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Effect of MON 12037 on the Growth and Tuber Viability of Purple Nutsedge (*Cyperus rotundus*)[1]

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Abstract: A field study was conducted in 1994 and 1995 to determine the efficacy of MON 12037 on purple nutsedge in a bermudagrass turf. The percentage of bermudagrass infested with purple nutsedge following a single application of MON 12037 decreased from 60 to 30% at 18 g ai/ha and to approximately 20% at 36, 54, and 72 g/ha. Regrowth of purple nutsedge occurred between 28 and 55 d after treatment (DAT) and was greatest at 18 g/ha. A second application of MON 12037 reduced purple nutsedge percent infestation similarly to one application. Tuber weight and number were not affected by either one or two applications of MON 12037; however, tuber viability decreased after two applications. These results suggest that when using MON 12037, a program of several years duration may be required to successfully manage purple nutsedge in a bermudagrass turf because viable tubers persist following two applications of MON 12037 in a season.

Nomenclature: MON 12037, methyl 5-[((4,6-dimethoxy-2-pyrimidinyl)amino)carbonylaminosulfonyl]-3-chloro-1-methyl-1*H*-pyrazole-4-carboxylate; purple nutsedge, *Cyperus rotundus* L. #[3] CYPRO; bermudagrass, *Cynodon dactylon* (L.) Pers. # CYNDA.

Additional index words: Tuber viability, nutsedge regrowth.

Abbreviations: DAT, days after treatment; POST, postemergence; WAT, weeks after treatment.

INTRODUCTION

Reducing tuber populations and tuber viability are important aspects in controlling purple nutsedge in turf grasses. Phloem mobile postemergence (POST) herbicides may injure or kill tubers as long as the rhizomes connecting tubers remain viable. POST herbicides cannot translocate to and kill detached tubers or tubers that are connected by nonviable rhizomes, and these tubers may reestablish purple nutsedge populations. In addition, tubers deep in the soil may be protected from herbicides by the soil, thatch, and dense foliage of the turf. Purple nutsedge recovery may also be faster in well-maintained turf as a result of high fertility, frequent irrigation, and favorable environmental conditions (Coats et al. 1987).

MON 12037 is a new product for effective control of both yellow (*Cyperus esculentus* L.) and purple nutsedges in warm- and cool-season turf grasses (Anonymous 1995; Jackson et al. 1992; Sherrick et al. 1993). Greater than 85% control of purple and yellow nutsedge at the three- to eight-leaf stage was obtained 4 to 8 wk after treatment (WAT) (Sherrick et al. 1993). Two applications of 36 and 72 g/ha provided excellent control of purple nutsedge (Sherrick et al. 1993). In greenhouse studies, a foliar application of MON 12037 at 53 g/ha reduced shoot regrowth to less than 5% of controls and root tuber dry weight by 80% 60 d after treatment (DAT) (Vencill et al. 1995).

In greenhouse studies using purple nutsedge grown in pots, significant reductions in shoot and root tuber growth and in shoot regrowth were obtained with foliar applications of imazaquin {(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-quinolinecarboxylic acid} (Derr and Wilcut 1993; Nandihalli and Bendixen 1988a), imazethapyr {(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-ethyl-3-pyridinecarbolilic acid} (Richburg et al. 1993), AC 263,222 {(±)-2-[4,5-dihydro-4-methyl-4-(1- methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-methyl-3-pyridinecarboxylic acid} (Richburg et al. 1994), MON 12037 (Vencill et al. 1995), and soil applications of chlorimuron (Reddy and Bendixen 1989). These results demonstrate that when applied to young, actively growing plants, excellent control was achieved and regrowth was prevented. However, in field studies with imazaquin and

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[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds,* Revised 1989. Available from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

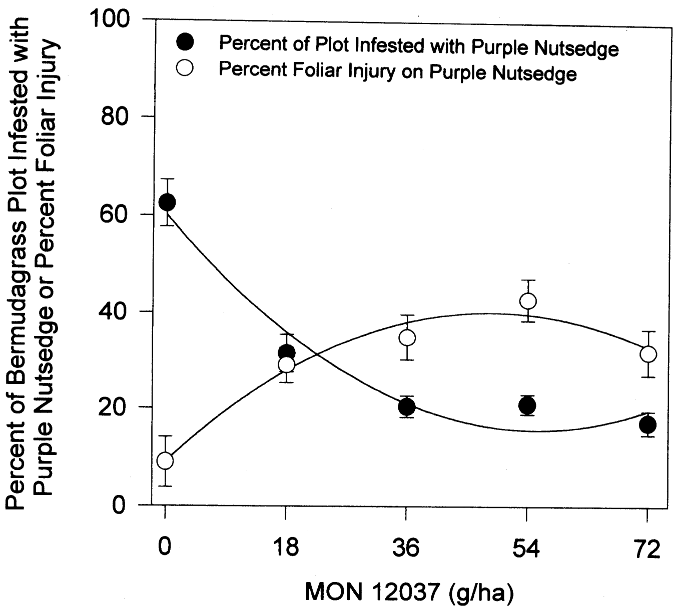

Figure 1. The percentage of the bermudagrass plot infested with purple nutsedge and percent injury to purple nutsedge foliage following a single MON 12037 application. Values represent the mean ± SE of six rating dates. Percentage of the bermudagrass plot infested with purple nutsedge: $y = 61.2 - 1.66x + 0.015r^2$; $R^2 = 0.56$, $P < 0.001$; Percent injury to purple nutsedge foliage: $y = 9.07 + 1.26x - 0.013r^2$; $R^2 = 0.22$, $P < 0.001$.

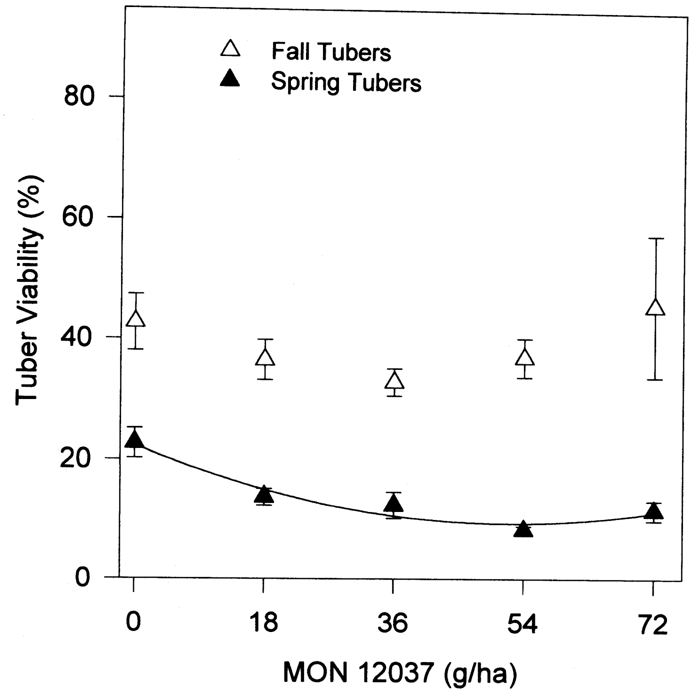

Figure 2. Purple nutsedge tuber viability in soil cores following a single MON 12037 application. Fall tuber viability: not significant; spring tuber viability: $y = 22.4 - 0.49x + 0.0048r^2$, $R^2 = 0.67$, $P < 0.001$.

MON 12037, the length of control was rate responsive (Coats et al. 1987; Jackson et al. 1992), and regrowth of purple nutsedge was observed (Coats et al. 1987; Jackson et al. 1992; Webster and Coble 1997). Several applications of imazaquin were required for complete control of nutsedge or regrowth could occur (Kopec et al. 1989, 1991a, 1991b). For example, a single application of imazaquin at 0.5 kg/ha only suppressed purple nutsedge temporarily (Kopec et al. 1989), and regrowth restored the stand to a level equal to or greater than the original stand (Kopec et al. 1989). These results indicate that some rhizomes and tubers were not killed by the herbicide. However, shoots that grew after an initial treatment with MON 12037 were small, weak plants and probably less competitive than those in controls (Webster and Coble 1997).

Imazaquin and chlorimuron were adsorbed by the roots and shoots of both yellow and purple nutsedges and were translocated both acropetally and basipetally (Nandihalli and Bendixen 1988a, 1988b; Reddy and Bendixen 1989). However, less than 1% of foliar-applied ^{14}C-herbicide was translocated to the roots or tubers in either case. These studies indicate that the sink strength of the roots or tubers may not be particularly strong and that POST applications may not be particularly injurious to tubers. Dormant tubers or plants that are not actively growing at the time of treatment may reduce the potential for control because of limited uptake.

The objectives of this study were to compare rates of MON 12037 on the control of purple nutsedge foliage in a bermudagrass turf observed over time and determine the effect of MON 12037 under field conditions on purple nutsedge with emphasis on its effect on tuber numbers, weight, and viability.

MATERIALS AND METHODS

MON 12037 was evaluated in the field on Randolph Golf Course, Tucson, AZ, a public golf course, for its effect on purple nutsedge shoot growth, tuber number, weight, and viability. MON 12037 rates were applied in water with 0.25% (v/v) of Unifilm 707[4] surfactant at 372 L/ha with a portable CO_2 sprayer equipped with two XR80015VS Teejet[5] nozzles spaced 45 cm apart. MON 12037 rates were 18, 36, 54, and 72 g/ha. The manufacturers' recommended application rates are 36 to 72 g/ha. Controls were sprayed with solutions containing surfactant only. Treatments included either one or two applications of MON 12037. Treatments involving a single application of MON 12037 were initiated on September

[4] Custom Chemicides, P.O. Box 11216, Fresno, CA 93772.
[5] Spraying Systems, P.O. Box 7900, Wheaton, IL 60189-7900.

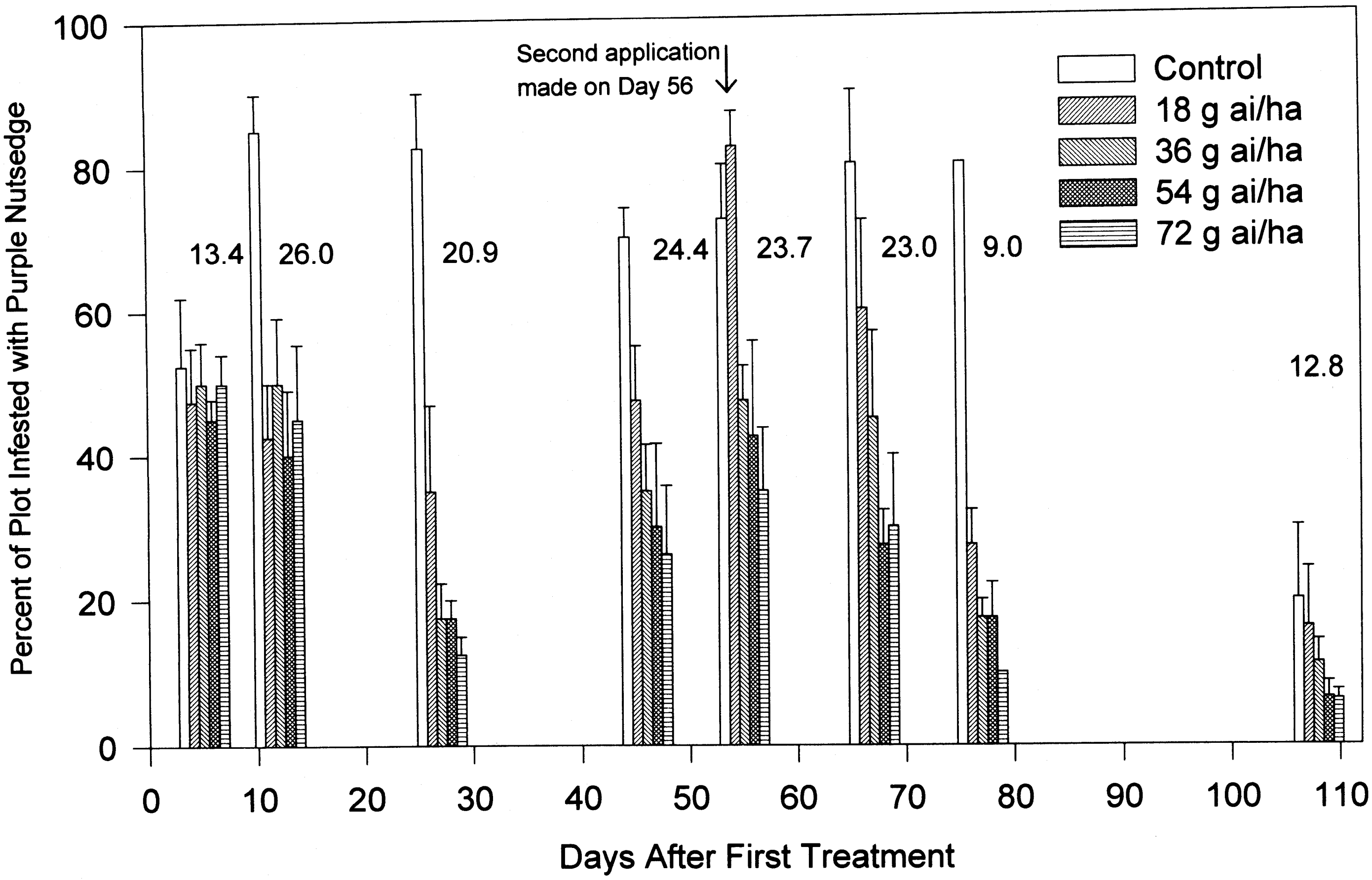

Figure 3. The percentage of the bermudagrass plot area infested with purple nutsedge following two applications of MON 12037 on day 0 and day 56. Bars are the means ± SE for ratings, and the values are the LSD for each group.

1, 1994. The study site was selected for a uniform density of purple nutsedge. The site was located in a level, bermudagrass rough adjacent to a fairway in close proximity to a sprinkler head. The site was not shaded. The only weed contaminating the plots was purple nutsedge.

Evaluations were made for the percentage of the bermudagrass plot infested with purple nutsedge and the percentage of foliar injury to purple nutsedge leaves. Foliar injury was estimated visually based on leaf desiccation, yellowing, and necrotic lesions. Visual evaluations were made at 7, 14, 21, 28, and 42 DAT for the single-application study. At 28 and 253 DAT, three soil cores 11.4 cm in diameter by 10.2 cm deep were cut from each plot using a putting green cup cutter. The tubers contained within each core were collected after washing the soil away from the plant mass on a fine mesh screen. The weight and number of purple nutsedge tubers and their viability were determined.

To determine tuber viability, the tubers were counted and placed in pots to facilitate shoot and root growth. The percentage of tubers forming shoots was determined at 3 wk after planting. Tubers initiating growth were cut in half and found to have turgid, white, storage parenchyma. Tubers that did not sprout roots or shoots but had turgid, white, storage parenchyma were also considered viable. Nongerminating tubers with decayed parenchyma were considered nonviable.

The second study involving two applications of MON 12037 was initiated on July 12, 1995, with the second application made at 56 DAT. The study site was once again selected for a uniform density of purple nutsedge. The site was partially shaded and located on the north-facing slope of a hillock of bermudagrass rough adjacent to a fairway in close proximity to two sprinkler heads. MON 12037 was applied as previously described.

Evaluations for injury to purple nutsedge were made at 5, 12, 27, 46, 55, 67, 77, and 108 DAT. At 108 DAT, soil cores were cut from each plot as previously described. Tuber weight, number, and viability determinations were made as previously described. Analyses were also performed on soil cores cut from the same plots in the spring at 258 DAT.

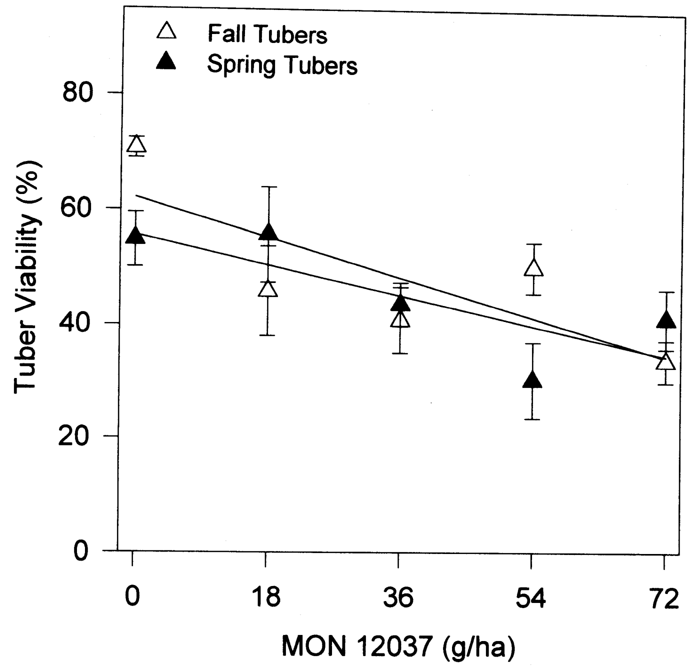

Figure 4. Purple nutsedge tuber viability following two applications of MON 12037. Regression equations for fall tuber viability: y = 62.2 − 0.38x, R^2 = 0.41, P = 0.0023; spring tuber viability: y = 55.7 − 0.28x, R^2 = 0.28, P = 0.017.

In both field experiments, the treatments were arranged in a completely randomized block design with four replicates. Plots were 92 by 153 cm. Differences in treatments and rates were determined using SAS ANOVA,[6] least significant difference (LSD, P = 0.05), and regression analysis using SigmaStat[7] software. All percentage data were arcsine transformed before statistical analysis.

RESULTS AND DISCUSSION

The percentage of the bermudagrass plot infested with purple nutsedge following a single application of MON 12037 at four rates is shown in Figure 1. Data were pooled over time and the mean response is shown. Purple nutsedge decreased from 60 to 30% at 18 g/ha and to approximately 20% at 36, 54, and 72 g/ha following a single application of MON 12037. Similarly, MON 12037 at all rates injured purple nutsedge foliage. There was no injury to the bermudagrass, and the bermudagrass became reestablished in the areas where purple nutsedge was removed by the MON 12037. Thus, the percentage of bermudagrass in the plots increased after treatment, which may have provided competition against the purple nutsedge.

There was no effect of MON 12037 on tuber weight or number for tubers harvested in fall 1994 or spring 1995. Hence, the effect from a single treatment of MON 12037 was largely on the leaves rather than on the tubers. There was no effect of MON 12037 on tuber viability for tubers harvested in the fall. However, in spring, the percentage of viable tubers in the plots was reduced by approximately 50% at 72 g/ha when compared to the untreated controls (Figure 2). These results suggest that effects on tuber populations may not be realized for several months following treatment.

Figure 3 shows the effect of two applications of MON 12037 on the percentage of the bermudagrass plot infested by purple nutsedge. The purple nutsedge in the treated plots decreased at all rates for the first 27 DAT. The lowest rate was least effective in reducing purple nutsedge and plants were the fastest to recover. By day 46, purple nutsedge was becoming reestablished as shown by the increase in purple nutsedge at all rates. The second application, made on day 56, reduced the purple nutsedge relative to the control plots in a manner similar to the first application. A rate response was observed 12 d after the second application for the 18, 36, and 54 g/ha treatments. The differences between treatments diminished with time. However, these treatments did not completely eliminate purple nutsedge. The bermudagrass became reestablished in the plots receiving MON 12037 and eventually covered from 70 to 90% of the plot area.

There was no effect of MON 12037 on tuber weight or number in the fall or spring (data not shown) following the second application. However, tuber viability decreased with increasing rates of MON 12037 in fall and spring tubers (Figure 4). Tuber viability was reduced from approximately 60 to 40%, indicating that MON 12037 reached some of the tubers in the soil. If some tubers were not connected to foliage by viable rhizomes, or the rhizomal connections between tubers were not functional, the tubers may have escaped treatment. It should be noted that tuber viability was not reduced to zero by two applications of MON 12037. Based on these results, more rigorous treatments would be required to control purple nutsedge in subsequent years.

Vencill et al. (1995) and Webster and Coble (1997) found that root and tuber weight and number were reduced by MON 12037, suggesting decreases in tuber viability. The single and double applications made in this study showed that viable tubers persisted in heavily in-

[6] Statistical Analysis Systems Institute Inc., SAS Circle Box 8000, Cary, NC 25712-8000.

[7] Jandel Scientific Software, P.O. Box 7005, San Rafael, CA 94912-7005.

fested purple nutsedge plots in the following spring. Obviously, some of the tubers present in the soil were not affected by the herbicide. Perhaps they did not receive herbicide via translocation because of dormancy or because they were not connected to the living network of rhizomes and shoots.

The timing of the second application relative to the regrowth of purple nutsedge may be critical in reducing populations in subsequent years. Making the second application of MON 12037 to purple nutsedge before robust regrowth has begun may further limit foliage development and reduce the supply of photosynthate available for root, rhizome, and tuber growth. However, there would also be less purple nutsedge foliage to intercept herbicide sprays if the second application was made earlier. The survival of a population of tubers even after two applications of MON 12037 indicates a need to continually monitor for newly emerging plants.

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