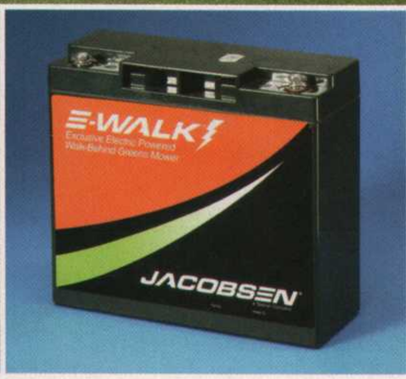

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TABLE 2

Quality ratings of bermudagrass planted 5/22/02 at Sand Mountain

Scale 1-9 with 9-ideal, 1-poor

Variety	August	September	October
Princess	8.5 A*	8.0 A	8.8 A
Riviera	8.5 A	7.5 AB	8.0 B
Blackjack	8.0 AB	7.0 BC	7.5 BCD
Sultan	8.0 AB	7.0 BC	8.0 B
Numex Sahara	7.8 AB	7.0 BC	8.0 C
Bermuda Triangle	7.8 AB	7.0 BC	8.0 B
Sydney	7.5 AB	7.0 BC	7.8 BC
Guymon	7.0 B	6.5 C	7.0 D
Yukon	5.8 C	6.3 C	7.3 CD
Tifway (419)	3.8 D	4.8 D	7.3 CD

*Varieties with the same letter are not significantly different based on analysis using Duncan's Test (a = 0.05)

with Blackjack having the most at 38 percent winterkill.

As summer approached, shoot density was also measured again. Similar to the previous year, Tifway had the greatest shoot density in the project throughout the entire summer. Princess was next and the highest among the seeded cultivars.

The remaining cultivars had significantly lower shoot density. Color and quality were also recorded during the summer of 2002 with similar results to shoot density with Tifway being superior, followed closely by Princess and then the rest of the seeded cultivars (Tables 1 & 2).

Sand Mountain—2002

Establishment at Sand Mountain took slightly longer because of heavy weed pressure. Similar results were observed as in the previous year at the AU TGRU. All of the seeded cultivars established in eight weeks, and the cultivars that established quicker had less competition from the weeds.

Most of the cultivars filled in at the same rate, but Guymon and Yukon seemed to germinate slower and not establish as quickly. Therefore, they encountered heavy weed pressure. Also, since Tifway sprigs are slow to establish, they had the greatest amount of weed infestation.

Shoot density for Sand Mountain was determined. Once they were completely established, Princess, Tifway and Riviera were all similar in shoot density. All the other seeded cultivars were similar in their shoot densities.

Princess and Riviera showed superior quality (Table 2). Note that Tifway quality is lower than expected. From the beginning of July to the middle of August, irrigation was under repair and could not be applied. The Tifway was not fully mature when the irrigation problem happened, and this slowed growth drastically. It did obtain full coverage in September soon after the irrigation was fixed.

This research will be completed during this spring and summer. Spring green-up and winterkill will be recorded. Color and quality will also be noted throughout the summer.

The new seeded cultivars of bermudagrass are approaching the quality of the hybrids. Our research shows that the newer seeded cultivars are gaining ground, but are still not quite up to the standard of Tifway. However, the reduced cost, ease of planting and quick establishment of the new seeded bermudagrasses will make them viable options for many turfgrass managers.

In conclusion, our research shows that:

- Some seeded cultivars establish much quicker than sprigged Tifway, and this helps compensate for weed pressure.
- Slower emerging and/or covering cultivars such as Yukon, Guymon and Tifway are susceptible to heavy weed pressure.
- Blackjack suffered the greatest amount of winterkill and Princess the least among seeded cultivars. Overall, Tifway suffered the least winterkill.
- At the AU TGRU, Tifway was superior in shoot density, quality and color.
- At the AU TGRU, Princess had the highest shoot density, color and quality of all the seeded cultivars.
- At Sand Mountain, Princess and Riviera had the highest shoot density and quality of the seeded cultivars.

Raciborski is a graduate research assistant at Auburn University. Han is an assistant professor and extension specialist of turfgrass management in the department of agronomy and soils at the school.

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Two developments over the past few years in the turfgrass field have required improvements in granular formulation technology. The first is the advent of newer turfgrass varieties for greens that produce over 225 tillers per square inch allowing for the drop in mowing heights to below 1/8 inch cut. The second is the new pre-emergent herbicides that have low solubility and low mobility. Both these developments dictate that fertilizer and fertilizer combination products provide enough particle density in the turf canopy for weed control as well as limit mower pick-up. The Andersons has developed a wide range of small SGN fertilizer and fertilizer combination products to address both areas. SGN or size guide number is a reference tool that outlines the "average particle diameter" of the product. For example, a product with an average particle size of 1.5 mm will have an SGN of 150. From Andersons Contec fertilizer products with SGN as low as 80 to fertilizer + pre-emergent herbicides products with SGNs of 150, we address these trends very well.

Particles Per Square Inch Calculator

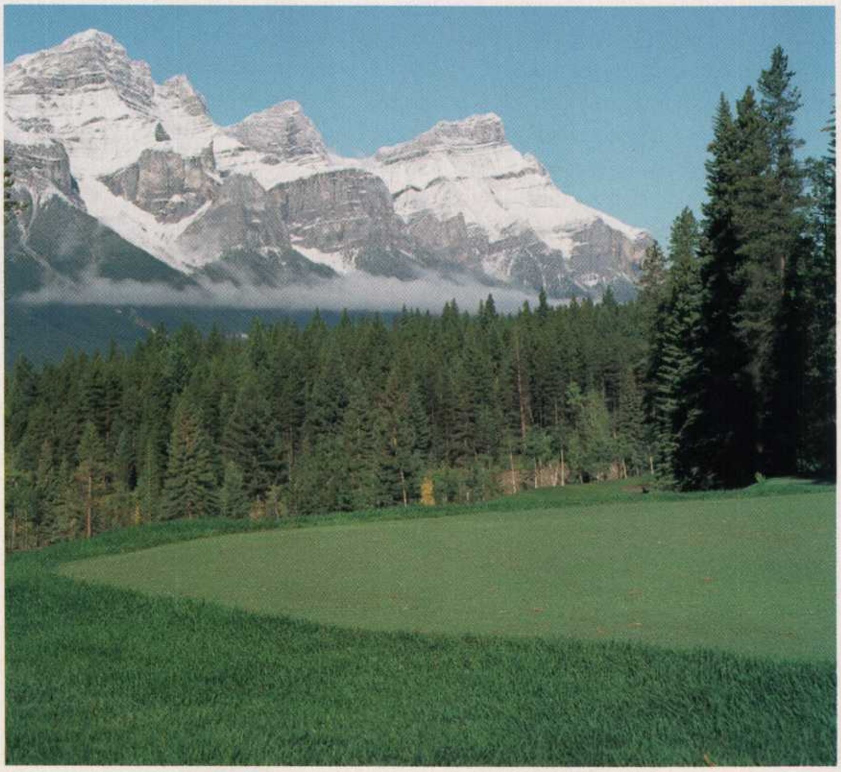
SGN → / Lbs/Acre ↓	SGN 100	SGN 125	SGN 150	SGN 175	SGN 215	SGN 240
100	10.6	5.4	3.1	2.0	1.1	0.8
125	13.3	6.8	3.9	2.5	1.3	1.0
150	15.9	8.2	4.7	3.0	1.6	1.2
175	18.6	9.5	5.5	3.5	1.9	1.3
200	21.3	10.9	6.3	4.0	2.1	1.5
225	23.9	12.2	7.1	4.5	2.4	1.7
250	26.6	13.6	7.9	5.0	2.7	1.9
300	31.9	16.3	9.4	5.9	3.2	2.3

SGN represents fertilizer particles in millimeters X 100. Granular fertilizer particles per square inch at intersection. Avg. SG (g/ml) = 1.3, 0.77

The matrix above is an easy to use reference tool to determine the number of particles per square inch that a granular product may be delivering. For example, an 150 SGN fertilizer applied at 200 pounds per acre will deliver greater than four times the amount of particles per square inch than a 240 SGN product at the same rate. This matrix is useful when making the decision on which fertilizer plus pre-emergent herbicide product to choose. The number of particles per square inch has a greater influence on the effectiveness of a pre-emergent product than the pounds per acre.

The Andersons has set the standard within the industry on granular formulation technology. In addition to particle sizing, The Andersons formulation process ensures handling integrity, ease of application and proper distribution of the active ingredient from the particle to the soil.

Article contributed by Rob Smith, Andersons Territory Manager.



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Frozen Soil Worsens Pesticide Runoff Problems

By Zachary M. Easton

Winters in the Northeast can be long and cold. Soils are generally frozen during this period (December-March). Significant runoff can occur in the winter due to snowmelt or rainfall on frozen soils, which can contain and transport unused or unbound nutrients and pesticides from turfgrass despite the fact that no compounds were applied in the winter.

Runoff from frozen soils can approach 100 percent of the precipitation and can occur even in the absence of rainfall. Soils become prone to runoff when they are saturated (i.e., all available soil pores are filled with water). When the soil is not frozen, this pore water drains quickly with sands and more slowly with clays (Hillel, 1998). However, when the pore water is frozen, internal drainage occurs slowly or, in extreme cases, not at all.

When no chemicals are applied during the winter, there theoretically should be little nutrient or no pesticide loss from turfgrass. But volatilization, microbial degradation, binding to organic matter, decay, metabolism of pesticides by turf and leaching are slowed or stopped, leaving runoff as the primary loss mechanism. Any pesticide not used or unattenuated when the temperature drops can potentially end up in runoff.

During the growing season, controlling runoff generally reduces pesticide losses as well. A dense stand of turfgrass will reduce and in many cases eliminate runoff. However, when the soil is frozen, water cannot enter the soil profile, which allows runoff from even the densest stand of turfgrass. This runoff has the potential to transport significant quantities of pesticide from a site. Concentrations of the pesticide in winter runoff are usually low, but the sheer runoff volume can contain large amounts of pesticides.

When the upper-most layer of soil is frozen, water is prevented from entering the profile. In central New York, the soil below 4 to 6 inches deep rarely freezes. Runoff during the winter corresponds closely with whether the soil is frozen or not. During the winter of 2000-2001, there was significant runoff due to the soil being frozen. However, during the winter of 2001-2002 there was very little runoff because the soil was rarely frozen.

In the first year, 83 percent of the total runoff was measured during the winter of 2000-2001. In the second year, only 2.5 percent of the runoff occurred in the winter. The soil was rarely frozen, and there was very low rainfall. What rain did fall easily infiltrated the unsaturated and unfrozen soil. As a result, little pesticide loss was recorded in the second year. However, when 83 percent of the runoff occurred in the winter, there were significant pesticide losses (Table 1).

Total pesticide losses from this study were extremely low on average. However, concentrations were, at times, very high. 2,4-D was detected at 1,236 micrograms per liter, or almost 18 times what is allowed in drinking water by the U.S. Environmental Protection Agency (USEPA, 1989). Dicamba was measured in excess of 200 micrograms per liter, the maximum contaminate level (MCL) allowed, and mecoprop at concentration of 27 micrograms per liter, which is nearly four times higher than the allowable levels (USEPA, 1989).

High pesticide concentrations in runoff are much more likely to be detected following pesticide application during the growing season. However, runoff losses during the growing season are generally low. Turfgrass is efficient at removing water from the soil (reducing soil moisture), which creates air-filled pore space in the soil which rainfall or irrigation water can easily enter.

Likewise, the dense growth habit and thatch-forming capabilities slow runoff water by creating a more tortuous pathway, (Krenitsky et al., 1998) and increases soil infiltration. Actively growing turfgrass can also increase the overall porosity of the soil, increasing the potential water storage capabilities of the soil. The interaction of these factors makes runoff during the growing season minimal in all but the most intense storms.

In contrast, when the soil is frozen, the above factors make little difference. Rainfall or snowmelt will generally end up as runoff. The question is, how can pesticides still be detected in runoff after so much time? Numerous pesticide and environmental properties must be considered when assessing the runoff potential of pesticides during the winter.

Pesticides with a long half-life will remain in the environment and are potentially available for transport by runoff. When the temperature is below freezing, the time needed to break down a pesticide increases.

Siduron is one such pesticide. With a half-life of 128 days, significant amounts of the compound would be present in the environment for a long period. Pesticides such as trichlorfon have a short half-life — less than six days — so they would not remain in the environment for long.

Another important pesticide property to consider is how tightly the pesticide is bound once applied. This is measured with the organic carbon partitioning coefficient (K_{oc}). Some pesticides can be easily washed from the turfgrass tissue or soil if they are weakly bound (low K_{oc}), whereas others are relatively immobile once applied (high K_{oc}).

Pesticides such as trichlorfon, dicamba and mecoprop are weakly bound, whereas pesticides such as fenoxaprop and siduron are tightly bound to turfgrass.

For a pesticide to be effective (particularly foliar herbicides), it must attach to the turfgrass tissue. Take siduron for example. It is tightly held to turfgrass tissue, so theoretically should not be detected in runoff, especially in March (which is when most of the pesticide was detected). Since siduron was applied pre-emergently, however, there was little turfgrass in place to immobilize the compound. As a result, siduron runoff from the frozen soil was 26 percent of the total siduron recovered.

Trichlorfon, which controls grubs, is weakly bound to turfgrass tissue. The compound needs to be in the area where grubs are active, which means in the thatch and shallow soil.

To get the pesticide where it is needed, it must be easily transported from the turfgrass tissue to the soil and thatch. The ease of wash-off and the short half-life make extended detection lengths unlikely. In fact, 93 percent of the total measured in runoff was within six days of application. However, any that did remain when the soils became frozen was easily transported.

Clearly, the relationship between runoff and pesticide loss can be complicated. There are many factors affecting the potential for runoff, including rainfall rate and duration, soil type, moisture level, grass type and growth stage. However, if runoff can be controlled, and/or eliminated, pesticide loss can be as well.

When runoff does occur, pesticides may run off at different rates. This is generally a function of the intrinsic pesticide properties, such as the half life and organic carbon partitioning coefficient.

While management practices may have a clear affect on runoff and pesticide loss during the growing season, it is generally the site and environmental conditions which control losses from frozen soils. It is therefore imperative to select pesticides, which pose a low threat to water contamination.

Despite what one may think, runoff on frozen soils can represent the majority of the total yearly runoff and may contain a significant portion of the total pesticide loss.

Easton is a graduate student at Cornell University in Ithaca, N.Y.

TABLE 1

Percent of total pesticide lost during each season (growing or winter)

Season	Runoff (mm)	Dicamba[1]	2, 4-D[1]	Siduran[2]	Trichlorfon[3]
		Percent of pesticide lost during each season			
00 Growing Season	1.4	95	51	74	*
00-01 Winter	7.5	5	49	26	*
01 Growing Season	7.1	100	97	0	95
01-02 Winter	0.5	0	3	0	5
02 Growing Season	14.5	*	*	*	0

*No pesticide applied

[1] Applied 9/27/00, 6/3/01, 6/14/01, 9/22/01

[2] Applied 7/22/00

[3] Applied 9/18/01

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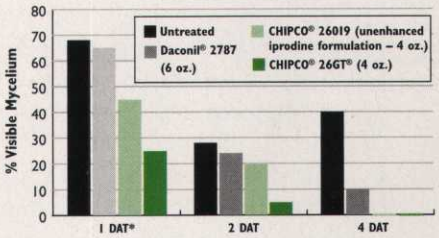

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Genetic Markers Identify Dollar-Spot Resistance

By Nanda Chakraborty and Geunhwa Jung

All modern bentgrass cultivars are susceptible to dollar spot, but there are significant differences in their susceptibility. Bentgrass is a large genus of more than 100 species. Only about four species are used for turfgrass in the United States. These are colonial, velvet, highland and creeping.

These species are perennial, outcrossing cool-season grasses and are used for golf courses. Currently, the stoloniferous, allotetraploid creeping bentgrass is the most adapted species for use on fairways and greens (Wipff and Fricker, 2001).

Dollar spot, caused by a fungus, is a major disease of turfgrass throughout the world and is the most prevalent and economically important turf disease in North America, particularly on intensively managed golf course putting greens and closely mown fairways (Couch, 1995; Vargas, 1994).

The disease occurs from spring through fall, but is most active during humid periods of warm days with cool nights in spring, early summer and fall. The optimum temperature for disease development is 70 degrees F to 80 degrees F, though the fungus will grow over a wider range, 50 degrees F to 90 degrees F.

On low-height turf, such as greens or fairways, the symptoms appear as round or irregularly shaped sunken, straw- to brown-colored patches approximately 1.2 inches in diameter (or about the same size as a silver dollar). When disease pressure is high, isolated spots grow together to form large, irregular patches. Since this fungus is not known to produce conidia or a sexual stage in the United States, the organism most likely spreads through mycelia or transport of infected leaf tissue by wind, water, machinery such as mowers, or by human traffic (Baldwin and Newell, 1992).

Why the interest in this disease?

Different current research strategies can be used to improve management strategies to combat this disease (Hensler, 2002). For example, research indicates that dollar spot severity can be reduced in a blended population by mixing a resistant cultivar with a susceptible cultivar (Abernathy et al., 2001).

Significant reductions have also been reported after morning mowing or poling treatment or both (Williams et al., 1996). According to some extension services, late-spring dollar spot severity can be minimized by the late-spring application nitrogen fertilizer, which will induce growth during early summer when dollar spot infections begin.

Two creeping bentgrass clones with significant difference in disease response were identified from more than 300 clones collected.

Some researchers have also shown that multiple applications of composts were effective in reducing disease incidence and severity (Boulter et al., 2002).

Dollar spot management, like other turf diseases, is highly dependent on chemical fungicide application. The causal fungus has, however, developed resistance to several important classes of fungicides such as benzimidazoles, dicarboximides and demethylation inhibitors (DMI) (Cole et al., 1968; Warren et al., 1974).

Fluazinam, a nonsystemic, pyridylaniline compound was able to suppress dollar spot caused by two benzimidazole and DMI resistant strains of the fungus to a threshold of less than 5 percent disease for more than 21 days (Burpee, 1997). Some fungicides have not been reregistered due to environmental concerns. This has stimulated research into alternative disease management strategies such as host resistance.

How this work differs

Previous reports indicate variability among bentgrass cultivars in their susceptibility to dollar spot. Two greenhouse inoculation experiments performed in our lab detected large genetic variation at the species, cultivar and clone level.

Eighty-one clones of 10 cultivars of the creeping, colonial, highland and velvet bentgrass species were inoculated with the dollar-spot isolate MN1.

Two creeping bentgrass clones with significant difference in disease response were identified from more than 300 clones collected from fairways and greens in golf courses throughout Wisconsin.

The clone 372 is highly resistant while 549 is susceptible to dollar spot. It has been well known that the colonial bentgrass species is naturally more resistant to dollar spot than creeping bentgrass. Our previous results indicated that the level of resistance detected in the 372 clone was approximately the same as that of cultivars of the colonial species.

When a differential response was noted between the clones using only one isolate, we were interested to determine the disease response of these clones using multiple isolates belonging to different Vegetative Compatibility Groups (VCGs). Sixteen new fungal isolates were provided to us by Jon Powell from the University of Minnesota.

We studied the genetic relatedness of the isolates to find if there is a correlation between the genetic distance and the VCGs. We found that some of the isolates belonging to the same VCGs are genetically similar but others are genetically distant from one another even though belonging to same VCGs.

The next step was to find the correlation between VCGs and virulence. We used eight isolates belonging to five VCGs to inoculate the two creeping bentgrass clones. There was an overall clone and isolate effect. Some of the isolates did not show significant difference in disease response between the two clones but two isolates, MN1-VCG A and Les Bolstead-VCG J, showed a significant clone effect.

The clone 372 was more resistant than the clone 549 for all the eight isolates. There was no race-specific interaction noted. We will further study the race-specific interaction and virulence by including 16 more isolates belonging to 11 VCGs.

Since we noticed a significant difference in disease response between the two creeping bentgrass isolates 372 and 549, that fact suggested that a mapping population created from the cross will segregate for dollar-spot resistance.

So a mapping population was created by crossing clone 372 by 549 in 2002. We will use the resulting progeny segregating for dollar spot resistance to analyze locations, numbers, and effect of dollar spot resistance genes using molecular markers and Quantitative Trait Locus (QTL) analysis. Currently more than 200 barley, oat and rice Restriction Fragment Length Polymorphism (RFLP) anchor probes are being screened using the two parental DNA, in order to use these probes as molecular markers (Lespinasse et al., 2000; VanDeynze et al., 1998; Wang et al., 2000).

Molecular markers for resistance to dollar spot are currently unavailable.

The probes tested so far hybridized with and detected abundant polymorphisms in both bentgrass DNA. Moreover RAPD (Random Amplified Polymorphic DNA) primers are currently being tested to collect molecular markers about the polymorphic nature of 94 progenies and the two parental clones.

We are going to score the bands that are polymorphic between the two parents and segregate among progenies. The polymorphism, as indicated by arrows, is created due to recombination and segregation during the event of crossing.

The polymorphic data will be used to create a linkage map with the help of a statistical program. The linkage map is a hypothetical map of the chromosomes, which shows the position of the markers, depending on their percentage of crossovers.

Thus all the necessary tools and expertise are already in place to successfully create the linkage map in bentgrass. This linkage map can be used to create durably resistant cultivars using multiple-resistance gene markers obtained through QTL analysis.

No other groups have yet studied race-specific interactions in clones, cultivars and species using multiple isolates of the dollar spot pathogen.

If any race-specific interactions are noted, results from the experiment using multiple isolates from 11 VCGs can be used to analyze whether the QTLs for disease resistance are similar or different for different isolates.

Potential benefit of this work

The proposed research program incorporates molecular and genetic methods, plant pathology, plant breeding and quantitative genetics. Every year, public health concerns due to synthetic chemicals applied on golf courses and other grassy areas are significantly increasing worldwide.

Late spring dollar-spot severity can be minimized by the application of late-spring nitrogen fertilizer.

Dollar spot resistance in bentgrass would considerably decrease the need for fungicide applications on bentgrass. In many cases, molecular markers are available for marker-assisted selection of novel genes. However, markers for resistance to dollar spot are currently unavailable. By pairing markers with novel resistance genes, producers and private industry will be able to access the germplasm diversity held within the public sector in improved forms well into the 21st century. This marker-assisted selection can result in higher gain from selection than phenotypic selection, thus expediting the disease resistance breeding progress.

The linkage map will also be useful to other researchers on this topic in the future, as our map will be the reference map, and they will be able to compare dollar spot resistance QTLs with our QTLs.

Help for breeders, superintendents

These research results will help turfgrass breeders to speed the selection process by using molecular markers, with the ultimate goal of developing disease-resistant breeding lines and cultivars.

Ultimately, superintendents, private seed companies and anyone using bentgrass will receive nearly immediate benefit from the development of disease-resistant cultivars. In the end, the amount of fungicides used for the control of dollar spot will be dramatically reduced.

Chakraborty is currently a Ph.D. student in the department of plant pathology at the University of Wisconsin-Madison. Jung is assistant professor/turfgrass pathologist at the school.

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