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REFLECTIONS ON FUSARIUM BLIGHT

By Dr. Richard W. Smiley

Fusarium blight on Kentucky bluegrasses results from the growth of these grasses under stress. The disease will continue to disfigure bluegrass stands as long as those grasses are grown under cultural and environmental conditions to which they are not well-adapted. Long-range disease control, therefore, is dependent upon removal of that stress, either through changes in the cultural management procedures, or through use of other varieties or other species that are better adapted for growth under current management and environmental regimes.

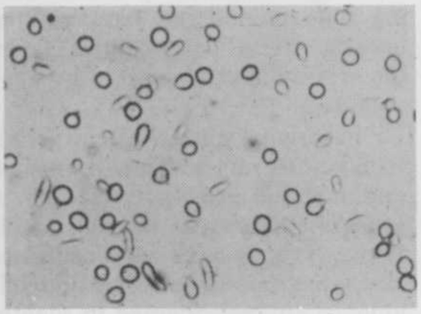
Various opinions on the causes of Fusarium blight have arisen, and some research results have differed. Opposing viewpoints arise because the precise causal reason for the development of Fusarium blight probably varies on every different bluegrass stand, and on different areas

within the stand. For example, thatch accumulations may be the primary stress factor in one area, low pH in another, drought in another, combinations of these in other areas, and so on.

The overall health of any turfgrass stand depends upon the balance which exists among the disease components — which are host plants, pathogens, and the environment. Each of these primary components are in turn comprised of a multitude of subcomponents. As the balances among the subcomponents are altered, an infinite number of gradations from severe disease to no disease may result. Long-term and stable control of Fusarium blight, therefore, depends upon the establishment of a turfgrass community where the pathogen's activity is restricted by as many subcomponents as is possible. A brief discussion of the more important variables may help you to find additional approaches for controlling this disease on your turfgrass.

The pathogens

Fusaria are among the most widely distributed fungi on earth, and they can be isolated from nearly all turfgrasses, soils and thatch, even though the turfgrasses remain healthy. Fusaria, including Fusarium tricinctum and various species of the F. roseum type, are a normal and necessary component of the soil and thatch microflora. These omnipresent soil fungi aid in thatch decomposition, recycling of nutrients, parasitism of other fungi (including pathogens) and insects, and other desirable phenomena. Widespread distribution of the fusaria occurs when mycelial fragments or spores are moved by the wind, on seed, on sod, on other wind-blown crop debris or soil, by water, by man and animals, and by other means.



Dispersal and survival of Fusarium is by spores and hyphae.

Photomicrograph of the macroconidia, the asexual fungus spore.

Fusarium blight on Merion fairway.

Fusaria frequently inhabit underground tissues of turfgrass plants, but only become weakly pathogenic and cause disease if plant growth becomes impaired. They cause little or no harm if the environment is favorable for growth of the host and of the general microflora. Since these fungi are very frequently found in and on normal turfgrasses, a manager should not be surprised to find them listed among the fungi isolated from healthy or diseased turfgrasses. It should also be recognized that reductions in their numbers through the use of fungicides are very temporary, at best.

Frequent applications of fungicides to repeatedly reduce the numbers of any common soil organism in any perennial crop involves a costly and often unnecessary program that is likely to fail after prolonged use. It is also important to recognize that fungicides simply offer a short-term relief of symptoms, and not a long-term solution to the problem.

The hosts

If the fusaria have been part of the normal microbiological equilibrium of sod for centuries, why has Fusarium blight been known to turfgrass managers for only about 16 years, and why does it continue to increase in importance. Answers to these questions are not easy, but they probably relate to the widespread introduction of Kentucky bluegrass selections for use as monocultures in the early 1950's.

The full acceptance of Kentucky bluegrasses was roughly coincidental with the discovery of Fusarium blight, which suggests that this host and its cultural and chemical management are more responsible for the disease than is the pathogen. Thus it is not surprising that the disease incidence and severity are generally greatest where the management of these grasses is most intense.

Kentucky bluegrass varieties differ greatly in susceptibility to Fusarium blight in the field, but all appear to be susceptible, to attack by the fusaria if they are grown under highly adverse conditions, and in artificial soil and microbial environments in the greenhouse. Fusarium blight thus appears to be a possibility in older stands wherever a manager is attempting to use a variety in an area where it is not well-adapted to the existing environmental stresses, or is attempting to use in environmentally marginal areas a resistant variety under management procedures for which the variety is not well-adapted.

Those varieties that are only moderately susceptible in the field may perform very well in areas where there is moderate disease pressure, but would not be recommended as highly as the most resistant varieties in areas where Fusarium blight occurs often. Since many different species and strains of fusaria are associated with Fusarium blight, resistance is based more upon environmental tolerances of the host than upon an incompatibility between specific Fusarium isolates and the host variety. Resist varieties are, therefore able to withstand drought, temperature or other stresses better than susceptible varieties in the selection nurseries and other test areas.

The environment

The environment is the most important factor affecting the growth capabilities of hosts and of pathogens. The environment is very complex since it consists of interdependent biotic and abiotic subcomponents, which in turn have many interdependent factors of their own.

Abiotic factors include air temperature and humidity, mowing, pesticides, soil moisture, soil fertility, soil compaction, soil acidity and many others. Biotic factors include the microorganisms on soil, thatch and leaves, the vegetative thatch components, insects and mites, nematodes and even smaller soil animals, and so on. But single environmental factors are probably never solely responsible for predisposing plants to Fusarium blight.

Interactions among factors are of greater importance than individual factors since a change in any specific factor may cause a change in many others until a new balance is achieved. That balance may or may not predispose the plant to disease development. Several examples of this complexity and their effect on turfgrass follow.

Nitrogen concentrations which are most favorable to turfgrass growth differ for each variety and its intensity of management. Excessive nitrogen, or its imbalance with other mineral elements, may increase the attraction of the fusaria to plant tissues and exudates (shoot and root), may increase the shoot-to-root ratio such that the rate of water depletion is accelerated, and may increase the rate of thatch accumulation by increasing the rate of vegetative growth more so than that of microbial decomposition of organic debris.

Excess nitrogen also reduces the plant's heat tolerance, the pH of thatch or soil, and the carbon-to-nitrogen ratio of thatch. All of these responses to excessive nitrogen favor mycelial growth and/or germination of dormant spores of Fusarium, and favor stimulated growth of the mycelium which has been relatively inactive inside the crowns of apparently healthy plants.

Optimal temperatures for many fusaria are above the optima for many Kentucky bluegrasses. High temperature stress may result in reduced growth, accelerated root maturation, and inhibition of enzymatic activity. The latter may cause shifts in nitrogen components from molecules that are structurally bound to those that are in the plant sap and the exudates of roots and leaves.

Fusarium blight is generally absent during cool to moderate temperatures.

Pathogenesis is favored by an increase in the nitrogen content of plant fluids. Heat hardiness is reduced by sudden drought, excessive nitrogen, acidic soils, and close mowing. Fusarium blight severity increases as the root temperature increases. Soil on south slopes may be considerably warmer than on north slopes, and the rate and magnitude of temperature changes are greatest on the drier soils.

Leaf temperatures may be much higher than air temperatures, and midday syringing is useful for reducing that leaf temperature. It is interesting also that these same fusaria can grow even at near-freezing temperatures, and can contribute to winter disease which is normally caused by Fusarium nivale. Fusarium blight is generally absent during cool to moderate temperatures because those temperatures favor the maximum expression of host resistance.

Fusarium spores often germinate best in very acid environments, and mycelial growth is favored in moderately acid to neutral conditions. The Kentucky bluegrasses and many microorganisms and soil animals are best adapted to slightly acid to neutral environments, and it is in this range that the host is best able to resist disease.

Gradients of pH occur in soils, and in the eastern United States, thatch is often more acidic than the underlying soil. Acidic thatch and soils impede nitrogen transformations, thatch decomposition, and other processes.

Fusarium blight is often first found on the driest sites because, unlike many fungi, the fusaria are adapted to growth in dry environments, while their Kentucky bluegrass host and most microorganisms are adapted to moist environments. Fusarium numbers are often greater in cyclically wetted and dried areas than in continually moist areas because the pathogen is attacked continually by other microorganisms in moist environments, and only periodically attacked where moisture levels fluctuate greatly. The pathogen also sporulates profusely as nutrients are released during the rewetting of dried thatch.

Fusarium blight is sometimes favored by the use of pesticides: 1) which accelerate thatch accumulation by inhibiting the activity of thatch — decomposing microorganisms; 2) which inhibit nitrification and other mineral transformation processes; 3) which suppress activities of microorganisms that are antagonistic toward or competitive with the pathogenic fusaria; and 4) which weaken the plant. Much more disease is likely to be found, for instance, on Kentucky bluegrasses where any suppressor of Poa annua has been used.

Each pesticide differs in its potential side effects, and the magnitude of side effects are frequently dependent upon other environmental variables. Since many pesticides have no observable side effects at all, it is wise to keep abreast of the latest information to identify those that do.

Keen competition exists among all organisms for food resources, and so it is with the microorganisms in the soil and thatch. Maintaining a microbial balance that favors the host and is unfavorable to pathogenic fusaria is extremely important because unintentional limitations imposed on primary competitors of pathogens could lead to pathogen multiplication and then severe disease. We need to utilize these competitive or antagonistic microorganisms, these natural biological control mechanisms, to help restrict the activity of pathogens.

Each pathogenic fungus is affected by different groups of microbial competitors and antagonists and each of these groups may in turn be affected by different levels or types of environmental factors, and by different pesticides. Fungicides vary widely in their toxicities to different groups of nontarget organisms as well as to pathogens. The use of a specific pesticide in the spring can, for example adversely affect components of the microflora other than the target pathogen. If those other nontarget microorganisms are

Fusarium blight will never be controlled in all areas because the plant's resistance is relative.

strong competitors or antagonists of pathogens which cause diseases in the summer, and if the spring-applied fungicide is ineffective against the summer pathogens, then that early pesticide application would increase the tendency for development of summer diseases. The overall efficiency of the pest management program would have been favored by the selection of a fungicide in the spring which did not affect antagonists of the pathogens which cause summer diseases. When one views turfgrass culture with these thoughts in mind, it is not uncommon to observe trends for more severe disease outbreaks where certain chemicals have been used earlier. Research on the effects of commonly-used fungicides on the microflora components of turfgrasses is badly needed.

Disease control

The first priority in any long-term plant disease control program is to choose the species and varieties that are best adapted to the area and to the management conditions under which they will be grown. Several varieties with good resistance are now available and should be used in sodding, reseeding, and overseeding programs in Fusarium blight-prone areas. The very latest precise information about varieties, their adaptation, and their culture will come from attandance at conferences, from extension personnel, and from other specific papers in trade and technical journals. The best overall compilation of philosophies and research on Fusarium control was presented at the 1975 Illinois Turfgrass Conference. Those proceedings were published in Weeds Trees & Turf (July, 1976), and reprints are available.

It is my opinion that Fusarium blight will never be controlled in all areas because the plant's resistance is a relative factor which depends upon the type and the amount of stress present.

Newly introduced, highly efficient Fusarium blight-resistant varieties will probably be used even further south than is possible with older varieties, and these new varieties will then also be subjected to stresses for which they are not adapted. These future abuses of newly introduced varieties are predictable.

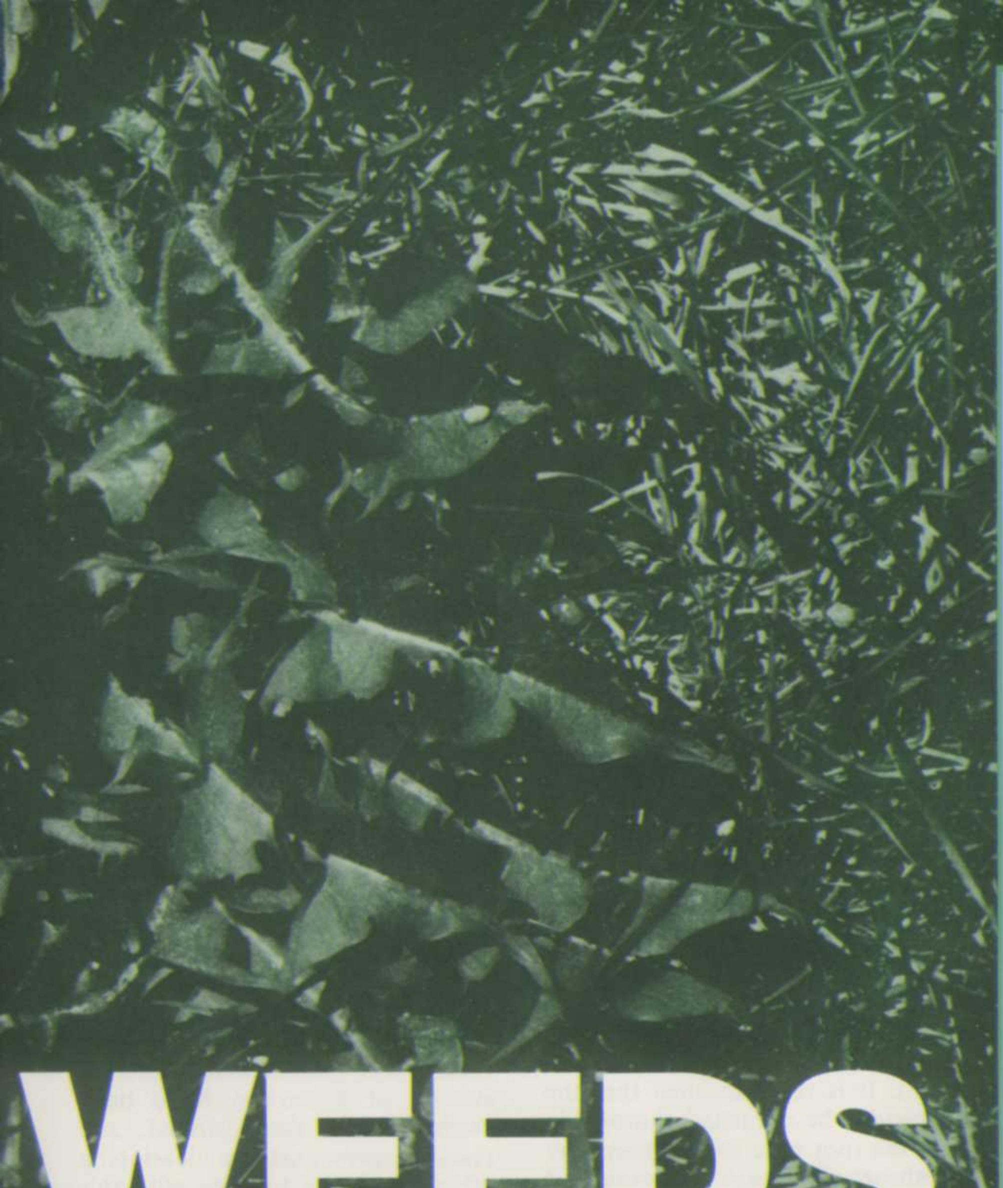
Turfgrass managers should remember that changes in turfgrass genera rather than varieties are a readily available means for achieving the overall goal of suppressing Fusarium blight. Grasses that appear to resist Fusarium blight in the field include bermudagrass, zoysiagrass, creeping bentgrass, and perennial ryegrass.

The second priority in long-term disease control programming is to utilize the best management procedures for the variety being grown. Even the most resistant variety can be predisposed to disease by adverse management. Likewise, the successful culture of any given variety can be extended further into hostile climatic regions if given the best possible management. Although it is beyond the scope of this paper to discuss details of these general approaches, some guidelines will be given.

Primary stresses which influence disease development on Kentucky bluegrasses include excesses of soil acidity, thatch, fertilizer, humidity, turf canopy temperature, and nematodes, as well as drought, low mowing height, incorrect timing of fertilizer applications, and use of certain pesticides. Excess soil acidity should be corrected by liming to maintain a pH of above 6.2. Light, frequent applications may be preferable where thatch rapidly becomes acidic due to high amounts of rainfall or irrigation.

Thatch should generally not ex-

Continued on page 28



Herbicide and Broadleaf Weed Susceptibility

Weed	2,4-D	Silvex	Meco-prop	Dicamba
Bindweed	S	S-I	S-I	S
Bittercress	S	S-I	S-I	S
Black medic	R	S-I	I	S
Buttercup	S-I	I	I	S
Carpetweed	S	S	S	S
Chickweed,				
common	R	S	S-I	S
Mouse-ear	I-R	S	S-I	S
Chicory	S	S	S	S
Clover, crimson	S	S	S	S
Hop	I	S	S	S
White	I	S	S	S
Cranesbill	S	S-I	S-I	S
Daisy, oxeye	I	I	I	I
Dandelion	S	S	S	S
Dock	I	I-R	I-R	S
Dogfennel	I	S	I	S
Garlic, wild	S-I	R	R	S-I
Ground ivy	I-R	S-I	I	S-I
Hawkweed	S-I	R	R	S-I
Henbit	I	S	I	S
Knapweed, spotted	I	S-I	I	S
Knawel	R	S	I	S
Knotweed	R	I	I	S
Lambsquarter	S	S	S	S
Lespedeza	I-R	S	S	S
Mugwort	I	I-R	I-R	S-I
Mustards	S	S-I	I	S
Nutsedge	I	R	R	R
Onion, wild	I	R	R	S-I
Ornamental plants	S-I	S-I	S-I	S
Woodsorrel	R	S	R	I
Pennycress	S	S-I	I	S
Pepperweed	S	S-I	S-I	S
Pigweed	S	S	S	S
Plantains	S	I	I-R	I-R
Poison ivy	I	S	R	S-I
Pony foot	S	I	I	S-I
Prostrate spurge	I	I	I	S
Purslane	I	S-I	R	S
Red sorrel	R	I	R	S
Shepherdspurse	S	S	S-I	S
Speedwell	I-R	I-R	I-R	I-R
Spotted spurge	I-R	I	S-I	S-I
Thistle, musk, curl	S	I	I	S
Thistle, Canada	I	I	I	S
Vegetables	S	S	S	S
Wild carrot	S	S-I	S-I	S
Wild strawberry	R	I	R	S-I
Yarrow	I	I-R	I-R	S
Yellow rocket	S-I	I	I	S-I

S = weed susceptible; I = intermediate, good control at times with high rates, sometimes poor, usually require more than one treatment; R = resistant weeds in most instances.

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ceed a depth of one-half inch, and it should not require mechanical removal if other environmental factors are favorable.

Well balanced fertility is essential for production of healthy turfgrass plants, and excesses of nitrogen should be avoided. Fertilizer applications should not be made shortly before or during the midsummer heat and drought stress period.

Deep, infrequent watering is essential for proper root growth. Shallow roots which result from light, frequent irrigations are highly susceptible to high heat and drought, but supplemental "syringes" just before the hottest part of the day can reduce leaf and surface temperatures and thus offset the full detriment of excess radiant heat buildup in leaf blades. In that nematodes can reduce the efficiency of roots, excess numbers should be controlled if research in your area indicates that they are contributing to the disease.

Areas of increased humidity due to poor air circulation also have a higher incidence of the disease. Proneness to Fusarium blight is increased in some varieties as the cutting height is reduced. Varieties differ in their tolerance to low mowing, and should be selected according to your specific management program. A variety that is very susceptible to the disease on golf course fairways may be highly resistant in the roughs and on institutional and residential sites.

Pesticides that weaken the plant, or that otherwise reverse the general overall goals of your management program can increase the incidence of diseases, such as Fusarium blight. Specific pesticides that have contributed to this disease include tricalcium arsenate and chlordane. Several fungicides are also suspected of being in this category, but since reasonably clear evidence is lacking at this time, names cannot be mentioned.

Where varietal and cultural controls remain ineffective, the turfgrass manager must utilize chemical controls until the causal stresses of Fusarium blight are overcome. A balance exists here also. As the proneness of turfgrasses to Fusarium blight is progressively increased, either through the use of varieties that are very susceptible to disease in your area or through adverse cultural management, increasing amounts of chemical fungicide will be required to effect satisfactory control.

As turfgrasses become extremely susceptible to the disease, it is possible that no chemical can provide adequate protection. Conversely, as the management becomes more favorable, less fungicide will be needed for disease control and, at some point, the application of any fungicide will become unwarranted.

Pesticide manufacturers and research personnel are in agreement that attempts at chemical control alone will be far less effective than if these attempts are coordinated with other control approaches.

Currently-registered fungicides that are effective against Fusarium blight all belong to the systemic benzimidazole class (benomyl, thiophanate-methyl, and thiophanate-ethyl). It is recommended that the fungicides be drenched thoroughly into the root zone so that they may be absorbed through the roots, and translocated systemically upward through the crown and leaf tissues to provide overall protection of the plant. These fungicides do not move significantly downward within the plant and, therefore, foliar applications will not adequately protect the root and crown tissues.

The benzimidazole fungicides are tightly bound to organic matter, and if they are allowed to dry, even briefly, onto leaf surfaces and thatch, subsequent drenches with water will be ineffective in moving the fungicide to the root zone. If rapid drenching is a problem, such as on warm days or where water is in limited supply, it is helpful to make the drenching applications early in the morning while dew is on the grass, or in the rain. Since aboveground symptoms of Fusarium blight develop only after extensive deterioration of roots and crowns, it is imperative that the first fungicide drench be made before these symptoms appear.

At least one follow-up application 10 to 14 days after the first application is recommended. Specific recommendations are available from your local cooperative extension personnel and from university turfgrass specialists.

Statements are sometimes made that the benzimidazoles are ineffective in controlling Fusarium blight at some locations. Diseased tissue can be sent to a laboratory to determine whether benzimidazole-tolerant fusaria are present, but most laboratory studies currently indicate that any lack of chemical control must be attributed to some other reason, such as improper timing, rates or methods of fungicide application, or such as adverse cultural management procedures and susceptible varieties which lead to conditions of excessive disease-proneness that cannot be overcome by even the best fungicide application procedures. Tolerance of the causal fusaria to the benzimidazole fungicides is seldom responsible for lack of effective Fusarium blight control.

I am aware of only a few locations where benzimidazole-tolerant strains of Fusarium have been experimentally demonstrated, and research personnel are developing other fungicides to cope with this problem. Promising new fungicides such as hydantoin (Rhodia, Inc.), fenarimol (Eli Lilly, Inc.), and bayleton (Chemagro Div., Mobay Chemical Corp.), and their effect on Fusarium blight in New York are shown in the photographs. The use of newly-discovered fungicides in rotation or in combination with the benzimidazoles would also lessen the tendency for tolerances to develop where the benzimidazoles are currently highly effective. □

Dr. Richard W. Smiley is assistant professor and turfgrass Pathologist at New York State College of Agriculture and Life Sciences at Cornell University.

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TOPDRESSING WITH SAND

by Dr. Douglas Hawes

Topdressing with sand versus none and summer versus winter fertilization are four management tools I am presently studying in an attempt to learn how to grow combination cool and warm season turfgrass combinations in the transition zone. I am attempting to grow these combinations for use on tees, athletic facilities, fairways and home lawns. In this study, topdressing with sand has greatly benefitted Penncross creeping bentgrass. At the same time Kentucky bluegrass, a blend of five varieties, has done better where it was not topdressed.

Topdressing was first applied in early summer of 1974. In 1975 and 1976 applications were made in late spring, mid-summer and early fall. The sand used has 89% of its size distribution between 0.1 and 1.0 mm. Each application consists of just under ⅛ inch. It is brushed and watered into the turf. The turf is maintained at ¾ of an inch from late spring till early fall. Height of cut is maintained at one inch after the fall topdressing till late spring.

The first noticeable benefit of topdressing was in the fall of 1975. During August, 1975, the bentgrass had been almost eliminated by chinch bugs, brown patch and drought. When the warm season grasses turned brown after the first hard frost it became very clear that the bentgrass was in much better shape where it had received topdressing. Similar data, but without clear differences, were obtained this fall.

On the topdressed half of these plots less winter annual weeds, lower severity of spring dead spot on bermuda, and a lower percentage of dead areas due to insect, drought and disease damage have been observed. Thus the quality of turf was found to be significantly better on topdressed plots in July and November of 1975 and in February, April, June and July of 1976. Thatch accumulation appears to be less in the topdressed plots. However, thatch has not yet become a problem, and thatch measurements have not been made yet.

Some layering of sand and organic matter has been observed. The layering does not appear to be creating a problem. Lighter, more frequent applications would eliminate this layering. Lighter applications would also be easier to work into the turf than the present ⅛ inch application.

There is very little literature on

The percentage of Kentucky bluegrass in a combination cool and warm season mixtures as influenced by topdressing.

Date	Topdressing Treatments None	3 appli./yr.
April thru July '75	34 avg.	33 avg.
Sept. 75	11	10
Nov. 75	18	17
March 76*	46	36
May 76*	50	39
June 76	39	30
July 76	25	17
Sept. 76	13	10

*Means for these dates different at the 5% level of significance.

The percentage of creeping bentgrass in combination cool and warm season mixtures as influenced by topdressing.

Date	Topdressing Treatments None	3 appli./yr.
April thru July '75	48 avg.	48 avg.
Sept. 75*	10	21
Nov. 75*	9	37
March 76*	29	49
May 76*	35	52
June 76*	40	51
July 76	36	45
Sept. 76	3	7

*Means for these dates different at the 5% level of significance.