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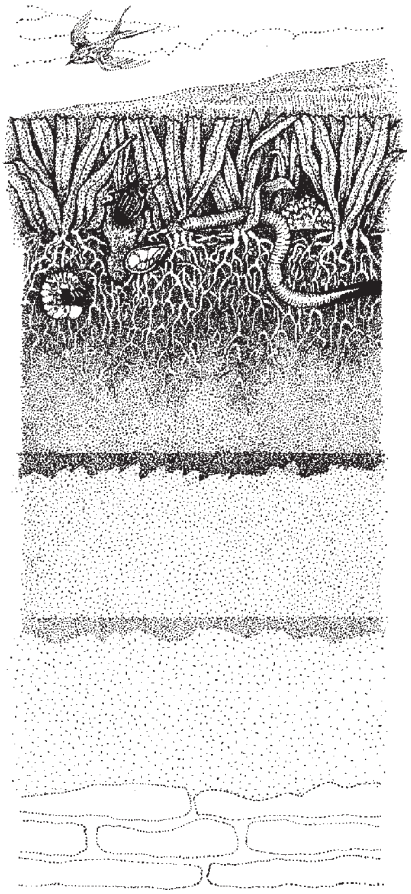

Maximizing Fungicide Performance

The use of fungicides is perhaps the most common method of turfgrass disease control. Despite the familiarity of fungicides to nearly all turfgrass managers, surprisingly few applicators are aware of the many factors that influence the performance of fungicides. It is generally believed that, if a fungicide is applied, it will control the disease. If it doesn't, then it is a problem with the fungicide or it is the wrong target disease. In this article, we will explore some of the factors that should be considered when applying fungicides in order to maximize their effectiveness. ■

Application

First, let's begin with application equipment and application techniques. Studies performed nearly a decade ago revealed that fewer than 25% of spray applicators were actually applying what they thought they were. Nearly all were making mistakes in mixing, loading, equipment configuration, and calibration of delivery rates. National losses due to these mistakes have been estimated to be in the billions of dollars.

It is important, therefore, that equipment be routinely and properly calibrated and maintained. This includes cleaning or replacing nozzles and checking nozzle pressure. Flat fan and swirl chamber nozzles often perform the best at pressures of 30-60 psi. Other equipment parameters to check on a routine basis include nozzle spacing, boom height, spray output per time per unit area, and spray coverage to avoid skips and overlaps.

Tank storage time and pH can also affect the efficacy of fungicides. Studies have shown that under alkaline (high pH) conditions, a number of commonly-used fungicides can break down and lose their effectiveness. For example, anilazine (Dyrene) is unstable at high pH values. Even at low pH levels, Dyrene stored in the tank for more than 20 hours will have reduced effectiveness. Fenarimol (Rubigan), on the other hand, is unstable at acid pH values when stored for 24 hours or more. Fungicides such as iprodione (Chipco 26019), vinclozolin (Vorlan), propiconazole (Banner), and triadimefon (Bayleton) are relatively insensitive to pH.

With the recent move toward IPM programs for turfgrass management, application timing is extremely critical. Things to consider with regard to application timing are the time of day, wind conditions, frequency relative to other pesticide applications or management inputs, and whether applications should be made preventively or curatively.

Fungicide placement is one of the more important factors affecting fungicide performance.

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Fungicide Performance

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The placement of the fungicide is largely dependent on the nature of the disease to be controlled and on some of the inherent properties of the fungicide being used. For example, if the disease to be controlled is caused by a pathogen that infects and survives in the foliage, placement of the fungicide is generally no problem. The fungicide can simply be applied as a spray.

The delivery of fungicides to the root zone to control root and crown diseases can be more problematic than for foliar diseases. Some properties of a fungicide may prevent it from coming in contact with the target pathogen, including: water solubility, systemicity (i.e. their ability to be absorbed and translocated throughout the plant), formulation, dilution, compatibilities, and the nature of the active molecule. Fungicides vary widely in their water solubilities. The water solubilities (expressed as ppm) of various fungicides are listed in Table 1. Generally, the more water soluble the fungicide, the greater its potential for being effectively drenched into the root zone.

Table 1. Water Solubility of Some Common Turfgrass Fungicides

Fungicide	ppm in water	Fungicide	ppm in water
Dyrene	Insoluble	Bayleton	20
Fore	Insoluble	Koban	25
Tersan 1991	Insoluble	Thiram	30
Daconil	<1	PCNB	87
Vorlan	3	Banner	110
Terreneb SP	8	Subdue	7,400
Fungo	9	Aliette	120,000
Chipco 26019	13	Banol	700,000
Rubigan	14		

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Contact or Systemic Fungicides

Fungicides used for turfgrass disease control can be categorized as contacts and systemics. Many of the older fungicides are contact fungicides, including anilazine (Dyrene), chlorothalonil (Daconil 2787), etridiazole (Koban, Terrazole), mancozebore), quintozene (Turfcide, Terraclor), and thiram (Spotrete, Thiramad). Contact fungicides are typically applied to foliage to prevent pathogenic fungi from infecting leaves. When allowed to dry on the leaves, contact fungicides provide short term protection from foliar diseases. If, on the other hand, they are to be used to control pathogen activity in thatch or in the root zone, they can be watered-in.

Most fungicides used for turfgrass disease control are systemic fungicides. This means that they are absorbed by the plant where they can move in the plant vascular system from the original site of application to other distant plant parts. Most of the currently used systemic fungicides are translocated upward in the plant. A few have downward movement as well. Some of the commonly-used systemic fungicides include benomyl (Tersan 1991), iprodione (Chipco 26019), vinclozolin (Vorlan), propiconazole (Banner), fenarimol (Rubigan), triadimefon (Bayleton), metalaxyl (Subdue), propamocarb (Banol), fosetyl Al (Aliette).

The way in which systemic fungicides move in the plant influences the manner in which they should be applied. In general, foliar disease control with systemic fungicides is more prolonged when they are drenched into the root zone. Drenching upward-moving systemic fungicides into the root zone provides a much longer period of protection as well as control against some root and crown diseases. Root disease control with these fungicides (e.g. Subdue) is only possible if they are drenched into the root zone whereas downward-moving systemic fungicides (e.g. Aliette) can provide control of root diseases when applied as a foliar spray.

Systemic fungicides have the advantage over contact fungicides in that they 1) have longer residual action, 2) can protect root and crown tissues, 3) can eradicate pathogens that have already infected plant tissues, and 4) can protect newly-formed plant tissues. Many systemics have some contact activity as well.

There are some disadvantages to the use of systemic fungicides. Nearly all of the systemic fungicides do not actually kill pathogenic fungi but simply suppress pathogen activity. This is usually accomplished through a very specific mode of action. Repeated application of one or more fungicides with the same mode of action greatly enhances the opportunity for pathogens to develop resistance to these fungicides. Once resistance to a particular fungicide develops, that fungicide is no longer effective. Therefore, one particular fungicide should never be used repeatedly over prolonged periods of time.

Minimize the development of fungicide resistance by 1) alternating fungicides with different modes of action, 2) using fungicides with different modes of action in mixtures, or 3) alternating or mixing systemic fungicides with contact fungicides to give the desired disease control.

Compatability

When mixing fungicides and other chemical inputs, their compatibility can affect their efficacy. In some cases, synergistic combinations have been identified. These include combinations of sterol inhibiting systemic fungicides and chlorothalonil for the control of a number of turfgrass pathogens, combinations of metalaxyl/mancozeb, chloroneb/thiram, and etridiazole/PCNB for the control of Pythium diseases, and anilazine/Zn (or Cu) for the control of anthracnose. In many cases, however, combinations of fungicides can be detrimental to their efficacy. Don't mix anything that will lead to a highly

alkaline or highly acid condition. Don't use adjuvants unless you know they are safe. If you are unsure of the phytotoxicity of the mixture, perform a test on a small area before mixing on a large scale. Finally, do not mix materials targeted for both foliar and root problems unless they are either both contacts or both upwardly-moving systemic fungicides. Otherwise less than optimal control will result for one of the diseases in the complex. Better yet, use one of the many fungicide combination products now on the market.

Environmental Parameters

The final group of parameters affecting fungicide performance are the environmental parameters. These include plant, soil, atmospheric, and pathogen factors. One of the first things to consider is the growth of the plants, since this will influence not only its overall vigor and natural resistance to pathogen attack, but will also affect the uptake of systemic fungicides. Generally, the more rapid the plant growth, the more readily systemic fungicides will be absorbed and translocated. Systemic fungicides should never be applied to dormant turf.

Temperature, moisture, and pH can affect the efficacy of fungicide applications. Temperature can indirectly affect the pathogen and the plant, but can also directly affect the volatility of some fungicides such as Bayleton and Banner. These fungicides are generally more effective at warm temperatures.

Moisture can also indirectly affect the pathogen and the plant, but can directly affect the movement of fungicides in soil and on plant surfaces. As stated before, contacts need to dry on the plant surface to be active whereas systemics can be watered in but not leached away.

Soil properties such as pH, soil type and thatch may also affect fungicide performance. Keep the soil pH in a range between 6 and 7 and thatch to a minimum thickness to maximize performance of the fungicide.

Life Cycle

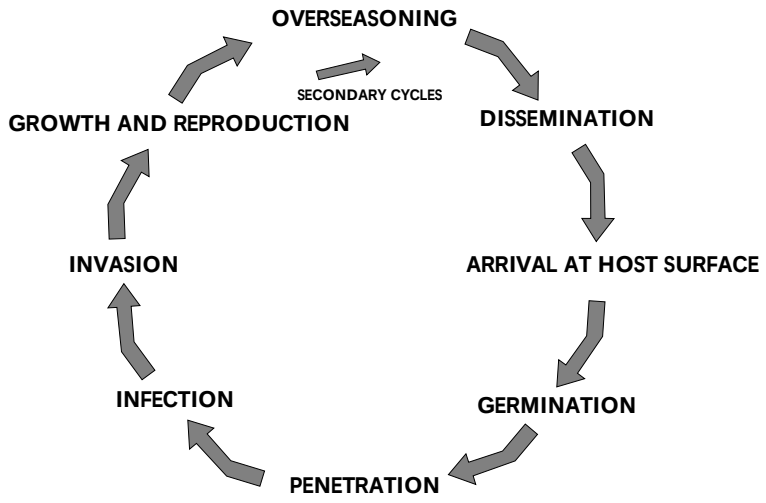
Fungal pathogens of turfgrasses exhibit developmental processes that are very cyclic in nature. Likewise, their interactions with plants are also very cyclic. Plant pathogens follow distinct stages of this developmental process, as shown in Figure 1. Spores or other propagules of the pathogen are disseminated to susceptible plants upon which the spores germinate. After germination, the pathogen will penetrate the plant and establish an infection. Following the growth of the pathogen through the plant tissues, a new "crop" of spores are produced.

At some point in the life cycle, fungal pathogens become dormant. This dormant phase allows the fungus to survive adverse conditions. For most pathogens, the dormant stage occurs during the winter months. However, for some pathogens (e.g. *Typhula* spp.), the dormant stage occurs during the summer months. During this dormant stage, the pathogen is generally resistant to most fungicides, particularly systemic fungicides. Only a few contact fungicides will actually destroy dormant pathogen propagules.

The germination of fungal spores is a particularly sensitive stage in the life cycle. Most fungicides are capable of inhibiting spore germination as well as spore production and other stages of the life cycle. However, some fungicides only inhibit spore germination but not spore production (e.g. iprodione) and may not be as effective against some pathogens under certain environmental conditions as other fungicides.

Systemic fungicides have the advantage over contact fungicides in that they 1) have longer residual action, 2) can protect root and crown tissues, 3) can eradicate pathogens that have already infected plant tissues, and 4) can protect newly-formed plant tissues.

Figure 1. A Generalized Turfgrass Disease Cycle



In summary, I have tried to briefly outline a number of factors that should be considered when using fungicides for the control of turfgrass diseases. Incorporating these suggestions into your turf disease control program should help to maximize the performance of fungicide applications. An awareness of the many elements affecting the performance of fungicides will, at the very least, aid in the selection of the appropriate material, application techniques, and use for particular sites.

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