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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of $25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Salinity Alters Rapid Blight Disease Occurrence

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SUMMARY

Scientists at Clemson University continue to investigate *Labyrithula terrestris* in an effort to clearly define the relationship between salinity and salinity tolerance with the incidence of rapid blight in three susceptible cool-season grasses. Their findings include:

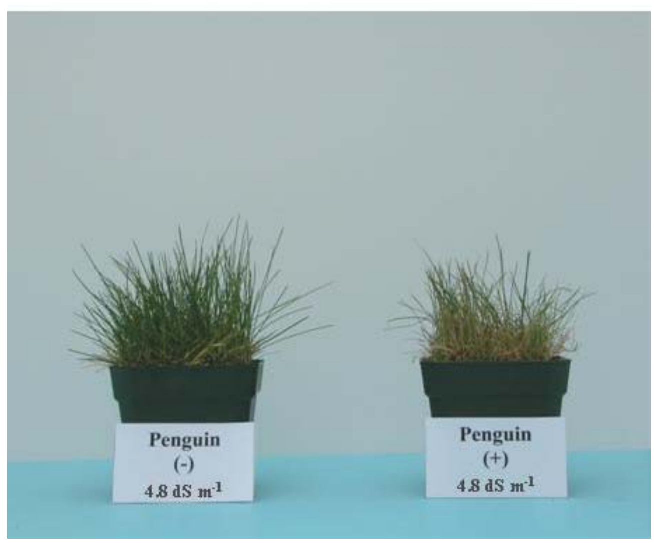
- Salinity increases rapid blight in Kentucky bluegrass, perennial ryegrass, and slender creeping red fescue.
- Salinity tolerance of the grasses is correlated with rapid blight tolerance.
- Slender creeping red fescue cultivars were more tolerant of salinity and rapid blight than Kentucky bluegrass or perennial ryegrass.

Rapid blight disease of cool-season grasses, caused by *Labyrinthula terrestris*, has been recognized since 1995 (1, 2, 3, 4). Rapid blight affects a wide range of cool-season turfgrasses (5), including bluegrasses, ryegrasses, bentgrasses, and fescues. Rapid blight affects both juvenile and mature turfgrass, although overseeded grasses in the seedling stage appear to be most vulnerable (e.g. rough bluegrass overseeded into bermudagrass). The disease can be severe on putting greens of mature annual bluegrass and creeping bentgrass.

On golf course turfgrass, rapid blight symptoms appear as yellow (chlorotic) and brown (necrotic) patches of variable size, often with water-soaked margins. The disease is difficult to diagnose; there are no obvious signs of pathogen invasion, such as fungal mycelia or spores. Accurate diagnosis requires microscopic detection of the presence of thin walled, spindle-shaped vegetative cells (measuring about 6 x 16 µm) inside leaf cells and/or the growth of the organism on a semi-selective culture medium.

Rapid blight occurs most commonly in the US in the west, southwest, and coastal south and southeast regions where irrigation water is compromised with salts. In many cases, rapid blight disease has been associated with saline irrigation water, drought, and a buildup of salt in the soil. For example, irrigation water electric conductivities from eight golf courses in Arizona, California, Texas, and Utah with rapid blight ranged from 0.5 to 3.5 dS m^{-1} (deciSiemens per meter), averaging 1.4 dS m^{-1} [Peterson, Martin, and Camberato, unpublished; one dS m^{-1} equals 640 parts per million (ppm)]. With drought conditions, water supplies from eight South Carolina golf courses with rapid blight ranged from 1.0 to 6.0 dS m^{-1}, with an average of 3.1 dS m^{-1} (Camberato and Martin, unpublished).

High salinity levels may provide a better environment for *L. terrestris* and/or may stress the host plant so that disease develops. A salt or sodi-



Symptoms of rapid blight on 'Penguin' perennial ryegrass 21 days after inoculation with *Labyrinthula terrestris* (+) with irrigation water of 4.8 dS m^{-1} (plant on the right). The plant on the left (-) has not been inoculated, but has been grown with the same salinity level.

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Species	Cultivar	Seed Source
Perennial ryegrass	Brightstar SLT	Turf-Seed Inc.
	Hawkeye	Seed Research of Oregon
	Peregrine	Seed Research of Oregon
	Penguin	Seed Research of Oregon
Kentucky bluegrass	Arcadia	Seed Research of Oregon
	North Star	Turf-Seed Inc.
	Kingfisher	Seed Research of Oregon
	SR 2284	Seed Research of Oregon
Slender creeping red fescue	Barcrown II	Barenbrug
	Dawson	Seed Research of Oregon
	Seabreeze	Turf-Seed Inc.
	SRX 55	Seed Research of Oregon

Table 1. Cultivars of perennial ryegrass, Kentucky bluegrass, and slender creeping red fescue examined for salinity tolerance and susceptibility to rapid blight disease.

um requirement for *L. terrestris* would not be unusual, since all other known *Labyrinthula* are marine organisms. Also, in our experiments, the rapid blight tolerance of 24 cool-season grass species was generally related to their reported salinity tolerance (5). The objectives of this study were to clearly define the relationship between salinity and salinity tolerance with the incidence of rapid blight in three susceptible cool-season grasses.

Experimental Set-up

Duplicate runs of an experiment were conducted in a greenhouse to examine the effects of salinity on rapid blight of perennial ryegrass, slender creeping red fescue, and Kentucky bluegrass. Treatments consisted of four cultivars of each cool-season turfgrass at five levels of salinity with or without inoculation with *L. terrestris*. Grass cultivars (Table 1) were selected for this experiment because they differed in susceptibility to rapid blight (5; 'Barcrown II' not previously examined).

Grasses were grown in plastic pots containing a 80:20 (vol:vol) sand:peat mix. Salinity treatments of 0.2, 1.3, 2.5, 3.6, and 4.8 dS m^{-1} were initiated three weeks after seeding. Half of each salinity treatment was inoculated five weeks after seeding with a composite inoculum of five isolates of *L. terrestris*. The percentage of chlorotic leaf tissue on a per pot basis was rated visually three times per week from six to 11 weeks after seeding.

Salinity Connection to Rapid Blight

Symptoms of rapid blight occurred 21 days after inoculation with *L. terrestris* on 'Penguin' perennial ryegrass at irrigation water EC_W of 4.8 dS m^{-1}. Chlorotic leaf tissue was visually obvious as early as 10 days after inoculation, eventually becoming necrotic with increased disease.

The effects of salinity and inoculation on leaf chlorosis differed depending on the species of turfgrass and cultivar. Additionally, effects induced by these factors varied somewhat between experimental runs and increased over time within each run. Data are presented for three grasses to illustrate the range in effects of salinity

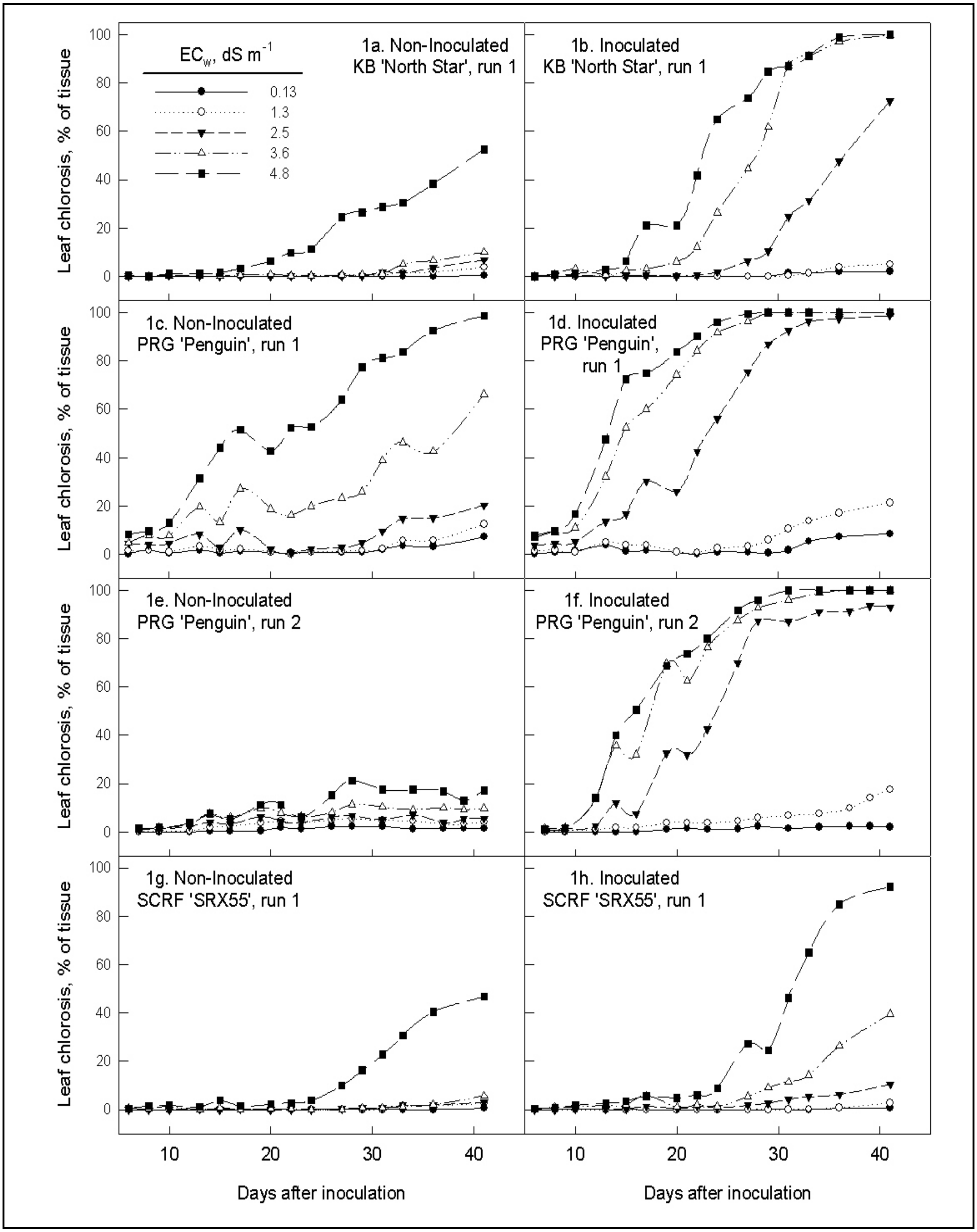

Figure 1 a-h. Effects of irrigation water electrical conductivity (EC_w, legend in panel A) and inoculation with *Labyrinthula terrestris* on leaf chlorosis over time. Data for selected cultivars and experimental runs shown to illustrate variation in response to the treatments. Each point represents the mean of four replications.

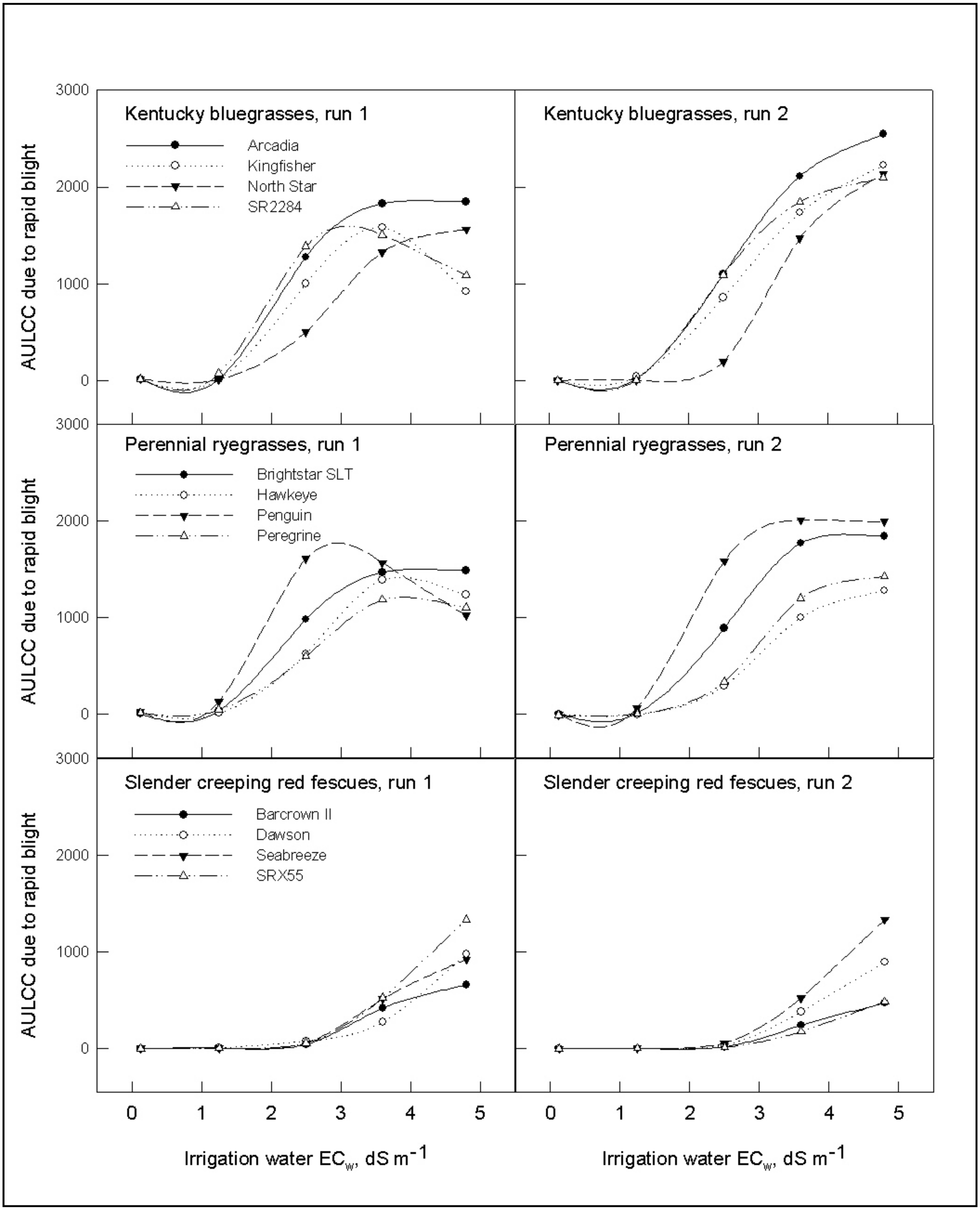

Figure 2. Area under the leaf chlorosis curve (AULCC) 41 days after inoculation with *Labyrinthula terrestris*, the causal agent of rapid blight, as affected by electrical conducitivity (EC_W) of the irrigation water for four cultivars each of Kentucky bluegrass, slender creeping red fescue, and perennial ryegrass for both runs of the experiment. Each point represents the mean of four replications.

	Run 1 - Kentucky bluegrasses				Run 2 - Kentucky bluegrasses			
EC_w	Arcadia	Kingfisher	North Star	SR2284	Arcadia	Kingfisher	North Star	SR2284
ds m^{-1}	------------- Days to 800 AULCC due to rapid blight (Std. Dev.) or AULCC due to rapid blight (Std. Dev.) -----------							
2.5	36 (1.8)	39 (1.9)	+	34 (1.5)	38 (3.3)	40 (3.1)	+	38 (3.6)
3.6	29 (1.5)	32 (1.5)	35 (2.1)	31 (3.6)	28 (0.6)	32 (1.7)	34 (3.5)	31 (1.3)
4.8	25 (1.8)	27 (0.0)	32 (5.5)	25 (2.1)	23 (1.2)	26 (1.7)	27 (4.3)	25 (2.2)

	Run 1 - Perennial ryegrasses				Run 2 - Perennial ryegrasses			
EC_w	Brightstar SLT	Hawkeye	Penguin	Peregrine	Brightstar SLT	Hawkeye	Penguin	Peregrine
ds m^{-1}	------------- Days to 800 AULCC due to rapid blight (Std. Dev.) or AULCC due to rapid blight (Std. Dev.) -----------							
2.5	39 (2.8)	+	32 (3.4)	+	+	+	32 (1.7)	+
3.6	32 (3.9)	34 (1.7)	30 (7.9)	36 (1.7)	31 (1.7)	38 (1.7)	27 (2.2)	37 (2.6)
4.8	28 (1.7)	33 (2.9)	25 (2.1)	33 (0.8)	29 (1.2)	36 (2.1)	27 (2.1)	34 (0.8)

+ Indicates 800 AULCC was not attained for this treatment/cultivar combination during the experiment.

Table 2. Number of days needed to attain a value of 800 for the area under the leaf chlorosis curve (AULCC) due to rapid blight for each cultivar in each run. Little leaf chlorosis occurred for ryegrasses and bluegrasses at EC_w < 2.5 ds m^{-1} or for fescues at any salinity, therefore data are not shown for these treatments. The AULCC due to rapid blight actually attained at the final rating is listed instead of days when three of four replications of a particular treatment did not attain 800 AULCC due to rapid blight.

and inoculation on leaf chlorosis (Figure 1). Leaf chlorosis became more severe with time (Fig. 1a-h) and was greater in Run 1 than Run 2 (1c-d versus 1e-f), especially in non-inoculated plants (panel 1c vs 1e). Higher temperatures in the greenhouse during Run 1 may explain the greater salinity damage.

Salinity and rapid blight affected slender creeping red fescue much less than it affected perennial ryegrass or Kentucky bluegrass (panel 1g-h vs 1a-f). One hundred percent leaf chlorosis was attained at 4.8 dS m^{-1} as early as four weeks after inoculation in rapid blight cultivars such as 'Penguin' perennial ryegrass (Fig. 1 d, f), whereas at least seven weeks were needed for complete chlorosis of 'SRX55' slender creeping red fescue (Fig. 1h).

Area under the leaf chlorosis curve (AULCC) due to rapid blight (the difference in leaf tissue chlorosis between inoculated and non-inoculated plants summed over the entire rating period) was determined for each run (Figure 2). All factors examined (salinity, species, and cultivar) interacted to influence rapid blight-induced chlorosis. Little rapid blight-induced chlorosis occurred at irrigation water electrical conductivities of EC_w =1.3 dS m^{-1} for any cultivar of any species (Figure 2) even though *Labyrinthula* was cultured from the leaf tissue of inoculated plants at both salinity levels (data not shown).

Cultivars of slender creeping red fescue had low AULCC values due to rapid blight even at EC_w of 3.6 and 4.8 dS m^{-1}. All cultivars of perennial ryegrass and Kentucky bluegrass (except 'North Star' Kentucky bluegrass in Run 2 at EC_w

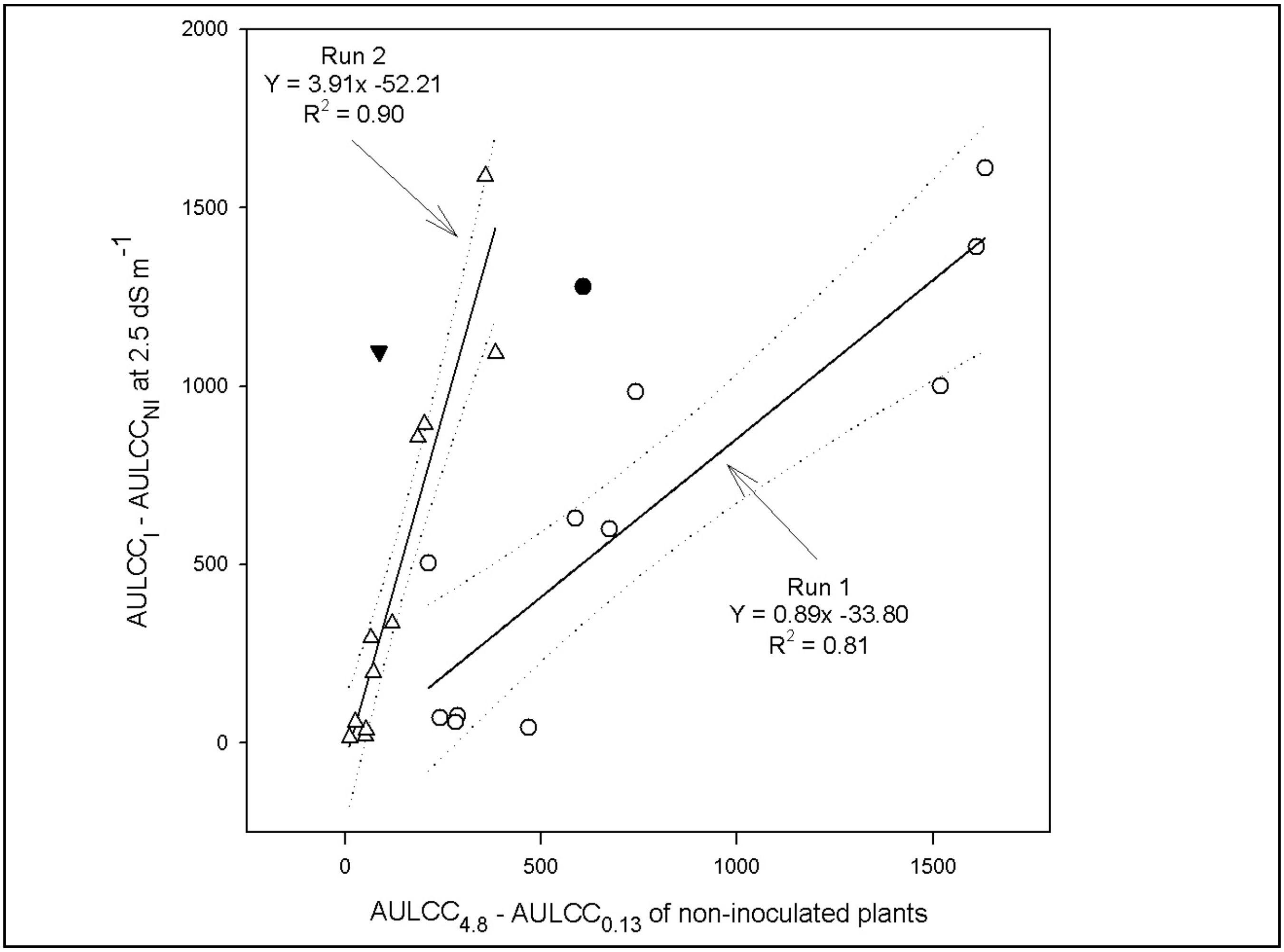

Figure 3. Area under the leaf chlorosis curve (AULCC) due to inoculation [$AULCC_I$ (inoculated) minus $AULCC_{NI}$ (non-inoculated)] at 2.5 dSm^{-1} as a function of AULCC due to salinity [$AULCC_{4.8}$ (4.8 dSm^{-1}) minus $AULCC_{0.13}$ (0.13 dSm^{-1})] for non-inoculated cultivars of Kentucky bluegrass, slender creeping red fescue, and perennial ryegrass for each of two experimental runs. Data for 'Arcadia' Kentucky bluegrass (solid symbols) omitted from the regression equations. Each point represents the mean of 4 replications. Dotted lines represent 95% confidence intervals.

= 2.5 dS m^{-1}) had detectable AULCC values due to rapid blight at EC_w= 2.5 dS m^{-1}. Irrigation water EC_w > 2.5 dS m^{-1} increased AULCC due to rapid blight of all perennial ryegrass and Kentucky bluegrass cultivars.

The length of time needed to reach a value of 800 AULCC due to rapid blight (75 to 100% tissue chlorosis) at 3.6 and 4.8 dS m^{-1} also varied among cultivars of Kentucky bluegrass and perennial ryegrass and decreased with increased salinity (Table 2). Attainment of a value of 800 AULCC was delayed as much as seven to 11 days for the least susceptible rapid blight cultivars compared to the most susceptible.

Cultivars of Kentucky bluegrass and perennial ryegrass varied in susceptibility to rapid blight. 'North Star'had lower levels of leaf chlorosis due to rapid blight compared to other Kentucky bluegrass cultivars (Figure 2), and chlorosis was slower to develop (Table 2). The other Kentucky bluegrasses were similar in the level and rate of leaf chlorosis due to rapid blight. 'Penguin' had the greatest amount and fastest occurring rapid blight induced leaf chlorosis of the perennial ryegrasses; 'Brightstar SLT' was intermediate; and 'Hawkeye' and 'Peregrine' showed the least leaf chlorosis due to rapid blight (Figure 2; Table 2).

Rapid blight induced leaf chlorosis was correlated with salinity induced leaf chlorosis for all but one turfgrass cultivar examined (Figure 3), suggesting rapid blight tolerance is related to salinity tolerance. This relationship held in Run 1 where leaf chlorosis due to salinity was high and in Run 2 where salt-induced leaf chlorosis was substantially less. Therefore, although salinity increases rapid blight disease and salinity tolerance is related to rapid blight tolerance, leaf chlorosis due to salt stress is not required for disease to occur.

Increased salinity increased the amount of leaf chlorosis resulting from inoculation with *Labyrinthula terrestris* in all cultivars of slender creeping red fescue, Kentucky bluegrass, and perennial ryegrass examined. These results confirmed our suspicion that salinity plays a major role in the occurrence of rapid blight. The level of salinity needed for symptoms of rapid blight to develop was highly dependent on the grass species. Significant disease occurred in the rapid blight tolerant slender creeping red fescue only at the highest salinity level examined, 4.8 dS m^{-1}. On the other hand, all cultivars of perennial ryegrass and Kentucky bluegrass (except 'North Star' Kentucky bluegrass) had substantial leaf chlorosis due to rapid blight at salinities of 2.5 dS m^{-1}. The amount of leaf chlorosis induced by *L. terrestris* was correlated with the amount of salt-induced chlorosis, suggesting rapid blight tolerance may indeed be related to salinity tolerance.

Soil salinity problems are likely to increase in the future as competition for high quality water sources encourages the use of more saline irrigation on golf courses. As a result, turf managers will need to develop management strategies that cope with the potential for increased rapid blight disease. Utilization of rapid blight tolerant turfgrass species and cultivars and irrigation water management to minimize soil salt accumulation are cultural practices that can be used to reduce the occurrence of rapid blight.

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