DOLLAR SPOT CONTROL
Integrating Systemics and Contacts

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SCLEROTINIA DOLLAR spot is a serious disease of bentgrass and may also be severe on other turfgrass species. The disease is caused by a fungus, *Sclerotinia homoeocarpa*, that overwinters in the crowns and roots of infected plants. The fungus does not begin to grow optimally until air temperatures have reached 70 to 80 degrees F. and the atmosphere is moisture saturated. The tan- to straw-colored spots of blighted grass, two to three inches in diameter — characteristic symptoms of the disease on bentgrass putting greens — generally appear shortly after the fungus begins active growth.

Although certain management practices, such as increasing nitrogen fertility and holding soil moisture at field capacity, have been shown to reduce dollar spot severity, it is generally necessary to apply fungicides to maintain satisfactory control of the disease on high maintenance turfgrass areas. A number of contact and systemic fungicides have been registered for control of dollar spot. Anilazine (Dyrene), chlorothalonil (Daconil 2787), thiram (Spotrete, Tersan 75), cycloheximide (Acti-dione) and cadmium chloride (Caddy) are examples of contact fungicides that are known to effectively control the dollar spot fungus.

Recently, the systemic fungicides benomly (Tersan 1991), thiabendazole (Mertect 140), thiophanate methyl (Spotkleen, Fungo), and thiophanate ethyl (CL 3336) have been used extensively in dollar spot control programs. This article deals with recent reports where systemic fungicides have failed to control *Sclerotinia* dollar spot because of the development of fungicide-tolerant fungal strains.

Figure 1 graphically illustrates the results of a fungicide trial in which three protectant fungicides (Caddy, Daconil and Dyrene) and two systemic fungicides (Tersan 1991 and CL 3336) were applied to control dollar spot on Penncross creeping bentgrass. The fungicides were applied in five gallons of water per 1,000 square feet on 10 by 10 foot plots. Applications were made at two week intervals beginning July 12, 1974. Disease was measured by counting the number of dollar spots per plot area. All of the fungicides tested eventually provided excellent control of the fungus.

Another fungicide trial was initiated on June 10, 1974, in the Columbus, Ohio, area on a Washington creeping bentgrass putting green where control of dollar spot with application of benomyl has been unsuccessful in the past. The systemic fungicides benomyl (Tersan 1991) and thiophanate ethyl (CL 3336), and the contact fungicides thiram (Spotrete), cycloheximide (Acti-dione TGF), anilazine (Dyrene), and chlorothalonil (Daconil 2787) were applied as foliar sprays every two weeks at the manufacturers' recommended rates (see Figure 2).

The fungicides were applied in five gallons of water per 1,000 square feet on four by four foot plots. Dyrene and Daconil 2787 provided excellent disease control, while Acti-dione and Spotrete suppressed the disease symptoms but did not offer acceptable control of the fungus. Application of Tersan 1991 and CL 3336 provided little or no control under these conditions.

Recently, researchers at Pennsylvania State University have re-

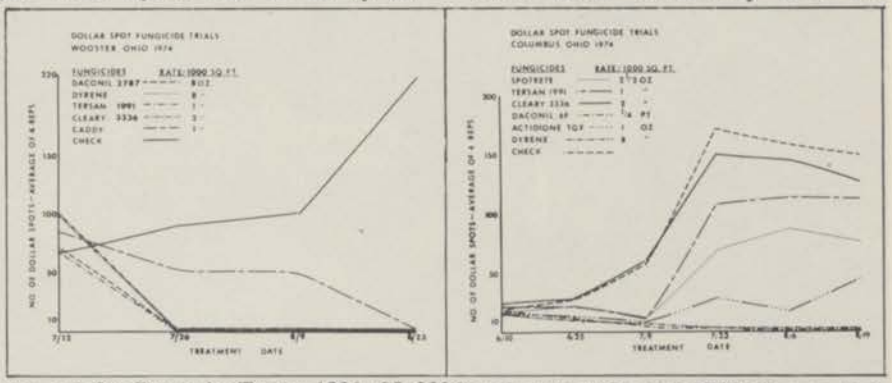

Fig. 1 (left): Systemic (Tersan 1991, CL 3336) and contact (Daconil 2787, Dyrene, Caddy) fungicides were applied as foliar sprays for control of dollar spot on Penncross creeping bentgrass. Disease was measured by counting the number of dollar spots per plot. All fungicides eventually provided excellent control. Fig. 2 (right): Systemic (Tersan 1991, CL 3336) and contact (Spotrete, Daconil, Acti-dione TGF, Dyrene) fungicides were applied as foliar sprays to plots of Washington creeping bentgrass where systemics had previously failed to control dollar spot. Dyrene and Daconil provided excellent control; Acti-dione and Spotrete suppressed but did not control disease to acceptable levels. Tersan 1991 and CL 3336 provided little or no disease control.

ported similar instances in which systemic fungicides failed to control dollar spot.[1,2] This observation has now been made in several states, indicating that tolerance of *S. homoeocarpa* to systemic fungicides is quite widespread.

In an effort to explain the occasional failure of systemic fungicides to control dollar spot, *S. homoeocarpa* was isolated from plots where systemic fungicides did not control the disease and from areas where systemic fungicides were effective. These isolates were cultured in the laboratory on artificial growth media containing various systemic and contact fungicides. *Sclerotinia* isolates from plots where systemic fungicides controlled disease would not grow on media containing systemic and contact fungicides that are registered for dollar spot control (see Figure 3A). Isolates originating from areas where systemic fungicides did not control disease grew readily on media containing systemic fungicides (see Figure 3B). These observations indicate that failure to control the fungus on the turfgrass plots with systemic fungicides was probably caused by the presence of a fungicide-tolerant strain of *S. homoeocarpa*.

Another example of tolerance of fungal turf pathogens to systemic fungicides has been demonstrated with the powdery mildew fungus, *Erysiphe graminis*, on Kentucky bluegrass.[3] A strain of the fungus was removed from a field plot of Merion Kentucky bluegrass where benomyl applications failed to control powdery mildew. This strain proved to be resistant to benomyl, thiabendazole and thiophanate methyl at concentrations that were not phytotoxic. The development of benomyl-tolerant strains of fungal pathogens has also been recorded for crops other than turfgrasses.[4,5,6]

Fungal strains that have been reported to be tolerant to benomyl were also tolerant to the thiophanate fungicides. This result is understandable, since it has been shown that both benomyl and thio-

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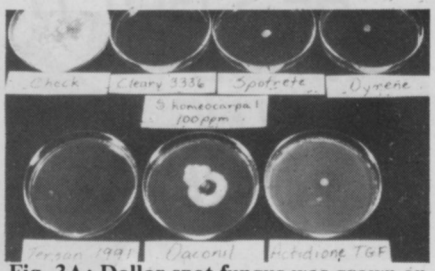

Fig. 3A: Dollar spot fungus was grown on artificial media containing 100 ppm active ingredient of systemic (CL 3336, Tersan 1991) and contact (Spotrete, Dyrene, Daconil, Anti-dione TGF) fungicides. Fungus was isolated from turfgrass where systemics effectively controlled dollar spot. No fungal growth observed with systemics.

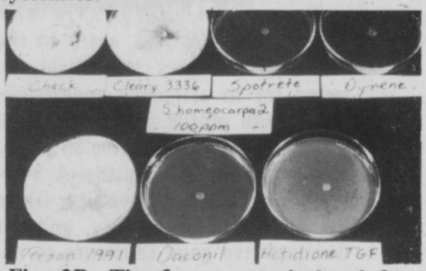

Fig. 3B: The fungus was isolated from areas where systemic fungicides did not control disease. Fungal growth was not inhibited on media containing systemic fungicides.

phanate methyl are converted to the same compound, 2-benzimidazole carbamic acid methyl ester, in plants,[6,7] and are quite similar with respect to their ultimate fate and modes of action in plant tissue.

Strains of *S. homoeocarpa* tolerant to Dyrene and cadmium fungicides have been reported,[2,8] indicating that fungicide tolerance is not strictly limited to the systemic fungicides. However, tolerance to systemic fungicides has been reported more often than tolerance to contact fungicides.

Various explanations have been offered for the fact that tolerance to systemic fungicides develops more frequently than tolerance to contact fungicides. Contact fungicides generally are active at several sites in the metabolism of the fungi they inhibit, whereas systemic fungicides are usually only effective at one or a few specific sites in the metabolic pathways of a fungus. This characteristic increases the potential for fungicide tolerance to develop with systemics, since only one or a few mutations in the fungus at chromosome sites governing fungicide sensitivity could render it insensitive to systemic fungicidal action. Mutations at several chromosome sites would be required to change the fungicidal capabilities of a contact fungicide which possesses broader based modes of action.

The relative concentration of fungicide to which a fungus is exposed influences the development of fungicide-tolerant fungal strains. With contacts, relatively high concentrations of fungitoxic materials are found on the leaf surface. This would lessen the opportunity for natural selection of fungal mutants having a low level of fungicide tolerance. Systemic fungicides are usually applied at lower concentrations than contact fungicides, and once inside the plant, tend to accumulate in leaf tips and margins, leaving the central leaf areas relatively free of fungicide. This uneven distribution of fungicide enhances the potential for development of fungal types having tolerance to low concentrations of fungicide.

Systemic fungicides do not cause mutations to occur in the normal fungus populations. Instead, the mutations occur in a random fashion. Reproduction in fungi oc-

curs much more rapidly than with higher plants and animals and, therefore, the opportunity for random mutations occurring is increased. This encourages the natural selection of fungal mutants possessing tolerance to systemic fungicides. Furthermore, the occurrence of random mutation at several fungal chromosome sites, resulting in tolerance to contact fungicides, would be less likely than mutation at one or a few sites, resulting in tolerance to systemics.

If it is determined that fungicide-tolerant strains of *Sclerotinia* are present in a turfgrass area, it is recommended that further use of systemic fungicides to control dollar spot be discontinued. An alternate contact fungicide should be chosen that can effectively eliminate the tolerant form of the fungus over a period of time.

When fungicide-resistant fungi have not been observed with dollar spot, it is suggested that alternate applications of systemic and contact fungicides registered for dollar spot control be used in an integrated control program to prevent the build-up of fungicide-tolerant fungus strains. The systemic fungicide will continue to eliminate the majority of the dollar spot fungus population that is sensitive to systemics, while the contact fungicide will be used primarily to prevent the build-up of systemic fungicide-tolerant strains of *S. homoeocarpa*.

The systemic fungicides have proven to be extremely effective and valuable tools for plant disease control and have a number of advantages over the contact fungicides: the interval between applications is generally longer with systemics; systemics are translocated inside the plant and have a curative effect, whereas the contacts are on the plant surface and are preventive; and, since systemics are internal, they are less vulnerable to wash-off or to inactivation by sunlight than are the contact fungicides.

When systemic fungicides are used wisely in an integrated control program alternated with broad spectrum contact fungicides, the opportunity for build-up of fungicide-tolerant fungal populations will be minimized and the advantages of using systemic fungicides may be realized.

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