GEORGIA GOLF ENVIRONMENTAL FOUNDATION

FINAL REPORT (November 2014-July 2017)

TEMPORAL, CULTURAL, BIOLOGICAL, AND CHEMICAL PRACTICES TO ENHANCE SPRING DEAD SPOT (SDS) CONTROL OF BERMUDAGRASS IN GEORGIA

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1. COMBINATION OF TEMPORAL, CULTURAL, AND CHEMICAL PRACTICES FOR SPRING DEAD SPOT CONTROL AND EVALUATION OF NEW CHEMISTRIES

Spring dead spot (SDS) *(caused by Ophiosphaerella korrae*, *O. narmari* and *O. herpotricha)* is a persistent and destructive disease of bermudagrass (*Cynodon* sp.) in Georgia. The disease can be devastating on bermudagrass greens, tees and fairways. The disease is particularly prevalent and damaging in the northern part of Georgia, especially in the Piedmont physiographic area (Martinez et al., 2011). Disease infestation is most noticeable in the spring when bermudagrass begins to break winter dormancy, but injury often lingers well into the summer. In some instances, bermudagrass may not fully recover before the onset of fall dormancy making it more susceptible to winter kill (Tredway et al., 2008). Application of dinitroanaline preemergence herbicides (ex. Barricade) in the spring may further hinder bermudagrass recovery (Beck et al., 2013).

SDS symptoms appear as well-defined, bleached, circular patches ranging in size from a few inches to several feet in diameter (Dernoeden et al., 1991; Tredway et al., 2008; Martinez et al., 2011). Turfgrass within these patches eventually collapses to the ground, leaving sunken necrotic areas. Infected plant parts, such as rhizomes, stolons, crowns, and roots appear dark black and rotten when removed from the soil. The fungus overwinters as mycelium in infected turfgrass roots and crowns. Patches return each year, often increasing in size and severity. Weed growth may occur in the center of patches due to slow bermudagrass re-colonization requiring the additional use of post-emergence herbicides (Dernoeden et al., 1991; Tredway et al., 2008; Martinez et al., 2011).

Fry and Tisserat (1997) reported that cultural practices that result in severe disturbance of the upper root zone could reduce SDS damage of bermudagrass turf. The combination of aeration and verticutting, when performed twice a year, was moderately effective in reducing SDS disease. However, these practices alone are erratic at best and were ineffective at reducing disease pressure below acceptable levels. High K_{oc} (soil sorption coefficient) values of several fungicides may inhibit their movement into the root zone following application. Two efficacious fungicides for the control of SDS, tebuconazole (Torque) and fenarimol (Rubigan), exhibit high K_{oc} values. Cultivation practices aimed at increasing infiltration and reducing thatch accumulation may increase penetration into the soil profile and enhance fungicide efficacy.

Although several fungicides are labeled for the control of SDS, the inability to identify *Ophiophaerella* infection timing has led to erratic control, varying from golf course to golf course and from year to year. Walker et al. (2009) observed disease colonization during spring and fall, while Butler and Tredway (2007) determined that colonization occurs primarily in the fall. Identification of colonization timing is critical for efficient and effective SDS control with fungicide applications. Once the disease has colonized the root system, fungicides are rendered ineffective. Applying fungicides earlier in the year (spring) may increase fungicide efficacy. In addition, several new chemistries have recently been introduced that may be effective at controlling SDS.

Nitrogen sources appear to be of impact in the development of spring dead spot in bermudagrass. Tredway et al. (2009) showed that spring dead spot pathogens responded to nitrogen sources differently. *Ophiospaerella korrae* was suppressed effectively by calcium nitrate, while *O. herpotricha* was suppressed most effectively by ammonium sulfate. One of the objectives of this proposal is to evaluate different nitrogen sources and the effect on SDS development in bermudagrass grown on soils unique to Georgia. Additionally, environmental stewardship, overreliance on chemical control, and increasing concerns about pesticide resistance has led turfgrass managers to examine alternative practices to reduce plant disease; therefore we are proposing to evaluate biologically based fungicides and organic products for SDS control.

This final report contains observations and data that was not analyzed by the time of last reporting. Additionally, on this report, all measurements and data points from the two years, two timings and two locations were re-analyzed. Data was analyzed in multiple ways, however the best comparisons that reveal greater ANOVA significance were when measurements were compared ***within year*** and whenever measurements required, ANOVA was performed ***within location***.

MATERIALS AND METHODS

1. Evaluation of Cultural Practices

a. Effect of Core Aeration

Field experimental areas were either core-aerated or not core-aerated (cultural treatment) using 1-inch solid tines immediately prior to fungicide applications in the fall and in the spring (temporal treatment)

2. Evaluation of Fungicide Treatments applied either in the fall or spring

a. Fall applications

Two fungicide trials were conducted on a 7-year-old sward of bermudagrass cv. "TifSport" grown on a clay loam soil (pH 5.8) at the University of Georgia-Griffin campus and on a 15-year-old 319 bermudagrass fairway at Towne Lake Hills Golf Club located in Woodstock GA. Turfgrass cultural practices were similar to those prescribed for maintenance of fairway areas in Georgia. Fertilizer treatments consisted of 1.0 lb nitrogen (10-10-10) per 1000 sq ft applied monthly during the growing season. The turfgrass was maintained at a height of 5/8 in. to 1 in. by mowing twice a week. The bermudagrass area located at the University of Georgia-Griffin campus has been artificially inoculated with an *Ophiosphaerella korrae* grown on an oat/barley/wheat seed mixture previously soaked in water overnight and then double sterilized in Erlenmeyer flasks. The infected seed was manually placed into the center of the plot and into the soil (@ 3 inches in depth) by pulling a golf course cup cutter plug and/or soil probe, depositing the infested grain in the soil and replacing the plug on top of the grain. The area located at Towne Lake Hill golf club has a history of severe SDS infections.

On both sites, treatments were arranged as plots (4 ft x 6 ft) in a randomized complete block design with four replications. At the University of Georgia-Griffin campus initial application was made in Oct 1, 2014 and Oct 29, 2014 at Townlake golf course and Oct 2, 2014 and Oct 30, 2014 at the Griffin location. In 2015, At the University of Georgia-Griffin campus initial application was made in 09 Oct. 2015 and the second application was made on 10 Nov 2015. At the Towne Lake Hills Golf Club site, fungicides applications were made on Oct 06, 2015 and Nov 03, 2015. Fungicides were mixed with water and sprayed in 2.0 gal. water per 1000 sq ft with a hand held, CO_2-pressured boom sprayer at 30 psi using XR TeeJet 800 2vs nozzles. Treatments were watered-in after application with 0.1 in. of irrigation. Normal irrigation was applied as per site management. Visual ratings were performed at 14-8 day intervals at green up. Visual estimates of disease severity were made using a modified Horsfall-Barratt rating scale (0 to 11), and then transformed to percent disease severity (0 = 1.17%, 5=37.5%, 11=98.82%) using ARM. Turf Quality was also rated using a percent (0=bad, unsightly quality; 100=excellent quality). Percent of disease severity and quality data were subjected to analysis of variance and means were separated Fisher's Protected LSD test (P= 0.05).

b. Spring applications

Two fungicide trials were conducted as described in Fall applications section. On both sites, treatments were arranged as plots (4 ft x 6 ft) in a randomized complete block design with four replications. At the University of Georgia-Griffin campus two fungicide applications were performed in April 8, 2015 and May 5, 2015 at Townlake golf course and April 3, 2015 and May 1, 2015 at the Griffin location. In 2016 At the University of Georgia-Griffin campus, the initial application was made on 24 Mar, 2016 and the second application was made on 20 Apr, 2016. At the Towne Lake Hills Golf Club site, fungicide applications were made on 29 Mar, 2016 and 26 Apr, 2016. Fungicides were mixed with water and sprayed in 2.0-gal water per 1000 sq ft with a hand held, CO_2-pressured boom sprayer at 30 psi using XR TeeJet 800 2vs nozzles. Granular formulations were weighed and distributed equally in each replicated plot using a canister with perforated lid. Treatments were watered-in after application with 0.1 in. of irrigation. Normal irrigation was applied as per in-site management. Visual ratings were performed at 14-28 day intervals at green up. Visual estimates of disease severity were made using a modified Horsfall-Barratt rating scale (0 to 11), and then transformed to percent disease severity (0 = 1.17%, 5=37.5%, 11=98.82%) using ARM. Turf Quality was also rated using a percent (0=bad, unsightly quality; 100=excellent quality). Percent of disease severity and quality data were subjected to analysis of variance and means were separated Fisher's Protected LSD test (P= 0.05).

c. Fungicides chemistries

Commercial Name	Active Ingredient (s)	Rate/1000 sq ft	Chemical Group	Company
1. Non Treated Control	------	-------	--------	--------
2. Torque	tebuconazole	0.6 fl oz	DMI	BASF
3. Pillar	triticonazole + pyraclostrobin	3.0 lb	DMI + Strobilurin	Nufarm
4. Headway	propiconazole + azoxystrobin	3.0 fl oz	DMI + Strobilurin	Syngenta
5. Rubigan	fenarimol	6.0 fl oz	DMI	Gowan
6. Briskway	difenconazole + azoxystrobin	0.75 fl oz	DMI + Strobilurin	Syngenta
7. Xzemplar	fluoxapyroxad	0.26 fl oz	SDHI	BASF
8. Tourney	metconazole	0.37 oz	DMI	Valent
9. Torque + Revolution	tebuconazole + modified alkylated polyol	0.6 fl oz + 6.0 fl oz	DMI + polyol	Nufarm, Aquatrols

In 2015-2016 field trials an additional, independent fungicide trial was carried using penthiopyrad (Velista)

Commercial Name	Active Ingredient (s)	Rate/1000 sq ft	Chemical Group	Company
1. Non-Treated Control	------	-------	--------	--------
2. Velista	penthiopyrad	0.3 oz	SDHI	Syngenta
3. Velista	penthiopyrad	0.5 oz	SDHI	Syngenta

RESULTS

Greater ANOVA significance were obtained when measurements were compared ***within year*** and whenever measurements required, ANOVA was performed ***within location***.

2015 (YEAR 1) RESULTS OF COMBINATION OF TEMPORAL, CULTURAL, AND CHEMICAL PRACTICES FOR THE CONTROL OF SPRING DEAD SPOT AND EVALUATION OF NEW CHEMISTRIES FALL-Griffin and TowneLake

1. Evaluation of Cultural Practices

a. Effect of Core Aeration

Core aeration (solid tine) cultural practice before fungicide application was statistically (P= 0.05) similar to non-core aeration in both, fall and spring. In other words, core aeration did not increased fungicide efficacy in spring or fall applications in any of the sites. Solid tine did not negatively impact fungicide efficacy, and neither promoted disease severity.

Table 1. Effect of core-aeration on Spring Dead Spot severity. Individual ratings taken when SDS symptoms were highest on non-treated control

Means with the same letter are not significantly different.			
t Grouping	Mean	N	aerate
A	13.093	72	0 (non aereated)
A	11.943	72	1 (aereated)

2. Evaluation of Fungicide Treatments applied either in the fall or spring

a. Fall applications

Table 2. P-values of F tests from analysis of variance (ANOVA) for the effect of fungicides applied in the fall on SDS severity. The data shown is for date when SDS symptoms were highest.

Source	DF	Pr > F
rep	3	0.3004
location	1	0.0002
rep*location	3	0.1384
aerate	1	0.5377
location*aerate	1	0.3097
rep*location*aerate	6	0.1261
trt	8	<.0001
location*trt	8	0.8247
aerate*trt	8	0.5690

Table 3. Mean of SDS severity after fungicides were applied in the fall. The data shown is the date when SDS symptoms were highest.

Means with the same letter are not significantly different.						
t Grouping			Mean	N	trt	
	A		30.956	16	1	Non-Treated control
	B		14.743	16	3	Pillar
C	B		12.691	16	6	Briskway
C	B		12.179	16	4	Headway
C	B	D	11.055	16	9	Torque + Revolution
C	B	D	10.983	16	2	Torque
C	B	D	9.956	16	8	Tourney
C		D	5.854	16	5	Rubigan
		D	4.244	16	7	Xzemplar

Overall and, considering the two locations in 2014-2015, all fungicides treatments provided statistically significant Spring Dead Spot suppression when compared to the untreated control.
SDHI and DMI's fungicides applied twice in the fall provided statistically significant SDS suppression. Mixed products of DMI's and strobilurins also provided statistically significant SDS suppression but ranked lower that the DMI's and SDHI chemical groups in 2014-2015 season.

b. Spring fungicide applications (curative)

Table 4. Mean of SDS severity after fungicides were applied in the spring. The data shown is the date when SDS symptoms were highest.

Means with the same letter are not significantly different.						
t Grouping			**Mean**	**N**	**trt**	
	A		23.337	16	1	Non-Treated Control
B	A		22.848	16	3	Pillar
B	A	C	16.697	16	4	Headway
B	A	C	16.256	16	2	Torque
B		C	15.621	16	8	Tourney
		C	13.767	16	9	Torque + Revolution
		C	10.543	16	5	Rubigan
		C	10.396	16	6	Briskway
		C	9.518	16	7	Xzemplar

Table 5. Mean of turfgrass quality after fungicides were applied in the spring. The data shown is the date turfgrass recovery reached an acceptable quality (foliar canopy was uniform in color and density) level

Means with the same letter are not significantly different.					
t Grouping		**Mean**	**N**	**trt**	
	A	92.500	16	7	Xzemplar
B	A	90.313	16	9	Torque + Revolution
B	A	89.688	16	5	Rubigan
B	A	89.375	16	8	Tourney
B	C	88.125	16	4	Headway
B	C	87.500	16	2	Torque
B	C	87.188	16	6	Briskway
	C	85.000	16	3	Pillar
	D	80.313	16	1	Non-treated control

Spring fungicide applications proved to suppress SDS severity up to 52% compared to the untreated control resulting in the acceleration of turfgrass recovery up to 47-70 days (days to acceptable quality=foliar canopy was uniform in color and density). An unforeseen benefit of spring fungicide applications is the control and /or prevention of other diseases especially dollar spot and large patch.
Quality ratings might have been influenced by these diseases.

3. **Evaluation of soil fertility-with emphasis of nitrogen source and fungicide alternatives for the control of sds.**

Field experiments were conducted on a 'TifSport' bermudagrass sward with SDS history, which is located at the University of Georgia-Griffin campus and at one golf course in Georgia in 2014 and continue through 2016. Plots measuring 6 ft x 6 ft will be arranged in a complete randomized block with four replications. Treatments will consist of fertilizers with different sources of nitrogen and bio-fungicides/organic products. Liquid products will be applied as per manufacturer use instructions. Granular formulations will be weighed and distributed equally in each replicated plot using a canister with perforated lid.

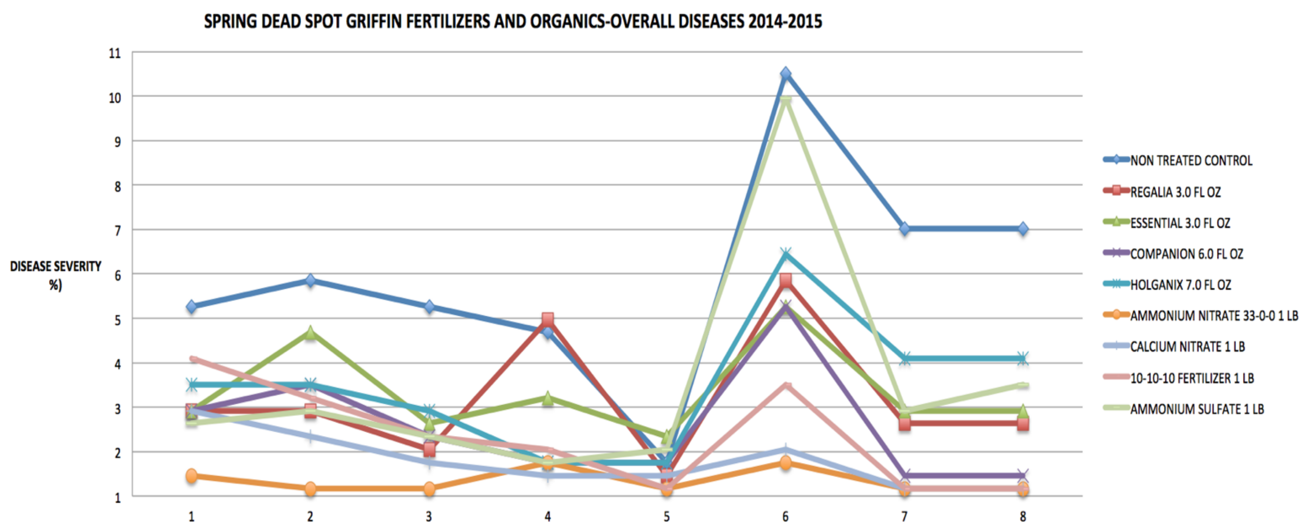
Ammonium nitrate, calcium nitrate, ammonium sulfate, and 10-10-10 fertilizers at a rate of 1 lb/1000 ft^2 and bio-fungicides/organic products were applied monthly starting in May and finalizing in September. Bio-fungicides/organic products consisted of Companion ® at 6 fl oz/1000 ft^2, Essential plus® at 3 oz /1000 ft^2, Rhapsody® at 10 fl oz /1000 ft^2, and Holganix at 7 fl oz /1000 ft^2

Percent SDS disease cover ratings (using a modified Horsfall-Barrat Scale) and # of disease patches were recorded visually monthly and/or every two weeks starting spring of 2015 after symptoms appear following bermudagrass spring green-up. Visual ratings continued until bermudagrass recovers in mid to late summer (2016). Digital photography (DP) (Butler, 2004) will be taken monthly with a Cannon (Rebel XT EOS) camera. Digital images will be analyzed using Photoshop software and/or SigmaScan Pro software (v. 5.0, SPSS Inc., Chicago, IL) to determine differences on SDS severity and/or turf quality.

At the Towne Lake Hills location, the monthly applications of the products where performed in 2015: 5 May, 2 Jun, 30 Jun, 28 Jul, 31 Aug. At the UGA Griffin location monthly applications were performed in 2015: 1 May, 30 May, 26 Jun, 24 Jul, 21 Aug, 18 Sept. Visual ratings were performed at 30-day intervals from the initial application date and depending on disease activity. using a modified Horsfall-Barratt rating scale (0 to 11) (where 0 = 1.17%, 5=37.5%, 11=98.82%). Turf Quality was rated using a percent (0=bad, unsightly quality; 100=excellent quality).

2015 (YEAR 1) RESULTS OF SOIL FERTILITY-WITH EMPHASIS OF NITROGEN SOURCE AND FUNGICIDE ALTERNATIVES FOR THE CONTROL OF SDS in Griffin and TowneLake

1. These trials started during the summer, which is the peak of the growing season. In general disease incidence was low in both locations. The highest disease severity only reached 10.5 %.
2. The effect of these different nitrogen sources and bio-fungicides/organic products was best observed when analyzing turf quality/turf recovery and after the second year of evaluation.
3. Monthly applications of calcium nitrate 1 lb/1000 ft^2, Ammonium nitrate,1 lb/1000 ft^2 and 10-10-10 fertilizer 1 lb/1000 ft^2 provided statistically significantly better turf quality/turf recovery (Fig 3).
4. Companion ® (*Bacillus subtillis* GB03) at 6 fl oz/1000 ft^2 and Holganix ft^2 (Compost tea, Endo and Ectomycorrhizae) at 7 fl oz /1000 also provided acceptable turf quality/turf recovery.
5. Based on preliminary data analysis of disease suppression and turfgrass quality different sources of nitrogen and bio-fungicides/organic products were divided in TIERS (Table 2)



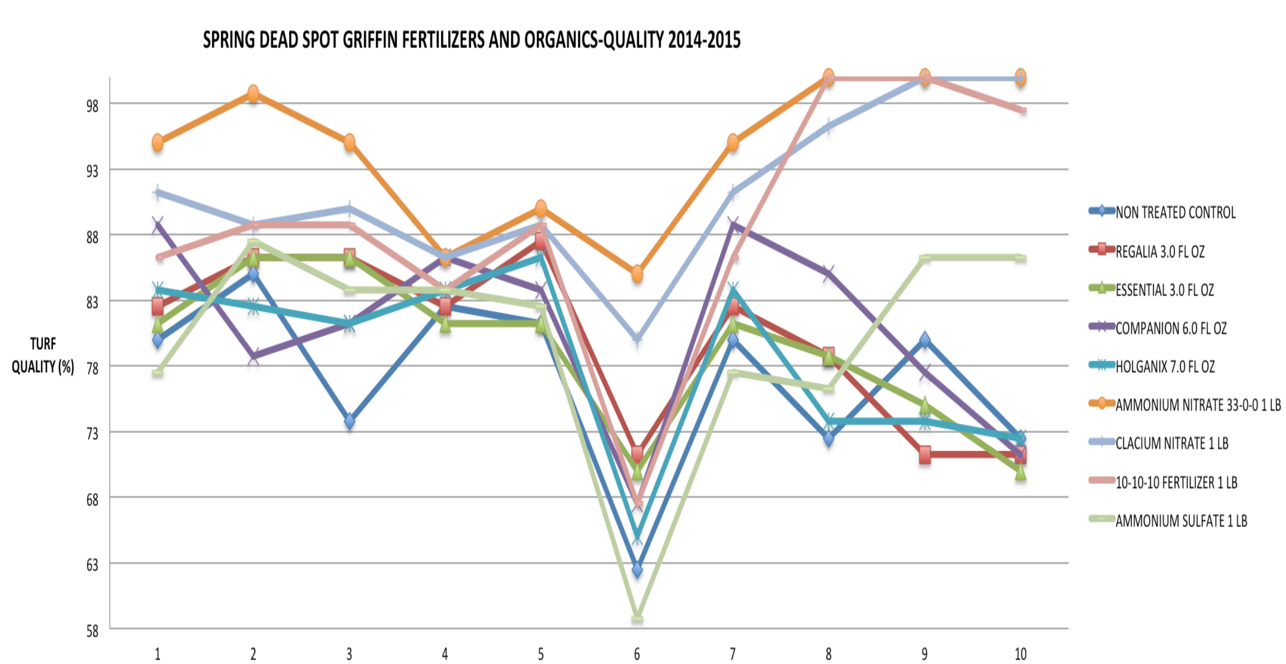


Figure 4. Effect of different sources of nitrogen and bio-fungicides/organic products on A) SDS disease severity and B) turfgrass quality 2014-2015.

Treatment	Type of Ingredient (s)	Rate/1000 sq ft	Tier
Calcium Nitrate	Fertilizer	1.0 lb	Tier 1
Ammonium Nitrate 33-0-0	Fertilizer	1.0 lb	Tier 1
Balanced 10-10-10	Fertilizer	1.0 lb	Tier 1
Companion	Bacillus subtillis	6.0 fl oz	Tier 1
Regalia	Plant Extract	3.0 oz	Tier 2
Essential	Humic acid, Plant extract, sugars, kelp, Organic N	3.0 oz	Tier 2
Holganix	Compost Tea, Endo and Ecto mycorrhizae	7.0 fl oz	Tier 2
Ammonium sulfate	Fertilizer	1.0 lb	Tier 3

Table 2. Grouping of different sources of nitrogen and bio-fungicides/organic products by turfgrass quality/recovery and efficacy on SDS.

CONCLUSIONS AND DISCUSSION FOR 2015 (YEAR 1)

1. Core aeration (solid tine) cultural practice before fungicide application was statistically (*P*= 0.05) similar to non-core aeration in both, fall and spring. In other words, core aeration did not increased fungicide efficacy in spring or fall applications in any of the sites. Solid tine did not negatively impact fungicide efficacy, and neither promoted disease severity.
2. All fungicide treatments provided significant disease suppression compared to the non-treated control in year 1
3. Fall applications are guided towards pre-epidemic (preventive) management
4. Spring applications are guided post-epidemic (curative) management
5. Based on preliminary data analysis of disease suppression and disease suppression consistency in fall and in spring, fungicides were divided in three Tiers
6. TIER 1. Fluoxapyroxad (Xzemplar) at 0.26 fl oz/1000 ft2, provided the most significant and consistent control.
   TIER 2. Fenarimol (Rubigan) at 6 fl oz/1000 ft^2; Azoxystrobin + difenconazole (Briskway) at 0.75 fl oz/1000 ft^2; Tebuconazole (Torque) at 0.6 fl oz/1000 ft^2 + wetting agent (Revolution) at 6 fl oz /1000 ft^2, Metconazole (Tourney) at 0.6 fl oz/1000 ft^2 formed the second most efficacious group of fungicides.
   TIER 3. pyraclostrobin + triticonazole (Pillar) at 3 lb/1000 ft^2
7. Spring fungicide applications proved to suppress SDS severity up to 52% compared to the untreated control resulting in the acceleration of turfgrass recovery up to 47-70 days (days to acceptable quality=foliar canopy was uniform in color and density).
8. An added benefit of spring fungicide applications is the control and /or prevention of other diseases especially dollar spot and large patch.
9. Monthly applications of calcium nitrate 1 lb/1000 ft^2, Ammonium nitrate,1 lb/1000 ft^2 and 10-10-10 fertilizer 1 lb/1000 ft^2 provided statistically significantly better turf quality/turf recovery.
10. Companion ® (*Bacillus subtillis* GB03) at 6 fl oz/1000 ft^2 and Holganix ft^2 (Compost tea, Endo and Ectomycorrhizae) at 7 fl oz /1000 also provided acceptable turf quality/turf recovery.

2016 (YEAR 2) RESULTS OF COMBINATION OF TEMPORAL, CULTURAL, AND CHEMICAL PRACTICES FOR THE CONTROL OF SPRING DEAD SPOT AND EVALUATION OF NEW CHEMISTRIES

Disease severity in 2015-2016 was much lower than in the previous year. This was expected, as treatments were performed in the sample pllace and order as in the previous year. However, data obtained was quite variable. At the Griffin site and when fungicides were applied in the fall; Headway 3.0 fl oz and Rubigan 6.0 fl oz provided the most significant SDS suppression followed by Tourney 0.37 oz, Torque 0.6 fl oz, Briskway 0.75 fl oz, and Xzemplar 0.26 fl oz. On this site, Pillar 3 lb and Torque 0.6 fl oz + Revolution 6.0 fl oz did not significantly reduced the SDS incidence when compared to the untreated control.

At the Townelake and when fungicides were applied in the fall; All fungicide treatments provided statistically significant SDS suppression. Additionally, SDS incidence in the non-treated control was considerable higher than that observed at the Griffin site. Rubigan 6.0 fl oz provided the highest SDS suppression with 78% of SDS reduction when compared to the non-treated control. Xzemplar 0.26 fl oz and Tourney 0.37 oz provided 63 and 73% SDS reduction when compared to the non-treated control. Percent of SDS reduction ranged from 51-38 % when Headway 3.0 fl oz, Torque 0.6 fl oz, Pillar 3 lb and Torque 0.6 fl oz + Revolution 6.0 fl oz were applied. On this site Briskway 0.75 fl oz only yielded 19 % of SDS reduction

Table 1. SDS severity and % of SDS reduction using fungicides applied in the FALL at GRIFFIN, 2015-2016 season.

Treatment	Disease Severity %	% SDS Reduction	Rank
1. Non Treated Control	11.14 ab	-----	------
2. Torque 0.6 fl oz	5.52 bcd	50.45	5
3. Pillar 3.0 lb	12.20 a	---	8
4. Headway 3.0 fl oz	2.30 d	79.36	1
5. Rubigan 6.0 fl oz	2.53 d	77.29	2
6. Briskway 0.75 fl oz	7.06 bcd	36.63	6
7. Xzemplar 0.26 fl oz	5.52 bcd	50.45	4
8. Tourney 0.37 oz	5.16 cd	53.63	3
9. Torque 0.6 fl oz + Revolution 6.0 fl oz	9.78 abc	12.79	7

[z] Within a column, values followed by the same letter are not significantly different according to Fisher's Protected LSD test (P= 0.05).

Table 2. SDS severity and % of SDS reduction using fungicides applied in the FALL at TOWNELAKE, 2015-2016 season.

Treatment	Disease Severity %	% SDS Reduction	Rank
1. Non Treated Control	19.26 a	-----	------
2. Torque 0.6 fl oz	11.91 bc	38.17	6
3. Pillar 3.0 lb	9.27 bcd	51.87	4
4. Headway 3.0 fl oz	11.34 bcd	35.26	7
5. Rubigan 6.0 fl oz	4.19 d	78.25	1
6. Briskway 0.75 fl oz	15.55 b	19.27	8
7. Xzemplar 0.26 fl oz	6.97 cd	63.82	3
8. Tourney 0.37 oz	5.12 cd	73.42	2
9. Torque 0.6 fl oz + Revolution 6.0 fl oz	11.81 bc	38.69	5

[z] Within a column, values followed by the same letter are not significantly different according to Fisher's Protected LSD test (P= 0.05).

Penthiopyrad (Velista) was included in the 2015-2016 field trials. Summary of thee data analysis of penthiopyrad is depicted on (Table 3). Two fall applications of Velista 50WG 0.5 oz significantly reduced SDS severity while two applications of Velista 50WG at 0.3 did not significantly reduced SDS severity.

Table 3. Evaluation of penthiopyrad against SDS in Griffin GA.

	Spring Dead Spot Severity Griffin (%)[z]					
Treatment and rate/1,000 sq ft	06 Apr 2016	21 Apr 2016	28 Apr 2016	11 May 2016	18 May 2016	18 Jun 2016
1. Non Treated Control	50.00a	19.95a	17.60a	40.65a	11.15a	6.45a
2. Velista 50WG 0.3 oz	25.78ab	14.68a	21.13a	23.85a	11.75a	4.13a
3. Velista 50WG 0.5 oz	10.55b	5.28b	6.45b	18.55b	4.40b	1.76a

[z] Within a column, values followed by the same letter are not significantly different according to Fisher's Protected LSD test (P= 0.05).

c. Spring applications

Efficacy of fungicide applied post-epidemically (curative) in the spring are summarized in table 4 and 6. It is noteworthy to mention that fungicides were applied when symptoms of the disease were present. Therefore, results of spring fungicide applications reflect the amount of recovery from the disease. Fungicide efficacy during the spring time correlated with turfgrass quality (table 5 and 7).

Table 4. SDS severity and % of SDS reduction using fungicides applied in the SPRING at Griffin, 2015-2016 season.

Treatment	Disease Severity %	% SDS Reduction/Turfgrass Recovery	Rank
1. Non Treated Control	13.72 a	---	
2. Torque 0.6 fl oz	7.24 bc	47.06	5
3. Pillar 3.0 lb	6.84 bc	50.15	3
4. Headway 3.0 fl oz	7.24 bc	47.24	4
5. Rubigan 6.0 fl oz	2.56 c	81.35	1
6. Briskway 0.75 fl oz	9.26 b	32.51	7
7. Xzemplar 0.26 fl oz	9.37 b	31.75	8
8. Tourney 0.37 oz	9.04 bc	34.15	6
9. Torque 0.6 fl oz + Revolution 6.0 fl oz	5.23 bc	61.89	2

[z] Within a column, values followed by the same letter are not significantly different according to Fisher's Protected LSD test (*P*= 0.05).

Table 5. Turfgrass quality using fungicides applied in the SPRING at Griffin, 2015-2016 season.

	Turfgrass Quality at 5/11/2016
1. Non Treated Control	84.37 c
2. Torque 0.6 fl oz	86.85 bc
3. Pillar 3.0 lb	87.50 bc
4. Headway 3.0 fl oz	90.62 ab
5. Rubigan 6.0 fl oz	92.50 a
6. Briskway 0.75 fl oz	89.37 ab
7. Xzemplar 0.26 fl oz	89.37 ab
8. Tourney 0.37 oz	89.37 ab
9. Torque 0.6 fl oz + Revolution 6.0 fl oz	90.00 ab

[z] Within a column, values followed by the same letter are not significantly different according to Fisher's Protected LSD test (*P*= 0.05).

Table 6. SDS severity and % of SDS reduction using fungicides applied in the SPRING at Townelake, 2015-2016 season

Treatment	Disease Severity %	% SDS Reduction/Turfgrass Recovery	Rank
1. Non Treated Control	47.76 a	---	
2. Torque 0.6 fl oz	32.84 abc	31.24	4
3. Pillar 3.0 lb	32.48 abc	32.00	3
4. Headway 3.0 fl oz	39.74 ab	16.80	7
5. Rubigan 6.0 fl oz	15.35 c	67.87	1
6. Briskway 0.75 fl oz	24.64 bc	48.41	2
7. Xzemplar 0.26 fl oz	39.45 ab	17.40	6
8. Tourney 0.37 oz	41.73 a	12.63	8
9. Torque 0.6 fl oz + Revolution 6.0 fl oz	37.54 ab	21.40	5

[z] Within a column, values followed by the same letter are not significantly different according to Fisher's Protected LSD test (*P*= 0.05).

Table 7. Turfgrass quality using fungicides applied in the SPRING at Townelake, 2015-2016 season.

Treatment	Turfgrass Quality at 6/03/2016
1. Non Treated Control	66.25 c
2. Torque 0.6 fl oz	81.25 ab
3. Pillar 3.0 lb	82.50 ab
4. Headway 3.0 fl oz	82.50 ab
5. Rubigan 6.0 fl oz	86.25 a
6. Briskway 0.75 fl oz	81.87 ab
7. Xzemplar 0.26 fl oz	80.00 ab
8. Tourney 0.37 oz	75.00 b
9. Torque 0.6 fl oz + Revolution 6.0 fl oz	81.25 ab

[z] Within a column, values followed by the same letter are not significantly different according to Fisher's Protected LSD test (*P*= 0.05).

SDS incidence in the non-treated control was considerably higher in the Townelake experimental site than that observed at the Griffin site.

At the Griffin site and when fungicides were applied in the spring; Rubigan 6.0 fl oz provided the most statistical significant SDS suppression followed by Headway 3.0 fl oz, Tourney 0.37 oz, Torque 0.6 fl oz, Pillar 3 lb and Torque 0.6 fl oz + Revolution 6.0 fl oz. On this site, Briskway 0.75 fl oz, and Xzemplar 0.26 fl oz. provided the lowest SDS reduction when compared to the untreated control with percent disease reduction of 32-31 % respectively. Turfgrass quality inversely correlated to disease incidence.

At Townelake, the disease incidence was high; Rubigan 6.0 fl oz and Briskway 0.35 fl oz provided the statistical significant SDS suppression when compared to the non-treated control. Except for Tourney 0.37 oz; all other fungicides provided an SDS reduction ranging from 17 to 32 %. However, the disease present after the application of all fungicide was high and far from reaching an acceptable threshold of turf recovery. Turfgrass quality inversely correlated to disease incidence. Is noteworthy to mention that turfgrass quality was influenced not only by SDS incidence but also by heavy epidemics of dollar spot, bipolaris leaf spot and large patch. Therefore, an added benefit of spring fungicide applications is the control and /or prevention of these other diseases.

CONCLUSIONS AND DISCUSSION FOR 2016 SEASON

On average and taking into account all treatments, there was significant disease suppression from year 1 to year 2 (@ 50%)

Overall; data from this year disease suppression by fungicides was variable between sites

Both application times (Fall and Spring) are effective;

On both timings; all SDS labelled fungicides have significant disease suppression

On both timings; "new" chemistries evaluated provided significant disease suppression

Fall applications are guided towards pre-epidemic (preventive) management

In the Fall;

- Still the most efficacious timing for sds management
- Preventative, pre-epidemic
- Use of a DMI (alone-Rubigan, Torque, Tourney). Maybe in combination with strobilurin (Briskway, Headway)
- or a SDHI (Xzemplar, Velista)

Spring applications are guided post-epidemic (curative) management

In the Spring

- Use of a DMI in combination with strobilurin (Briskway, Headway, Pillar).
- Use of fungicides shortens the time to achieve acceptable turf quality for up to 3-4 weeks
- Effect of preventative effect on dollar spot, Bipolaris and Rhizoctonia

Use of wetting agent did not significantly enhanced fungicide efficacy

Fungicide rate matters (see Velista, Rubigan)

2. Evaluate the effect of soil fertility-with emphasis of nitrogen source and fungicide alternatives for the control of SDS.

Two fungicide trials were conducted on a 7-year-old sward of bermudagrass cv. "TifSport" grown on a clay loam soil (pH 5.8) at the University of Georgia-Griffin campus and on a 15-year-old 319 bermudagrass fairway at Towne Lake Hills Golf Club located in Woodstock GA. Area was kept intact to perform the field experiments, therefore no additional fertilizers or pest management was implemented in the area. Both sites had a history of severe SDS infections. On both sites, treatments were arranged as plots (4 ft x 6 ft) in a randomized complete block design with four replications. monthly applications of different sources of nitrogen and bio-fungicides/organic products were performed during the remainder of summer. Treatments consisted of fertilizers with different sources of nitrogen and bio-fungicides/organic products. Liquid products were applied as per manufacturer use instructions. Granular formulations were weighed and distributed equally in each replicated plot using a canister with perforated lid. Ammonium nitrate, calcium nitrate, ammonium sulfate, and 10-10-10 fertilizers at a rate of 1 lb/1000 ft^2 and bio-fungicides/organic products were applied monthly starting in May and finalizing in September. Bio-fungicides/organic products consisted of Companion ® at 6 fl oz/1000 ft^2, Essential® at 3 oz /1000 ft^2, Rhapsody® at 10 fl oz /1000 ft^2, and Holganix® at 7 fl oz /1000 ft^2. Experimental areas received normal irrigation as per in-site management. Visual ratings were performed at 14-

28 day intervals. Visual estimates of disease severity were made using a modified Horsfall-Barratt rating scale (0 to 11), and then transformed to percent disease severity (0 = 1.17%, 5=37.5%, 11=98.82%) using ARM. Turf Quality was also rated using a percent (0=bad, unsightly quality; 100=excellent quality). Percent of disease severity and quality data were subjected to analysis of variance and means were separated Fisher's Protected LSD test (*P*= 0.05).

Table 1. Fertilizers and biological products evaluated

Commercial Name	Type of Ingredient (s)	Rate/1000 sq ft	Company
1. Non Treated Control	------	-------	--------
2. Regalia	Plant Extract	3.0 oz	Marrone BioInnovations/Engage Agro
3. Essential	Humic acid, Plant extract, sugars, kelp, Organic N	3.0 oz	
4. Companion	Bacillus subtillis	6.0 fl oz	Growth Products LTD
5. Holganix	Compost Tea, Endo and Ecto mycorrhizae	7.0 fl oz	Holganix
6. Ammonium Nitrate 33-0-0	Fertilizer	1.0 lb	----
7. Calcium Nitrate	Fertilizer	1.0 lb	----
8. Balanced 10-10-10	Fertilizer	1.0 lb	----
9. Amonium sulfate	Fertilizer	1.0 lb	----

RESULTS FOR 2015-2016 SEASON

In general, SDS incidence was low in both locations. The highest disease severity only reached @ 15 %. No significance statistical SDS suppression was found among treatments and non-treated control. Therefore, the effect of fertilizers and biologicals was best assessed using turfgrass quality/turf recovery ratings. Turfgrass quality, in general was higher at the Griffin location.

Table 2. Turfgrass quality using fertilizers and biological products- Griffin, 2015-2016 season

Treatment	Average of Turfgrass Quality
1. Non Treated Control	83.75 b
2. Regalia	83.75 b
3. Essential	83.54 b
4. Companion	82.91 b
5. Holganix	84.16 ab
6. Ammonium Nitrate 33-0-0	84.16 ab
7. Calcium Nitrate	85.83 a
8. Balanced 10-10-10	82.91 b
9. Ammonium sulfate	84.27 ab

^{z} Within a column, values followed by the same letter are not significantly different according to Fisher's Protected LSD test (*P*= 0.05).

Table 3. Turfgrass quality using fertilizers and biological products- Townelake, 2015-2016 season

Treatment	Average of Turfgrass Quality
1. Non Treated Control	76.00 bc
2. Regalia	78.00 ab
3. Essential	77.00 ab
4. Companion	79.50 ab
5. Holganix	81.00 a
6. Ammonium Nitrate 33-0-0	76.00 bc
7. Calcium Nitrate	72.25 c
8. Balanced 10-10-10	75.50 bc
9. Ammonium sulfate	78.75 ab

^{z} Within a column, values followed by the same letter are not significantly different according to Fisher's Protected LSD test (*P*= 0.05).

At the Griffin site, monthly applications of Calcium nitrate, Ammonium nitrate, and Holganix provided the highest turf quality/turf recovery. While at the Townelake; Holganix, Companion, Ammonium sulfate, Essential and Regalia provided the highest turf quality/turf recovery.

Table 4. Rankings of fertilizers and biological products based on turfgrass quality- Griffin, 2015-2016 season

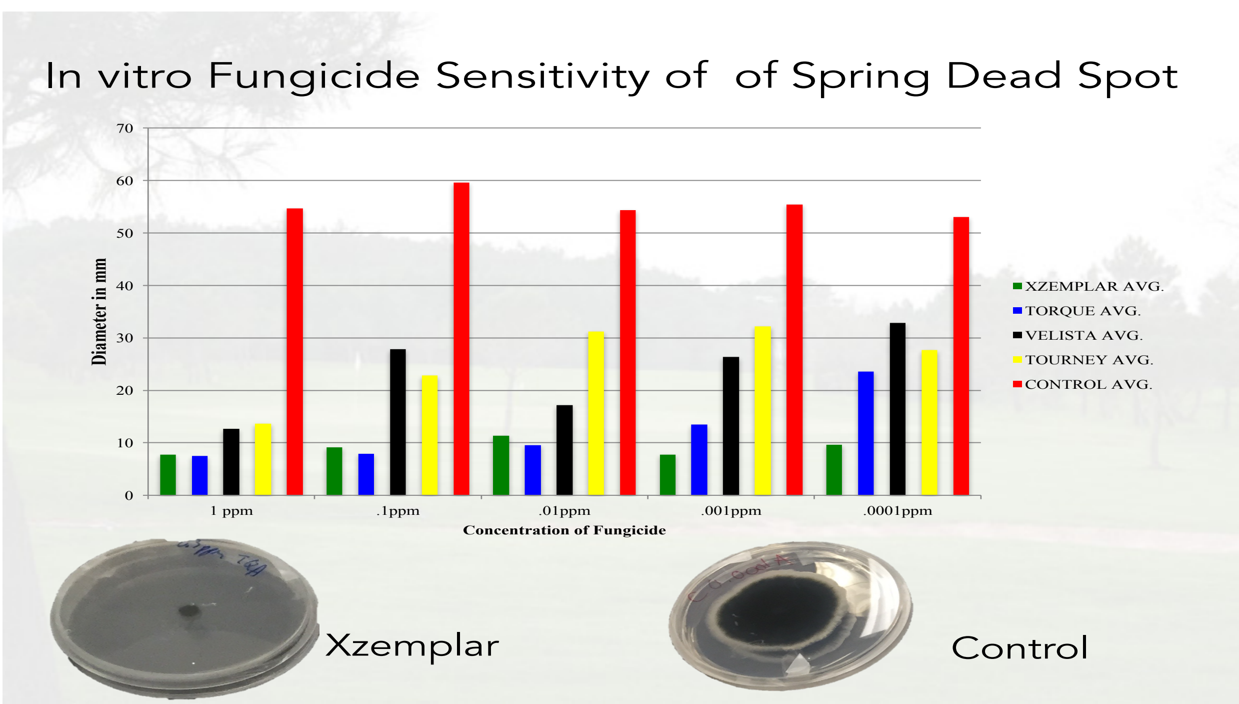
Ranking Turfgrass Quality/Recovery/ Griffin Site
Calcium Nitrate
Ammonium Nitrate 33-0-0
Holganix
Ammonium sulfate
Companion
Regalia
Essential
NTC
Balanced 10-10-10

Table 5. Rankings of fertilizers and biological products based on turfgrass quality- Townelake, 2015-2016 season

Ranking Turfgrass Quality/Recovery/Townelake site
Holganix
Companion
Ammonium sulfate
Regalia
Essential
Ammonium Nitrate
NTC
10-10-10
Calcium nitrate

ADDITIONAL SPRING DEAD SPOT RESEARCH

***IN VITRO* FUNGICIDE SENSITIVITY OF SPRING DEAD SPOT.**
VICTOR CAMA, BRIAN VERMEER AND ALFREDO MARTINEZ ESPINOZA.



Outputs

1. Publication of SDS GGEF-funded research results at the UGA College of Agricultural and Environmental Sciences Impact Statements web page. http://apps.caes.uga.edu/impactstatements/)
2. Presentation of SDS research results at the 2016 Turfgrass Research and Extension Field Day. Griffin GA. August 4, 2016. Public acknowledgment for Georgia Golf Environmental Fund. 600 people reached.
3. Publication of SDS research results at Martinez-Espinoza, A.D. Waltz, C., and Raymer P. 2016. Turfgrass Research and Extension Field Day, 2016. University of Georgia-Extension, Special Bulletin. http://extension.uga.edu/publications/detail.cfm?number=AP117-1. Page 26-27. Prominent acknowledgment for Georgia Golf Environmental Fund.
4. Signage and demonstration of SDS trial at 2016 Turfgrass Research and Extension Field Day. Prominent display of acknowledgement to GGEF.
5. Oral Presentation at Young Scholars Conference. *In vitro* fungicide sensitivity of spring dead spot. Victor Cama, Brian Vermeer and Alfredo Martinez Espinoza. (won first place at competition).
6. Update article in "Through the Green"
7. Seminar presentation. Update on Ongoing Turfgrass Research on Spring Dead Spot (SDS) Control of Bermudagrass in Georgia. Georgia Golf Environmental Foundation Seminar (GGCSA). Jan 06, 2016. Griffin, GA.
8. Seminar presentation. Defending Georgia's Turf: Latest Research on Fungicides and Bermudagrass Disease Control. GCSAA Bermudagrass Forum. Sept 14, 2015. St. Simons Is. GA.
9. Seminar presentation. 2015. Temporal, Cultural, Biological, and Chemical Practices to Enhance Spring Dead Spot (SDS) Control of Bermudagrass in Georgia Update. Georgia Golf Environmental Foundation Seminar (GGCSA). Jan 14, 2015. Griffin, GA.