Journal of Biofertilizers & Biopesticides

Smith et al., J Biofertil Biopestici 2013, 4:2
DOI: 10.4172/2155-6202.1000139

Research article Open Access

Early Summer Slender Aster Control in Bermudagrass using Bioherbicide *Phoma macrostoma*

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Abstract

Phoma macrostoma is a fungus being developed as a natural herbicide (bioherbicide) for selective weed control in turfgrass. Previous research with this product is limited to cool-season turfgrass, and information is limited on appropriate application rates or efficacy at higher temperatures and weeds associated with warm-season turf. Field studies were conducted in College Station, TX to evaluate efficacy of the bioherbicidefor slender aster (*Aster subulatus*var. *ligulatus* Shinners) control in common bermudagrass. In 2011, applications of 128 g m^{-2}, split-applied between days 0 and 28 resulted in good control (88%); however, 64 and 32 g m^{-2} rates failed to provide adequate control. In 2012, single applications of 128 gave excellent control (94%), while the 32 and 64 g m^{-2} rates gave poor control (54 and 68%, respectively) relative to untreated plots.No injury to common bermudagrass occurred in either study.

Keywords: Natural weed control; Organic weed control; Bioherbicide; Photobleaching

Introduction

In recent decades, synthetic herbicides have come under increased scrutiny around the world. While some legislation has targeted the removal of herbicides for cosmetic use, others have banned the use of all weed and feed products, only allowing the use of herbicides for spot treatment applications [1]. With growing pressure to ban synthetic herbicides, the need for alternative weed control options has increased.

Currently, there are few effective natural options for weed control in turfgrass systems. Some alternative herbicides available for use include vinegar, essential oils (clove and cinnamon oil), citric acid, fatty acids (pelargonic acid), and combinations of these different products. These products are primarily used as nonselective herbicides, with effective weed control being dependent upon product concentrations with vinegar, citric acid and clove oils providing better control at higher use rates [2-4]. Use of higher product rates, however, results in greater potential for crop injury [5].

Corn gluten meal (CGM) is a granular-applied herbicide that is a byproduct of commercial corn milling, containing approximately 10% nitrogen by weight. It is primarily used in turf as a crabgrass pre-emergence herbicide, but may inhibit other broadleaf and grassy weeds [6]. One disadvantage to CGM is that it is effective only as a pre-emergence product, and has minimal post-emergent activity on established weeds [7]. As a granular-applied product, challenges associated with CGM include relatively high use rates (60 to 120 g m^{-2}) and inconsistent reports of weed control [8-10]. While natural herbicides do exist, finding products that are safe to turfgrass and provide consistent, effective weed control has been a challenge.

The bioherbicide *Phoma macrostoma* is a natural herbicide being developed by the Scotts-Miracle Gro Company, Marysville, OH. It is produced from the solid fermentation of the fungus *Phoma macrostoma* on grain. *Phoma macrostoma* was discovered in Canada, when field isolates were collected from infected Canada thistle exhibiting symptoms of bleaching and chlorosis [11]. To date, this bioherbicide has been evaluated primarily in northern climates on weeds, including dandelion (*Taraxacum officinale* Weber ex F. H. Wigg.), Canada thistle (*Cirsium arvense* (L.) Scop.), chickweed (*Stellaria media* (L.) Vill.) and English daisy (*Bellis perennis* L.), with maximal reported efficacy at temperatures ranging from 15 to 25°C [12]. Currently, limited research has been conducted to determine if this product could provide weed control at higher temperatures associated with southern climates in which warm-season turfgrass is managed.

Slender aster (*Aster subulatus*var. *ligulatus* Shinners) is a troublesome summer annual weed that thrives under high temperatures in many areas of the southern U.S. This plant's ability to grow in a prostrate growth pattern allows it to survive mowing, making it problematic in southern turfgrass. Slender aster can be difficult to control if not treated early on in its growth cycle, because it becomes woody as the season progresses, necessitating repeated herbicide applications. Early summer applications of synthetic herbicide formulations, 2, 4-D+MCPP+Dicamba, do provide good control of slender aster (Paul Baumann, personal communication), but the focus of this study was to evaluate the activity of the bioherbicide on slender aster.

The objectives of this study were to 1) evaluate efficacy of the bioherbicide *Phoma macrostoma* at elevated temperatures following early summer applications, 2) determine effective application rates for slender aster control and 3) evaluate potential phytotoxicity on common bermudagrass (*Cynodon dactylon* L. Pers.).

Materials and Methods

Field studies were conducted during late spring/early summer of 2011 and 2012 at the Texas A&M University Turfgrass Research Field Laboratory, College Station, TX. In 2011, trials were initiated on 1 June 2011, and carried out until 12 August 2011. The 2012 trials were initiated

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Received November 08, 2013; **Accepted** November 26, 2013; **Published** November 30, 2013

Citation: Smith J, Wherley B, Baumann P, Senseman S, White R, et al. (2013) Early Summer Slender Aster Control in Bermudagrass using Bioherbicide *Phoma macrostoma*. J Biofertil Biopestici 4: 139. doi: 10.4172/2155-6202.1000139

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on 2 May 2012, and carried out until 26 June 2012. The studies were conducted on an established stand of common bermudagrass (*Cynodon dactylon* L. Pers.), intermixed with slender aster (*Aster subulatus* var. *ligulatus* Shinners) at the 3 to 4-leaf stage, and approximately 7 cm tall at treatment. Soil at the site was a Lufkin fine sandy loam soil with a pH of 9.8. Field plots were arranged as a randomized complete block design (RCBD) with four replications. Individual plots measured 0.91 m×0.91 m with a 0.3 m buffer between plots. Turf was mowed weekly to a height of 6.4 cm. Just prior to initiation, the study area was fertilized at a rate of 49 g N ha^{-1} using 46-0-0 (N: P: K) urea fertilizer.

Granular bioherbicide was produced under contract for The Scotts Miracle-Gro Company, at a pilot scale manufacturing facility on grain using solid state fermentation. The experimental bioherbicide product supplied for this experiment had half the potency that will be delivered in the commercially produced batches, as such higher application rates were used to compensate in this study. To initiate the studies, plots were irrigated to dampen weed and turf foliage, and treatments were applied to the dampened foliage *via* shaker jar at application rates of 32, 64 or 128 g m^{-2}. In 2011, treatments were split-applied, with half of the herbicide applied at trial initiation and half applied 28 days after treatment (DAT). For 2012, the same overall rate of herbicide was applied, but treatments were applied once at trial initiation. Granules were left on weed foliage for 24 hours, at which time granules were washed off of plant foliage and into the soil by irrigation.

Temperature and rainfall data were recorded by an onsite weather station during the studies. Mean daily air temperature for 2011 was 31˚C, with an absolute maximum of 41˚C and minimum of 20˚C during the study period. For 2012, mean daily temperature was 27˚C, with maximum of 41˚C and minimum of 17˚C. During the study period, plots were irrigated 4 to 5 times weekly receiving a total of 25 mm of water per week. Additionally, rainfall of 81 mm and 93 mm were received throughout the course of the 2011 and 2012 study periods, respectively.

Slender aster weed counts were made using a 0.91 m^{-2} grid rating system consisting of thirty-six 12.7 cm×12.7 cm squares. Squares which contained green slender aster plants were totaled (0-36) and used to

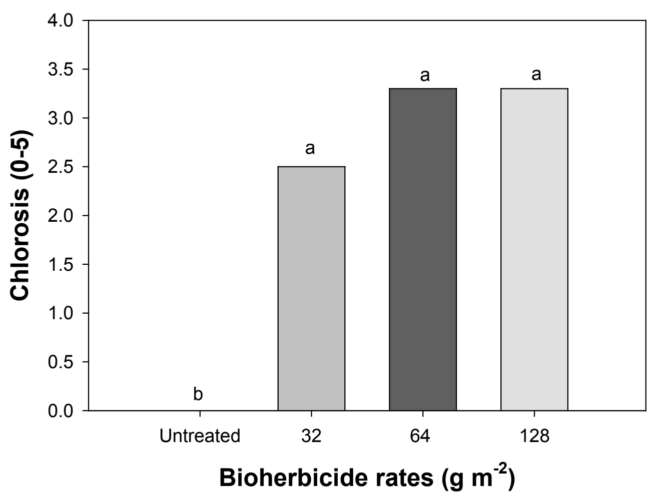

Figure 1: Bleaching and chlorosis of slender aster (0=no bleaching or chlorosis, 5=complete necrosis) 13 days after treatment (DAT). Trial was initiated on May 2, 2012, in College Station, TX, with single bioherbicide applications made at the beginning of the trial. Means followed by the same letter are not significantly different according to Tukey's Test ($P \leq 0.05$).

calculate percent weed control based on the Henderson-Tilton Method [13]. Weed counts were recorded prior to treatment applications and biweekly, thereafter for the duration of the trials. Weed chlorosis/necrosis was also evaluated biweekly using a scale of 0 to 5, with 0=no chlorosis injury, and 5=complete necrosis. Phytotoxicity of common bermudagrass in plots was monitored using a scale of 0=no injury to 5=complete chlorosis.

Data were subjected to analysis of variance using the general linear model, univariate test procedure using SPSS ver. 21.0 (IBM Corp, Armonk, NY) to determine statistical significance of the results. Means separation procedures were performed using Tukey's test at the $P \leq 0.05$ level.

Results and Discussion

Initial slender aster populations in the selected test areas were very high. Grid counts were taken prior to study initiation and showed test plots contained slender aster in ~ 34 out of 36 grids in 2011, and ~ 33 out of 36 grids in 2012. By the conclusion of the study, significant reductions in weed populations were seen in both 2011 and 2012 with the higher two rates of the bioherbicide. The final grid counts for the 128 g m^{-2} rate were 3.5 and 1.8 out of 36 grids in 2011 and 2012, respectively.The 64 g m^{-2} ended the study with slender aster in 5.8 and 9.8 out of 36 grids in 2011 and 2012, respectively.Though the 32 g m^{-2} rate did not significantly reduce final slender aster populations in 2011 (17 grids out of 36), weed populations were significantly reduced in 2012, ending the study with slender aster in 10.5 out of 36 grids. While the same total application amounts were applied in both years, the bioherbicide treatments were split-applied between day 0 and day 28 in 2011, and applied entirely at day 0 in 2012. No injury to bermudagrass was observed following application in either year. Ongoing research with this product using other warm-season species has shown no injury in other major warm-season grasses [14].

Chlorosis and Bleaching

A potential concern of natural products may be a slow or delayed efficacy, relative to synthetic products. Turfgrass managers and home owners prefer rapid control, indicating that the treatments are working. Therefore, rapid visual weed injury and decline following application is an important characteristic of an effective natural consumer product. During both years, initial foliar chlorosis and bleaching of slender aster became evident at all rates within 3 to 4 DAT. By 13 DAT in the 2012 study, moderate (3.25/5) foliar bleaching of weeds was observed in plots receiving both the 64 and 128 g m^{-2} application rates, with slightly less (2.5/5) chlorosis noted in 32 g m^{-2} rate plots (Figure 1). Photobleaching of susceptible weeds was followed by necrosis and gradual decomposition of weeds in plots over the course of 2-4 weeks.

Weed Control

While equivalent total rates of the bioherbicide were applied in both studies, the split applied applications of 2011 resulted in considerably delayed control relative to the single application of 2012 (Figure 2). Herbicide-induced chlorosis was quickly evident in treated plots within the first two weeks of both years, but these did not result in significant differences in control, until weeds had fully decomposed. In 2011, by 28 DAT, the 64 and 128 g m^{-2} bioherbicide rates exhibited significantly improved control (18 and 11% control, respectively) compared to untreated plots (Figure 2). By the end of the 2011 study (72 DAT), the highest rate of bioherbicide (128 g m^{-2}) provided significantly improved slender aster control (88%), when compared to the untreated. In

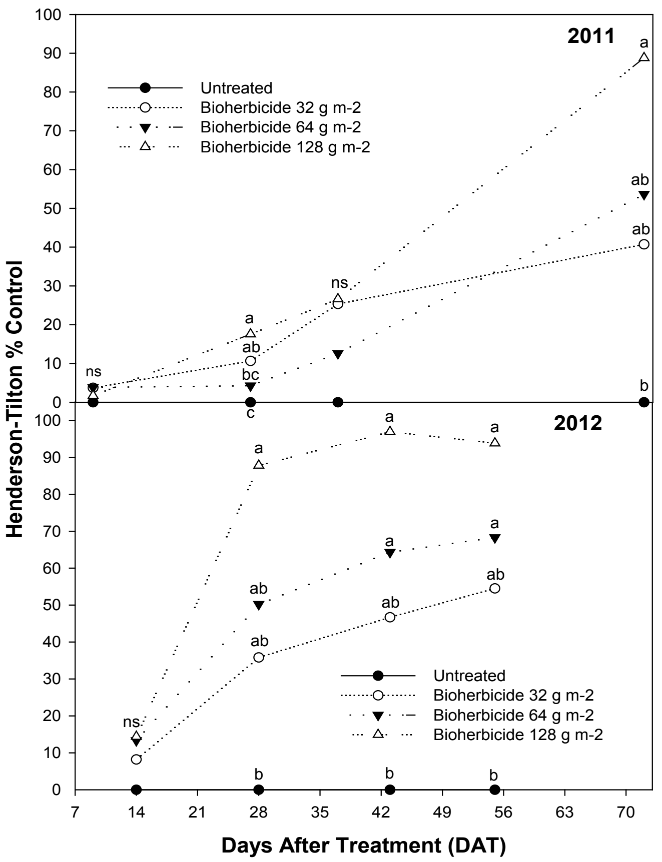

Figure 2: Henderson-Tilton % control of slender aster.Percentages were calculated using the Henderson-Tilton formula based on treated vs. untreated plots. Trials were initiated on June, 1 2011, and May 2, 2012, in College Station, TX. Bioherbicide was split applied in 2011, and single applications were made in 2012 at trial initiation. Means followed by the same letter are not significantly different according to Tukey's Test ($P \leq 0.05$).

addition, the lower two rates of bioherbicide (32 and 64 g m^{-2}) provided marginal control (41 and 54%, respectively) when compared to the untreated.

Onset of weed injury and subsequent control following application occurred much more rapidly in 2012 compared with 2011, likely due to bioherbicide treatments being applied as a single application. Another factor which could have contributed to the more rapid weed injury in the 2012 trial is that treatments were applied in May, on slightly younger weeds. Herbicide activity has been shown to occur much more rapidly when applied early in the weed life cycle to younger weeds when herbicide uptake and translocation are favored [15]. As in 2011, no significant differences in weed control were observed in any treatment until 28 DAT, at which time the 128 g m^{-2} bioherbicide treatment provided 88% control. Rates of 32 g m^{-2} and 64 g m^{-2} again provided marginal (~ 50%) control; however, these were not statistically different from untreated plots, due to a naturally occurring decline in weed population in untreated plots. By the end of the 2012 study (55 DAT), both the 64 and 128 g m^{-2} bioherbicide rates provided significantly improved control relative to untreated plots, (68 and 94%, respectively). Final levels of slender aster control were similar between both years, with the 128 g m^{-2} application rate providing 88 to 94% control, the 64 g m^{-2} application providing 55-65% control, and the 32 g m^{-2} application rate providing 40 to 50% control.

Temperature Effects

Previous research has shown this bioherbicide effectively controlling weeds under mild temperatures ranging from 15°C to 25°C [12]. However, prior to this research, it was not known what levels of control could be expected under higher temperatures. Despite the high temperatures around 41°C (with mean temperatures of 31°C in 2011 and 27°C in 2012) in both years, the bioherbicide provided effective control of slender aster in this study. Based on these results, the bioherbicide appears to retain good efficacy as a natural weed control product during summer months in areas receiving high temperatures, following application. It should be noted, however, that irrigation was provided frequently (4 to 5 times weekly) during this study, and may have also contributed to success of the bioherbicide under these conditions. Daily irrigation may not be agronomically appropriate or feasible in some situations, especially where municipal water restrictions limit the frequency of irrigation allowable on a landscape.

Potential Carryover

Another area of interest is the potential of this product to persist and carry over into subsequent seasons in the soil. Although no analysis of microbial fractions were attempted in this study, field observations indicate limited to no carryover into the following year, as successive weed seeds germinated in plots and produced green, healthy slender aster plants. However, research has shown that clay soils will retain the bioherbicide product longer than sandy loam soils [16], similar to those used in this study. Our observations are consistent with the findings of Zhou et al. [17], who found that residual activity of *Phoma macrostoma* begins to decline after 4 months, with no negative effects seen on susceptible plants in the year following application.

Implications on Use in Lawns

The results from this study demonstrate that the bioherbicide is effective at controlling slender aster, with a final level of control dependent on rate applied. Though significant control was not observed either year at the lowest application rate (32 g m^{-2}), limited activity was observed. Again, it should be noted that the material tested only contained half of the potency of the target commercial product intended for consumer use. Therefore, the amount of product used in these studies was twice that of the anticipated final commercial product. While a 128 g m^{-2} rate may be required for lawns with high weed pressure, lower rates (32 and 64 g m^{-2}) may be adequate for light weed infestations. Furthermore, unlike CGM, which must be broadcast applied at high rates over the entire lawn for preemergence control, the bioherbicide could be used as a remedial postemergence weed spot-treatment product, thereby reducing the total application amount substantially.

Effective weed control using the bioherbicide has been observed under a range of temperatures and appears to be limited to the season of application and site of placement, with no apparent phytotoxicity to desirable warm-season turfgrass. While future research is needed to more clearly define the spectrum of weed species controlled by this bioherbicide, it appears to be a suitable candidate for use as a natural broadleaf weed control option for lawns.

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