product per 1,000 square feet applied in two applications on a preventive basis gave no control. Because of the problem of cross-tolerance among 11 benzimidazoles, all currently registered fungicides are eliminated for 1976 for effective use on *this* golf course for the disease.

In summary, *Fusarium* blight is a many-sided problem affected by various aspects of the environment. Most turfgrass scientists will agree that warm air and soil temperatures, soil moisture stress, high nitrogen fertility, thatch accumulation, turfgrass age, and turfgrass variety play a major role in disease development. However, for most of these factors the specific details of their influence have not been worked out, and we can speak at present in generalities only. For certain critical aspects of the disease cycle, such as symptom appearance and crown-root rot infection vs. foliar infection, I do not believe that we have a sound basis for understanding the natural situation in the field. We need much more information in all areas if we are to cope with this problem in a rational manner. Hence, we in turfgrass research must direct our efforts to further understanding of *Fusarium* blight if we are to provide meaningful recommendations to the turf industry. My first priority would be to resolve the crown and root rot vs. foliar infection controversy. After this is resolved, I believe many other things will fall into place quite rapidly.

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Factors Affecting Fusarium Blight in Kentucky Bluegrass

by R. E. Partyka

Fusarium blight on Kentucky bluegrass varieties is a major disease in the Midwestern and Eastern States. In general, it is assumed that the organisms are present in most turf areas, and infection is related to stress conditions. Some consideration should be given to what causes the turf to go into stress.

Two components of stress are soil drought and temperature. These problems prevail where there are heat sink areas, such as curb stones, sidewalks, or driveways. Poor soils (gravel) in these areas dry out sooner, allowing the turf to go into stress. Sloping terrain with a southern exposure is often stressed before other areas. Another consideration is the physiological drought of the plant and its relation to temperature. Plants with restricted roots will stress easily. Reasons for a limited root system are varied but most include clay soils where oxygen and carbon dioxide levels are not conducive to good root growth. Soil pH may be a limiting factor as may be nutrient levels, especially phosphorus. Compaction may be important in some areas, especially if heavy riding equipment is used on wet soils at the wrong times.

Thatch contributes to the potential of inoculum carryover, but it may also interfere with active root development. Careful examination of turf growing in a thick thatch layer will reveal active roots in the thatch layer with little contact with the soil and, thus, out of contact with the capillary moisture level. Thatch may actually develop to become a definite moisture barrier. Some concern may exist as to the gasses produced in the thatch level from microbial activity and their effect on root growth and nutrient absorption; this could be a factor if high levels of carbon dioxide are involved. Stress may be related to improper practices of handling sod after it is harvested. Dry sod or sod allowed to heat in transit may be damaged so that *Fusarium* can become established without being evident until some later date. Sod laid down on dry soil or not watered for a long time can be stressed. Another phase of stress may be associated with a sod-soil (clay) interface problem. Poor permeation of water or capillary action at the interface will result in a poor root system, which can result in a stress situation. If temperature conditions are favorable and the organism is present, *Fusarium* blight will become evident.

Other root-damaging causes are often related to insect feeding, nematodes, and, if present, possibly garden symphylans. Any one or a combination of these causes may result in stressed turf. Predisposing root organisms may be involved under certain conditions. One may question whether organisms such as *Pythium* or *Rhizoctonia* may be present at low levels of activity early in the growing season and are capable of weakening the turf so that *Fusarium* becomes established readily under favorable conditions. Nutritional imbalance that favors rapid top growth and poor root development may result in stressed plants. Calcium levels in plant tissue as related to soil and thatch levels have been discussed in the literature. The question of calcium nutrition in plants with the entire root system in the thatch layer may relate to pH levels and stress.

Cultural factors that relate to the area may have to be considered in some cases. Construction site and soil type are important with modern building practices. Bulldozer work and fill soils do not provide optimum soils for turf. The degree of the grade coupled with thatch

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Fusarium Blight

continued

may result in poor water penetration and predispose the turf to stress conditions. Irrigation practices based on weather requirements or a time clock may be a factor in creating less than optimum growing conditions. Nutrient levels used to maintain turf at a specific aesthetic quality may be providing nutrients favorable for pathogen buildup. In some cases, one may question major shifts in climate or community design that favor the buildup of disease-causing organisms.

Improved turfgrass varieties may be a better host for the pathogen or provide better microclimate conditions for the fungus to grow. A greater need for instant grass has resulted in more sod being grown on soils that may be contaminated with *Fusarium,* or there may be selectivity for *Fusarium* associated with the use of fungicides or related pesticides. The changing air pollution load in some areas may be associated with stress. Sod handling practices by subcontractors leave much to be desired at times when sod stress is the issue. The degree of *Fusarium* blight indicates that the complexity of the problem is more than realized initially. To determine whether this is strictly associated with the pathogen or whether changing cultural practices also influence the level of stress will require further research to identify the situation as it currently exists.

Effects of Cultural Practices On Fusarium Blight Incidence In Kentucky Bluegrass

by A. J. Turgeon

Diseases of turf result from the combination of a susceptible host and environmental conditions conducive to the pathogenic activity of specific disease-causing organisms. For example, leaf spot *(Helminthosporium vagans)* disease typically occurs in susceptible varieties of Kentucky bluegrass under the cool, moist conditions occurring in midspring, while brown patch *(Rhizoctonia solani)* develops on closely clipped turfs during the hot, humid weather of midsummer. However, the extent of turfgrass deterioration from pathogenic organisms is frequently associated with additional factors as well. The cultural program of fertilizing, mowing, and irrigating may substantially affect the severity of disease incidence in a turf during certain periods in the growing season.

Field research and practical experience in managing turfs have resulted in the evolution of certain principles of turfgrass culture that are based, in part, on the association of mowing height and frequency, fertilization rate and timing, and other such factors with the incidence and severity of diseases. Most of these observations have been on Kenblue-type (common) or Merion Kentucky bluegrasses and traditionally have used cultivars of other turfgrass species. Today, increasing numbers of superior cultivars are being planted for many different uses and cultural intensities. Questions arise regarding the application of established principles of culture to the newer varieties. Apparent differences in turfgrass density, vigor, disease susceptibility, and other parameters suggest that the principles of culture may change somewhat from cultivar to cultivar.

A study was initiated at the University of Illinois in which five Kentucky bluegrass cultivars (Nugget, Merion, Fylking, Pennstar, and Kenblue) were maintained under two mowing heights 0.75 and 1.5 inches) and four fertilization regimes (2, 4, 6, and 8 pounds of nitrogen per 1,000 square feet annually) beginning April, 1973. By early August, with half of the fertilizer applications made, differential development of *Fusarium* blight disease was observed in plots (Turgeon and Meyers, 1974). Generally higher spring fertilization rates were associated with substantially higher incidence of the disease in summer. This was evident in all cultivars except Kenblue, which was severely affected regardless of fertility level. Pennstar was essentially unaffected at the lowest (2 pounds) level of nitrogen fertilization, while slight to moderate blighting occurred in plots receiving the 4-pound level of nitrogen. The 6- and 8-pound nitrogen levels were associated with a severe incidence of *Fusarium* blight. Fylking was slightly to moderately blighted at the 2- and 4-pound nitrogen lev-

Table 1. Effects of Mowing Height and Fertilization on the Incidence of Fusarium Blight Disease in Seven Kentucky Bluegrass Varieties in 1975[a]

Mowing height (in.)	Fert.[b] (lb. N/ 1,000 sq. ft./yr.)	Variety: Windsor	A-20	Nugget	Merion	Fylking	Pennstar	Kenblue
.75	2	1.0	1.0	1.0	1.3	1.3	1.3	5.7
1.50	2	1.0	1.0	1.0	1.3	1.0	1.3	6.0
.75	4	1.0	1.0	1.0	1.3	1.7	2.0	5.7
1.50	4	1.0	1.0	1.0	1.3	1.7	1.3	4.7
.75	6	1.0	1.0	1.0	2.0	4.0	4.7	6.0
1.50	6	1.0	1.0	1.0	2.0	2.7	4.3	5.7
.75	8	1.0	1.0	1.7	4.3	6.0	6.3	7.0
1.50	8	1.0	1.0	1.3	4.3	5.0	6.0	7.0

[a]*Visual ratings of disease were made using a scale of 1 through 9 with 1 representing no disease and 9 representing complete necrosis of the turf.*
[b]*Fertilization was performed using a 10-6-4 (N:P_2O_5:K_2O) analysis water-soluble fertilizer applied in equal amounts in April, May, August, and September for two years on Windsor and A-20 and for three years on Nugget, Merion, Fylking, Pennstar, and Kenblue.*