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IN THIS ISSUE

Maximizing Disease Control with Fungicide Applications:

The Basics of Turfgrass Fungicides

Part Three: Plant and Pathogen Factors Affecting Fungicide Efficacy

by Eric B. Nelson
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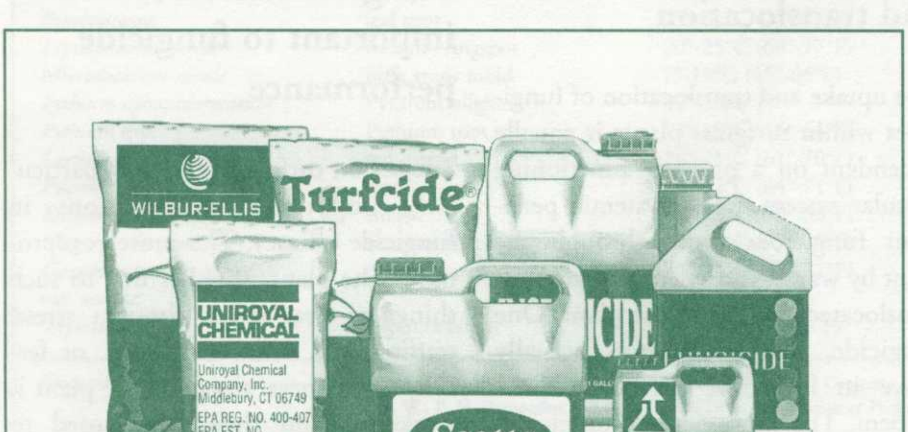
An important consideration when estimating the overall efficacy of fungicide applications is the growth of the turfgrass plants. Vigorously-growing plants not only have a greater natural defense mechanism to pathogen attack, but they also take up penetrant fungicides more readily. Both situations make disease control more effective at lower rates or with fewer applications.

Vigorously-growing turfgrass plants are not to be confused with excessive turfgrass growth. Vigorously-growing plants are those in a balanced state of growth where top growth is such that the root system can supply adequate levels of water and nutrients, maintaining the plant in a metabolic balance.



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Excessively-growing plants are those that are producing more top growth than the root system can adequately handle, creating a metabolic imbalance wherein the turfgrass foliage remains more succulent and susceptible to foliar diseases such as leaf spots and leaf blights. This is particularly the case if the turfgrass foliage remains wet for prolonged periods of time. So, although vigorous growth is desirable, excessive growth should be avoided.

In healthy turfgrass plants, water and minerals move from the soil into the roots where they are translocated to the turfgrass foliage; whereas, the carbon-containing products of photosynthesis are either used for foliar growth and development, or transported to the root system to support root growth and development. These processes of translocation require a vascular system, made up of the xylem (upward translocating elements) and phloem (downward translocating elements), that is properly functioning.

Turfgrass growth and vigor affect fungicide absorption and translocation

The uptake and translocation of fungicides within turfgrass plants is equally dependent on a properly functioning vascular system. Most systemic penetrant fungicides move through the plant by way of the xylem and are thus translocated upward in the plant. One fungicide, fosetyl Al, may actually move in both the xylem and the phloem. The movement of fungicides in plants is further facilitated by transpiration, or the evaporative loss of water through the leaf stomata. This usually increases the upward movement of fungicides in the xylem.

Generally, the more vigorous the growth of the turfgrass plant, the more movement of water and photosynthate through the vascular system and the higher the rate of transpiration; likewise, in a vigorously-growing plant, the greater the uptake and translocation of penetrant fungicides. For maximum efficiency, therefore, systemic penetrant fungicides should never be applied to dormant turf.

Questionable results will be obtained when applying systemic penetrant fungicides to severely diseased turf, particularly if affected by root pathogens. Many root- and crown-infecting fungi may cause extensive damage to root systems long before symptoms appear on the above ground parts of the plant. A dysfunctional root system is unable to properly absorb and translocate penetrant fungicides. Therefore, in cases of severe disease development, contact fungicides would be preferred over systemic penetrant fungicides.

Turfgrass stresses important to fungicide performance

Stresses on turfgrass plants are particularly important considerations in fungicide efficacy. The more compromised the plant, whether due to such things as heat stress, drought stress, traffic stress, soil compaction, or fertility imbalances, the more the plant is weakened and thus predisposed to infection by pathogens that would otherwise not typically be a problem. Similarly, plant infection and disease development may be enhanced in stressed turf allowing pathogens to develop much faster and symptoms to progress much more quickly than would otherwise be the case. Usually, the greater the level of stress, the greater the fungicide application rate and frequency needed to achieve adequate levels of disease control.

Pathogen factors affect fungicide efficacy

Aside from the consideration of the overall health and vigor of the turfgrass plant, there are a number of pathogen attributes, including the life stage, inoculum properties, plant tissues affected, and inherent fungicide sensitivities, that can influence the performance of fungicides.

➻ *Life stage* - Of particular importance to fungicide performance is the life stage of the pathogen. Turfgrass pathogens follow a cyclic chain of events during the development of a turfgrass disease. These events include the developmental stages of the pathogen as well as a progression of plant responses. All infectious disease-causing agents go through such a disease cycle.

The overseasoning stage of most fungal turfgrass pathogens occurs in the winter months. During this time, the pathogen persists in either soil, thatch, or in root and crown tissues as a quiescent spore or other form of inoculum. Snow mold pathogens are the exception to this rule as they overseason during the summer months. When temperature and moisture conditions again become favorable, inoculum can be transported to adjacent healthy turfgrass plants by wind, rain, moving water, equipment, etc.

Table 1. Temperature and moisture conditions favoring the activity of turfgrass pathogens.

Pathogen	Disease	Optimum Temperature for Pathogen Activity	Required Moisture Period for Spore Germination
Colletotrichum graminicola	anthracnose	22°-28°C (71°-82°F)	4-6 *hr.*
Rhizoctonia solani	brown patch	23°-32°C (73°-90°F)	5-7 hr.
Rhizoctonia zeae	brown patch	33°C (91°F)	4-8 hr.
Sclerotinia homoeocarpa	dollar spot	16°-27°C (61°-81°F)	8-24 hr.
Magnaporthe grisea	gray leaf spot	24°-28°C (75°-82°F)	16-24 hr.
Dreschlera spp.	leaf spot	12°-16°C (54°-61°F)	12-24 hr.
Bipolaris spp.	leaf spot	25°-35°C (77°-95°F)	8-48 hr.
Leptosphaeria korrae	necrotic ringspot	20°-25°C (68°-77°F)	48-72 hr
Microdochium nivale	pink snow mold	7°-19°C (45°-66°F)	48-72 hr.
Pythium aphanidermatum	Pythium blight	30°C (86°F)	14 hr.
Pythium spp.	Pythium root rot	13°-18°C (55°-64°F)	48-72 hr.
Laetisaria fuciformis	red thread	16°-21°C (61°-70°F)	4-24 hr.
Puccinia, Uromyces	rusts	18°-22°C (64°-71°F)	3 hr.
Entyloma, Urocystis, Ustilago	smuts	10°-18°C (50°-64°F)	24 hr.
Magneporthe poae	summer patch	25°-30°C (77°-86°F)	48-72 hr.
Gaeumannomyces graminis var. *avenae*	take-all patch	20°-25°C (68°-77°F)	48-72 hr.
Typhula spp.	Typhula blight	5°-10°C (41°-50°F)	Days to weeks

Compiled from:
Couch, H. B. 1995. *Diseases of Turfgrasses*, 3rd Ed. Krieger Publishing Company. Malabar, FL. 421 pp.
Smiley, R. W., P. H. Dernoeden, and B. B. Clarke. 1992. *Compendium of Turfgrass Diseases*, 2nd Ed. APS Press. St. Paul. 98 pp.
Smith, J. D., N. Jackson, and A. R. Woolhouse. 1989. *Fungal Diseases of Amenity Turfgrasses*, 3rd Ed. E. & F.N. Spon. London. 401 pp.

Once at the surface of the healthy plant, the spore can then germinate and penetrate the plant tissues. In penetrating tissues, a nutritional relationship is eventually established between the pathogen and the plant. It is at this stage that the plant is considered to be infected. As the pathogen continues to grow between and within cells of the host plant, it can rapidly invade adjacent tissues and organs. It is during this invasive stage that plant symptoms become apparent. Eventually, a new batch of spores are produced on and within infected plant tissues. Once again, these spores can be transported to adjacent healthy plants where they either initiate secondary disease cycles or overseason in a quiescent state.

The dormant overseasoning period of turfgrass pathogens is a particularly important aspect of pathogen biology and is important to the efficacy of fungicide applications. Typically, this dormant phase allows the fungus to survive adverse environmental conditions, usually during the winter months. Also, many other pathogens may have dormant periods throughout the growing season in response to drastic soil environmental changes and certain pesticide applications. During this dormant stage, the pathogen is generally resistant to most fungicides, particularly those with only fungistatic activity (i.e., many of the penetrant fungicides). Only a few contact fungicides will actually destroy dormant pathogen propagules.

The importance, for fungicide applications, of understanding the cyclic nature of diseases becomes apparent when one considers that each stage in the disease cycle is required for the next stage. Most fungicide applications are aimed at preventing spore germination, penetration, and invasion of the fungal pathogen on and in turfgrass plants. For the most part, fungal pathogens prefer continuously moist conditions with temperatures ideal for spore germination, growth, and plant infection (Table 1). Therefore, it can be assumed that, with the exception of those pathogens that prefer exceptionally warm (some *Pythium* and *Rhizoctonia* species) or exceptionally cool (*Typhula* and *Microdochium* species as well as some *Pythium* species) conditions, fungicide applications will have the highest level of efficacy when applied during relatively cool to moderately warm conditions since the majority of pathogens would be in an active state of growth and most sensitive to the applied fungicide. The efficacy of applications at other times will likely be less than optimal.

➻ *Inoculum properties* - The germination of spores is a particularly sensitive stage in the life cycles of fungal turfgrass pathogens. Nearly all of the fungicides used in turfgrass management are capable of inhibiting spore germination, as well as spore production and other active stages of the life cycle. Some fungicides, however, are more limited in action and only inhibit spore germination, but not spore production (e.g. iprodione); as a result, under certain environmental conditions, these fungicides may not be as effective as other fungicides against some pathogens.

The density of inoculum (i.e. the population level of the pathogen) and the nutrition of the pathogen will greatly affect the efficacy of fungicide applications. The higher the pathogen population, the higher the rates of fungicides needed to achieve effective control and, possibly, the more frequently applications need to be made.

Additionally, the greater the nutrition and vigor of the pathogen, the less sensitive the fungus will be to fungicide applications. During active disease development, usually both the nutrition and the population level of the pathogen are elevated, making disease control more problematic. This is the reason that most turfgrass fungicide labels contain both low and high label rates. If applied before the disease has a chance to develop to any significant degree, the lower rates are generally suitable for effective disease control. If, however, the disease has been allowed to progress, greater amounts of fungicide are required for the same level of disease control. This issue in particular emphasizes the need for timely and accurate disease diagnoses.

➻ *Plant tissues affected* - The plant tissues most commonly infected by the target pathogen will influence not only the choice of fungicide, but also the effectiveness of a given fungicide. Whereas fungicide applications for the control of foliar diseases are relatively straightforward, the control of root diseases is often more difficult. The control of perennial infections in root tissues presents special logistic problems that generally require the use of penetrant fungicides; once pathogens infect root tissues, they are inaccessible to contact fungicides. Furthermore, unless penetrant fungicides are absorbed by roots or translocated to root tissues, diseases from root-infecting pathogens will not be effectively controlled. In most instances, proper fungicide selection can overcome some of the difficulties with root diseases.

Pathogen sensitivities to fungicides vary

It is also important to note that fungal pathogens vary widely in their inherent sensitivity to fungicides. While it is clear that pathogens causing different diseases vary in their sensitivity to specific fungicides, different strains of a single pathogen may also vary in their sensitivity to the same fungicide. I have observed, on several occasions, specific fungicides that, while effective on certain parts of golf courses, fail miserably when applied to other parts of the same course. This also raises some important considerations when interpreting University fungicide trials; this topic will be covered in a later part of this series on fungicides. Those fungicides that are most efficacious in a fungicide trial may not necessarily be the most effective on your particular site. While results of research trials with various fungicides may reveal some general trends in fungicide efficacy and the variability of pathogen sensitivities, applicator experience is often the best estimation of the variability of turfgrass pathogens and the efficacy of fungicides in specific turfgrass sites.

Fungicide resistance

One of the more important and emerging problems with the widespread use of fungicides with a narrow mode of action is the problem of fungicide resistance. Fungicide resistance becomes particularly serious when prolonged and continued applications of fungicides with the same mode of action are made to the same turfgrass site (Fig. 1). The reasons for the development of such resistance are related largely to the toxic properties of the fungicides and to the biology of turfgrass pathogens.

For the most part, many of the fungicides used for turfgrass disease control, especially the penetrant fungicides, do not actually kill pathogen populations. Rather, they stop the mycelial growth and spore germination of the fungus, often forcing the fungus into a dormant state. This generally results in the production of more fungal spores which serves to increase the population level in soil. This has been observed occasionally with soil populations of *Pythium* species following the application of *Pythium*-selective fungicides. As mentioned previously, in this dormant state, the fungus can remain alive, but is no longer sensitive to the applied fungicide; therefore, disease resulting from the germination of previously-dormant spores may make it appear as if the pathogen was resistant to the fungicide when, in fact, it was not sensitive only because of its dormancy.

Even though fungicide applications may be effective in stopping the immediate development of the disease, they tend to maintain soil populations of turfgrass pathogens, thus insuring that the same disease will appear time after time if environmental conditions are appropriate. By remaining alive in the presence of a fungicide, more insidious biological processes can take place. Because of the genetic diversity within most fungal pathogen populations, a small proportion of the population of any turfgrass pathogen will be insensitive to a given fungicide. If the fungicide to which that small proportion is resistant is applied continually to the same site or applied at less than optimum rates, this provides a means of selection for that resistant portion of the pathogen population. Therefore, as the fungicide continues to suppress the sensitive population, the resistant population slowly dominates, becoming even more resistant and eventually making the fungicide totally ineffective for that disease on that particular site.

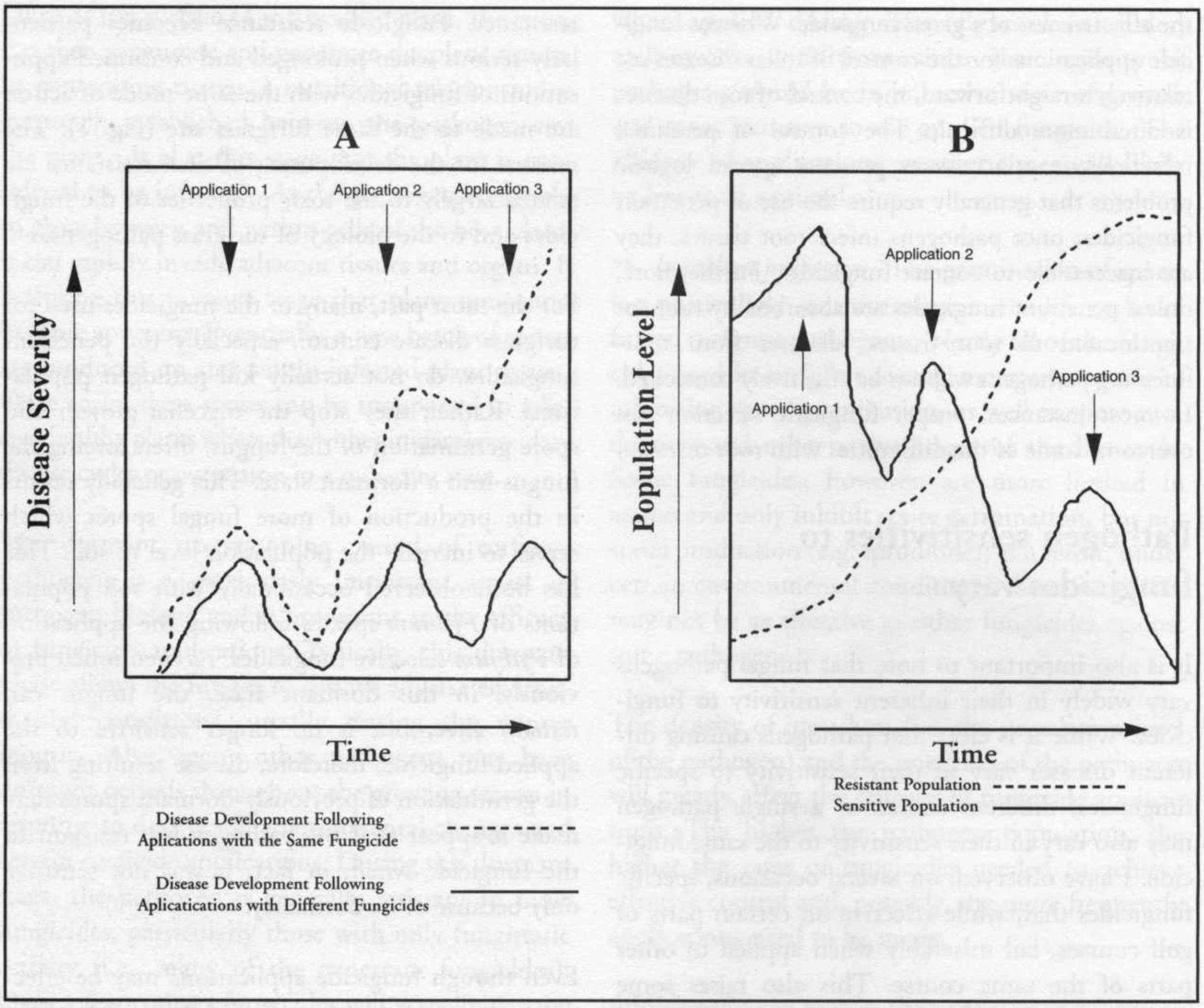

Figure 1. Hypothetical scenarios illustrating the possible effects of continuous and rotated applications of fungicides on disease severity and the development of fungicide-resistant pathogen populations. A) Effects on disease severity, B) Effects of continuous applications of the same fungicide on the sensitive and resistant proportions of the pathogen population.

Take steps now to minimize the potential for developing fungicide resistance

Whenever possible, the frequent and continued use of the same fungicide or combinations of fungicides with the same modes of action should be avoided. For the specific modes of action of all commonly used turfgrass fungicides, refer to Part 1 of this series (*Turfgrass TRENDS*, February 1996). Similarly, rates less than those specified on the label should also be avoided since reduced rates allow an even greater proportion of the potentially resistant population to survive and proliferate. The following steps should be considered in any attempt to reduce the risk of fungicide resistance problems:

1. As the first line of defense against any disease problem, incorporate disease-resistant or disease-tolerant turfgrass cultivars or varietal mixtures into the turfgrass site whenever practical.

2. Attempt to minimize the problem by employing cultural or biological methods of

disease control. No known resistance has occurred in response to a cultural or biological disease control strategy.

3. If you must use fungicides, make sure that the same fungicide is used for no more than two successive applications before rotating to a different fungicide with a different mode of action.

4. Avoid applications at less-than-label rates. To assist in this, make sure that the proper amounts of fungicide are placed in the spray tank and mixed with the appropriate amounts of water. Care should also be taken to assure that your equipment is properly calibrated and delivering the correct levels of fungicide to the turf.

5. Make sure that you are getting complete spray coverage, avoiding skips and overlaps.

6. Finally, avoid preventive applications whenever possible. There is no point in introducing a fungicide into the environment if it is not warranted. This simply provides more selection pressure for a potentially-resistant pathogen population. The only exception to this would be the necessary preventive application of fungicides for summer patch control. If you suspect a summer patch problem, be sure to have it properly diagnosed before making any preventive fungicide applications the following season.

Management recommendations

The best advice here is to constantly monitor your sensitive turfgrass sites, and get early diagnoses on potential disease problems. Early detection and diagnosis will allow you to apply the proper fungicide at the earliest stages of disease development when plants are still functioning relatively well and the pathogens are clearly active yet only beginning to build up populations. Following these principles will increase the likelihood of getting adequate fungicide uptake and distribution inside the plant, and of catching the pathogen at its most sensitive stage. This should also reduce the amount and frequency of the fungicide applied, making for more economical applications and more effective disease control. Finally, always be aware of the potential of fungicide resistance and take the proper precautions to avoid it.

In the June issue, I will discuss a number of points related to the handling, applying, and monitoring of fungicide applications.

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Terms to Know

Inoculum - The pathogen or parts of the pathogen that can cause infection. Inoculum consists of spores, mycelium, sclerotia, etc.

Phloem - Food conducting tissue in a plant that moves sugar from the leaves down to the root system.

Photosynthate -The product of photosynthesis: carbohydrates.

Stomata - Pores in the surface of the foliar parts of plants that allow for gas and water exchange. Stoma = (singular)

Translocation - The transfer and movement of materials, including fungicides, through a plant.

Transpiration - The loss of water from the surface of leaves.

Vascular System - The water and nutrient-conducting tissues of a plant (e.g. Xylem and Phloem).

Xylem - Nutrient- and water-conducting tissue in a plant that moves water and nutrients from the root system up to the above-ground portions of the plant.

Herbicide Effects on Bermudagrass Turf

by Fred Fishel
University of Missouri

Commercial sod producers and their customers desire high quality sod. An important sod quality is the absence of weeds, as weedy sod is generally considered poor in quality. Preemergence herbicides applied in the early spring are the primary means of controlling summer annuals, such as the crabgrasses. Preemergence herbicides, however, have caused adverse effects to some turfgrass species and cultivars (3,4,10).

Potential adverse effects

Dinitroaniline herbicides, such as oryzalin and pendimethalin, have been used extensively in turfgrass weed control. As far as their effects on root growth are concerned, varying results have been reported. One study showed that neither numbers nor tensile strength of roots was adversely affected (9). A second study associated pendimethalin with lower tensile strength and reduced root growth (2). Other dinitroaniline herbicides, including benefin and prodiamine, produced similar results in a third study; and in a fourth study, so did pendimethalin in some cases, but not in others (5,6).

Another concern with these preemergence herbicides is their potential to cause injury in zones of the soil profile where root initiation occurs. Under some conditions, such as high moisture and low soil organic matter content, dinitroaniline herbicides have been detected in areas of the soil profile where rhizomatous turfgrasses would be initiating roots (1). This is of concern since those herbicides can affect root and rhizome development (7). Certain warm season turfgrasses, such as the bermudagrasses, rely on root initiation from stolons as well as rhizomes. Under conditions which would not be favorable for downward movement of herbicides, their presence further up in the soil profile may still inhibit root initiation from stolons.

Rapid rooting is necessary for establishment of healthy sod or sprigs. Detrimental effects from preemergence herbicides may also add stress to established turfgrasses and cause delays in resumption of early spring growth. Ideally, adverse effects from herbicides should be minimal during these important periods of growth.

Measurement of root injury

Let's take a look at some research on a common bermudagrass sod that was conducted over a two year period about five years ago in Mississippi. Turf managers in that region typically try to have their preemergence herbicides applied by the middle of March. This is also the time that warm season turf is resuming active growth. Anything that might adversely affect this growth is obviously to be avoided.

The objective of this research was to determine if commonly-used preemergence herbicides would cause root injury to commonly-grown bermudagrass in this environment. In this particular set of experiments, herbicides were applied to the sod in early March. At three different times following herbicide application (two, four, and eight weeks), plugs of sod were removed from the field plots and replanted in a greenhouse in cups containing sand. After allowing growth in the greenhouse for a further six week period, the sod plugs were removed from the cups, the sand was washed from the roots, and observations were taken.

The first of these observations was the total number of roots which had grown down into the sand. The second was the number of roots which appeared to be malformed, and for purposes of comparison the number of roots which appeared to be normal. Roots malformed by dintitroaniline herbicides typically appear shortened or stubby, with swollen tips. Many call such symptoms "clubbed roots" or "baseball bats." After all the counting was done, the roots were clipped from under the soil line of the plugs and weighed.

Looking first at total number of roots (Table 1), we can draw several conclusions. The most significant

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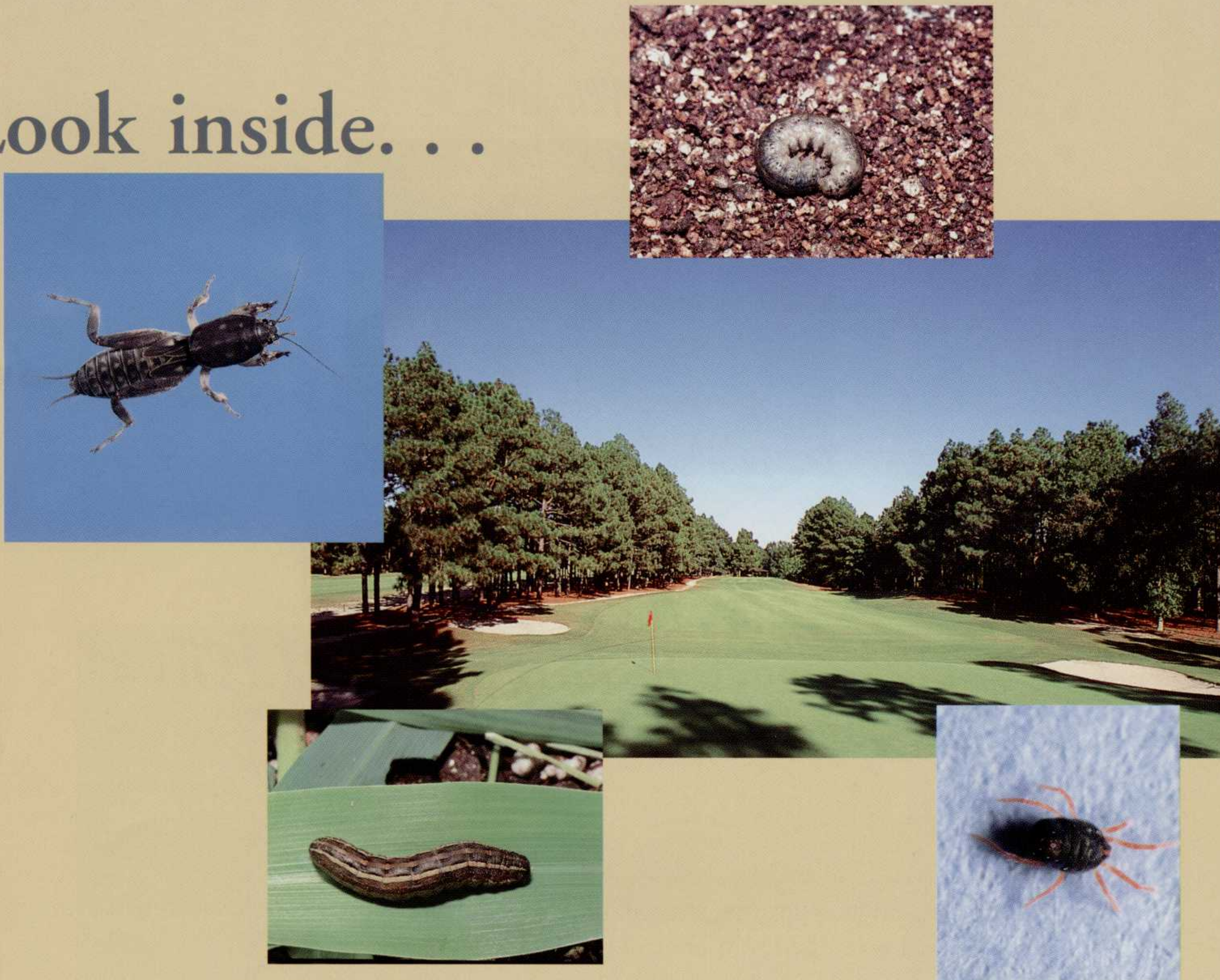

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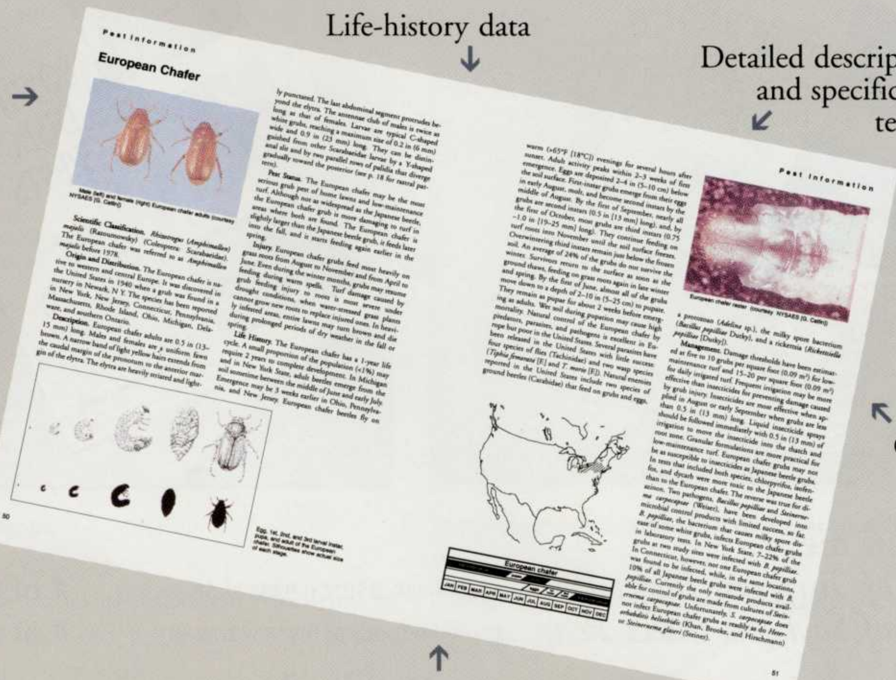

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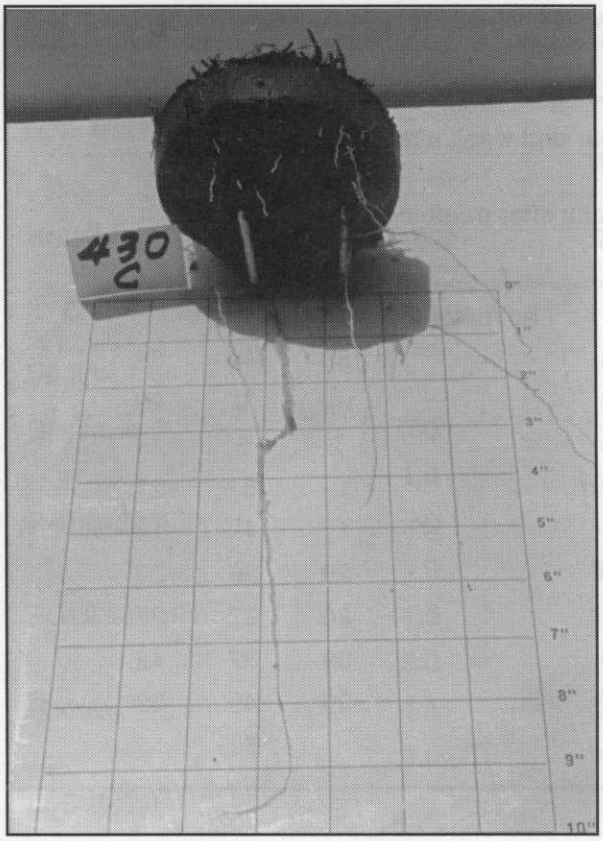
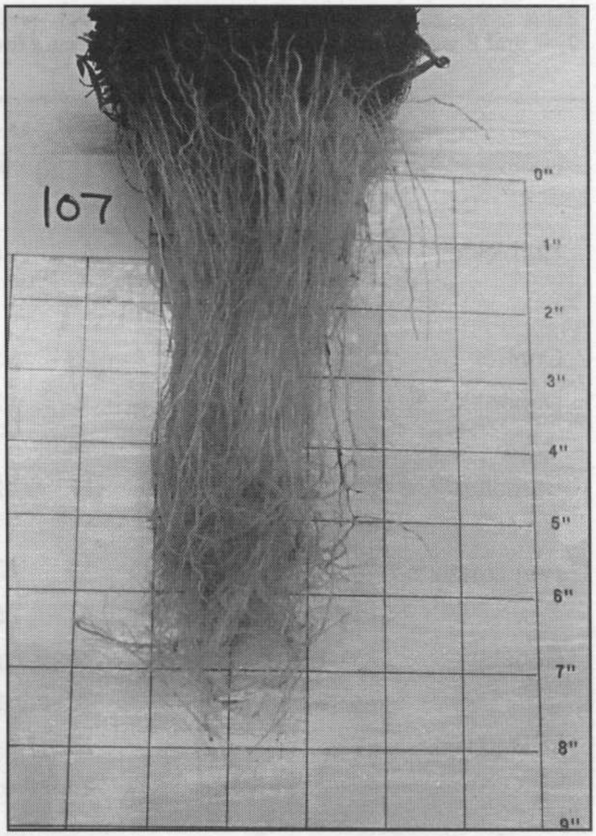


Untreated bermudagrass



Bermudagrass treated with a dinitroanaline herbicide

reduction in the number of total roots occurred in plots which had received applications of prodiamine (Barricade®) or dithiopyr (Dimension®). These reductions did not occur early (two weeks after treatment), but only at four and eight weeks. As indicated earlier, pendimethalin has been associated with reduced root numbers in other research trials, but no consistent pattern developed over the years (9).

The underlying story becomes apparent, however, when the number of normally-growing and then abnormally-growing roots are compared (Tables 2 and 3).

Compared with grasses grown in untreated plots, Dimension® and Barricade® use led to the greatest reductions in the number of normal roots in both trial years. Another way of looking at this is by comparing the numbers of abnormal roots observed in these plots. Barricade® and Dimension® use led to more shortened and swollen roots. In some cases, these effects were observed as long as eight weeks after the plots were treated.

Pendimethalin could be thought of as "intermediate" in its effects. This herbicide caused some

Table 1. Number of roots from plugs of common Bermudagrass sod taken from field plots 2, 4, and 8 weeks after treatment and grown on sand for 6 weeks in the greenhouse.

		Weeks after treatment		
Herbicide	Rate	2	4	8
	lb ai/A		no./pot	
Control	. . .	37	38	37
Dimension®	.50	34	28	29
	1.0	32	30	25
Barricade®	.50	45	36	33
	1.0	41	40	28
Pendimethalin	1.5	36	33	34
	3.0	38	31	34
Ronstar®	1.5	37	32	41
	3.0	37	36	40
LSD (0.05)			8	

Table 2. Number of normal roots growing from plugs of common bermudagrass sod taken from field plots 2, 4, and 8 weeks after treatment and grown on sand for 6 weeks in the greenhouse.

		Year and week after treatment					
		1989			1990		
		Week after treatment					
Herbicide	Rate	2	4	8	2	4	8
	lb ai/A			no./pot			
Control	. . .	33	23	36	38	44	38
Dimension ®	.50	1	4	23	4	9	23
	1.0	4	3	14	2	5	14
Barricade®	.5	12	11	29	1	6	21
	1.0	2	6	18	1	4	14
Pendimethalin	1.5	25	20	34	29	36	32
	3.0	9	7	31	20	27	35
Ronstar®	1.5	33	20	40	39	37	42
	3.0	34	22	39	36	46	39
LSD (0.05)			10			7	

Table 3. Number of abnormal roots growing from plugs of common bermudagrass sod taken from field plots 2, 4, and 8 weeks after treatment and grown on sand for 6 weeks in the greenhouse.

		Year and week after treatment					
		1989			1990		
		Week after treatment					
Herbicide	Rate	2	4	8	2	4	8
	lb ai/A			no./pot			
Control	. . .	0	0	0	0	0	0
Dimension®	.50	32	21	7	31	22	4
	1.0	30	24	10	27	27	13
Barricade®	.50	28	19	1	50	37	14
	1.0	36	28	5	43	41	20
Pendimethalin	1.5	9	8	1	8	1	0
	3.0	27	20	1	20	6	1
Ronstar®	1.5	2	7	0	0	0	0
	3.0	3	4	1	0	0	0
LSD (0.05)			9			7	

Table 4. Root fresh weight from plugs of common bermudagrass sod taken from field plots 2, 4, and 8 weeks after treatment and grown on sand for 6 weeks in the greenhouse.

		1989		
		Week after treatment		
Herbicide	Rate	2	4	8
	lb ai/A		mg/pot	
Control	. . .	1470	1250	1080
Dimension®	.50	260	610	930
	1.0	110	510	680
Barricade®	.50	970	1280	1190
	1.0	450	830	880
Pendimethalin	1.5	1370	1390	1210
	3.0	790	710	1130
Ronstar®	1.5	1330	1210	1210
	3.0	1150	870	1290
LSD (0.05)			530	

		1990		
		Week after treatment		
Herbicide	Rate	2	4	8
	lb ai/A		mg/pot	
Control	. . .	2390	4690	4120
Dimension®	.50	900	1910	4410
	1.0	510	2170	3550
Barricade®	.50	790	2110	3720
	1.0	300	1460	2690
Pendimethalin	1.5	2230	4110	4500
	3.0	1870	4150	4680
Ronstar®	1.5	2470	4050	5220
	3.0	2290	4630	4640
LSD (0.05)			990	

Table 5. Rainfall amounts by weekly intervals.

Week interval	Rainfall (inches)	
	Year 1	Year 2
0-2	2.1	2.6
2-4	2.0	9.4
4-8	4.8	12.4

reductions in normal root production, and some malformed roots. Its effects did not appear to be as long-lived as those of Barricade® and Dimension®, however.

Based solely on these experiments, oxadiazon (Ronstar®) could be considered the safest material for use on common bermudagrass. Compared with untreated plots, there were no observable reductions in number of normal roots. Also, compared once again with untreated plots, Ronstar® did not damage roots significantly. The only damage noted occurred in 1989.

The more shortened and swollen roots, coupled with fewer normal roots, produced reductions in root fresh weight in these same plots (Table 4).

Compared to untreated plots, Dimension® caused root weight decreases through week four in both years. Barricade® was not as consistently damaging as Dimension®. It did cause some reductions, however. It appeared to be more severe in 1990, as root weight was lower at both four and eight weeks after treatment. In 1989, Barricade® caused problems only at two weeks following application. As with the numbers of roots, pendimethalin could also be considered intermediate in its effects on root weight. It did not behave consistently in both years, as reductions were noted only in 1989. Ronstar® did not cause any negative effects with root weight and of the materials evaluated, based on these results, it would be considered the safest for common bermudagrass.

Injury to rhizomes

The location of the herbicide within the soil profile is also an important factor in the amount of injury that may occur. Turfgrasses that initiate growth from rhizomes, such as bermudagrass, can be injured by preemergence herbicides. Several factors affect the potential for injury, including soil type, moisture conditions and the chemical properties of the herbicide.

Experiments were conducted to determine if several commonly used preemergence herbicides could inhibit common bermudagrass root growth initiated from rhizomes. The study was conducted on two different soil types: a very fine sandy loam and a sandy clay loam. Following herbicide application, soil samples were removed from the 0 in. to 1 in., 1 in. to 2 in., and 2 in. to 3 in. layers of the soil profile. These samples were taken at two, four, and eight weeks after the March herbicide application. To determine if residues were present in these soil layers, each sample was placed in a cup, and a plug of 'Tifgreen' bermudagrass was placed directly on the soil sample. The bermudagrass was grown in this cup in the greenhouse for an additional three weeks, then root weight was determined for each plug.

The results of these experiments suggest that some preemergence herbicides can cause damage to roots initiated from rhizomes. The potential for such damage may be greater in lighter-textured soils and under greater amounts of rainfall.

For example, Barricade® is not considered highly water soluble; special conditions may facilitate this herbicide's causing rhizome damage, however. We normally associate highly water soluble herbicides with significant downward movement through the soil profile.* Root damage in the 2 in. to 3 in zone of the coarse-textured soil was observed from plots which were treated with Barricade®. No equally significant injury occurred at this same depth in the finer-textured soil, however.

* See the article on pesticide fate by Prof. Richard J. Hull in September 1995 *TurfGrass TRENDS*.

Water also influences herbicide injury. With Barricade®, for example, injury in the coarse-textured soil was not seen in those 2 in. to 3 in. zones until eight weeks after treatment the first year of the study. In contrast, in the second year of the study, injury from Barricade® occurred more rapidly (at two and four weeks following application) in this same soil type. Rainfall patterns at this site are displayed in Table 5, and are the most likely reason we see such differences in the two years' data.

There was no significant evidence of Dimension® being present or causing injury in these areas of the soil profile. It was detected in only the top inch of the soil profile in both soil types, suggesting little potential for downward movement and subsequent root damage.

Oryzalin (Surflan®), on the other hand, was found in concentrations high enough to cause root injury in the 2 in. to 3 in. layer of the coarse-textured soil during the second year of the study. This would again indicate the importance of rainfall in herbicide movement downward. Additionally, the coarser soil type would be more conducive for this herbicide's movement than a finer textured soil. Surflan® is also relatively more water soluble than Dimension®; thus, we may expect some potential for its downward movement.

Pendimethalin was also evaluated for downward movement in these experiments. There was no indication that it was present in the 2 in. to 3 in. soil profile zone in concentrations great enough to cause rooting problems. Pendimethalin tended to cause more damage in the top inch of the soil during the first year of the study, when there was less rainfall. During the second year, pendimethalin did not appear to be present in this top inch of the coarse-textured soil in damaging levels by eight weeks after treatment. This was most likely due to herbicide degradation from the wet conditions experienced during this period. Pendimethalin has been reported to degrade more rapidly under wet conditions (8).

Several conclusions can be drawn from the results obtained in this study. In turfgrasses with a rhizomatous growth habit, such as bermudagrass, root growth can be affected by relatively low concentrations of some herbicides. Soil type and moisture are important moderators of the effects caused by these herbicides, however.

From a sod producer's view, these data would have practical implications concerning harvesting. Where herbicides that tend to affect rooting have been applied, the time interval between their application and sod harvest should be as long as possible. In contrast, high quality sod, which will root quickly, can be harvested without significant delay after treatment with herbicides that cause little or no root damage.

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Ask the Expert: Questions regarding pre-emergence herbicides and their effects on bermudagrass

by Fred Fishel
Coordinator of Pesticide Programs
University of Missouri

Question 1. *Following application of several of the commonly-used preemergence herbicides, I have noticed that the roots appear to be shortened and swollen. Why does this occur?*

Answer: Many of the preemergence herbicides on the market today are inhibitors of mitosis. This is an important process in cell division which is required for plant growth. When this process is disrupted, the results are visibly evident by exactly what you see with the roots. Additionally, you may notice a lack of secondary or lateral root formation. Some of the active ingredients that you may have used which cause this effect include benefin, dithiopyr, oryzalin, pendimethalin, prodiamine, and trifluralin.

Question 2. *How long will we continue to see the effects from these herbicides on the root growth?*

Answer. There are many factors involved which may affect the herbicide's activity including rate, soil moisture, temperature, soil texture and others. In our experiments, there were still significant numbers of abnormal-appearing common bermudagrass roots by 2 months following herbicide application. Our last sample date was 6 months after treatment and abnormal-appearing common bermudagrass roots were virtually non-existent by that time.

Question 3. *Since some turfgrasses initiate new growth from rhizomes, would these herbicides be likely to move throughout the soil profile where roots would initiate growth off of the rhizomes?*

Answer. Some of the factors which would affect the mobility of any given herbicide include soil moisture, soil texture, and water solubility of the herbicide. Our experiments suggest there is a potential for herbicide movement into rhizome-containing areas of the soil profile, particularly with high rainfall and coarse soil textures.

Question 4. *How well does common bermudagrass compensate for growth following application of preemergence herbicides?*

Answer. Research has shown bermudagrass to recover quite nicely after preemergence herbicide treatment. For example, in some of our work, pendimethalin, in some cases, decreased the total number of new roots initiated. On the other hand, the actual biomass or root weight taken from the same plot was not any less than plots which did not receive a herbicide application. This shows that bermudagrass is capable of producing an adequate root biomass from fewer numbers of total roots.

Question 5. *Are there above-ground symptoms from these herbicides such as delayed greenup of warm season turfgrasses in the early spring?*

Answer. There can be a very slight delay of spring greenup where standard use rates of preemergence herbicides are used on warm season turfgrasses.

Letter from the Publisher

Dear Readers:

As you know, *TurfGrass TRENDS* is now considered <u>the</u> practical research digest for turf managers. We have been presenting you up-to-date research information review articles from major universities. And we have referenced additional reading material. There is more out there, about which you might not know, however.

With this issue, we are introducing to you the *Handbook of Turfgrass Insect Pests,* published by the Entomological Society of America. You know the editors: Dr. Michael Villani of Cornell University, and Dr. Rick Brandenburg of North Carolina State University. Both have written for you in *TurfGrass TRENDS.*

Dr. Villani, presently active in both research and extension work, concentrates on the interrelationships between soil insects, their host plants, and the soil environment. He summarized his research reports on this work for you in September of last year. In June, he informed you about "What's New in Turfgrass Insect Pest Management Products? Focus on Biological Controls". This included his work on B.t. Buibui and Merit.

Dr. Brandenburg's research and extension interests include the use of biological control techniques, innovative insecticide application technology, and public education on pesticide and the environment. In his most recent article in *TurfGrass TRENDS,* he wrote about his work on "Intuitive Forecasting of Turfgrass Insect Pests".

In future issues we're also going to let you know how to obtain educational videos, other important books, further information. Watch for it.

We don't have the time or staff to review all the material that comes across our desks. We'll let you know what's out there that's important, however. As always, I appreciate every phone call or letter that gives us feedback ... positive or negative. Let us know what you found useful, what you think we should skip, what we might do differently.

Sincerely,

Maria L. Haber

Maria L. Haber

In Future Issues

- Risk-taking and Pest Management
- BioTrek 22G: Biological Fungicide
- Heat Stress and Creeping Bentgrass
- High Altitude Turf Management
- Biostimulants
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