

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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Fusarium Blight

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 stresses 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 is 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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