Fusarium Blight

At the Illinois Turfgrass Conference last year, seven top turf people from across the country took part in a symposium on Fusarium blight. According to A. J. Turgeon of the University of Illinois, although there is still much to learn about the problem, this symposium "summarizes our current knowledge on the subject."

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Fusarium Blight of Turfgrasses — An Overview

by Houston B. Couch

In 1959 a severe foliar blighting was observed on Merion Kentucky bluegrass in southeastern Pennsylvania. The symptom pattern did not fit that of any of the known foliar diseases of turfgrasses, and isolations from diseased leaves only yielded pathogenic organisms that were known to incite symptoms distinct from those observed for the disease in question.

During 1960 and 1961 this same disease was found on Merion Kentucky bluegrass, bentgrasses, and creeping red fescues in eastern Pennsylvania, eastern Ohio, eastern New York, New Jersey, Delaware, Maryland, and the District of Columbia. Beginning in 1960 and continuing through the following three growing seasons, plant and soil samples were collected from the geographic areas that showed the characteristic symptoms of the disease. Isolations from the diseased leaves were attempted in order to determine if pathogenic fungi were present. The soil samples were also checked for the presence of parasitic nematodes. Certain of the soil samples were found to contain parasitic nematodes of the genera *Hoploaimus, Xiphinema, Paratylenchus,* and *Tylenchorhynchus.* In some samples the populations were high enough to produce foliar stress. However, there was no consistency among the samples — neither in the frequency of occurrence of a given genus nor in populations high enough to cause foliar symptoms. Furthermore, many soil samples obtained from turfgrass that showed symptoms of the disease were free from parasitic nematodes. On the basis of this evidence, it was concluded that the disease was not caused by nematodes.

The isolations from diseased leaves consistently yielded two fungus species — *Fusarium roseum* and *Fusarium tricinctum* f. sp. *poae.* Both of these organisms were known to be turfgrass pathogens, but neither had been identified as foliar parasites. *Fusarium roseum* was known to cause a root and crown rot of turfgrasses, while *tricinctum* had been recognized for several years as the cause of "silver top," a disease of turfgrass floral tissue. Pathogenicity tests with isolates of these two fungus species were made on Merion Kentucky bluegrass, Highland bentgrass, and Pennlawn creeping red fescue. While some of the isolates were weakly pathogenic, a very high percentage of those tested incited 100 percent foliar blighting within two to five days from the time of inoculation.

On the basis of (a) consistency of isolation from diseased turfgrass plants over a broad geographic area for several growing seasons, (b) the general lack of consistency of isolation of other microorganisms, and (c) the high degree of pathogenicity of *Fusarium roseum* and *Fusarium tricinctum,* we concluded that these two organisms were the actual incitants of the disease. With further research it was learned that the total syndrome of the disease consisted of two phases — a blighting of the

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leaves, and a crown and root rot. Because of the predominant leaf-symptom pattern, we named the disease "*Fusarium* blight."

SYMPTOMS

Leaf Blighting Stage

In overall view, affected turfgrass stands first show scattered, light-green patches 2 to 6 inches in diameter. Under environmental conditions favorable for disease development, the color of these patches changes in 36 to 48 hours to a dull reddish brown, then to tan, and finally to a light straw color. Initially, the shapes of the patches are elongated streaks, crescents, or circular patches.

The most characteristic feature of the gross symptomatology is seen in the later stages of disease development, when more or less circular patches of blighted turfgrass 1 to 3 feet in diameter are present. Light tan to straw colored, these patches often have reddish-brown margins 1 to 2 inches wide and contain center tufts of green, apparently unaffected, grass. This combination produces a distinctive "frog-eye" effect. When optimum conditions for disease development exist for an extended period of time, these affected areas coalesce. As a result, large areas of turfgrass may be blighted. Leaf lesions originate both at the cut tip and at random over the entire leaf. At first, lesions appear as irregularly shaped, dark-green blotches. These rapidly fade to a light green, then assume a reddish-brown hue, and finally become a dull tan. Individual lesions may involve the enitire width of the leaf blade and may extend up to ½ inch long.

Root Rot State

Turfgrass plants affected primarily by the root rot phase of the disease are stunted, pale green in color, and

'Because of the predominant leaf-symptom pattern, we named the disease Fusarium blight' — Couch

do not readily recover from mowing or adverse weather conditions. Their roots are characterized by a brown to reddish-brown dry rot. As the disease progresses, these roots become darker in color due to the colonization of soil saprophytes. During periods of relatively high soil moisture, the pinkish growth of *Fusarium roseum* and *F. Tricinctum* can be seen on the root and crown tissue near the soil surface.

DISEASE CYCLE

Sources of Inoculum

Both species of *Fusaria* have been reported to be transmitted on turfgrass seed. Also, they are known to be capable of surviving in the soil as saprophytes. These two sources constitute the main reservoirs of primary inoculum for the development of the disease in newly seeded stands of turfgrass. In established turfgrass, the main sources of inoculum are dormant mycelium in plants infected the previous season and thatch that has been colonized by the pathogens.

How Fusarium Penetrates Leaves

Leaves are infected both by germinating spores and by mycelium from the saprophytic growth of the pathogens on the thatch and other organic matter. Most of the primary infections probably originate from the thatch. Spores germinate 12 hours from the onset of favorable environmental conditions. Penetration of intact leaf surfaces occurs at the junction of epidermal cells. At the points of direct leaf penetration, there is no evidence of degradation of the host cell walls. The most common area of penetration of foliage by the pathogens appears to be cut ends of the leaves. With both direct penetration and entry through cut leaf tips, the fungus grows between the cells over an area of 12 or more cells and then becomes intracellular. This explains the sudden appearance of large blotches on the leaves, instead of small spots that progressively become larger.

Optimum Conditions for Disease Development

Certain isolates of *F. roseum* and *F. Tricinctum* have been shown to vary in their temperature requirements for optimum pathogenicity. As a general rule, however, the foliar stage of *Fusarium* blight is most severe during prolonged periods of high atmospheric humidity with daytime air temperatures of 80° to 95° and night air temperatures of 70° F. or above. Turfgrass grown under deficient calcium nutrition is more susceptible to *Fusarium* blight than well-nourished turfgrass. Incidence and severity of the disease is also greatest under conditions of high nitrogen fertilization. The development of *Fusarium* blight has been reported to be greater in turfgrass when the soil moisture content has been allowed to be extracted to the permanent wilting percentage.

CONTROL OF FUSARIUM BLIGHT

Cultural Practices

While high nitrogen fertilization does increase the susceptibility of turfgrass to *Fusarium* blight, it is unlikely that a significant reduction of the disease can be effected by reducing nitrogen levels. In general, the level of nitrogen fertilization required to significantly reduce the severity of *Fusarium* blight is well outside the range necessary to meet the basic nutritional requirements of the grass. From a field standpoint, then, nitrogen fertilization, and its effects on the disease, should be considered with respect to thatch management.

Since the thatch serves as the major reservoir of inoculum in established stands of turfgrass, a successful program of *Fusarium* blight control requires that the quantity of this material be held to a minimum consistent with the proper management of the grass species in question. For most turfgrasses, this optimum thickness is approximately ½ inch. In order to keep the *Fusarium* blight potential of a stand of turfgrass to a minimum, therefore, increases in the rate of nitrogen fertilization should be balanced with concurrent increases in the intensification of the thatch management program.

Host Resistance

Ranked in order of susceptibility to *Fusarium* blight, the bentgrasses are the most prone to the disease. The Kentucky bluegrasses are next in susceptibility. The fescues are most resistant. Among certain varieties of Kentucky bluegrass, the range of susceptibility to *F. roseum* and *F. tricinctum* is determined by a complex interaction of air temperature and pathogen and host genotypes.

Chemical Control

A preventive fungicide program, coupled with that control, is essential for effective control of *Fusarium* blight. The fungicide application should be made immediately after the first occurrence of night temperatures that do not drop below 70°F. For most effective control of *Fusarium* blight, spray 1,000 square feet with 6 gallons of water containing 5 to 8 ounces of benomyl 50-percent wettable powder. The total amount of benomyl applied to the turfgrass within one calendar year should not exceed 8 ounces.

Factors Affecting Fusarium Blight Development

by Herbert Cole, Jr.

This symposium provides a unique opportunity to explore in depth a disease that remains an enigma to all who work with turf. From the view of the research scientist, it is a frustrating challenge to gain understanding. From the view of the golf superintendent with bluegrass fairways, it has become an impossible monster. The papers in this symposium will, we hope, present the best knowledge currently available about *Fusarium* blight. There will not be agreement among the participants; in fact, agreement will be out of the question. Each view will be based on the geographic region and experience of the researcher.

The following discussion of factors affecting *Fusarium* blight is based on my personal observations in Pennsylvania and the mideastern United States, complemented by a review of the available research literature. I believe that we do not fully understand *Fusarium* blight development even 10 years after the report of its first occurrence and development (Couch and Bedford, 1966). Our lack of understanding includes all aspects of the disease: symptoms, turf age, water, grass nutrition, thatch, varietal susceptibility, and control practices. Some researchers believe the disease differs in symptoms as well as infection cycle in the various geographic areas of its occurrence. Most, if not all, of the experimental research on the infection cycle of the disease has been done with seedling grass plants in growth chambers of greenhouses. The problem in the field is associated with aging of turf stands (three years and older), yet most of the researcher has been done with seedlings. Our knowledge with other plants diseases has always indicated that it is questionable to use seedlings to study a disease of mature or aged plants. Because of this, we desperately need new disease-cycle research on mature turf.

We are not certain if the predominate problem is a foliar blight phase or a root and crown rot infection phase. On seedling and mature turfgrass in a dew chamber, foliar lesions develop. However, on the golf course or home lawn during dry weather and moisture stress, turf may wilt and die in a period of days with no clear foliar lesion picture — merely badly rotted crowns and portions of roots. Californians feel strongly that in the West only crown and root rot are involved; in the East the battle rages between the foliar blighters and the nematode-root rot complexers. At this time we just don't have an understanding of the Midwest-Eastern problems. I believe the failure of classic protectant fungicides to provide control suggests a major role for the crown and root rot hypothesis in the East also. No one has reproduced the frog eye, ring, or serpentine symptom through artificial inoculation, in either the greenhouse or the field. Classic foliar infection epidemiology cannot explain a ring or a frog-eye tuft in the center of a dead area. No other foliar-infection fungus disease produces similar symptoms on plants, including the grasses. The ring or frog eye seldom or never occurs in the Far West. To my knowledge, no turf pathologist has attempted to explain why rings or frog eyes may occur.

Most researchers would agree that the major factors influencing disease development include the physical and biological environments, especially cultural practices that affect these environments. The major factors that most of us would agree upon in terms of importance in disease development are grass variety, turf age, temperature, moisture and irrigation, thatch, and nitrogen fertilization. The role of plant parasitic nematodes in predisposing turf to *Fusarium* blight remains highly controversial at this date. A serious study of the disease should include review of all the papers listed in the references, among others. In particular, the research and review papers of Cook (1968, 1970), who has worked extensively with a *Fusarium* root and crown rot of moisture-stressed winter wheat, may be among the most pertinent in understanding *Fusarium* blight of turfgrass.

Fusarium blight is primarily a disease of bluegrass fairways of golf courses and intensively managed bluegrass home lawns. Although some research would suggest that greenhouse growth chamber studies show bentgrass is most susceptible, the field experience indicates that in practice bentgrass green, tees, or fairways are seldom affected. It would seem this lack of disease is due to the vigorous nature of bentgrass summer growth and stolon production coupled with regular irrigation intervals. In the East we are seeing some problems on fescue and ryegrasses but certainly not any remotely approaching bluegrass disease incidence. Merion is the variety with by far the most problems. The new varieties vary in susceptibility but their ultimate field response is not clear. *Fusarium* is a highly variable fungus genus. Research so far suggests that there will be races and strains of the *Fusarium* organism interacting with different species and strains of grass. A variety may be resistant one place and susceptible in another. In all probability the dense, vigorous, decumbent bluegrass will have problems with the disease if grown widely.

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continued

Temperature plays a major role in disease development. The most severe problems occur on the southern range of bluegrass adaptation, where high midsummer temperatures occur. A hot summer is always worse than a cool summer. In terms of micro-climate a southern slope or exposure or warm bank is usually worse than a cool northern slope. Sites with poor air drainage that heat up are usually worse than well-cooled areas. Problems can appear whenever air temperatures reach the high 70's for prolonged periods during the day, such as mid-June through September in much of the Midwest and East. Data are lacking, however, on the critical precise temperature aspects of the problem under field conditions.

'From the view of the golf superintendent with bluegrass fairways, it has become an impossible monster'—Cole

Moisture stress must be present for symptom appearance. It is not known whether soil moisture stress or internal plant moisture stress is the most critical factor for disease development and symptom appearance. However, in the field situation both moisture stresses will occur simultaneously. The work of Cook (1968) on *Fusarium* root rot of wheat may explain this aspect of the problem. For example, external moisture stress in the soil and thatch may enhance growth of the *Fusarium* fungus in these areas and suppress bacterial antagonists of the *Fusarium*. Internal moisture stress in the grass plant may enhance explosive colonization of the crown and roots as well as other areas by the *Fusarium* fungus. Much can be learned about the turf *Fusarium* blight problem, I believe, by analysis of the dry land wheat *Fusarium* root rot literature. At first glance, regular summer irrigation would be the simple answer to this problem. However, most turf managers intentionally drought-stress Kentucky bluegrass turf during the summer to minimize competition from annual bluegrass and creeping bentgrass. Hence, a management practice to suppress one problem may accentuate another.

Thatch accumulation appears necessary for severe disease development, but there is not complete agreement on this issue. Usual thatch measurement procedures and dethatching experiments have not shed much light on the matter. Unfortunately, many unaccounted variables enter into any discussion of thatch. In certain soils grass may be growing roots and all in an accumulation of thatch with little soil penetration; in others, roots may be several inches deep in soil regardless of thatch accumulation. Most experimentation has involved a single season with no control over or observation of other variables beyond thatch *per se*. When extensive multi-year comprehensive experimentation is done, I believe thatch will be demonstrated to play a significant role in disease development, especially from the view of *Fusarium* survival and a food base for crown invasion. The need for thatch may partially explain the failure of artificial inoculation procedures employing spore (conidial) sprays on young, thatch-free turf plots. *Fusarium* blight usually does not appear until a turfgrass planting reaches three or more years of age. The preceding thatch discussion may explain this delayed appearance. Another factor may be physiologic maturity changes in the turfgrass plant. It is well documented for many plant species that physiologic chemistry and even anatomical details change with increasing age. In addition, alterations in characteristics of tillers may take place through nutrient depletion or accumulation, crowding, or soil physical changes. Hence, an individual tiller in a turfgrass planting at an age of three years may differ in susceptibility and response from the original seedling plants.

Many field observations and greenhouse experiments suggest that high levels of available soil nitrogen increase disease severity. However, there is not complete agreement on this point, and some greenhouse studies have not demonstrated any nitrogen fertilizer effects. Cook's research (1968) with wheat root rot may shed light on this apparent paradox. In that instance, the nitrogen fertilizer effect induced development of a vigorous plant, which resulted in accentuated water extraction and greatly increased water strees both within the plant and within the soil. The resulting water stress allowed explosive invasion and colonization of the crown and root area of the plant as well as reduction of soil bacterial antagonism against the *Fusarium* fungus. A possible explanation of the confused results regarding nitrogen fertility in bluegrass may be the recycling of nitrogen through organic matter decay. A single year's shift in fertilization practices will not offset several preceding years of high nitrogen treatments. Fertilization management must be considered in terms of multiple years, preferably beginning with a new planting. Attempts to manipulate nitrogen in a 5-year-old turf stand may be hopeless from a commercial or research viewpoint, if considerable organic nitrogen in present.

The nematode question with regard to *Fusarium* blight remains a sticky, unresolved issue at the nationwide level. In Pennsylvania we have not been able to demonstrate an associative or causative relationship between any plant parasitic nematode and the presence of or control of *Fusarium* blight. One of our worst *Fusarium*-blighted golf courses had almost no plant parasitic nematodes, and extensive nematicide treatment did not suppress the disease in any way. However, I believe that such a relationship is possible and may be present in the East, but we have not yet worked with the site where it may be present. The nematodes' role, as I view it, could be twofold: They could provide infection sites, as demonstrated with other *Fusarium* diseases, and they could restrict root development and water uptake, thus predisposing the plants to infection through moisture stress. I do not feel that a nematode presence is essential for disease development. Fungicide tolerance has recently appeared among the *Fusarium* species. This has been reported for turf from New York (Smiley, personal communication) and observed recently in Pennsylvania. In one instance benomyl was successfully used in a course-wide program during 1974 for *Fusarium* blight suppression; the next year massive course-wide tolerance to benomyl appeared — 16 to 19 ounces of 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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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.*

Table 2. Relative Susceptibility of Kentucky Bluegrass Varieties to Fusarium *Blight in Illinois*

Disease susceptibility levels						
High	**Moderate**		**Low**		**No symptoms**	
Delft	**Ba 61-91**	**Kenblue**	**A-34**	**Merion**	**A-20**	**Monopoly**
EVB-305	**Brunswick**	**IL-3817**	**Ba 62-55**	**Cheri**	**Adelphi**	**P-59**
K1-138	**EVB-307**	**Nugget**	**Baron**	**Parade**	**Campina**	**P-140**
	Fylking	**PSU-197**	**Bonnieblue**	**Plush**	**Edmundi**	**PSU-150**
	Geronimo	**Park**	**EVB-391**	**PSU-169**	**Glade**	**Sodco**
	K1-157	**Pennstar**	**Galaxy**	**PSU-190**	**K1-132**	**Touchdown**
	K1-187	**RAM No. 2**	**K1-131**	**RAM No. 1**	**K1-143**	**Victa**
			K1-133	**Sydsport**	**Majestic**	**Windsor**
			K1-155	**Vantage**		
			K1-158			

els and severely diseased at higher levels. Merion responded in much the same manner as Pennstar, and Nugget was largely unaffected except at the highest nitrogen level. The incidence of *Fusarium* blight in Nugget, Merion, and Fylking was slightly higher in plots maintained at the 1.5-inch mowing height. No such difference was apparent in the Pennstar and Kenblue plots.

Continuation and expansion of this study with the inclusion of Windsor and A-20 Kentucky bluegrasses provided similar results during the next two growing seasons. No *Fusarium* blight symptoms were observed in Windsor or A-20, while Nugget, Merion, Fylking, and Pennstar characteristically showed more disease with increasing spring fertilization rates (Table 1). As in 1973 the severity of *Fusarium* blight disease was uniformly high in the Kenblue plots. Random probing of the plots revealed very severe soil compaction in the section of the field where the Kenblue plots were located, suggesting that compacted soil conditions may so weaken the turf that its susceptibility to *Fusarium* blight disease is much greater. Data from the Kentucky bluegrass variety plots, established in April, 1972, do not show Kenblue to be inherently more susceptible to *Fusarium* blight than Fylking, Pennstar, or Nugget under a moderate intensity of culture (4 pounds of nitrogen per 1,000 square feet a year, 1.5 inches mowing height) and fairly uniform soil physical conditions (Table 2).

Based on these observations, the varieties Delft, EVB-305, and K1-138 should not be planted on sites where *Fusarium* blight is a concern; other varieties, including A-20, Adelphi, Glade, Majestic, Sodco, Touchdown, and Victa, appear promising because of the apparent lack of *Fusarium* blight symptoms during the period of observation.

Another factor believed to be of importance in the development of *Fusarium* blight disease is thatch. Many turfgrass scientists feel that the susceptibility of a turf to *Fusarium* blight may be greatly increased where substantial levels of thatch have been allowed to develop. While this may be true, there was no clear correlation between the thatching tendency of Kentucky bluegrass varieties (Table 3) and their relative susceptibility to *Fusarium* blight. For example, Touchdown Kentucky bluegrass was the most thatch-prone variety — its thatch layer averaged over 1.9 centimeters thick — while Park was the least thatch-prone variety, with only 0.71 centimeters of thatch. Yet, Park was found to be moderately susceptible to *Fusarium* blight while Touchdown showed no symptoms of the disease. Since recent results from tests at Rutgers showed that *Fusarium* blight incidence in Kentucky bluegrass varieties was dramatically increased where thatch-inducing calcium arsenate was applied to the plots (Funk, 1975), it is likely that thatch development is associated with more severe incidence of this disease in susceptible varieties. However, this relationship apparently does not exist when comparing the differenctial thatching tendency and *Fusarium* blightsusceptibility of different Kentucky bluegrass varieties.

An additional factor frequently associated with the severity of turfgrass diseases is whether or not clippings are removed as part of the mowing operations. Results from a study initiated in early 1974 showed that, at high nitrogen fertilization rates, the severity of *Fusarium*

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Table 3. Relative Thatching Tendency of Kentucky Bluegrass Varieties During the Fourth Season After Planting

Thatch depth, cm[a]	Varieties
More than 1.50	**Brunswick, EVB-305, Glade, Cheri, Nugget, P-140, RAM No. 1, Touchdown**
1.50 - 1.25	**A-20, Ba62-55, Baron, EVB-391, Fylking, K1-131, K1-132, K1-143, K1-187, Majestic, P-59, Plush, PSU-190, RAM No. 2, Sodco, Victa**
1.25 - 1.00	**A-34, Adelphi, Ba 61-91, Bonnieblue, Campina, Delft, Edmundi, EVB-307, Galaxy, Geronimo, K1-133, K1-138, K1-155, K1-157, K1-158, IL-3817, Merion, Monopoly, Parade, Pennstar, PSU-150, PSU-169, Sydsport, Vantage, Windsor**
Less than 1.00	**Kenblue, Park, PSU-197**

[a]*Thatching depth was determined by measuring the thickness of the thatch at four places on two plugs 2 inches in diameter taken from each of the three replicate plots of each variety.*

Fusarium Blight

continued

blight was reduced by clipping removal (Table 4). The basis for this relationship is not clearly understood; however, it does appear that clipping removal with mowing should be considered on highly fertilized sites where *Fusarium* blight has been a recurring problem.

Table 4. Effects of Clipping Removal and Fertilization on Fusarium *Blight Incidence in Kenblue Kentucky Bluegrass Turf*

Fertilization[a] (lb. N/1,000 sq. ft./yr.)	*Fusarium* blight rating[b]	
	Clippings removed	Clippings returned
2	1.3	1.2
5	1.5	1.7
8	1.5	3.7

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

A final cultural factor of importance in controlling *Fusarium* blight is irrigation. This is most evident during midsummer stress or drouthy periods when light watering has been instrumental in reducing disease symptoms and promoting turfgrass survival. A turf with a deteriorated root system cannot survive prolonged stress periods unless supplemental irrigation is frequent enough to prevent dessication of the plants. Although this practice is inconsistent with traditional principles of turfgrass culture, it may be necessary for the survival of a severely diseases turf.

In conclusion, there are two fundamental approaches
to controlling *Fusarium* blight in Kentucky bluegrass. The "environmental-oriented" approach is to adjust the cultural program by avoiding excessive nitrogen fertilization during spring, providing adequate moisture for turfgrass survival during stress periods through irrigation, performing appropriate cultivation practices to control thatch and alleviate soil compaction and applying effective fungicides properly. The "plant-oriented" approach involves the introduction of superior Kentucky bluegrass varieties that, under local conditions, do not appear to be adversely affected by the *Fusarium organism.*

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The Role of Nematodes in the Development of Fusarium Blight

by J. M. Vargas, Jr.

Extensive surveys were made to determine if factors other than *Fusarium roseum* and *Fusarium tricinctum* were involved in the development of *Fusarium* blight. The surveys revealed that high populations of nematodes, especially the nematodes *Tylen-chorhynchus dubius* and *Creconemoides* spp., occured in *Fusarium*-blighted turfs.

A greenhouse study was conducted to determine what role, if any, the stunt (*T. dubius*) nematode played in the development of *Fusarium* blight. In this study, only *T. dubius* was able to produce most severely stunted top growth and root system, the two characteristic symptoms normally associated with *Fusarium* blight-infected turfgrass plants. The *F. roseum*-treated plants had reduced root and top growth, but the reduction was not significant when compared to the untreated controls. It appeared that the nematode was the dominant pathogen in the *F. roseum/T. dubius* interaction, which is responsible for *Fusarium* blight in Michigan. It must be remembered that Michigan is really borderline for *Fusarium* blight development. Michigan does not have the long periods of hot, humid weather normally associated with *Fusarium* blight development in more southern areas. In fact, our *Fusarium* blight outbreaks usually occur during periods of drought stress, whether it is hot and dry or cool and dry. Our worst outbreaks have been in late September and early October when the daily temperature did not go above the high 70's. So while the nematodes may be important in Michigan and other northern edges of the *Fusarium* blight region, they may not be as important in the more southern regions.

Before we had determined that nematodes were involved in the disease interaction, we had obtained control of the disease with the systemic fungicide Tersan 1991, but only where we drenched the material into the root zone. We originally thought this was related to the upward translocation in the plant of the systemic fungicide. These results were puzzling in light of the involvement of the nematodes in the development of the disease. Upon further investigation, Tersan 1991 was shown to be a nematicide in addition to a systemic fungicide. We now believe if it is drenched into the root zone and grass plants roots will pick it up and prevent nematodes from feeding. Tersan 1991, of course, can also protect the plant from infection by the *F. roseum* fungus. If *Fusarium* blight is an interaction between a nematode and a fungus, with the nematode being the dominant pathogen, then one should be able to control the disease with nematicides Dasanit and Oxymal. However, it appears that they must be applied early in the season, before the *Fusarium* blight symptoms begin to appear.

Drought stress appears to be the main factor in symptom development after infection has taken place. This is logical, since you have a weakened grass plant with a poorly developed root system; as soon as drought stress is applied, it will begin to wilt and eventually die. Light, frequently watering of *Fusarium*-blighted turfs during periods of drought stress can prevent *Fusarium* blight symptom development. During hot, dry weather, syringing lightly about midday may also be necessary, and symptom development of the disease can be prevented by following such a watering program. Not enough information is known to make recommendations concerning varieties that are resistant to *Fusarium* blight. However, there is enough evidence to show that Merion, Fylking, and Pennstar are three very susceptible Kentucky bluegrass varieties that should not be used in areas where *Fusarium* blight is a problem.

SUMMARY

The disease *Fusarium* blight appears to be an interaction between nematodes and a fungus in which the nematode is the dominant pathogen. The symptoms of the disease occur during periods of drought stress in warm or cold weather. The disease can be controlled culturally by light, frequent watering during periods of drought stress or chemically with one of the recommended systemic fungicides or nematicides. Check with the turfgrass experts in your area for specific recommendation. CAUTION: Nematicides are exretemly dangerous to human health, and proper clothing and equipment must be worn when applying them. Again, it is advisable to check with an expert in your area before applying nematicides.

Developing Genetic Resistance To Fusarium Blight

by C. Reed Funk

The development of improved levels of a stable, race-nonspecific resistance to *Fusarium* blight should receive high priority in all areas where this disease is a present or potential hazard. This resistance must be combined with other genetic factors involved in the creation of attractive, dependable turfgrass cultivars with good turf-forming properties, tolerance of environmental stress, and good resistance to other important pests. These improved turfgrasses need to be widely adapted and have reduced maintenance requirements.

TYPES OF DISEASE RESISTANCE

Disease resistance in plants has been characterized as either race-specific or race-nonspecific. Race-specific resistance has been widely used in the genetic control of plant disease. It generally is controlled by a single, usually dominant, gene and produces a high degree of resistance to one or more specific races of the disease pathogen. Unfortunately, a variety possessing such resistance may be highly susceptible to other races of the same pathogen. Breeding programs using this race-specific form of disease resistance are frequently faced with the task of continually finding and adding new resistance genes to combat new races of the pathogen. This race-specific resistance has been used extensively in annual crops where new resistant varieties can readily be substituted as resistance in old varieties breaks down. Obviously, it is of much less value in our long-lived perennial turfgrasses.

Race-nonspecific resistance is normally conditioned by the combined action of several genes. It imparts a degree of resistance to all races of the pathogen and is generally relatively stable over long periods of time. In most cases race-nonspecific resistance does not confer the high level of disease resistance normally observed in varieties posessing a race-specific type of resistance. Plant breeding procedures using race-nonspecific resistance are also more difficult. Nevertheless, the development of varieties having the highest possible and most stable forms of race-nonspecific forms of disease resistance should be the primary goal of breeders of perennial species.

PREDISPOSING FACTORS

Observational and experimental evidence suggest that the *Fusarium* blight disease is more serious on turfgrass weakened by one or more environmental stress factors. Factors predisposing the turf to *Fusarium* blight might include the following:

- High temperatures.
- High humidity.
- Recurring drought stress.
- Reduced air circulation.
- Excessive nitrogen.
- Dense, lush growth.
- Thatch.
- Close mowing.
- Nematodes.
- Other diseases.

Varieties better able to tolerate the weakening effects of any of the above factors, which may occur at a critical stage in disease development, are less likely to be seriously damaged by *Fusarium* blight. This might account for much of the variety x test interaction observed in ratings of variety resistance. A variety such as Vantage, which is less tolerant of close mowing than some compace turftypes, may show very little *Fusarium* blight at a 2-inch mowing height but can be weakened by closer mowing to the extent that it becomes moderately susceptible. A variety growing in its area of best adaptation and receiving the management most favorable to its best performance is likely to be damaged less by this disease. The above factors, considered in connection with a highly variable pathogen and our present less than adequate evaluation techniques and information exchange, complicate our understanding of the amount and stability of the genetic resistance available. Nevertheless, we do see substantial variation in the amount of *Fusarium* blight damage to different turfgrass selections. The genetic components of this variation can be used in breeding varieties of improved resistance.

KENTUCKY BLUEGRASS

Kentucky bluegrass, *Poa pratensis* L., is the most important lawn-type turfgrass in the northern half of the United States. It is hardy, attractive, and widely adapted. A number of attractive turf-type bluegrasses with good resistance to the *Helminthosporium* leaf spot and crown rot disease have been developed in recent years. Most of these improved varieties are giving good performance in areas where summer stress conditions are not too severe. Nevertheless, the development of bluegrasses with greater tolerance of the long, hot summers of the transition zone remains a real challenge to the turfgrass breeder. An extensive program to collect and evaluate adapted germplasm from summer stress areas should provide germplasm to produce varieties

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Fusarium Blight

continued

with greatly improved summer performance and dependability.

Detailed examination of old turfgrass stands and variety trials located in summer stress areas of the Middle Atlantic region is providing us with valuable insights into different types of Kentucky bluegrass. Under conditions of moderately low nitrogen fertility and high, infrequent mowing, the tall, erect-growing, narrow-leafed common types such as Kenblue dominate. However, old turf areas that have been mowed regularly have very few bluegrasses of the erect, narrow-leaf common type. The narrow-leafed common types have apparently been weakened by leaf spot and replaced by large patches of a broader leafed, more prostrate, moderately open type with extensive deep rhizomes. These might be referred to as a Middle Atlantic common. Vantage, PS2, and P-154 are selections of this type. This Middle Atlantic common type of bluegrass with its deep rhizomes, somewhat greater intrinsic tolerance of heat, greater summer food reserves, deeper roots, and somewhat open growth is well suited to survive summer stress, especially if not overfertilized or mowed too closely.

Many of the very attractive, dense, lower-growing turf-type bluegrasses selected from cooler summer climates of Northern Europe and from other breeding and evaluation trials in less severe environments are often disappointing in southern trials. Their dense, attractive turf is the result of a very high population of tillers per unit area. This results in increased competition between each tiller for light, water, carbon dioxide, and nutrients. Each tiller has a smaller percentage of the root system for support and is more subject to drought stress. A higher humidity develops in this dense turf. Excessive thatch accumulation is more likely to occur. This favors many disease organisms, including *Fusarium*. Kentucky bluegrass is best able to tolerate the frequent close mowing, high fertility, and other factors associated with the production of dense, compact turf desired on golf course fairways and similar turf areas in regions of high light intensity, cool temperature, and low to moderate humidity. As we go into less favorable climates, we must compensate with improved varieties and better management.

There may be a fourth type of bluegrass, which we might refer to as a southern turftype, that is widely adapted, pest resistant, and tolerant of heat and drought. This type has the ability to produce an attractive, compact, dense, disease-free turf in favorable environments. It also has the phenotypic plasticity to produce the deeper roots and rhizomes and the more open growth habit of the middle Atlantic common type in areas of severe and prolonged summer stress. It has good heat tolerance and the ability to maintain higher levels of carbohydrate reserves through prolonged periods of hot weather. A few of our very best bluegrasses are approaching this description. Further improvements in heat tolerance and pest resistance, including better resistance to *Fusarium* blight, will be most helpful in meeting the challenge of the transition zone. For commercial success these varieties also have to be economical seed producers. Expanded efforts should be made to develop and identify these grasses.

New Brunswick Trials

Turf trials at New Brunswick, New Jersey, show that bluegrass varieties exhibit a wide variation in resistance to *Fusarium* blight under the conditions of our evaluation program (Table 1). We have had very little damage from *Fusarium* blight on most test fields. High levels of earthworm activity and perhaps other factors have virtually eliminated any thatch buildup except on fields treated with tricalcium arsenate or chlordane.

Three bluegrass tests on fields treated with tricalcium arsenate all show considerable thatch buildup

Table 1. Fusarium Blight Incidence on Kentucky Bluegrass Varieties, Blends, and Mixtures Grown at New Brunswick, New Jersey, 1975[a]

Variety	Percent diseased	Variety	Percent diseased
Enmundi	1	Merion	15
Windsor	1	Park	16
Adelphi	1	Victa	18
P-59	1	Baron	18
Parade	1	Cheri	21
Sydsport	3	Merion-Pennstar	23
Bonnieblue	4	Merion-Kenblue	24
Adelphi-Kenblue	4	Fylking-C26	27
Adelphi-Nugget	5	Nugget	29
Sodco	5	Nugget-Pennstar	29
Glade-Nugget	6	Fylking	31
Vantage	7	Pennstar	31
Glade	7	Delft	37
Adelphi-Fylking	8	Fylking-Pennlawn	37
Touchdown	8	Nugget-Park	38
Majestic	8	Fylking-Jamestown	45
Glade-Adelphi	10	Modena	52
Vantage-Victa	10	Enita	59

[a]*Test planted April, 1972. Half of each plot received tricalcium arsenate treatment, which produced a four-fold increase in Fusarium blight. Plots were mowed at ¾-inch height with moderately high fertility.*

and substantial damage from *Fusarium* blight. One half of each plot on the 1972 regional bluegrass test was treated with 4.8 pounds of tricalcium arsenate in both the spring and the fall of 1973. Thatch buildup has occurred on the treated half but not on the untreated half. The treated half shows four times as much damage from *Fusarium* blight as the untreated half. At our Adelphia location we have seen considerable *Fusarium* blight disease in fields not treated with tricalcium arsenate. Areas of these fields having reduced air circulation show substantially more from *Fusarium* blight.

THE FINE FESCUES

Fine fescues are generally tolerant of acid soils, low fertility, and shade. They perform best in cool climates and during cool seasons. They are intolerant of higher levels of nitrogen fertilizer and poor drainage during hot weather. The fine fescues currently showing the greatest potential for turf use can be classified into five types. Dr. Robert W. Duell, who is working closely with the fine fescues at Rutgers, refers to them as the Chewings, Creeping, Spreading, Hard, and Sheeps fescues. The Chewings, Creeping, and Spreading fescues are currently included in one species, *Festuca rubra* L. However, these three types are very different in appearance, growth habit, management requirements, adaptation, breeding behavior, and cytological characteristics. They should be classified as separate species.

The **Chewings type,** *F. rubra* L. subsp. *commutata* Gaud., is a fine-leafed, lower growing grass without rhizomes. Under mowing, these plants spread slowly by basal tillering. Where summers are cool, they will tolerate rather close mowing and will produce attractive dense turf requiring less fertilizer and less mowing than needed for a good bluegrass turf. A number of very attractive varieties of Chewings fescue have been developed in recent years by breeders in the United States and Europe. 'Jamestown,' 'Banner,' 'Koket,' and 'Highlight' are representative of the improved varieties within this group. Their dense growth habit can make them much more competitive and persistent in mixtures with Kentucky bluegrass than fescue varieties formerly available. This can be either an advantage or a disadvantage.

The **Creeping type,** *F. rubra L.* subsp. *Trichophylla* Gaud., is represented by European varieties such as 'Cumberland Marsh,' 'Dawson,' 'Golfrood,' and 'Oasis.' They are fine-leafed, low-growing varieties with short, thin rhizomes. Under mowing, they develop a turf similar in appearance to the improved Chewings type fescues. Some varieties within this group have demonstrated good salt tolerance. Currently available Creeping types are highly susceptible to dollar spot and are generally low seed producers. These factors limit the potential use of the Creeping types. It is hoped that improvements can be made in these characteristics, for some of our most leafspot-resistant germplasm is found within this group.

The **Spreading type,** *F. rubra* L. subsp. *rubra* Hack, is represented by varieties such as 'Fortress' and 'Ruby.' Spreading fescues have 56 chromosomes while Chewings and Creeping fescues have 42 chromosomes. Spreading fescues have somewhat wider leaves, longer and thicker rhizomes, and better seedling vigor than other fine fescues. They are less tolerant of close mowing, have a lower turf density, and produce less thatch than the Creeping and Chewings types. In trials in New Jersey and Maryland the Spreading types have shown considerably less damage from *Fusarium* blight than the Chewings types. Improved selections of Spreading fescues would appear to be more compatible with Kentucky bluegrass and would have greater seedling vigor, better performance under low maintenance, and possible better shade tolerance. Increased breeding efforts should be made to improve the Spreading fescues, especially in areas of severe summer stress.

The **Hard fescues,** *F. longifolia* Thuil., are receiving considerable attention since the development and release of 'Biljart' hard fescue (Scotts C-26) in Holland. The improved Hard fescues produce a turf comparable in texture and growth habit with the better varieties of the Chewings type fescue but with a somewhat slower rate of vertical growth, better resistance to some hot-weather diseases, and better adaptation to some poor

'The development of improved levels of a stable, race-nonspecific resistance to Fusarium blight should receive high priority' — Funk

soil conditions. Spring dormancy, slow recovery from injury, and costly seed production are problems that need improvement.

The **Sheeps fescues,** *F. ovina* L., collected from old turf areas of the Northeast look interesting in our turf evaluation plots. Most selections appear "grainy" under mowing but have shown excellent persistance under severe summer stress conditions. They have good shade tolerance and good adaptation to poor soils.

TALL FESCUE

Tall fescue, *Festuca arundinacea* Schreb., is used extensively for pasture, hay, general-purpose turf, and erosion control throughout the summer heat stress zone of the United States. It has the ability to tolerate summer heat and drought stress in areas where other cool season grasses perform poorly. There would appear to be considerable potential for the plant breeder to make substantial improvements in the appearance and turf performance of this interesting grass even though breeding efforts to date have met with only limited success. Dense, attractive, fine-textured lower growing types currently available in our breeding collection need further improvements in pest resistance and tolerance of temperature extremes. Recent work in central Alabama show that nematodes can seriously limit rooting depth, drought tolerance, persistence, and productivity of tall fescue and other cool-season grasses. Well-organized and adequately supported team efforts by pathologists, nematologists, physiologists, and plant breeders might well produce tall fescue varieties of considerable value for areas where *Fusarium* blight is prevalent.

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PERENNIAL RYEGRASS

The development of improved turf-type perennial ryegrass (*Lolium perenne* L.) varieties such as 'Manhattan,' 'Pennfine,' 'Citation,' 'NK200,' 'Eton,' 'Derby,' 'Yorktown,' 'Diplomat,' and 'Omega' has made this species of considerable usefulness to the turf industry. These improved ryegrasses are substantially superior to common perennial ryegrass for many turf purposes. Like all ryegrasses, the new turf-types are quick and easy to establish and are adapted to a wide range of soil types and uses. When properly managed in their area of adaptation, these ryegrasses can be durable, persistent, and attractive. Instances have been reported where turf-type ryegrasses have given good performance on turf areas where Kentucky bluegrass has been seriously damaged by *Fusarium* blight. The turf-type ryegrasses appear to produce much less thatch than bentgrass, Kentucky bluegrass, and the Chewings-type fescues. A number of golf course superintendents in summer heat stress areas such as Washington, D.C., are having very promising success with overseeding established bermudagrass with blends of improved turf-type ryegrasses such as Manhattan, Pennfine, and Citation. Continued breeding efforts should lead to further improvements in mowing quality, summer performance, winter hardiness, and resistance to crown rust *(Puccinia coronata)*, brown patch *(Rhizoctonia solani)*, and leaf spot *(Helminthosporium siccans)*. Improved resistance to *Pythium* is also needed for good summer performance of ryegrass in the humid summer heat stress region.

Techniques for Determination of Fusarium Blight Susceptibility In Kentucky Bluegrass

by William A. Meyer and Frank H. Berns

Fusarium blight is now recognized as a major disease problem of Kentucky bluegrasses and some other cool-season turfgrasses in the northeastern and midwestern sections of the United States (1,6) and in California (2) *Fusarium roseum* and *F. tricinctum* are the two species of fungi found by Couch and Bedford (1) to be the incitants of this disease.

Disease symptoms seldom appear until a turf stand is two or more years old. Occasionally, symptoms may appear during the first year of turf establishment. The severity of this disease may vary greatly from year to year, depending upon such environmental factors as heat and moisture stress. It is usually very difficult to get a uniform distribution of *Fusarium* blight throughout a replicated turf plot area. In the development of new Kentucky bluegrass varieties, it is important to establish their degree of susceptibility to *Fusarium* blight as well as other major diseases before they are released. Because of the time required for this disease to develop consistently in turf plots, rapid screening techniques are needed. The following paper will describe techniques which were developed to aid in the screening of Kentucky bluegrass cultivars for *Fusarium* blight susceptibility.

TILLER-PUNCTURE TECHNIQUE

With the tiller-puncture technique (4), 14 Kentucky bluegrass varieties were propagated from individual tillers and grown in 2-inch pots in the greenhouse for 50 to 75 days. They were then transferred to a growth chamber (14-hour day at 29° C, 24° C night; 4,000 foot candles; and 70 percent relative humidity) for three days prior to inoculation. A small sound (2 mm long) penetrating to the youngest enclosed leaf was made in each of two healthy tillers per pot between the crown area and third leaf. Mycelium pieces of *Fusarium trincinctum* isolate MSU1 or of *F. roseum* isolates U12 or KC1 were then placed in the wounds. Wet sterile peat moss was used to cover the wounded area of each inoculated tiller. Other tillers were wounded but noninoculated to serve as controls. In all, 60 tillers of each variety were inoculated with the MSU1 isolate, 36 tillers with the UI2 isolate, and 12 tillers with the KC1 isolate. All pots were then returned to the growth chamber and the peat moss was kept moist.

Foliar lesions could be seen on the emerging leaf two to three days after inoculation. In many tillers the initial fungal infections in the new and old leaves would advance down into the crown area of the plant and eventually cause death. Some tillers were killed within seven days on the most susceptible varieties. After two weeks all pots were removed from the chamber and rated for severity of infection. The MSU1 isolate was the most virulent isolate followed by UI2 and KC1. Leaf and crown lesions caused by the three isolates were similar on all of the varietiies. The experimental variety WTN-I-13 had the smallest percentage of crown-rotted and dead plants. Eighteen percent of the WTN-I-13 tillers were crown rotted or dead with the MSU1 isolate, 8 percent with UI2, and none with KC1. WTN-I-2 and Belturf were ranked next with slightly higher percentages of dead or diseased plants. The varieties P104, WTN-J79, and Fylking were the most severely affected.

Foliar lesions could be seen on the emerging leaf two to three days after inoculation. In many tillers the initial fungal infections in the new and old leaves would advance down into the crown area of the plant and eventually cause death. Some tillers were killed within seven days on the most susceptible varieties. After two weeks all pots were removed from the chamber and rated for severity of infection. The MSU1 isolate was the most virulent isolate followed by UI2 and KC1. Leaf and crown lesions caused by the three isolates were similar on all of the varieties. The experimental variety WTN-A 13 had the smallest percentage of crown-rotted and dead plants. Eighteen percent of the WTN-I-13 tillers were crown rotted or dead with the MSU1 isolate, 8 percent with UI2, and none with KC1. WTN-I-2 and Belturf were ranked next with slightly higher percentages of dead or diseased plants. The varieties P104, WTN-J79, and Fylking were the most severely affected. Fylking

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continued

had the highest percentage of dead or crown-rotted plants with 85, 68, and 42 percent, respectively, for the three isolates. The varieties A-20, WTN-H-7, A-34, Merion, and WTN-A-20-6 were intermediate in their reaction to the three isolates.

FIELD STUDIES

Field studies were developed in an attempt to determine the usefulness of laboratory tests such as the tiller-puncture technique for the determination of the susceptibility of Kentucky bluegrass varieties to *Fusarium* blight. One study was conducted on a golf course fairway in central Illinois that had a history of severe *Fusarium* blight. Eight-inch plugs of nine Kentucky bluegrass varieties were placed in a severely diseased portion of the fairway in November, 1973. Three healthy plugs were placed together in each of three replications for each variety. These were allowed to root down and were mowed and maintained like the rest of the fairway.

In the summer of 1974 *Fusarium* blight was not severe; all of the plugs were easily recognized and healthy except for Baron and Fylking, which were slightly thinned. During the summer of 1975 *Fusarium* blight was severe, and the varieties Fylking and Baron were severely damaged, as was the surrounding turf. The variety WTN-I-13 showed the least amount of damage with the varieties WTN-H-7, WTN-A-20-6, A-20, and WTN-I-2 ranking close behind. After two years the varieties WTN-I-13 and WTN-H-7 had grown laterally from the original 8-inch plugs, while the percentage of cover on the plugs of the other varieties had decreased in diameter. These changes, along with the difficulty in differentiating some of the plugs from the original fairway turf, made rating more difficult.

Another field study was initiated in the fall of 1974 in an area severely infested by *Fusarium* blight at the University of Illinois turf plots. In this test an 18-inch sod cutter was used to remove diseased sod to a depth of approximately 2 inches. Soil from a nearby field was used to fill these 18-inch strips back to the original grade and infested turf was left intact on both sides of the strips. Seed of 32 varieties, including most of the abovementioned varieties, was then used to plant 3 replicated plots for each variety in plots 3 feet long in the 18-inch strips. *Fusarium* blight was severe in the turf surrounding the 18-inch strips, but the new seedings remained free of *Fusarium* blight during the 1975 growing season.

DISCUSSION

The variation in the virulence of the three isolates in the tiller-puncture test is similar to the variation reported by other workers (3) with different *Fusarium* isolates. A limitation with the tiller-puncture test is that each inoculation is made with a single strain of the pathogen. Since the *F. roseum* and *tricinctum* species vary greatly in nature, a larger number of isolates need to be included in tests to increase their validity.

None of the varieties in the tiller-puncture test remained completely healthy. WTN-I-13 was the least severely affected variety in both the tiller-puncture and the field study. Other tests are needed in different locations with this variety to verify its degree of susceptibility to *Fusarium* blight. Some of the varieties that ranked intermediate in the laboratory tests also ranked intermediate in the field test. It should be noted that Merion was not the most susceptible variety in the test. The high degree of susceptibility of Fylking to *Fusarium* blight has been reported in different locations (5). The susceptibility of the variety WTN-J-79 at a level similar to Fylking is an indication that this variety may perform poorly in areas where *Fusarium* blight is severe. The tiller-puncture test with a limited number of isolates may be most useful as a method to detect a high degree of susceptibility in a variety before it is released. Many experimental and commercial Kentucky bluegrass varieties besides the 14 reported in this paper have been inoculated with the MSU1 isolate, using the tiller-puncture technique. To date, no variety has remained free of infection. It is hoped that this technique will at some time aid in detecting a source of germ plasm that has a high degree of physiological resistance to *Fusarium* blight.

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