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BY

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OCCURRENCE OF THE ZONATE-EYESPOT FUNGUS HELMINTHOSPORIUM GIGANTEUM ON SOME ADDITIONAL GRASSES[1]

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INTRODUCTION

In a previous paper[3] the occurrence of the zonate-eyespot fungus (*Helminthosporium giganteum* H. and W.) on more than a score of grasses was recorded and a brief description of the lesions as they appear on each host was given. The account in question incorporated the results of observation begun in 1922, when the parasite was especially destructive and abundantly distributed, and continued as occasion offered not only in the vicinity of the District of Columbia but also in various other localities during the four following seasons, all of which were marked by a considerably diminished prevalence of the fungus. The season of 1927 likewise revealed only moderate development of zonate eyespot, so that observations in the territory previously covered yielded little additional information. In 1928, however, the disease reappeared with more than ordinary severity. Its obvious destructiveness to a number of favorable hosts in the experimental grass plots at Arlington Experiment Farm, Rosslyn, Va., insured throughout August and September a liberal supply of conidia to which the other grasses under cultivation were exposed to a greater or less degree, depending, of course, somewhat on the relative distances and the positional features which the arrangement of the grounds entailed. Opportunity was thus afforded for noting especially the degree of susceptibility of a rather rich assortment of graminaceous species added to the plantings since 1922, among which many represent introductions from foreign lands where the parasite under consideration is not known to occur at present.

PRESENT INVESTIGATION

Foliar injury attributable to *Helminthosporium giganteum* was manifested in 11 grasses not hitherto recorded as hosts of that parasite. The determination of *H. giganteum* as the causal agent was accomplished through the identification either of fructifications growing out of the lesions or, in the case of the more unfavorable hosts, of the adhering evacuated conidial membrane, which from its position relative to the diseased tissue could safely be regarded as the envelope of the spore that had occasioned some particular instance of injury. It may be mentioned that two other species of Helminthosporium were present in large quantities in the experimental plots. One was the unnamed form briefly characterized in 1925[3] as a parasite of redtop (*Agrostis palustris* Huds. = *A. alba* L.) but here found energetically

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[2] The writer gratefully acknowledges his indebtedness to Agnes Chase and A. S. Hitchcock for identification of various grasses discussed in the present paper and for information relating to nomenclatorial questions.

[3] DRECHSLER, C. A LEAF-SPOT OF REDTOP CAUSED BY AN APPARENTLY UNDESCRIBED SPECIES OF HELMINTHOSPORIUM. (Abstract) Phytopathology 15: 51–52. 1925.

parasitic on seaside bent grass (*A. maritima* Lam.). The other caused severe leaf spot, mostly of the spot-blotch type, of a considerable number of grasses belonging to the genera Bromus, Calamagrostis, Elymus, Festuca, and Lolium, and would seem referable to *H. sativum* P. K. and B. Although in most cases the appearance of the lesion provided a valuable clue to the identity of the species of Helminthosporium involved, it could not be relied on sufficiently to obviate the necessity of procedure more trustworthy than macroscopic inspection. Thus a sprinkling of lesions of the simple eyespot type found on the leaves of *Calamagrostis epigeois* Roth, which strongly suggested injury from *H. giganteum*, was found attributable rather to the spot-blotch fungus. And again extensive foliar injury observed in a plot of buffalo grass (*Bulbilis dactyloides* (Nutt.) Raf.), which bore great resemblance to the zonate development of *H. giganteum*, could not be referred to any species of Helminthosporium, nor indeed to any other fungous agent, but was apparently of nonparasitic origin.

Among the various grasses severely attacked by *Helminthosporium sativum*, several bore evidence also of injury from *H. giganteum*, though the number and extent of the lesions due to the latter organism in such instances were for the most part inconsiderable. The pathological effects of the eyespot fungus on these grasses will not be discussed in the present paper, as it is hoped that in some other season a decreased development of the spot-blotch parasite, or preferably its absence, may make available a supply of less ambiguous material. In most of the plots of *Agrostis maritima* the presence of the sclerotium-forming species of Helminthosporium already referred to interposed a similar cause of confusion. However, in a few of the plantings, perhaps because of a greater degree of resistance in the host strain involved, infection from that source was present only in negligible quantity. Their close proximity to grass plots heavily infected with zonate eyespot, on the other hand, encouraged a fair representation of lesions due to *H. giganteum*, so that the reaction of seaside bent to this parasite could be observed under tolerably favorable conditions. The material used for illustrating the eyespot lesions on seaside bent, like that of the other hosts on which the presence of other parasites could be suspected, was first examined microscopically and the presence of an evacuated spore membrane of *H. giganteum* on each lesion confirmed. The likelihood of leaf spots other than those due to the zonate-eyespot fungus being included in the illustrations of this paper or in those of the preceding contribution, therefore, was effectively obviated.

In the following paragraphs the pathological effects appearing on the several grasses from exposure to *Helminthosporium giganteum* are briefly considered. Except when otherwise stated, the discussions are based on observations made at the Arlington Experiment Farm during August and September, 1928.

PATHOLOGICAL EFFECTS OF HELMINTHOSPORIUM GIGANTEUM ON VARIOUS GRASSES

In all plots velvet bent (*Agrostis canina* L.) was found very severely attacked by *Helminthosporium giganteum*. Because of the unusually narrow foliage characteristic of this host, the manifestation of injury is somewhat unlike that found in grasses with broad leaves. (Pl. 1, A–I.) On close inspection the incipient or small lesions, to be

sure, present the usual picture—a small, dead, bleached region surrounded by healthy green tissue. (Pl. 1, A, B.) With subsequent increase in extent as a result of secondary development, which very readily takes place under suitably moist conditions, the lesions soon occupy the entire width of the leaf. (Pl. 1, C–I.) As a result, a large proportion of the foliar organs in an actively growing stand exhibit dead segments of variable length alternating with living portions. Although in itself the destruction of segments of a leaf does not involve, at least immediately, the death of parts more distal in position, further extension of the fungus generally eventuates in the withering of the greater length of the blade affected. As the dead foliage is light-gray or light-straw colored, the general aspect of a growing turf in which the parasite has been operating for some time may be rather aptly compared to that of graying hair.

A very similar grizzly appearance is characteristic also of badly affected turf of susceptible creeping bent (*A. stolonifera* L.), especially when a narrow-leaf habit is encouraged through frequent mowing. A graying aspect is offered by diseased creeping bent even when cutting is infrequent; for, although on a close view the separate lesions can generally be distinguished on the somewhat broader leaves as discrete spots (pl. 1, T–Y; A′–J′), at a distance of 1 meter or more their individuality as well as that of the numerous completely withered leaves (pl. 1, Z) is much less apparent and thus becomes subordinate to the general appearance.

Information is not available as to whether the zonate eyespot is prevalent on velvet bent in the region, including especially the Northeastern States, where the grass is utilized in an economic sense both in ordinary lawns and more particularly as turf for golf courses. The section referred to is well north of the presumptive natural range of the disease, as far as the limits of that range may be surmised from the few collections which the writer has made. In this connection it may be pertinent to refer again to the discovery of *Helminthosporium giganteum* on creeping bent in artificially irrigated golf greens in various localities in Michigan, Minnesota, northern Ohio, northern Indiana, and northern Illinois, although no infection of other favorable hosts growing under ordinary natural conditions was found in those instances where a search was made. That the commercial distribution of infected stolons from sources within the natural range of the parasite may be held largely responsible for such northern occurrence can hardly be doubted. The distribution of velvet bent, however, has been almost wholly by seed, although a very limited traffic in material for vegetative propagation seems to have taken place in recent years. Because of its small size and the somewhat prolonged storage regularly entailed in commercial handling, bent seed would seem considerably inferior to stolons as a vehicle for the transmission of a fungus of apparently only ordinary hardiness. The human agencies operating in favor of a wide artificial distribution of the parasite in the case of creeping bent may, therefore, not have been equally effective in the case of velvet bent.

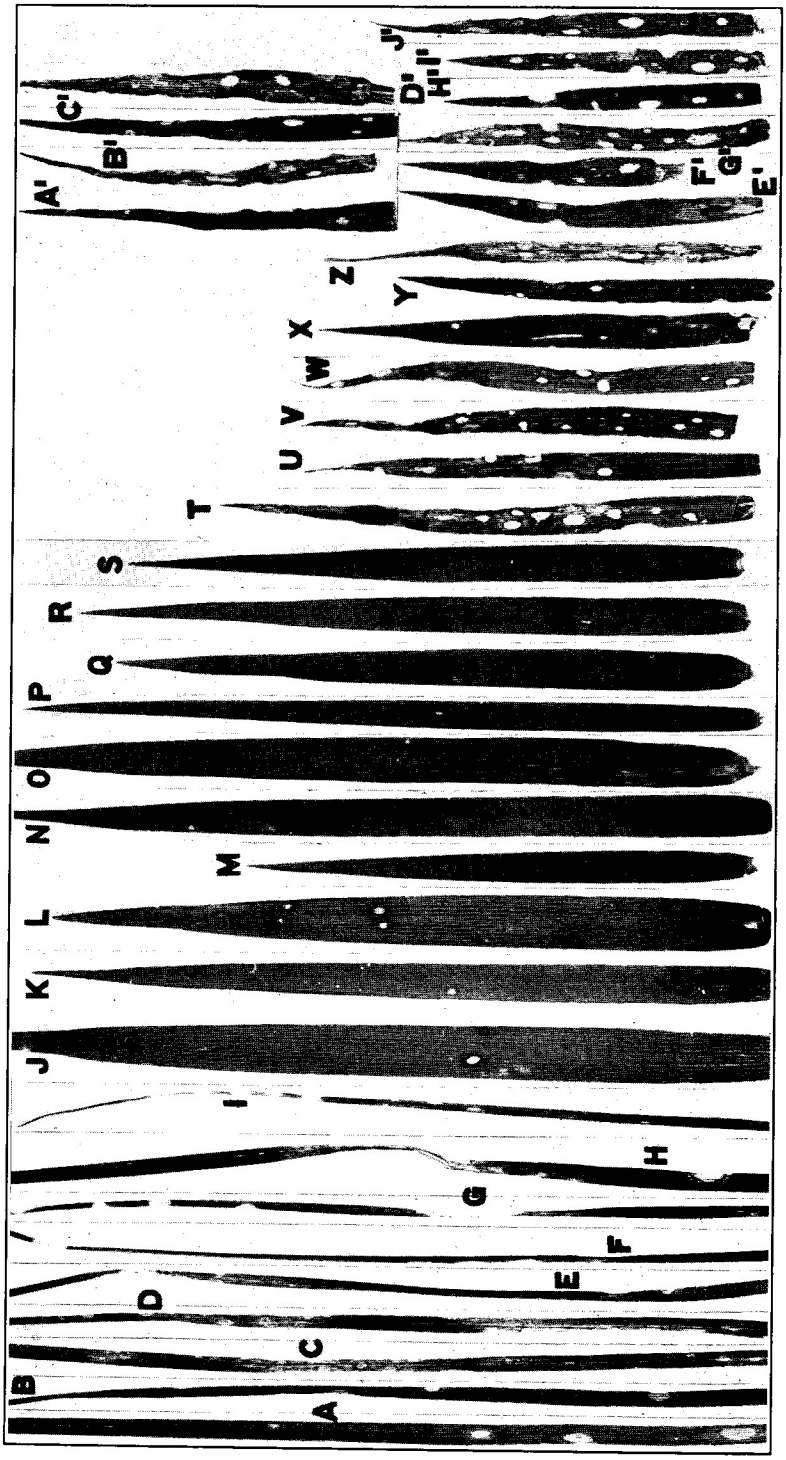
On the other hand, if the strains of velvet bent cultivated at Arlington Experiment Farm may be taken as representative of the species, this grass, once the parasite is established in a green, would suffer presumably quite as severely as the most susceptible selections of creeping bent. Irrespective of the kind of grass employed, the

conditions provided in putting greens, of course, are unusually favorable for the fungus. The frequent watering necessitated in the management of a satisfactory turf enables the parasite to extend its lesions and to continue producing conidiophores and conidia in quantity regardless of the intervention of droughty periods. Local distribution of conidia—a feature in respect to which the fungus would seem less successful under natural conditions than most of its graminicolous congeners—is undoubtedly promoted very materially by mechanical operations like mowing, rolling, or the removal of dew. Moreover, the extended season (from early in spring until late in fall) through which turf is kept in active vegetative condition can not but operate especially to the advantage of a pathogene somewhat slow in developing its attack.

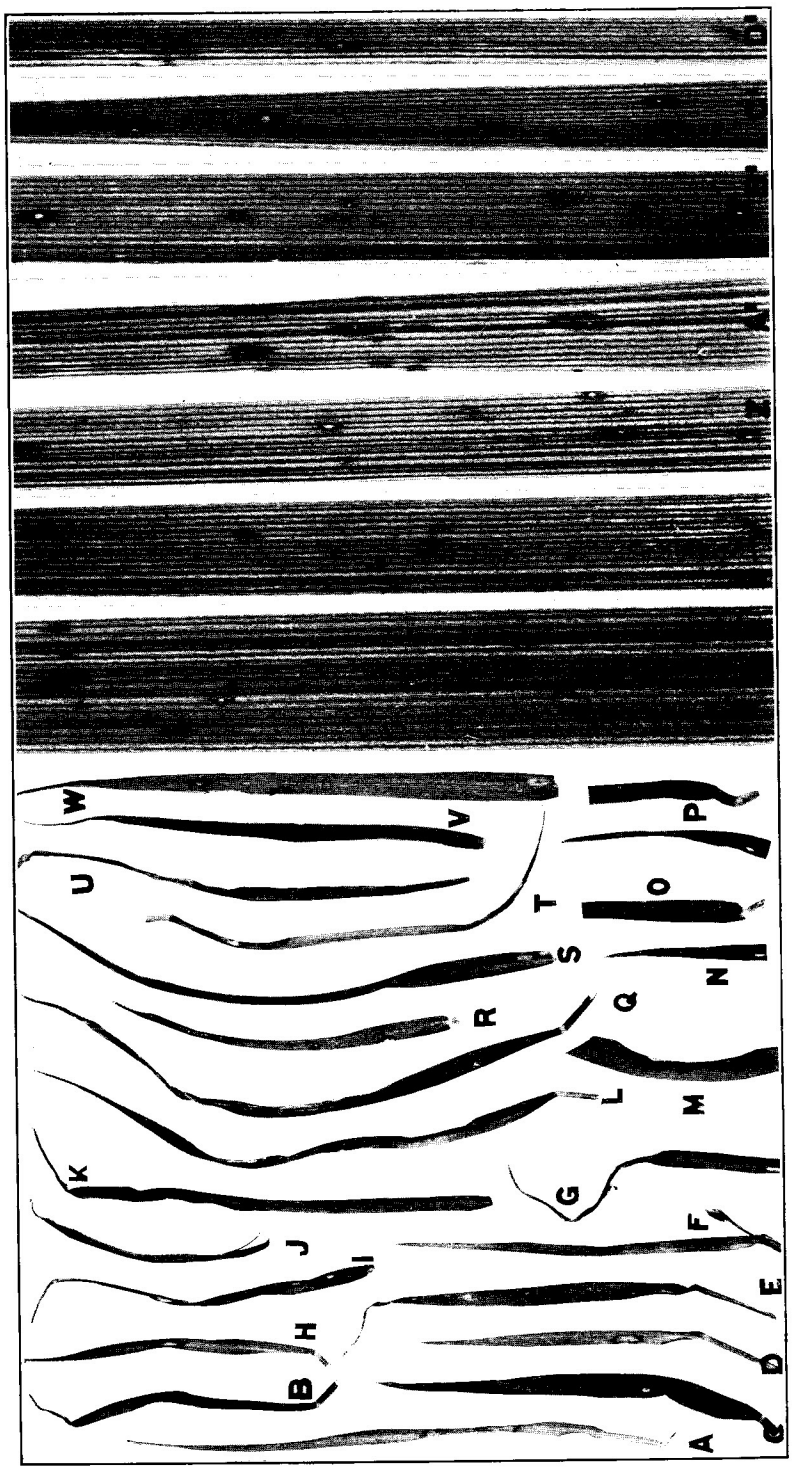
Agrostis maritima, growing in close proximity to very badly infected creeping bent, displayed only a relatively small number of lesions due to *Helminthosporium giganteum*. These lesions were of the simple eyespot type, relatively small, usually not measuring more than 0.5 mm. in length and 0.2 mm. in width, though occasionally attaining dimensions somewhat more than twice as great. (Pl. 1, J–S.) Even macroscopically the injury due to *H. giganteum* could usually be distinguished from spots attributable to the congeneric parasite so abundant on the same species of grass by their smaller size and especially by the relative proportion of central bleached tissue to the width of colored margin. In the main, the central areas of lesions due to *H. giganteum* were bleached rather completely, the contrast with the surrounding tissue being pronounced and the line of demarcation well defined, and the colored margin was comparatively narrow. On the other hand, the lesion caused by the other species of Helminthosporium consisted of a somewhat more vaguely defined, less completely bleached area surrounded usually by a wide zone of dull reddish coloration. It is hardly necessary to add that conidiophores of *H. giganteum* were never observed on the feebly attacked foliage of seaside bent, and that the latter, as far as present observations may be trusted, would not serve as host in the absence of other grasses.

Eragrostis caroliniana (Spreng.) Scribn. was found heavily attacked by *Helminthosporium giganteum*. (Pl. 2, A–W.) In the beginning individual infections were manifested in lesions of the eyespot type, which were often not more than 0.3 mm. in width and 0.5 mm. in length, and which had minute bleached centers delimited from the healthy tissue by moderately broad dark-brown or purplish-brown zones. (Pl. 2, E, K, N, O, R, W.) Subsequent enlargement of the diseased areas through centrifugal extension of the parasite occurred readily, not only bringing about malformations in younger leaves, traceable to locally impeded growth (pl. 2, B, C, M, S, L, T), but also eventually resulting in the complete or partial destruction of the foliar organ. (Pl. 2, B, G, I, L, P, Q, T, U.) Such destruction was apparent usually as a progressive withering of the affected leaf from tip toward base. As microscopic inspection of the dead tissue revealed an abundance of conidial fructifications of the parasite, there can be no doubt that *E. caroliniana* is to be reckoned among the more congenial hosts on which the parasite can maintain itself without difficulty.

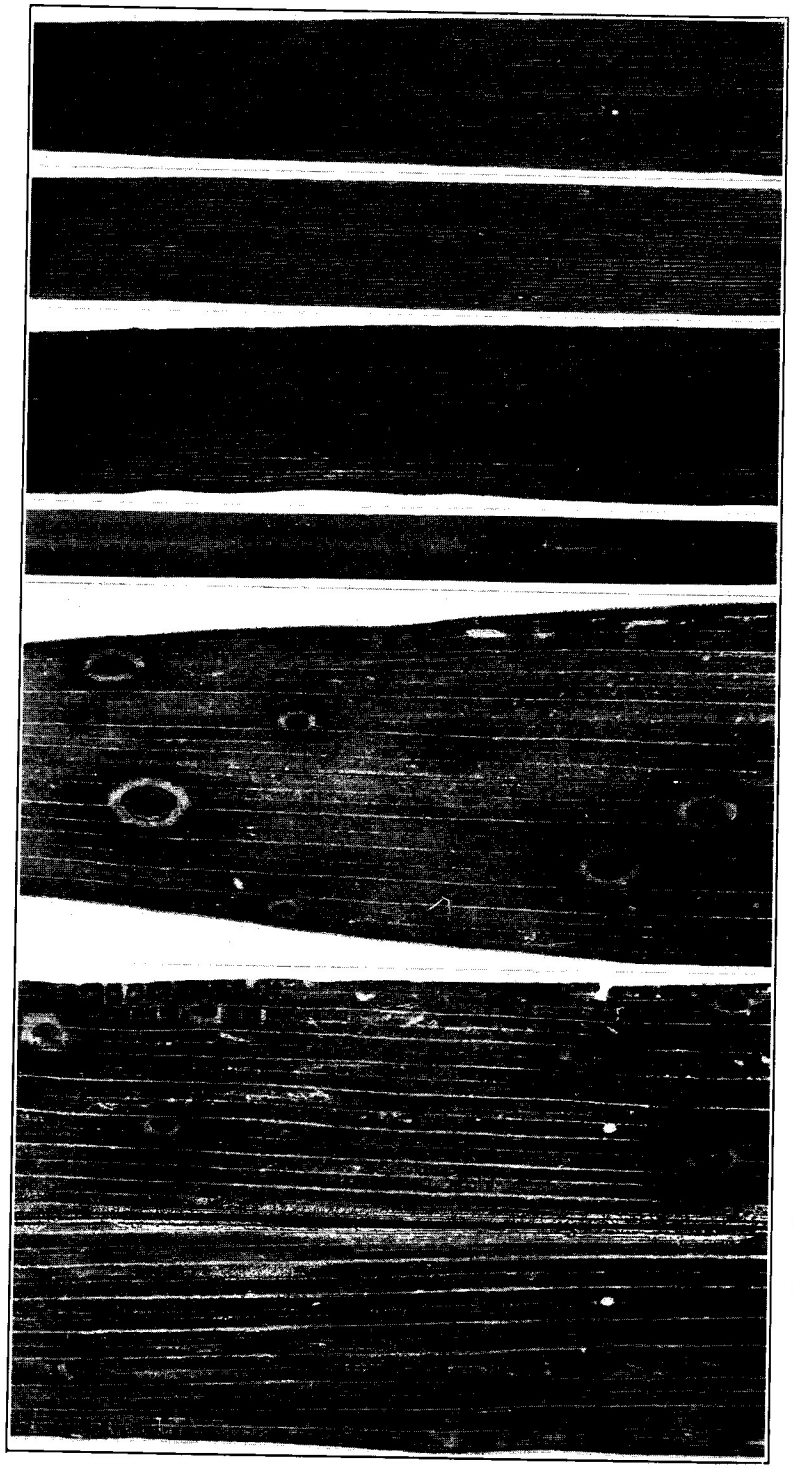
Festuca hookeriana (Benth.) Müll. (=*Schedonorus hookerianus* Benth.), a grass that plays a part in the agriculture of New South



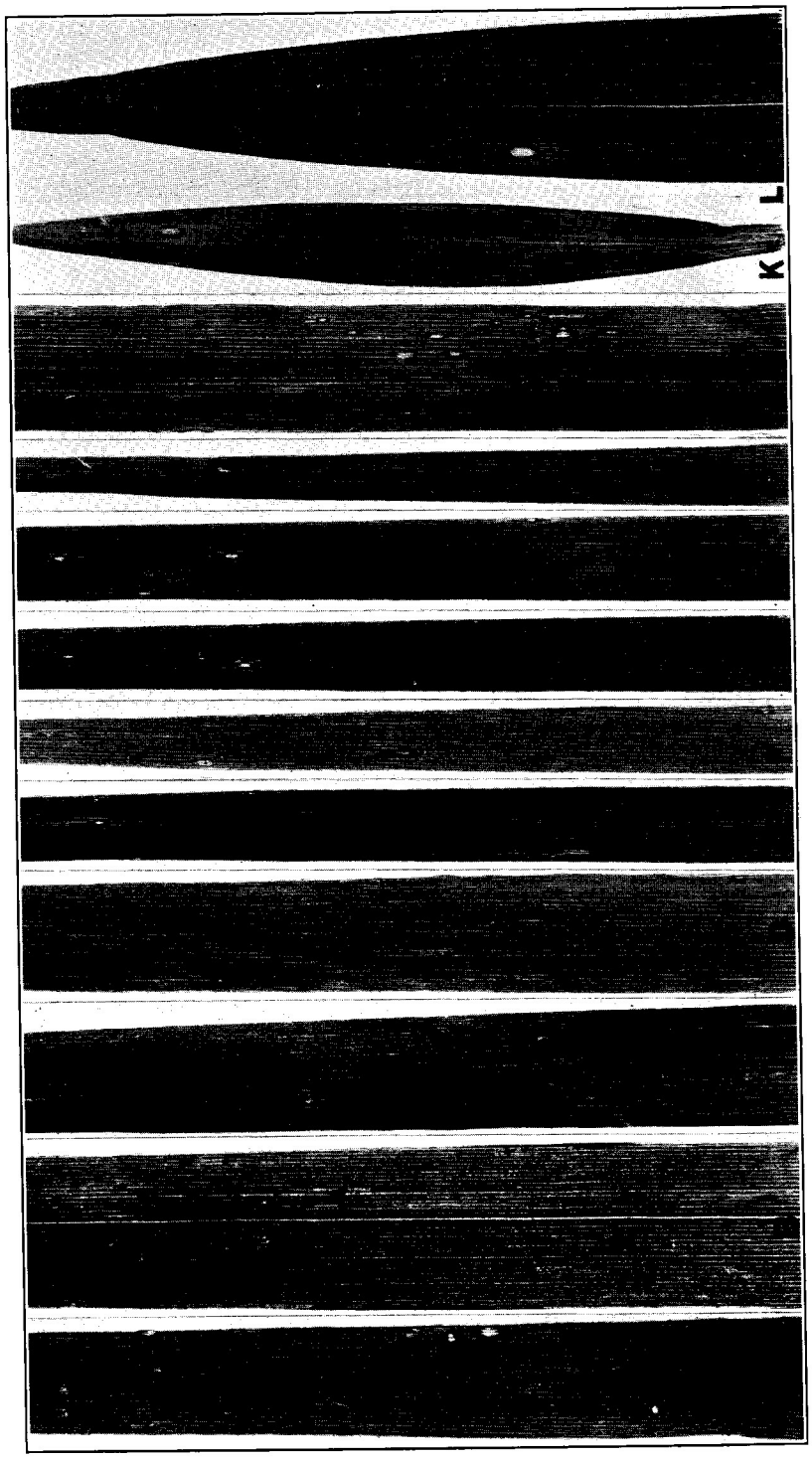
Leaves of grasses attacked by *Helminthosporium giganteum*, × 2: A–I, *Agrostis canina*; J–S, *A. maritima*; T–Z and A'–J', *A. stolonifera*



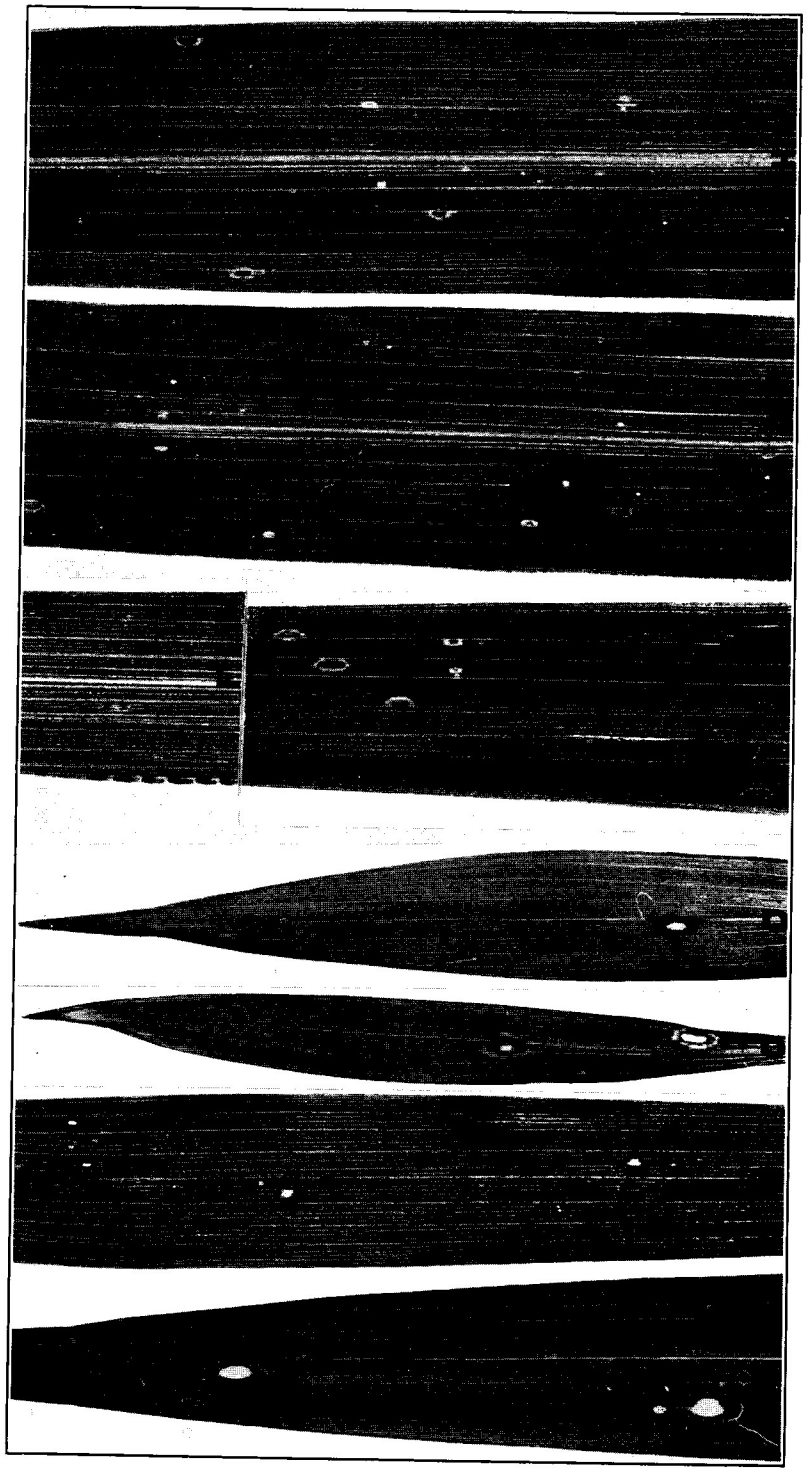
Leaves of grasses attacked by *Helminthosporium giganteum*, × 2: A–W, *Fragrostis carolinana*; X–Z and A′–D′, *Festuca hookeriana*



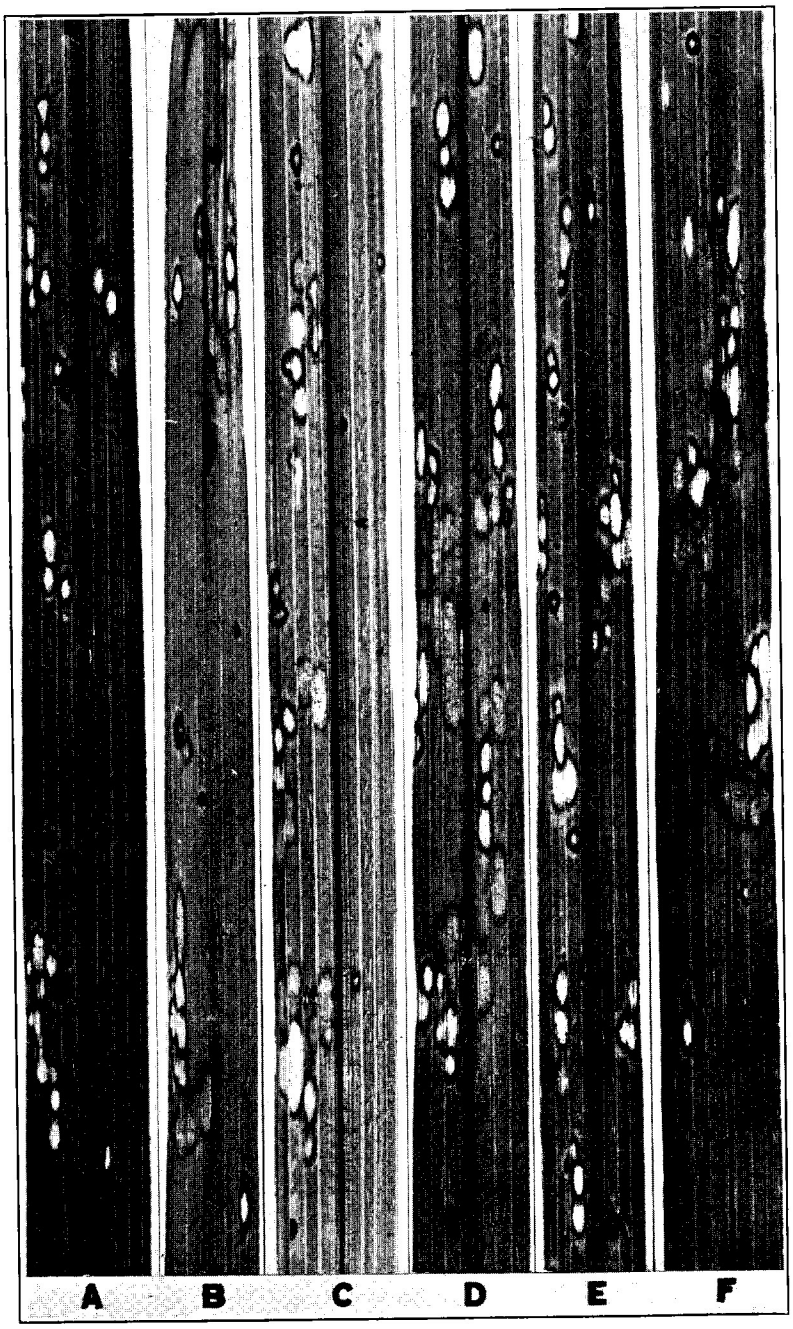
Leaves of grasses attacked by *Helminthosporium giganteum*, × 2; A and B, *Iropliorus unisetus*; C, *Pennisetum ciliare*; D–F, *Phalaris bulbosa*



Leaves of grasses attacked by *Helminthosporium giganteum*, × 2: A and B, *Phalaris bulbosa*; C–J, *P. stenoptera*; K and L, *Spodipogon sibiricus*



Leaves of grasses attacked by *Helminthosporium giganteum*, × 2: A–D, *Spodipogon sibiricus*; E–H, *Tripsacum dactyloides*



Leaves of *Sporobolus* sp. (S. P. I. No. 75378) attacked by *Helminthosporium giganteum*, × 2: A–D, series showing fresh peripheral infection in water-soaked stage present in increasing quantity; E, lesions abundant but with little zonal extension in progress; F, two zonate lesions with fresh peripheral increments; the other lesions show no current enlargement

Wales, Australia, somewhat comparable to that played in the United States by the brome grasses utilized here, was found spotted liberally with lesions due to attack by *Helminthosporium giganteum*. (Pl. 2, X–Z; A′–D′.) These were evident often as minute dark-brown spots sometimes not exceeding 0.1 mm. in width and 0.5 mm. in length. (Pl. 2, X, Y.) Occasionally the unrelieved eyespot type of discoloration persisted even in the largest of morbid regions with a width of approximately 1 mm. and a length of 4 mm. (Pl. 2, X, A′, and D′.) More generally, however, the larger number of all except the smallest lesions revealed sharply delimited, somewhat bleached central areas, often so minute as to be barely discernible, but in instances of better development sometimes attaining widths of 0.5 mm. and lengths of 1 mm. (Pl. 2, Z, B′ and C′.) In the resultant eyespot arrangement the dark-brown marginal zone was often, though not always, rather broad in comparison with the size of the central straw-colored portion. Distinctive zonate development was never observed, and microscopic examination uncovered no evidence of sporophores of *H. giganteum* arising from the discrete areas of affected tissue. It is hardly possible, therefore, that under ordinary conditions the grass would serve as a host of the parasite independently of other grasses. However, the abundance in which infection occurred would suggest that, under especially favorable conditions, with perhaps more extensive areas of morbid tissue resulting from the coalescence of separate lesions, the production of conidiophores and conidia might take place.

Ixophorus unisetus (Presl.) Schlecht, a native of Mexico, became marked in a somewhat unusual manner as a result of infection by *Helminthosporium giganteum*. The deep marginal discoloration evident in many hosts was represented on the upper aspect of the leaf by a blotch of purplish hue fading gradually into the green of the surrounding healthy tissue. In Plate 3, A and B, these purplish blotches are represented rather inadequately by the vaguely delimited dark regions surrounding the elliptical patterns, though their considerable extent is not inaccurately shown; the blotch exhibited near the upper left corner of Plate 3, B, for example, measures approximately 16 mm. in length and 7 mm. in width. The elliptical patterns consist, as the illustrations indicate, of outer zones of light coloration surrounding central regions of darker coloration, the former being of a light brownish hue and the latter of a darker reddish-brown or nearly brick-red color. The undersurface of the infected leaf generally exhibited no evidence of purple discoloration, but it did exhibit the reddish brown in the area corresponding to the central region, though usually in a slightly paler tone. The light-brown tone was represented on the undersurface only by a faintly colored halo separating the elliptical brown region from the green of the adjacent normal leaf tissue. In spite of the somewhat pronounced chromatic effects produced by the fungus, microscopic inspection failed to reveal any indication of conidiophores on any of the material examined. From the information available, therefore, *I. unisetus* can hardly be regarded as a sufficiently congenial host to propagate the fungus in the absence of other grasses.

On the leaves of *Pennisetum ciliare* (L.) Link were found a small number of longitudinally elongated dark-brown blotches attributable from microscopic examination to the germination of conidia of *Helminthosporium giganteum*. One of the largest of these lesions,

approximately 4 mm. in length and 1 mm. in width, is represented in Plate 3, C. Some of the blotches had bleached central parts, thus bringing about a somewhat poorly defined eyespot effect. Conidiophores were never observed. Evidently the grass under consideration, like the congeneric *P. alopecuroides* (L.) Spreng., is far too uncongenial as a host to support the parasite in the absence of more susceptible species.

Phalaris bulbosa L. bore a meager sprinkling of lesions, associated with overlying conidia of *Helminthosporium giganteum*. (Pl. 3, D–F and pl. 4, A, B.) Except for the incipient stages (pl. 4, B), the infections adhered to the eyespot type, a minute bleached speck being discernible often in examples not exceeding 0.7 mm. in length or 0.2 mm. in width. (Pl. 3, D, E.) In the larger examples measuring up to 2 mm. in length and 0.7 mm. in width, bleached center and dark-brown margin usually appeared in sharp contrast with each other and with the adjacent healthy tissue. (Pl. 3, F and pl. 4, A.) Conidiophores of the parasite were never observed on any of the affected leaves examined. However, the production of such structures could not well be expected from morbid tissue so inconsiderable in quantity. The independent propagation of the parasite on the host in question would seem altogether improbable.

A substantially identical reaction to the presence of *Helminthosporium giganteum* was observed on the congeneric and very similar *Phalaris stenoptera* Hackel. To be sure, an appreciably greater abundance of lesions is evident in the illustrations of the latter host (pl. 4, C–J) but this is to be attributed to the fact that the material utilized here consisted of leaves that had grown intermingled with badly infected foliage of *P. arundinacea* L. and had consequently been exposed most rigorously to conidia of the parasite. Indeed, if allowance is made for the obvious disparity in the severity of exposure, it is not certain that *P. stenoptera* might not be regarded as inherently of somewhat less rather than of greater susceptibility than *P. bulbosa*. In any case conidial fructifications of *H. giganteum* were as completely absent as in the latter species, and an approximately equal incapacity for the independent propagation of the fungus is indicated.

Spodipogon sibericus Trin. exhibited a relatively meager sprinkling of foliar lesions of the simple eyespot type attributable to infection by *Helminthosporium giganteum*. (Pl. 4, K, and pl. 5, A–D.) Bleached central parts were evident in some of the lesions that measured only 0.5 mm. in length and 0.2 mm. in width. (Pl. 5, A, B.) In the largest lesions observed, the dimensions of which were about six times as great, the elliptical cream-colored central areas were delimited rather sharply by the dark-brown or purplish-brown borders. (Pl. 4, L, and pl. 5, A, C, D.) In some instances a purplish discoloration appeared diffused in the tissue for some distance above and below the distinctly morbid part, a condition that may have been expressive of a certain measure of centrifugal infection. Under especially favorable conditions the host would seem to permit zonate development, although only to a slight extent, the halos surrounding the two larger lesions in Plate 5, A, and the grouping of the smaller lesions in Plate 5, B, being suggestive in this connection. However as microscopic examination failed to reveal presence of conidiophores on any of the affected leaves, *S. sibericus* should be considered among the more uncongenial hosts of *H. giganteum*.

An unidentified species of Sporobolus (S. P. I. No. 75378) recently introduced from Nairobi, Africa, by the Office of Foreign Plant Introduction, Bureau of Plant Industry, was revealed as one of the most favorable host of *Helminthosporium giganteum* hitherto encountered by the writer. The large number of individual lesions observed on the foliage provided evidence of a relatively low resistance to infection from germinating conidia (pl. 6, A–E), while an abundance of well-developed zonate patterns testified to the ready centrifugal extension of the parasite under suitable environmental conditions. (Pl. 6, A–F.) On microscopical inspection conidial fructifications of the parasite were found in quantity on the larger regions of killed tissue, indicating that once the parasite becomes established in a stand of this grass not only is the infection apt to become increasingly severe within the stand, but other grasses growing near by may be expected to become spotted in a measure commensurate with their proximity and inherent susceptibility. As the material used for the illustrations included in Plate 6 was collected at a time when rainy weather had prevailed during the preceding 16 hours, enlarging water-soaked zones are represented especially in Plate 6, D and F, in the somewhat poorly defined patches surrounding certain of the lesions. The more pronounced differentiation between cream-colored or straw-colored bleached areas and their delimiting dark-brown or occasionally purplish-brown borders becomes evident in this host, as in others, with the drying out of the affected tissue. The color values referred to are represented with fair approximation in the discrete lesions and older portions of zonate tracts shown in Plate 6.

Gama grass (*Tripsacum dactyloides* L.) was found very sparingly marked with incipient lesions attributable to *Helminthosporium giganteum*. (Pl. 5, E–H.) The morbid parts were manifested as brown elliptical spots, which were usually about 0.3 to 0.4 mm. in width and 1.5 mm. in length and surrounded by etiolated zones approximately 0.2 mm. in width. As might be expected in view of the inconsiderable mass of the tissue affected, the microscope revealed no sporophores of the parasite on any of the material examined. The rôle played by gama grass in the biology of the parasite, would seem, therefore, to be nearly negligible.

SUMMARY

Near Washington, D. C., 11 grasses not hitherto recorded as hosts of *Helminthosporium giganteum* were found naturally infected by it when growing under ordinary cultivation—that is, without artificial watering or other procedure that might accentuate the severity and prevalence of disease. Severe injury and abundant sporulation of the parasite was observed on velvet bent (*Agrostis canina*), a grass of some economic importance because of its usefulness in lawns and golf courses; on *Eragrostis caroliniana*, a common weed of no known value; and on an unidentified species of Sporobolus recently introduced from Nairobi, Africa, and of problematical economic utility. Readily noticeable though not severe injury, without sporulation, was observed on *Festuca hookeriana*, *Ixophorus unisetus*, and *Spodipogon sibericus*. On *Agrostis maritima*, *Pennisetum ciliare*, *Phalaris bulbosa*, *P. stenoptera*, and *Tripsacum dactyloides* only inconsiderable injury was detected, the lesions usually being both few and small.

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