Texas Journal of Agriculture and Natural Resources 32:42-55 (2019)

Tolerance of Seashore Paspalum (*Paspalum vaginatum*) and Bermudagrass (*Cynodon dactylon*) on Putting Greens to Xonerate (amicarbazone).

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ABSTRACT

On seashore paspalum and bermudagrass putting greens maintained at 7/32 in. at the Tarleton State University Turfgrass Field Laboratory in Stephenville, TX, Xonerate four SC (amicarbazone) was applied at 2.8, 5.6, and 11.2 fl oz/A, and Xonerate 70 WG was applied at four oz/A on 3 Jun 2013. All treatments included a two week sequential application except the 11.2 fl oz/A treatment; and the 5.6 fl oz/A treatment was evaluated with and without a two week sequential application. Plots were evaluated from 3 Jun to 15 Aug 2013 for chlorophyll indices and visual quality and from 3 Jun to 12 Jul 2013 for visual injury. Xonerate at 5.6 fl oz/A with a sequential application was the only treatment to cause visual estimates of quality to be significantly lower (5.6) than the non-treated (6.9) 22 days after treatment in seashore paspalum. None of the treatment mean estimates of visual quality were significantly different from the non-treatment in bermudagrass. Mean chlorophyll indices of higher rate treatments were less than the non-treated on six sample dates up to 31 days after initial treatment in seashore paspalum. No treatments reported mean chlorophyll indices that were different from the non-treated in bermudagrass. All treatments caused acceptable injury (<4%) three days after treatment in seashore paspalum and bermudagrass. Amicarbazone may have plant growth regulator properties as a period of rapid growth followed a 3.9 in rain event resulting in scalping in bermudagrass near the end of the trial. Amicarbazone appeared to have a long soil residual as broadleaf weeds were suppressed greater than 70 days in an area where remaining spray solutions were applied.

KEY WORDS: seashore paspalum (*Paspalum vaginatum*); bermudagrass (Cynodon dactylon); Xonerate; amicarbazone; tolerance

INTRODUCTION

The perennial biotype of annual bluegrass (*Poa annua* var. *reptans*) is a difficult to control, cool-season weed on putting greens that reduces the aesthetics and playability of the putting surface (Beard 1970 1973). Turf infested with annual bluegrass requires more intensive management to maintain acceptable quality (McCullough et al. 2010). Very few post emergence herbicides are labeled for use on putting greens, and preemergence herbicides often provide erratic control (Callahan and McDonald 1992; Juska and Hanson

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1967). Turfgrass managers would benefit from an herbicide that controls annual bluegrass postemergence on putting greens.

In the transition zone of the United States, golf course superintendents may manage either cool-season grass putting greens like creeping bentgrass (*Agrostis stolonifera*) or warm-season grass putting greens like bermudagrass (*Cynodon dactylon*); however, creeping bentgrass may require more hand watering and fungicides in summer and more mowing in winter than warm-season grass putting greens. Thus, some golf courses may convert from creeping bentgrass to bermudagrass or seashore paspalum (*Paspalum vaginatum*) in order to reduce water, costs, and labor. Warm-season grasses may be dormant when annual bluegrass is growing, which further reduces the aesthetics and playability of the putting surface.

Seashore paspalum is a warm-season turfgrass managed in tropical and warm temperate regions for uses such as golf courses, athletic fields, and lawns, (Duncan and Carrow 2000). Seashore paspalum has traditionally been grown in coastal areas in place of other species such as bermudagrass. Popularity of seashore paspalum is increasing since it is tolerant to salt-laden water, and golf courses and athletic fields are beginning to irrigate with reclaimed water which is higher in salts (Dudeck and Peacock 1985; Duncan and Carrow 2000). A major limitation to seashore paspalum serving as a high quality playing surface is its lack of tolerance to post emergence herbicides used at rates high enough to control annual bluegrass (Yu et al. 2015). For example, sulfonylureas, such as foramsulfuron which is labeled for use on bermudagrass golf putting greens to control annual bluegrass, can cause unacceptable injury (yellowing to foliage) (>20 %) to seashore paspalum (McCullough et al. 2012). Ethofumesate rates required for effective annual bluegrass control may cause excessive injury (>20%) to seashore paspalum (Unruh et al. 2006). Annual bluegrass in seashore paspalum and bermudagrass may be controlled with pronamide; however, control is slow, and pronamide may move laterally to sensitive species (McCullough et al. 2012; Askew 2011).

Amicarbazone (Xonerate) is a triazoline herbicide that inhibits photosystem II in susceptible species when applied pre and post emergence (Dayan et al. 2009; Senseman 2007). Phytotoxic symptoms in susceptible plants include stunted growth, tissue chlorosis, and necrosis and eventual plant senescence (Senseman 2007). Amicarbazone controls annual bluegrass in cool-season turfgrasses, and perhaps amicarbazone could be used to control annual bluegrass in species, such as seashore paspalum, which have unacceptable sensitivities to triazine or sulfonylurea herbicides that are used to control annual bluegrass (McCullough et al. 2010; Perry et al. 2011; Yu et al. 2013). The limitations of selective, post emergence herbicides available for use in seashore paspalum and bermudagrass putting greens also have important implications for herbicide resistance management (Yu et al. 2015). Seashore paspalum has shown potential tolerance to amicarbazone; however, application timing and rates for adequate annual bluegrass control and turfgrass safety have received limited investigation (Yu et al. 2015). The objective of this research was to evaluate seashore paspalum and bermudagrass tolerance to amicarbazone in summer.

MATERIALS AND METHODS

On 3 Jun 2013, 24 – 4 ft. x 4 ft. plots ([5 amicarbazone (Xonerate) treatments & 4 untreated] x 4 replications) were established in a randomized, complete block on a seashore paspalum (*Paspalum vaginatum*) putting green mowed at 7/32 in. with clippings collected at the Tarleton State University Turfgrass Field Laboratory in Stephenville, TX in order to evaluate seashore paspalum tolerance to Xonerate 4 SC and 70 WG formulations (Anonymous 2012). The varieties of seashore paspalum are SeaIsle 2000 (replications one and two) and SeaSpray (replications three and four). Similarly, 10 ft. by 10 ft. plots in a Mini-Verde bermudagrass (*Cynodon dactylon*) putting green, previously overseeded with ryegrasses in fall 2012, were established to evaluate bermudagrass tolerance to Xonerate 4 SC and 70 WG formulations except only three replications were used. The bermudagrass plots were over seeded with either annual, intermediate, or perennial ryegrass in fall 2012. The same treatments and rates were used on both the seashore paspalum and bermudagrass plots and are shown on Table 1. Treatments were applied on 3 Jun 2013 using a two wheeled, mounted CO_2–pressurized 4 ft. boom with three TeeJet XR11005 nozzles calibrated to deliver 87 gallons per acre at 36 psi. A plug (blank nozzle) was placed on the 4 nozzle fitting on the right side of the 4 nozzle boom. Sequential treatments were applied on 17 Jun 2013, and a dye was included to delineate the spray swath and to illustrate any over application that can occur at the beginning and end of a spray swath due to a pause in the forward motion of the sprayer while spraying or an overlap of side by side treatments. Residual spray solutions were sprayed in 4 ft. swaths in a weedy area mowed infrequently with populations of hophornbeam copperleaf (*Acalypha stryifolia*), spreading dayflower (*Commelina diffusa*), and purple nutsedge (*Cyperus rotundus*) lining 1 ft. wide strips of established zoysiagrass (*Zoysia japonica*) sod placed 0.5 ft. apart.

Table 1. Tolerance of Seashore Paspalum and Bermudagrass to Xonerate, Turfgrass Field Laboratory, Tarleton State University, Stephenville, TX.

	Treatment	Rate		Application Date
1	Untreated Check	0		
2	Xonerate 4 SC [1]	2.8 [2]	fl oz/A	6/3, 6/17/2013
4	Xonerate 70 WG	4.0	oz/A	6/3, 6/17/2013
3	Xonerate 4 SC	5.6	fl oz/A	6/3/2013
5	Xonerate 4 SC	5.6	fl oz/A	6/3, 6/17/2013
6	Xonerate 4 SC	11.2	fl oz/A	6/3/2013

[1] All Xonerate treatments contained a NIS at 0.25% v/v.
[2] Rates from Xonerate label (Anonymous, 2012).
NIS Nonionic surfactant at 0.25% v/v basis.

The plots were rated for visual quality on 6/03, 6/06, 6/11, 6/17, 6/25, 7/01, 7/12, 8/2, 8/9, and 8/15/2013 which are 0, 3, 8, 14, 22, 28, 39, 60, 67, and 73 days after initial treatment [DAIT], respectively. Chlorophyll indices were measured on 5/30, 6/06, 6/10, 6/17, 6/21, 6/24, 7/01, 7/04, 7/11, 7/18, 8/1, and 8/9/2013 which are 0, 3, 7, 14, 18, 21, 28, 31, 38, 45, 59, and 67 DAIT, respectively. Treatments were evaluated for visual estimates of percent injury where the rating scale ranged from: 0 = no injury to 100 = all plants severely injured. The plots were rated for visual estimates of injury on 6/03, 6/06, 6/11, 6/17, 6/25, 7/01, and 7/12/2013 which are 0, 3, 8, 14, 22, 28, and 39 DAIT, respectively. Treatments were evaluated using visual estimates of quality where the rating scale ranged from: 0 = dead or no turf; 5 = minimal acceptance; 7 = average turf; 9 =ideal turf. Chlorophyll indices were determined using a Spectrum Field Scout CM 1000 chlorophyll meter. Chlorophyll meter readings were recorded when the brightness index was equal to or greater than two. Ten chlorophyll measurements were recorded and averaged for each plot. Greater chlorophyll measurements indicate greater turfgrass quality, and lower chlorophyll measurements can suggest either lower fertility, weed/turfgrass injury from treatments, or scalping in the case of excessive growth between mowings.

The study was conducted as a worst case scenario where the seashore paspalum stand was initially weak. In addition, nitrogen fertilizer was used sparingly to reduce mowing frequency which may have caused the injury to last longer than where a professional turfgrass manager would apply more nitrogen sooner to hasten the recovery. Nitrogen was applied at 0.2 #N/1000ft^2, 0.5#N/1000ft^2, and 0.5#N/1000ft^2 on 6/26, 7/14, and 8/9/2013, respectively. Nitrogen at 0.5#N/1000ft^2 was applied using a granular source before and after a 3.9 in. rain event to demonstrate that the treated plants were not stunted and could return to the quality of the untreated plots by the end of the study.

Similarly, topdressing and vertical mowing may also have hastened recovery; however, these maintenance practices were not implemented during the trials. In some cases, plots responded to the stress of herbicide injury by having greater growth (clippings) than the untreated later in the study. Just as two applications of a herbicide can provide better weed control than one application when applying the same total amount of herbicide, two applications can cause more host crop injury for a longer time period.

The study design was a randomized, complete block with three replications for bermudagrass and four replications for seashore paspalum. Standard F tests were used to determine significant ($\alpha \leq 0.05$) main effects along with appropriate means separation using Fisher's Protected LSD test (SAS 2012).

RESULTS

Mean visual estimates of quality of the seashore paspalum plots ranged from 5.6 to 7.3 (Table 2). Significant differences in visual quality were detected following the sequential 5.6 fl oz/A treatment application on 25 Jun and 1 Jul 2013 where Xonerate at 5.6 fl oz/A applied twice was associated with visual quality estimates (5.6 and 6.0, respectively) significantly lower ($p \leq 0.05$) than the untreated (6.9 and 7.3, respectively). There were no significant differences among the visual estimates of quality in the bermudagrass trials (Table 3).

Mean chlorophyll indices in the seashore paspalum trial ranged from 242 to 399 (Table 4). Significant differences ($p \leq 0.05$) in mean chlorophyll indices in the seashore paspalum were detected on all sampling dates after treatments were applied, except 7/18, 8/01, and 8/09 (45, 59, and 67 DAIT). Xonerate 4 SC at 5.6 fl oz/A applied twice was associated with significantly lower ($p \leq 0.05$) chlorophyll indices (253 to 384) than the untreated (271 to 417) on five sampling dates. There were no significant differences among the mean chlorophyll indices in the bermudagrass trials (Table 5).

Mean visual estimates of seashore paspalum injury ranged from 0 to 16% (Table 6). Significant differences were detected on 6 Jun 2013 (3 DAIT) where all treatments were associated with percent injury (3.3 to 4.0) significantly greater ($p \leq 0.05$) than the untreated (0). Xonerate at 5.6 fl oz/A applied twice tended to be associated with more injury for a longer duration in seashore paspalum, which is consistent with other measurements where treatments with sequential applications were associated with lower visual estimates of quality and mean chlorophyll indices. Similarly, in the bermudagrass trials, significant differences were detected on 6 Jun 2013 (3 DAIT) where all treatments were associated with percent injury levels (2.7 to 3.0) significantly greater ($p \leq 0.05$) than the untreated (0) (Table 7). (Figure 1).

Figure 1. Xonerate at 5.6 fl oz/A applied twice was injurious to bermudagrass; however, the stress caused the bermudagrass to grow more than the untreated 60 days after initial treatment as shown.

Residual spray solutions were sprayed in 4 ft. swaths in a weedy area mowed infrequently with populations of hophornbeam copperleaf (*Acalypha stryifolia*), spreading dayflower (*Commelina diffusa*), and purple nutsedge (*Cyperus rotundus*) lining 1 ft. wide strips of established zoysiagrass (*Zoysia japonica*) sod spaced 0.5 ft. apart. Xonerate controlled the broadleaf weeds postemergence and provided residual control for over 70 days. The purple nutsedge was injured but not controlled. The zoysiagrass (*Zoysia japonica*) was not injured. (Figure 2).

Figure 2. Broadleaf weed control and nutsedge suppression 67 days after initial treatment.

Table 2. Seashore Pasplaum Visual Quality, Tarleton State University Turfgrass Field Laboratory, Stephenville, TX.

Treatment [1]	Product	6/3/2013[2]	06/06/13	06/11/13	06/17/13	06/25/13	07/01/13	07/12/13	08/02/13	08/09/13	08/15/13
		0	3	8	14	22	28	39	60	67	73
		Visual Estimate [3]									
1	Untreated	6.5 A[4]	6.6	6.9	7.0	6.9 A	7.3 A	7.2	7.3	7.1	7.3
2	Xonerate 4 SC 2.8 fl oz/A	6.3 A	6.1	6.3	6.4	6.6 A	6.8 A	6.9	6.5	6.4	6.9
3	Xonerate 70 WG 4 oz/A	6.3 A	6.0	6.5	6.9	6.2 AB	6.6 AB	6.9	6.6	6.6	7.1
4	Xonerate 4 SC 5.6 fl oz/A	6.5 A	6.3	6.4	6.8	6.9 A	7.1 A	7.2	6.8	6.8	7.1
5	Xonerate 4 SC 5.6 fl oz w/Sequential	6.0 A	5.7	6.1	6.4	5.6 B	6.0 B	6.5	6.6	6.7	7.1
6	Xonerate 4 SC 11.2 fl oz/A	5.9 A	5.8	5.6	5.9	6.4 AB	6.8 AB	6.8	6.6	6.7	7.0
	LSD	0.7	NS	NS	NS	0.9	NS	NS	NS	NS	NS
	p	0.0029	0.1432	0.4483	0.3673	0.0351	0.0073	0.2761	0.1984	0.1941	0.0757

[1] All treatments were initially applied on 6/03/2013, and sequential treatments were applied 6/17/2013.

[2] Background data.

[3] 0 = dead or no turf; 5 = minimal acceptance; 7 = average turf; 9 =ideal turf.

[4] Means followed by the same <u>upper</u> case letter are not significantly different according to Fisher's protected LSD t-test at $p \leq 0.05$.

DAT	Days after initial treatment.
LSD	Least significant difference.
p	Differences are significant when $p \leq 0.05$.
NS	Not significant.

Table 3. Bermudagrass Visual Quality, Tarleton State University Turfgrass Field Laboratory, Stephenville, TX.

Treatment [1]	Product	6/3/2013[2]	06/06/13	06/11/13	06/17/13	06/25/13	07/01/13	07/12/13	08/02/13	08/09/13	08/15/13
		0	3	8	14	22	28	39	60	67	73
		Visual Estimate [3]									
1	Untreated	7.0	6.8	7.0	6.8	6.8	7.0	7.3	7.2	7.2	7.3
2	Xonerate 4 SC 2.8 fl oz/A	6.7	6.4	6.0	6.0	6.1	6.5	7.2	5.7	6.0	7.0
3	Xonerate 70 WG 4 oz/A	6.5	6.3	4.8	5.0	5.0	5.5	6.4	6.4	6.6	7.1
4	Xonerate 4 SC 5.6 fl oz/A	6.8	6.4	5.6	5.4	5.8	6.3	7.0	6.3	6.6	6.9
5	Xonerate 4 SC 5.6 fl oz w/Sequential	6.7	6.8	5.4	5.3	5.3	5.7	6.8	5.5	5.8	6.8
6	Xonerate 4 SC 11.2 fl oz/A	7.0	6.5	5.3	5.2	5.3	5.9	6.7	6.8	6.8	7.2
	LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	p	0.7299	0.7022	0.3437	0.3921	0.316	0.443	0.4513	0.5972	0.5061	0.7276

[1] All treatments were initially applied on 6/03/2013, and sequential treatments were applied 6/17/2013.

[2] Background data.

[3] 0 = dead or no turf; 5 = minimal acceptance; 7 = average turf; 9 =ideal turf.

[4] Means followed by the same <u>upper</u> case letter are not significantly different according to Fisher's protected LSD t-test at $p \leq 0.05$.

DAT	Days after initial treatment.
LSD	Least significant difference.
p	Differences are significant when $p \leq 0.05$.
NS	Not significant.

Table 4. Mean Chlorophyll Inidices for Seashore Pasplaum, Tarleton State University Turfgrass Field Laboratory, Stephenville, TX.

Product [1]	5/30/2013²	06/06/13	06/10/13	06/17/13	06/21/13	06/24/13	07/01/13	07/04/13	07/11/13	07/18/13	08/01/13	08/09/13	
	0	3	7	14	18	21	28	31	38	45	59	67	DAT
	Chlorophyl Index [3]												
Untreated	356 A[4]	399 A	354 A	417 A	353 A	335 AB	329 AB	316 A	352 ABC	368	271	269	
Xonerate 4 SC 2.8 fl oz/A	383 A	364 AB	340 AB	440 A	289 BC	346 AB	320 ABC	291 ABC	354 ABC	352	266	259	
Xonerate 70 WG 4 oz/A	374 A	347 B	309 BC	400 A	251 DC	294 BC	276 BC	264 BC	322 BC	327	261	269	
Xonerate 4 SC 5.6 fl oz/A	373 A	340 B	298 CD	382 AB	329 AB	373 AB	338 A	328 A	378 A	373	271	268	
Xonerate 4 SC 5.6 fl oz w/Sequential	348 A	325 B	303 BCD	384 AB	242 DC	273 C	267 C	253 C	302 C	309	264	263	
Xonerate 4 SC 11.2 fl oz/A	373 A	333 B	264 D	328 B	290 BC	340 AB	314 ABC	306 AB	359 AB	364	271	271	
LSD	51	50	42	64	41	57	55	42	55	NS	NS	NS	
p	0.002	0.0004	0.0014	0.0069	0.0001	0.0148	0.0153	0.0058	0.0514	0.2135	0.4384	0.5677	

[1] All treatments were initially applied on 6/03/2013, and sequential treatments were applied 6/17/2013.

[2] Background data.

[3] Chlorophyll indices were measured using a hand-held Spectrum Field Scout CM 1000 Chlorophyll meter with 10 measurements per plot.

[4] Means followed by the same upper case letter are not significantly different according to Fisher's protected LSD t-test at $p \leq 0.05$.

DAT	Days after initial treatment.
LSD	Least significant difference.
p	Differences are significant when $p \leq 0.05$.
NS	Not significant.

Table 5. Mean Chlorophyll Inidices for Bermudagrass, Tarleton State University Turfgrass Field Laboratory, Stephenville, TX.

Product [1]	5/30/2013[2]	06/06/13	06/10/13	06/17/13	06/21/13	06/24/13	07/01/13	07/04/13	07/11/13	07/18/13	08/01/13	08/09/13	
	0	3	7	14	18	21	28	31	38	45	59	67	DAT
	Chlorophyll Index [3]												
Untreated	242	307	262	309	302	262	298	295	333	438	289	283	
Xonerate 4 SC 2.8 fl oz/A	258	286	240	336	263	269	320	342	376	470	343	327	
Xonerate 70 WG 4 oz/A	238	259	217	298	238	235	296	316	358	436	322	338	
Xonerate 4 SC 5.6 fl oz/A	257	300	244	345	320	319	331	350	379	458	316	321	
Xonerate 4 SC 5.6 fl oz w/Sequential	230	264	235	322	248	237	304	316	365	446	352	329	
Xonerate 4 SC 11.2 fl oz/A	238	272	224	275	258	287	289	308	343	419	307	340	
LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
p	0.9215	0.747	0.9294	0.7701	0.194	0.1221	0.8343	0.3724	0.7456	0.8561	0.4797	0.4693	

1	All treatments were initially applied on 6/03/2013, and sequential treatments were applied 6/17/2013.
2	Background data.
3	Chlorophyll indices were measured using a hand-held Spectrum Field Scout CM 1000 Chlorophyll meter with 10 measurements per plot.
4	Means followed by the same upper case letter are not significantly different according to Fisher's protected LSD t-test at $p \leq 0.05$.

DAT	Days after initial treatment.
LSD	Least significant difference.
p	Differences are significant when $p \leq 0.05$.
NS	Not significant.

Table 6. Seashore Pasplaum Visual Injury, Tarleton State University Turfgrass Field Laboratory, Stephenville, TX.

Treatment [1]	Product	6/3/2013[2]	06/06/13	06/11/13	06/17/13	06/25/13	07/01/13	07/12/13
		0	3	8	14	22	28	39
		Visual Estimate [3]						
1	Untreated	0.0	0.0 B[4]	0.0	0.0	0.0	0.0	0.0
2	Xonerate 4 SC 2.8 fl oz/A	0.0	3.3 A	1.8	3.3	5.0	2.3	5.8
3	Xonerate 70 WG 4 oz/A	0.0	3.8 A	4.5	4.3	5.5	5.0	6.0
4	Xonerate 4 SC 5.6 fl oz/A	0.0	4.0 A	3.0	4.8	3.3	1.8	0.0
5	Xonerate 4 SC 5.6 fl oz w/Sequential	0.0	4.0 A	10.5	10.3	14.0	11.3	15.0
6	Xonerate 4 SC 11.2 fl oz/A	0.0	3.3 A	14.8	16.0	12.3	7.5	7.3
	LSD	NS	2.7	NS	NS	NS	NS	NS
	p	- -	0.0268	0.1101	0.2042	0.3073	0.3891	0.1858

1 All treatments were initially applied on 6/03/2013, and sequential treatments were applied 6/17/2013.
2 Background data.
3 0 = no injury, 100 = All plants severely injured.
4 Means followed by the same upper case letter are not significantly different according to Fisher's protected LSD t-test at p ≤ 0.05.

DAT Days after initial treatment.
LSD Least significant difference.
p Differences are significant when p ≤ 0.05.
NS Not significant.

Table 7. Bermudagrass Visual Injury, Tarleton State University Turfgrass Field Laboratory, Stephenville, TX.

Treatment [1]	Product	6/3/2013[2]	06/06/13	06/11/13	06/17/13	06/25/13	07/01/13	07/12/13
		0	3	8	14	22	28	39
		Visual Estimate [3]						
1	Untreated	0.0	0.0 B[4]	0.0	0.0	0.0	0.0	0.0
2	Xonerate 4 SC 2.8 fl oz/A	0.0	2.7 A	16.7	18.3	21.7	15.0	2.7
3	Xonerate 70 WG 4 oz/A	0.0	3.0 A	28.3	28.3	31.7	23.3	12.7
4	Xonerate 4 SC 5.6 fl oz/A	0.0	3.3 A	24.7	20.0	16.7	10.0	3.7
5	Xonerate 4 SC 5.6 fl oz w/Sequential	0.0	2.7 A	20.0	22.3	30.0	21.7	6.0
6	Xonerate 4 SC 11.2 fl oz/A	0.0	2.7 A	24.7	27.0	25.0	15.7	14.3
	LSD	NS	1.9	NS	NS	NS	NS	NS
	p	- -	0.0236	0.5785	0.4026	0.1979	0.1599	0.5325

1 All treatments were initially applied on 6/03/2013, and sequential treatments were applied 6/17/2013.
2 Background data.
3 0 = no injury, 100 = All plants severely injured.
4 Means followed by the same upper case letter are not significantly different according to Fisher's protected LSD t-test at p ≤ 0.05.

DAT Days after initial treatment.
LSD Least significant difference.
p Differences are significant when p ≤ 0.05.
NS Not significant.

A rain gauge near the study area measured rain fall on five dates for a total of 5.4 inches. When the plots were rated on 2 Aug 2013 following a 3.9 in. rain event during 7/15 and 7/16/2013, scalping (removal of green portion of turf canopy due to excessive growth [period of greater shoot elongation paired with inability to mow at regular interval while wet]) occurred in the plots treated with Xonerate which may have been incorrectly measured as lower quality and chlorophyll; however, scalping may have occurred because treated plots were actually growing better (more clippings) than non-treated plots. This response to a large amount of rain suggests that Xonerate was acting as a plant growth regulator and remaining in the soil for an extended period at concentrations high enough to cause growth effects until leached out of the root zone by a large quantity of infiltrating rain water. Following a period of suppressed shoot growth when using a plant growth regulator, there may be a period of rapid shoot growth (cell division or elongation) which may lead to scalping which may make the turf look like the mowing height was lower excessively. Perry et al. 2011 and Jeffries et al. 2013 demonstrated greater amicarbazone uptake in roots than shoots.

Figure 3. Xonerate at 5.6 fl oz/A applied twice was injurious to bermudagrass; however, the stress caused the bermudagrass to grow more than the untreated 60 days after initial treatment. In addition, on 8/01/2013 after a 3.9" rain event 7/15 and 7/16/2013, scalping occurred. Perhaps the rain leached the Xonerate which was acting as a plant growth regulator. After a period of suppressed growth is a period of rapid growth resulting in scalping.

CONCLUSION AND DISCUSSION

The objective of this research is characterize the tolerance of seashore paspalum and bermudagrass putting greens to Xonerate 4 SC and 70WG (amicarbazone) which may be used to control annual bluegrass in other turfgrass species. There were indications that seashore paspalum and bermudagrass have some acceptable susceptibility issues with

Xonerate, which was most evident between plots where an over application occurred due to a pause in the forward motion of the sprayer while spraying, or an overlap of two different side by side treatments. Xonerate 4 SC at 5.6 fl oz with a sequential application caused more visual injury, lower visual quality, and lower mean chlorophyll indices than the untreated in seashore paspalum. There were no significant differences between the treated and the untreated 31 to 73 DAIT in seashore paspalum. Furthermore, there were no significant differences in visual estimates of quality or mean chlorophyll indices in bermudagrass. However, visual estimates of injury for all treatments were significantly greater than the untreated 3 DAIT in bermudagrass. Xonerate controlled broadleaf weeds post emergence and provided for over 70 day residual preemergence broadleaf weed control and purple nutsedge suppression in a zoysiagrass area where residual spray solutions were applied. The zoysiagrass was not injured. Scalping in the treated plots occurred following a 3.9” rain. Scalping may have occurred because treated plots were actually growing better (more clippings) than non-treated plots as Xonerate may have been acting as a plant growth regulator and remained in the soil for an extended period at concentrations high enough to inhibit cell elongation until leached out of the root zone by a large quantity of infiltrating rain water.

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ACKNOWLEDGEMENTS

This research was supported by Arysta LifeScience North America Corp. Special thanks to Ray Molina and Jordan Young for their help with the field work and plot maintenance.