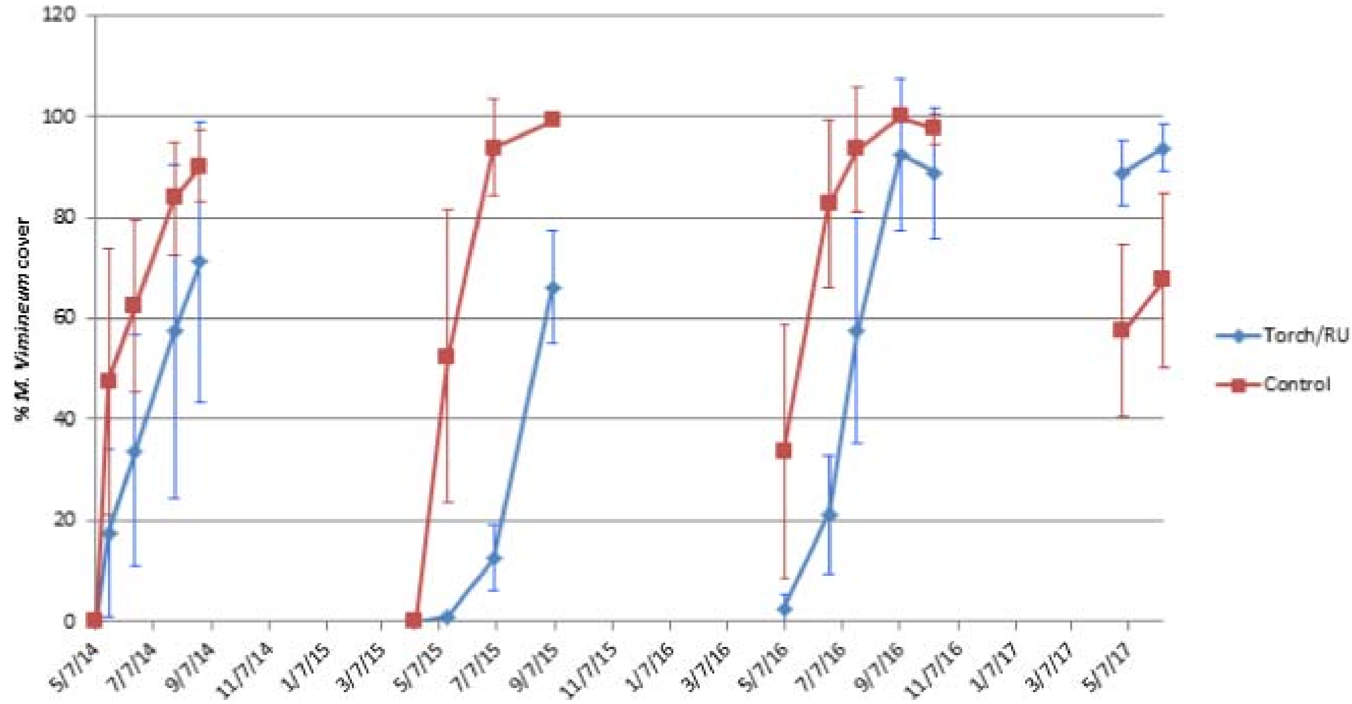

Fig. 1. Percent Japanese stiltgrass (M. vimineum) cover over time in nontreated control plots versus plots burned in spring followed by a glyphosate (RU) application in fall of 2014 and 2015. Vertical bars indicate standard error.

not different between treated and nontreated plots in 2017, showing the rapid replenishment of Japanese stiltgrass populations following two years of torching and glyphosate applications.

Raking in spring appeared to increase the cover of Japanese stiltgrass relative to nontreated plots during the spring and summer (Fig. 2). Although glyphosate was applied to these plots in fall, it did not lead to a decrease in cover the following spring, probably due either to seed produced by surviving plants or to seed produced in previous years. Dense cover of Japanese stiltgrass may have prevented complete coverage of Japanese stiltgrass foliage with the glyphosate spray. Applying glyphosate only in August reduced Japanese stiltgrass cover in 2015 but the population rebounded in 2016. Applying glyphosate in spring and late summer significantly reduced Japanese stiltgrass cover in successive years.

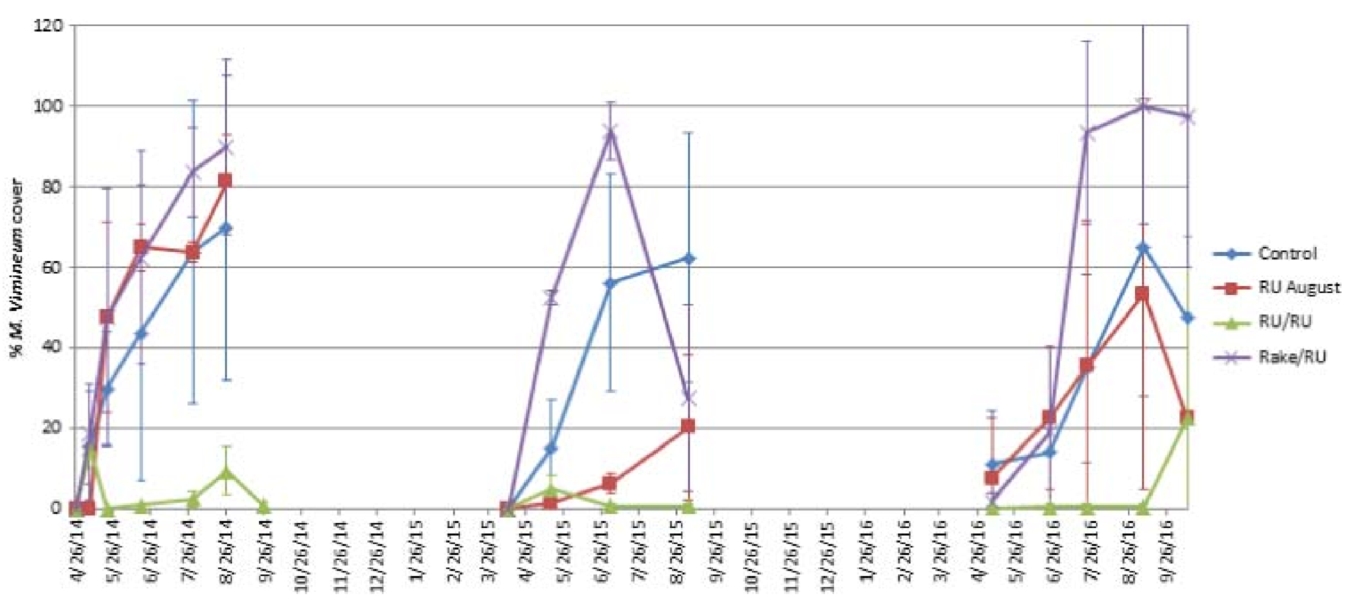

Fig. 2. Percent Japanese stiltgrass (M. vimineum) cover over time in nontreated control plots versus plots raked in spring followed by a glyphosate (RU) application in fall, glyphosate applied in fall, and glyphosate applied in spring and fall of 2014, 2015, and 2016. Vertical bars indicate standard error.

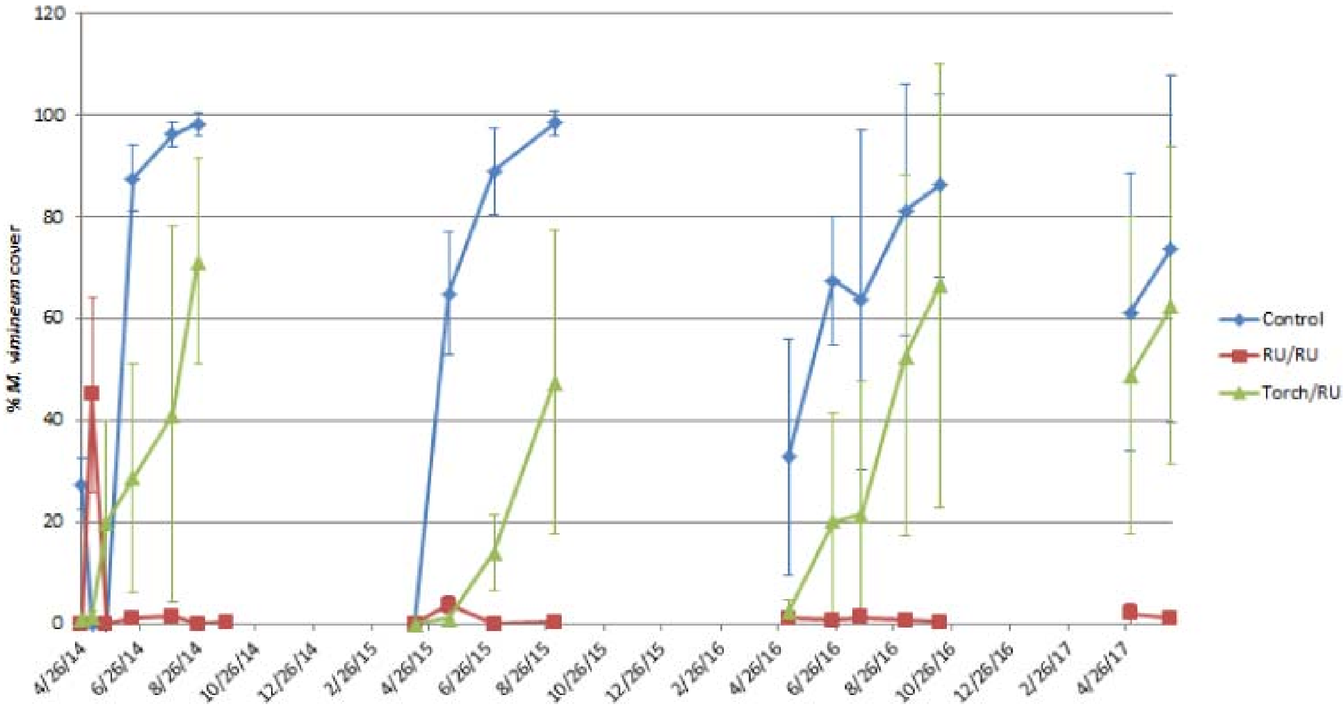

Fig. 3. Percent Japanese stiltgrass (M. vimineum) cover over time in nontreated control plots versus burned in spring followed by a glyphosate (RU) application in fall, or plots treated with glyphosate in spring and fall of 2014, 2015, and 2016. Vertical bars indicate standard error.

Burning plots in spring followed by a glyphosate application in fall significantly reduced Japanese stiltgrass cover the following spring (Fig. 3), similar to that seen with raking followed by a glyphosate application (Fig. 2), but the population increased during that summer. The torch/glyphosate treatment increased effectiveness of control in its consecutive treatment, but Japanese stiltgrass cover increased to approximately 60 to 70% after treatments stopped. Two applications of glyphosate gave excellent control of Japanese stiltgrass with near complete control after the second year of this treatment.

Two burnings, one in spring and one in fall, and two applications of glyphosate both gave complete control of Japanese stiltgrass in 2015 and 2016 (Fig. 4). The spring plus fall burnings appeared to be effective at controlling Japanese stiltgrass, but two years after applications stopped this weed returned to its former density of approximately 70% cover by the end of the season in 2017.

Removing Japanese stiltgrass in a longleaf pine ecosystem using burning would require an early May torching to allow for the native community to recover while still stopping Japanese stiltgrass from maturing, with a second burning late season before seed production/maturation to control plants that escaped the initial burning. Burning in late summer or early fall may not be advisable in dry years due to the potential for starting uncontrolled forest fires. Also, the program would need to be repeated in multiple years for eradication and this number of burnings may adversely affect desired vegetation. To completely deplete the seedbank, which can last 3 to 5 years based off information from Barden (1987) and Emery et al. (2011) respectively, treatments would need to be repeated for 3 to 5 years.

Treatments ended in 2016, but by the end of 2017 Japanese stiltgrass had increased significantly by the end of the year (Fig. 4). This is possibly due to germination from the seedbank or seed being introduced from outside the study area. By June 2018, Japanese stiltgrass in the glyphosate only or torch only application plots were similar to the control plots, showing how rapidly this species can recover after treatments are discontinued. By a year after three years of treatments, the percentage of Japanese stiltgrass coverage increased to pre-treatment levels.

Torchings in April are likely applied too early to control the majority of Japanese stiltgrass that would germinate that season, leaving the subsequent generation to produce seed, adding to the seedbank for next season. Two applications of glyphosate are very effective for Japanese stiltgrass control, especially if applied in multiple years.

All treatment that utilized ether burning or glyphosate in spring followed by glyphosate applications decreased competing vegetation during the four years of the trials (Data not shown). Torching in spring and fall decreased competing vegetation in 2014, 2015, and 2016, but after the burning ended, competing vegetation did increase in 2017. This is not surprising as glyphosate is a systemic herbicide while burning may allow for regrowth. In 2016 it was observed that after a year of treatment, the competing vegetation in each treatment plot by October had all attained close to equal coverage percentages (approximately 27%) regardless of what month glyphosate was applied to the plot. The most important factor for treating is timing the first treatment so the emerging Japanese stiltgrass is controlled before reaching maturity. Treating with fire first allows for increased competing vegetation in the treated area.

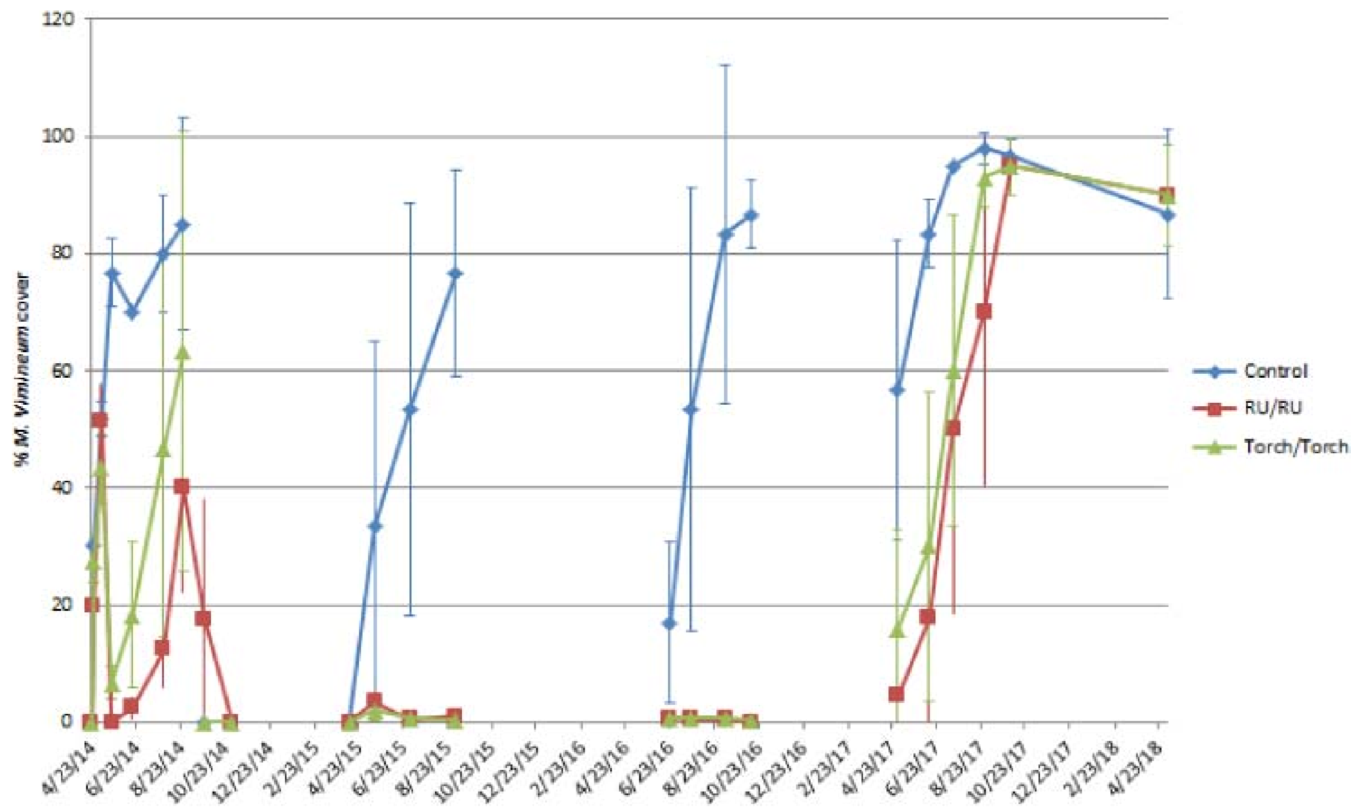

Fig. 4. Percent Japanese stiltgrass (M. vimineum) cover over time in nontreated control plots versus burned in spring and fall or plots treated with glyphosate (RU) in spring and fall of 2014, 2015, and 2016. Vertical bars indicate standard error.

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