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Management of Salinity and Rapid Blight Disease on Annual Bluegrass Putting Greens 2019 Report

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Management of Salinity and Rapid Blight Disease on Annual Bluegrass Putting Greens 2019 Report

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The Bottom Line: Seventeen commercial and experimental fungicide treatments were tested alone or in combination against an untreated control under two fertility regimes for their ability to alleviate salinity stress and potential development of rapid blight disease caused by *Labyrinthula terrestris* on an annual bluegrass turf maintained as a golf course putting green and irrigated with saline water (electrical conductivity = EC ≈ 2.0 dS/m). Study was conducted at the UCR Turfgrass Research Facility in Riverside. All treatments, including saline irrigation, were applied from July to November 2019. To minimize the potential impact of other pathogens on the study outcome, blanket fungicide applications with proven inactivity against rapid blight were applied throughout the study duration. Although signs of the target pathogen were confirmed in the study area, random occurrence of *Labyrinthula* in samples collected from treated plots, lack of typical disease symptoms and control from fungicides with known rapid blight activity, and relatively low levels of accumulated soil salinity (below 0.35 dS/m in average), led us to surmise that salinity stress was more likely responsible for turf stress and stand losses than rapid blight disease. Overall, regardless of the nature of the damage to annual bluegrass, no significant impact of fertility source (UMAXX 46-0-0 vs. Calcinit K 14-0-3) was observed for any of the evaluated parameters. However, all treatments containing potassium phosphite (Appear II) - either as a standalone product or tank-mixed with acibenzolar-S-methyl and chlorothalonil (Daconil Action) or fluazinam (Secure Action) - resulted in improved turfgrass visual quality and color, and prevention of turf loss due to salinity stress and possible rapid blight disease.

Acknowledgments

Thanks to the California Turfgrass & Landscape Foundation (CTLF) for financial support of this research and to companies for donating products, especially greens mix and gravel from P.W. Gillibrand Co. and 'Two Putt' Poa reptans seed from Steve Link, superintendent, Skagit Golf Club. Thanks also to the University of Florida Rapid Turfgrass Diagnostic Service for disease diagnoses.

Introduction

Increasing salinity issues caused by insufficient precipitation, drought, and increasing use of alternative non-potable sources of irrigation water are inevitable for turf and landscape plants in the southwestern United States. Most golf course superintendents in California who manage annual bluegrass putting greens are faced with managing salinity resulting from use of reclaimed irrigation water and/or salt accumulation during extended drought. Leaching and modification of soil physicochemical properties can

Cover photo taken by L.H. Monticelli on September 12, 2019. Riverside, CA.

help alleviate salinity stress. Overall, numerous products are purported to aid in salinity management, many of which have not been tested under non-biased, replicated experiments on turf.

Rapid blight, caused by the terrestrial slime mold *Labyrinthula terrestris*, was first discovered as a disease of turfgrass in the early part of this century. Since then, it has been found in at least 11 states in the U.S. including California. As the name implies, rapid blight symptoms appear quickly as water-soaked patches, which soon coalesce into large dead areas. In California, the disease is most severe on *Poa annua* greens, but also can be troublesome on *Poa trivialis* and perennial ryegrass in overseeded turf, particularly in Arizona. Almost always, rapid blight is associated with elevated sodium chloride caused by poor irrigation water and/or extensive periods without rainfall or sufficient leaching of salts. Historically, only a few fungicides have provided effective control of rapid blight, including pyraclostrobin (Insignia Intrinsic or Lexicon Intrinsic), trifloxystrobin (Compass), and mancozeb (Fore). More recently, our research identified penthiopyrad (Velista) and fluazinam (Secure) as additional products with activity against this disease.

Objectives

This study was conducted to evaluate various fungicide and fertility treatments for effective Rapid Blight (*Labyrinthula terrestris*) disease control and management of salinity on annual bluegrass maintained as a golf course putting green.

Materials and Methods

A 5400-ft^2 research putting green was constructed in 2018-2019 conforming to USGA guidelines. A 12-in sand/peat root zone was chosen to simulate a mature putting green with minimum suggested infiltration rate. Furthermore, gravel and drainage were installed below the root zone layer. The green was established with *Poa annua* var. *reptans* 'Two Putt' seed in the spring of 2019. During the trial, turf was mowed at 0.125 in 5 times/wk, topdressed biweekly with sand, and received blanket applications of Primo Maxx at 0.125 oz/1000 ft^2 every two weeks, as well as the following rotation of fungicides (at lowest labeled rates) for control of diseases other than Rapid Blight:

- Briskway + Daconil WeatherStik
- Banner Maxx II + Subdue Maxx
- Briskway + Medallion SC
- Banner Maxx II + Subdue Maxx
- Briskway + Daconil WeatherStik
- Banner Maxx II + Subdue Maxx

Starting on July 24, 2019, plots were irrigated with saline water (2.0 dS/m) at 120% ET_{os} replacement using irrigation system. In addition, the green was hand watered as needed to prevent drought stress. Fungicide treatments were applied every 14 days beginning on July 21, 2019 (before disease symptoms or stress were present) for a total of 8 applications. Fertilizer (0.125 lbs N/1000 ft^2/wk) was applied as liquid treatments starting on August 1, 2019 for a total of 14 applications. All treatments were applied using a CO_2-powered backpack sprayer equipped with either TeeJet 8004VS nozzles calibrated to deliver 2 gallons/1000 ft^2 for fungicide applications or with TeeJet 8003VS nozzles and calibrated to deliver 1 gallon/1000 ft^2 for fertilizer applications. Treatments were arranged in a split-plot design with fungicide treatments randomized within fertilizer treated plots with 3 replications. The 60 ft × 90 ft area was divided into six 30 ft × 30 ft areas (whole plot) and sub-plot size was 4 ft × 6 ft with 2-ft alleys.

Starting on July 19, plots were evaluated biweekly for: visual turf quality (1-9; 9=best), visual green color intensity (1-9; 9=highest), turfgrass turf stand cover (0-100%), injury caused by treatments (phytotoxicity; 0-10; 10=highest), as well as disease cover (0-100%). In addition, volumetric water content (VWC) and soil electrical conductivity (EC_e) using POGO, normalized difference vegetation index (NDVI)

using GreenSeeker, and dark green color index (DGCI), cover and density using Digital Image Analysis (DIA) were also evaluated.

Data collected throughout the study were analyzed using analysis of variance for each evaluated trait separately and means were compared using the Fisher's protected least significant difference (LSD) test at the 0.05 probability level ($P \leq 0.05$).

Results

No significant natural precipitation was recorded during entire study period. Data were collected until November 4, 2019 (16 WAIT – weeks after initial treatment/2 WAFT – weeks after final treatment). At the end of the study, the only treatments resulting in significantly lower overall disease cover compared to the untreated control and regardless of fertilizer source were: Appear II and tank-mixes of Appear II with Daconil Action or Secure Action, as well as the tank-mix of Daconil Action and Secure Action. Overall disease cover of the aforementioned fungicide treatments did not exceed 20% for Appear II and when tank-mixed with Daconil Action, or 40% for Secure Action tank-mixed with either Appear II or Daconil Action, while disease cover exceeded 60% in untreated control (Figure 1, Table 3). However, the tank-mix of Daconil Action and Secure Action did not result in significantly lower disease cover when compared to untreated control prior to the final rating date (data not shown).

Only treatments containing Appear II, either alone or as a tank-mix component, resulted in significantly lower turfgrass loss relative to initial cover (final levels ranged from 2.6% to 12.4%), as well as higher NDVI rating, when compared to untreated control (Tables 3 and 4).

Those observations are supported by results of green cover and dark green color index (DGCI) using digital image analysis (DIA). All treatments containing Appear II resulted in significantly higher cover (above 95%) and DGCI when compared to untreated control and other treatments with the only exception of CIVITAS TURF DEFENSE Pre-M1xed treatment (Table 4). Surprisingly, despite unsatisfactory turfgrass visual quality, relatively high overall disease cover and turfgrass loss (Table 3), the CIVITAS treatment resulted in statistically non- significant cover and significantly higher DGCI, when compared to treatments containing Appear II (Table 4). Speculating, this might have been due to the nature of the pigment in the CIVITAS pre-mix, which may have impacted readings by sustained masking of voids arising in damaged turf.

In terms of visual color estimation, statistically darkest turf was observed on plots treated with tank-mix of Daconil Action and Appear II. Significantly lighter turf was noted in plots treated with either Appear II alone or when tank-mixed with Secure Action, and equally with plots treated with CIVITAS. Third in line were plots treated with mixture of Daconil Action with Secure Action (Table 3).

Despite some slight and insignificant turf injury observed throughout the trial on either untreated or treated plots (data not shown), there was also significant and consistent phytotoxicity observed with UCR 002 and UCR 003 treatments starting from August 26 (6 WAIT; data not shown). This injury was demonstrated mostly by uniformly straw-colored turf, which increased until crossing the threshold of acceptable damage (score '3') on final rating date (Table 3).

Fertilizer formulation had no significant impact on: turfgrass visual quality, overall disease cover, turfgrass loss in respect to initial ratings, turfgrass injury with treatments, turfgrass visual color (Table 3), soil electrical conductivity (EC_e), normalized difference vegetation index (NDVI), cover (evaluated using DIA) or on dark green color index (DGCI; also evaluated using DIA; Table 4). Additionally, neither fertilizer nor

fungicide applications had a significant effect on volumetric water content (VWC) throughout the study (data not shown). We hypothesized that, since soil salinity did not accumulate during the study most likely due to favorable root zone conditions for drainage and leaching, additional Ca supplied by Calcinit-K was inconsequential to replace Na.

To be certain that disease symptoms corresponded to a pathogen or pathogens, samples were collected from the 6 untreated plots (individual sample consisted of 3 plugs, each 2.5 inches in diameter) on August 27 (6 WAIT) and sent to the University of Florida Rapid Turfgrass Diagnostic Service for analysis. Results confirmed the presence of two pathogens: *Labyrinthula terrestris* (rapid blight; Fig. 2) and *Curvularia* spp. (*Curvularia* leaf blight) in the majority of samples submitted (data not shown). On November 4 (16 WAIT/2 WAFT) an additional set of samples for target pathogen presence confirmation was collected from either untreated plots or plots treated with: Insignia (at 0.7 oz/1000 ft^2 only), Velista, UCR 001, Appear II (standalone) and tank-mixes of Appear II with either Daconil Action or Secure Action. Furthermore, those samples were collected separately from areas treated with UMAXX or Calcinit-K. The outcome of this identification was ambiguous, since the presence of *Labyrinthula terrestris* seemed to be inconsistent and random within samples, therefore not directly dependent on the applied treatments (Table 5).

Moreover, by the date of final data collection (November 4), EC_e did not exceed 0.93 dS/m (data not shown) and on this date it averaged 0.33 dS/m throughout the trial area (ranging from 0.24 dS/m in Daconil Action and Appear II tank-mix, to 0.49 dS/m in UCR 002; treatment 17). However, no treatment separation for EC_e was shown with either fertilizer or fungicides (Table 4).

Overall, despite confirmation of *Labyrinthula terrestris* presence within the study area, it is unlikely that the pathogen and/or environment (low salinity) were sufficient to cause rapid blight disease. Moreover, none of the fungicides known to control rapid blight performed well in this study. Therefore, observed turf stand deterioration was most likely caused by chronic salinity stress from saline irrigation water. To recapitulate, regardless of the nature of the damage, visual turf quality in comparison to the untreated control was not only preserved, but also improved throughout the study as a result of the application of either: Appear II alone or tank-mixed with Daconil Action or Secure Action. Furthermore, Daconil Action tank-mixed with Appear II demonstrated the highest visual quality among all treatments and this difference was statistically significant (Table 3). This effect has continued to persist for several months after the study was concluded and potable irrigation was restored in combination with natural rainfall (Figs. 9-11).

Tables and Figures

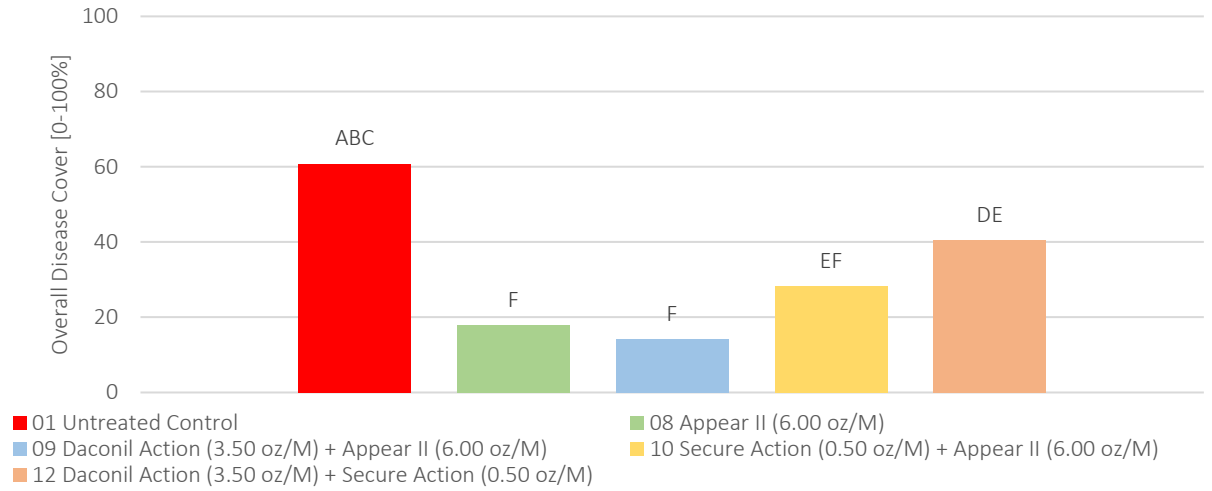
Table 1. Fertility treatments tested in the rapid blight control and salinity management study in Riverside, CA. 2019.

Sym.	Treatment	Analysis (NPK)	Company	Rate (lbs N/M)	Interval
A	Calcinit K	14-0-3	YaraLiva	0.125	weekly
B	UMAXX	46-0-0	Koch	0.125	weekly

Table 2. Fungicide treatments tested in the rapid blight control and salinity management trial in Riverside, CA. 2019.

No.	Treatment	Active ingredient	Company	Rate (oz/M)	Timing
1	Untreated Control	-	-	-	-
2	Compass	trifloxystrobin	Bayer	0.20	A-H
3	Maxtima	mefentrifuconazole	BASF	0.80	A-H
4	Navicon Intrinsic	mefentrifuconazole, pyraclostrobin	BASF	0.85	A-H
5	Insignia SC Intrinsic	pyraclostrobin	BASF	0.50	A-H
6	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	A-H
7	Velista	penthiopyrad	Syngenta	0.50	A-H
8	Appear II	potassium phosphite	Syngenta	6.00	A-H
9	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	A-H
	Appear II	potassium phosphite	Syngenta	6.00	
10	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	A-H
	Appear II	potassium phosphite	Syngenta	6.00	
11	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	A-H
	Velista	penthiopyrad	Syngenta	0.50	
12	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	A-H
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	
13	Mancozeb 80WD	mancozeb	Lesco	6.00	A-H
14	CIVITAS TURF DEFENSE Pre-M1xed	mineral oil	Intelligro	17.00	A-H
15	UCR 001	*classified*	-	-	A-H
16	UCR 002	*classified*	-	-	A-H
17	UCR 002	*classified*	-	-	A-H
18	UCR 003	*classified*	-	-	A-H

Application codes (timing):
A – 07/21/2019
B – 08/01/2019
C – 08/15/2019
D – 08/29/2019
E – 09/14/2019
F – 09/26/2019
G – 10/10/2019
H – 10/24/2019



* Means followed by the same letter are not significantly different (P=0.05).
** WAIT – weeks after initial treatment
*** WAFT – weeks after final treatment

Figure 1. The effect of best performing treatments on overall disease cover (0-100%) caused by salinity stress or rapid blight on November 4 (16 WAIT**/2 WAFT***) evaluated on annual bluegrass 'Two Putt' turf. Riverside, CA. 2019.

Table 3. Effects of fertility and fungicide treatments on turfgrass visual quality (1-9; 9=best), overall disease cover (0-100%) caused by salinity stress or rapid blight, turfgrass cover loss in respect to initial state (0-100%), turfgrass injury (0-10; 10=highest), turfgrass visual dark green color intensity (1-9; 9 = highest) on November 4 (16 WAIT**/2 WAFT***) evaluated on annual bluegrass 'Two Putt' turf. Riverside, CA, 2019.

No.	Treatment	Visual Quality	Disease Cover	Turfgrass Cover Loss	Turfgrass Injury	Color
A	Calcinit K	3.6*	49.6*	29.9*	0.8*	4.0*
B	UMAXX	3.6	49.2	29.4	0.7	4.0
1	Untreated Control	2.8 EF*	60.8 A-C*	35.8 A-C*	0.0 C*	2.8 DE*
2	Compass (0.20 oz/M)	3.5 DE	50.8 B-D	29.2 A-D	0.0 C	3.5 CD
3	Maxtima (0.80 oz/M)	3.5 DE	45.0 C-E	29.7 A-D	0.0 C	3.3 CD
4	Navicon Intrinsic (0.85 oz/M)	3.2 D-F	51.8 B-D	35.9 A-C	0.0 C	3.3 CD
5	Insignia SC Intrinsic (0.50 oz/M)	3.0 D-F	60.8 A-C	31.3 A-D	0.0 C	3.0 DE
6	Insignia SC Intrinsic (0.70 oz/M)	3.3 D-F	58.3 A-D	33.0 A-D	0.7 C	3.3 CD
7	Velista (0.50 oz/M)	3.7 DE	50.8 B-D	26.8 A-D	0.0 C	3.7 CD
8	Appear II (6.00 oz/M)	5.5 B	17.8 F	10.2 DE	0.0 C	6.8 B
9	Daconil Action (3.5 oz/M) + Appear II (6.00 oz/M)	7.0 A	14.2 F	2.6 E	0.0 C	8.3 A
10	Secure Action (0.5 oz/M) + Appear II (6.00 oz/M)	5.3 BC	28.3 EF	12.4 DE	0.0 C	6.8 B
11	Secure Action (0.5 oz/M) + Velista (0.50 oz/M)	3.0 D-F	53.3 B-D	37.1 A-C	0.5 C	2.8 DE
12	Secure Action (0.5 oz/M) + Daconil Action (3.5 oz/M)	4.2 CD	40.5 DE	21.9 C-E	0.0 C	4.5 C
13	Mancozeb 80WD (6.00 oz/M)	2.5 EF	58.3 A-D	37.3 A-C	0.0 C	2.8 DE
14	CIVITAS TURF DEFENSE Pre-M1xed (17.00 oz/M)	3.5 DE	48.3 CD	23.8 B-E	0.0 C	5.8 B
15	UCR 001	3.3 D-F	46.7 C-E	28.2 A-D	0.0 C	3.5 CD
16	UCR 002	2.2 F	69.2 AB	45.0 AB	4.0 B	2.7 DE
17	UCR 002	2.5 EF	60.8 A-C	44.4 A-C	3.2 B	2.7 DE
18	UCR 003	2.2 F	73.3 A	48.5 A	5.3 A	2.0 E

* Means followed by the same letter or by no letter in a column are not significantly different (P=0.05).
** WAIT – weeks after initial treatment
*** WAFT – weeks after final treatment

Table 4. Effects of fertility and fungicide treatments on soil electrical conductivity (EC_e; dS/m), normalized difference vegetation index (NDVI; -1-1), cover (DIA; 0-100%) and dark green color index (DGCI; DIA) on November 4 (16 WAIT**/2 WAFT***) evaluated on annual bluegrass 'Two Putt' turf. Riverside, CA, 2019.

No.	Treatment	EC_e	NDVI	Cover (DIA)	DGCI
A	Calcinit K	0.32*	0.51*	71*	0.41*
B	UMAXX	0.34	0.51	71	0.41
1	Untreated Control	0.32*	0.47 C-E*	61 B-E*	0.38 C*
2	Compass (0.20 oz/M)	0.36	0.52 B-D	71 BC	0.38 C
3	Maxtima (0.80 oz/M)	0.30	0.51 B-D	70 BC	0.39 C
4	Navicon Intrinsic (0.85 oz/M)	0.32	0.48 C-E	61 B-E	0.38 C
5	Insignia SC Intrinsic (0.50 oz/M)	0.33	0.50 CD	69 B-D	0.38 C
6	Insignia SC Intrinsic (0.70 oz/M)	0.32	0.51 B-D	69 B-D	0.38 C
7	Velista (0.50 oz/M)	0.32	0.51 B-D	75 B	0.38 C
8	Appear II (6.00 oz/M)	0.30	0.60 AB	98 A	0.46 B
9	Daconil Action (3.5 oz/M) + Appear II (6.00 oz/M)	0.24	0.65 A	97 A	0.46 B
10	Secure Action (0.5 oz/M) + Appear II (6.00 oz/M)	0.36	0.60 AB	97 A	0.48 B
11	Secure Action (0.5 oz/M) + Velista (0.50 oz/M)	0.39	0.48 C-E	66 B-D	0.39 C
12	Secure Action (0.5 oz/M) + Daconil Action (3.5 oz/M)	0.35	0.51 B-D	66 B-D	0.39 C
13	Mancozeb 80WD (6.00 oz/M)	0.35	0.45 C-E	58 B-E	0.38 C
14	CIVITAS TURF DEFENSE Pre-M1xed (17.00 oz/M)	0.30	0.52 B-D	97 A	0.58 A
15	UCR 001	0.30	0.55 BC	73 B	0.38 C
16	UCR 002	0.29	0.43 DE	52 DE	0.39 C
17	UCR 002	0.49	0.45 C-E	55 C-E	0.39 C
18	UCR 003	0.38	0.40 E	46 E	0.39 C

* Means followed by the same letter or by no letter in a column are not significantly different (P=0.05).
** WAIT – weeks after initial treatment
*** WAFT – weeks after final treatment

Table 5. Effects of fertility and selected fungicide treatments on the identification of rapid blight disease causal agent presence – *Labyrinthula terrestris* – in annual bluegrass sampled on November 4 (16 WAIT***/2 WAFT****). Riverside, CA, 2019.

No.	Treatment	A Calcinit-K	B UMAXX
1	Untreated Control	+*	-**
6	Insignia SC Intrinsic (0.70 oz/M)	-	+
7	Velista (0.50 oz/M)	+	+
8	Appear II (6.00 oz/M)	-	+
9	Daconil Action (3.5 oz/M) + Appear II (6.00 oz/M)	+	-
10	Secure Action (0.5 oz/M) + Appear II (6.00 oz/M)	+	-
15	UCR 001	-	-

* '+' – samples positively identified for *Labyrinthula terrestris* presence
** '-' – samples negatively identified for *Labyrinthula terrestris* presence
*** WAIT – weeks after initial treatment
**** WAFT – weeks after final treatment

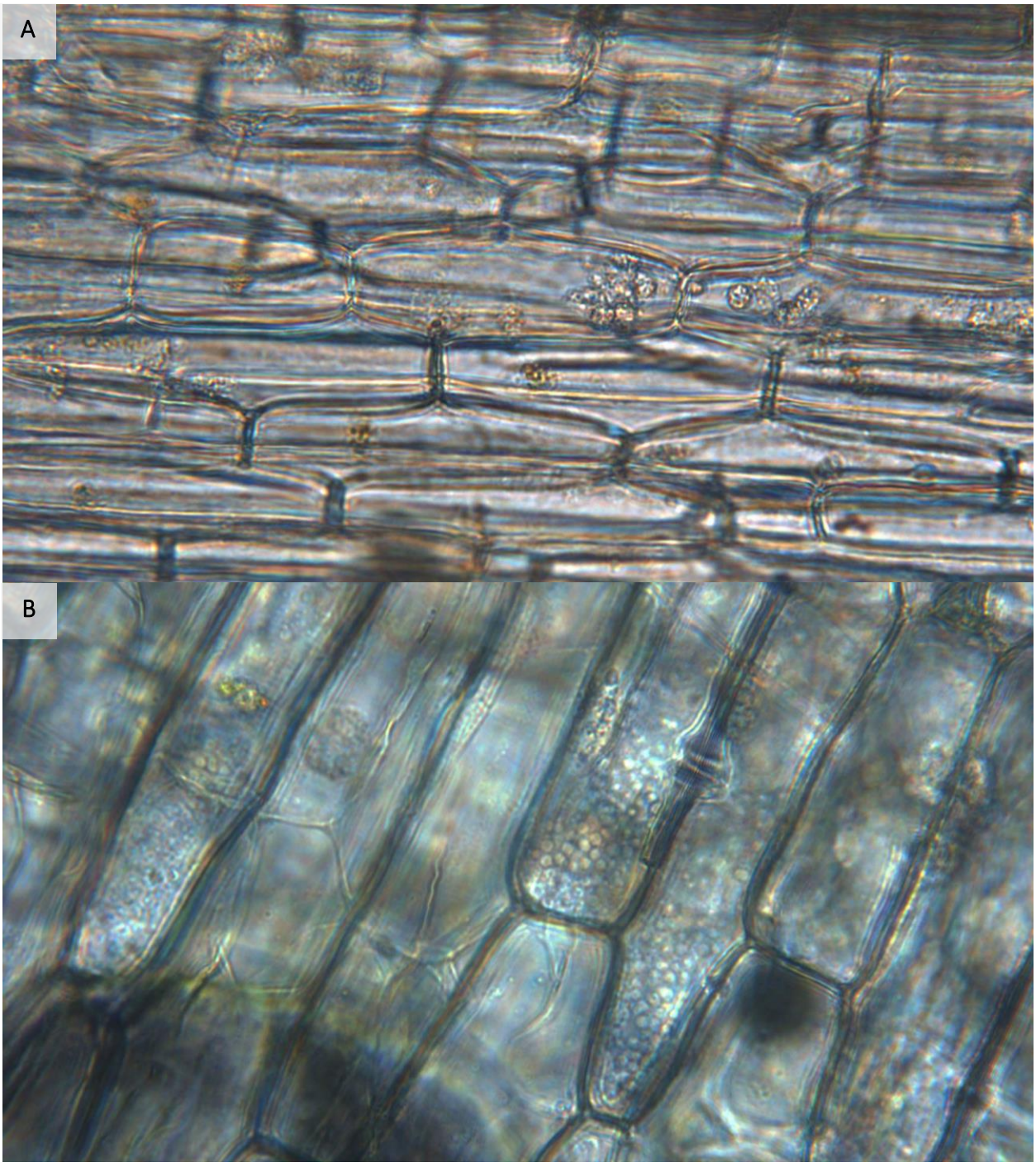


Figure 2. Microscopic images of (A) spindle (typical) cells and (B) round (atypical) structures of *Labyrinthula terrestris* identified in plant material collected on November 4, 2019. Photos taken by P.F. Harmon on December 2, 2019. Gainesville, FL.

Figure 3. Comparison of plot treated with Compass (0.20 oz/1000 ft^2) (left) to plot treated with tank-mix of Secure Action (0.50 oz/1000 ft^2) and Appear II (6.00 oz/1000 ft^2) (right). Photo taken by P. Petelewicz on October 20, 2019. Riverside, CA.

Figure 4. Comparison of plot treated with Appear II (6.00 oz/1000 ft^2) (left) to plot treated with Insignia SC Intrinsic (0.50 oz/1000 ft^2) (right). Photo taken by P. Petelewicz on October 20, 2019. Riverside, CA.

Figure 5. Comparison of plot treated with tank-mix of Daconil Action (3.50 oz/1000 ft^2) and Appear II (6.00 oz/1000 ft^2) (left) to untreated plot (right). Photo taken by P. Petelewicz on October 20, 2019. Riverside, CA.

Figure 6. Comparison of plot treated with tank-mix of Daconil Action (3.50 oz/1000 ft^2) and Appear II (6.00 oz/1000 ft^2) (left) to plot treated with Velista (0.50 oz/1000 ft^2) (right). Photo taken by P. Petelewicz on October 20, 2019. Riverside, CA.

Figure 7. Comparison of plot treated with tank-mix of Daconil Action (3.50 oz/1000 ft^2) and Appear II (6.00 oz/1000 ft^2) (left) to plot treated with Navicon Intrinsic (0.85 oz/1000 ft^2) (right). Photo taken by P. Petelewicz on October 20, 2019. Riverside, CA.

Figure 8. Comparison of plot treated with Daconil Action (3.50 oz/1000 ft^2) and Appear II (6.00 oz/1000 ft^2) (left) to plot treated with Mancozeb 80WD (6.00 oz/1000 ft^2) (right). Photo taken by P. Petelewicz on October 20, 2019. Riverside, CA.

Figure 9. General view of one of the blocks showing overall damage within the study area. Standing out was plot (arrow) treated with tank-mix of Daconil Action (3.50 oz/1000 ft^2) and Appear II (6.00 oz/1000 ft^2). Photo taken 6 weeks after final treatment by P. Petelewicz on December 2, 2019. Riverside, CA.

Figure 10. Close-up of a plot treated with Daconil Action (3.50 oz/1000 ft^2) and Appear II (6.00 oz/1000 ft^2) tank-mix. Photo taken 6 weeks after final treatment by P. Petelewicz on December 2, 2019. Riverside, CA.

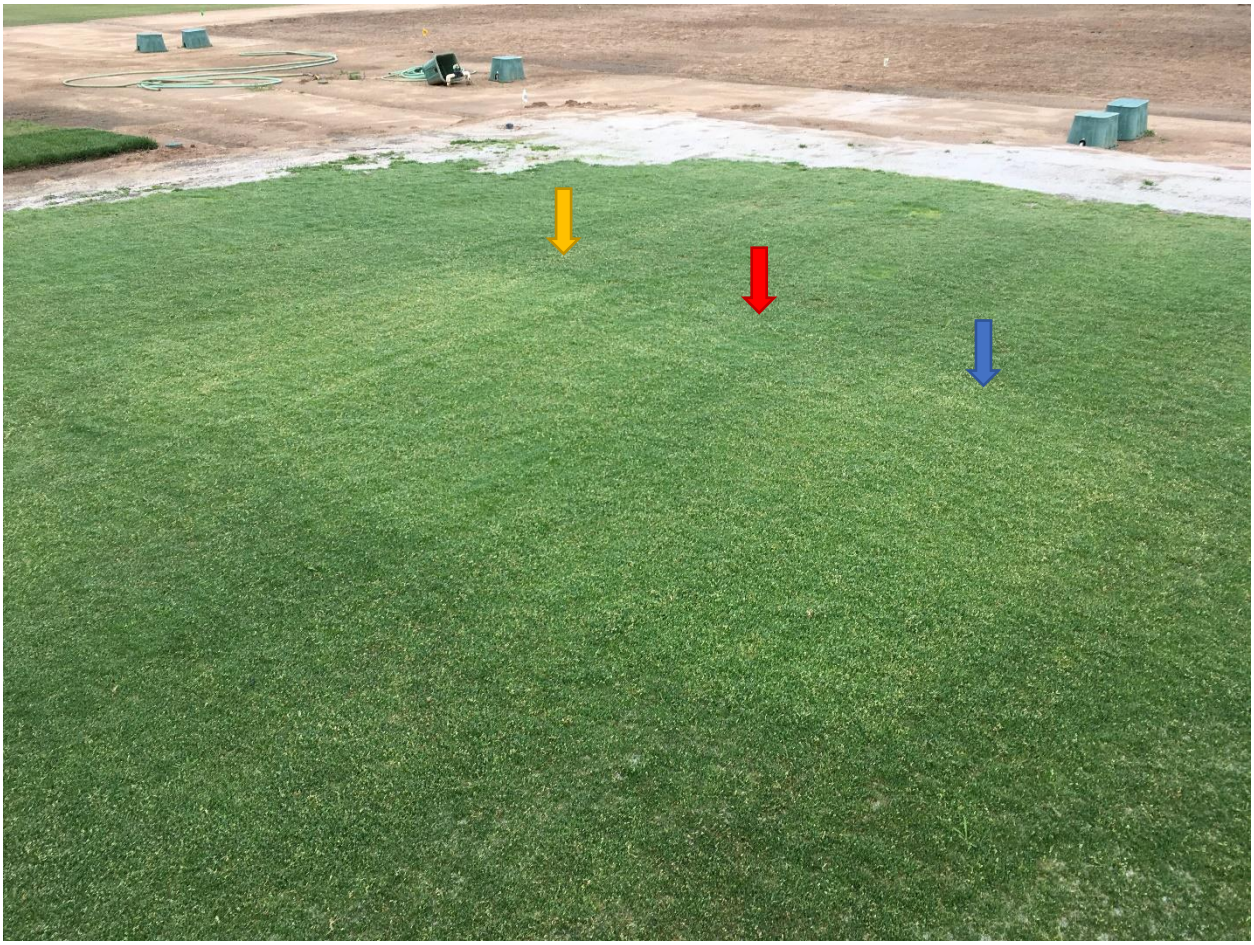


Figure 11. General view of one of the blocks showing impact of Appear II (6.00 oz/1000 ft^2) applications – either as a standalone treatment (blue arrow) or as a tank mix with Daconil Action (3.50 oz/1000 ft^2; red arrow) or Secure Action (0.50 oz/1000 ft^2; yellow arrow). Photo taken 21 weeks after final treatment by P. Petelewicz on March 18, 2020. Riverside, CA.