Some Graminicolous Species of *Helminthosporium* and *Curvularia* Occurring in South Africa.

By

K. M. Putterill.

The form-genus *Helminthosporium* is so broadly defined that it has accommodated many types of dematiaceous fungi possessing phragmospores, despite fundamental differences they may have shown. Since its foundation in 1809, the genus has become an unwieldy and heterogeneous collection of species, out of which a number of smaller genera need to be formed as natural groupings become apparent. *Curvularia* is another form-genus, recently split from *Helminthosporium*, but even in this comparatively small group there may be no true relationship between species, since their perfect states are still unknown.

Cylindro-Helminthosporium, a subgenus discussed later, appears to show more affinities among its species than merely a common characteristic conidial form. Several of its species also produce a *Pyrenophora* stage, indicating close relationship throughout their life-cycle, which is the only true criterion of affinity. Similarly the species of *Eu-Helminthosporium* are conidial states of the ascomycete genus *Cochliobolus*.

In the present paper, twenty species distributed in *Helminthosporium* and *Curvularia* are described. Most are new records for South Africa; some are previously undescribed species. The perfect states of these conidial forms have not yet been seriously sought in this country, but are recorded elsewhere for some of these species. The descriptions given here are based primarily on South African material.

Not the least of the taxonomic problems concerned in this study was that of determining the generic limits of *Helminthosporium*. For example in species such as *H. miyakei* (see p. 367), the conidia are strongly tapering and unlike those found in *Eu-* or *Cylindro-Helminthosporium*, but rather approaching the form of *Cercospora* conidia. Chupp gives evidence that species such as *Cercospora phaeocarpa* Mitter (56, p. 239) with thick-walled conidia might be better classified under *Helminthosporium*, but such species differ in several important features from typical Helminthosporia. *C. phaeocarpa* possesses a stromatic base, the upper cells of which form one-celled conidiophores about 6–15 μ long. The development of conidiophores on a pseudoparenchymatous foundation is not a feature ordinarily associated with *Helminthosporium*, which typically produces separate or only basally fused conidiophores each as a several-celled branch of a basal hypha. Obviously, dealing with form-genera, there must be borderline cases and intergrading between genera, each setting its individual problem for the taxonomist.

Collections in the National Herbarium, Pretoria, include a number of *Helminthosporium* forms parasitic on species of *Meliola*, and not typical of either *Eu-* or *Cylindro-Helminthosporium*. They have been described by Hansford (21).

The conidial forms present numerous other problems connected with their great variability in nature and in culture. First is the fact that many are collective species consisting of several strains differing from one another in morphological or physiological detail, but forming a continuous series within specific limits. The protean nature of *H. sativum*, for example, has become so apparent with intensive study that systematists have had to define the species in more and more elastic terms. This has

had the unfortunate result that other Helminthosporia associated with foot-rots are often overlooked. Important parasites have been studied most, and are thus known to have several strains; the tendency to regard newer or little-known species as more rigid is quite unjustifiable. The policy adopted in this paper has been to use existing names rather than tentative new ones, for experience has shown that the full range of a species may not be covered in the first description. *H. leersii* (see p. 365) is cited as an example of this conservative treatment.

In nature, as well as in artificial culture, new forms constantly arise by saltation. In culture different strains may even be obtained from a single conidium. Some species are more prone to saltation than others, and there are certain conditions not necessarily identical for all species, which will predispose a fungus to behave thus. The literature on *H. gramineum*, *H. sativum* and *H. sacchari* (q.v.) deals extensively with controlled experiments to study conditions inducing saltation.

Related to the phenomenon of saltation are those of staling and deterioration in culture. Some species are much more unstable than others under conditions generally found suitable for the maintenance of Helminthosporia in the laboratory. Species presenting the greatest difficulty are those which appear in insufficient quantity on the natural substratum, yet deteriorate so rapidly in culture under standard conditions, that it is impossible to continue obtaining characteristic samples. *H. bicolor* and *H. rostratum*, in particular, soon resulted in cultural forms so different from the original as to lead to conflicting identifications discussed under these titles.

The fact that various strains of a species may differ from one another in physiological behaviour or pathogenicity is most important in phytopathology. As host varieties may also differ in susceptibility to fungal attack, much caution is necessary in drawing conclusions from varietal resistance tests.

The possibility of attack by more than one fungus at a time requires mention. In association with other parasites, a weakly pathogenic strain may accomplish what it could not do alone, or mixed strains may inhibit the growth of one another. Mixed associations have been encountered repeatedly in the course of this study, and are discussed under the heading of *H. sativum* and other foot-rotting species.

Though this paper is not primarily concerned with the disease aspect, yet any account of species of *Helminthosporium* would be incomplete without reference to their relationship to their hosts. This aspect is dealt with under each species, and references to phytopathological literature are given. Disease symptoms are characteristic only within certain limits; eye-spot, stripe, foot-rot, etc., are symptoms which may be produced by several different species. Symptoms attributed to many species described in this paper are uncertain, often because of the presence of other fungi. The need for further investigation in view of the incompleteness of such descriptions is stressed.

Host differences are an aid in the distinction of species of *Helminthosporium*, but are not completely reliable. Although many *Helminthosporium* species are very similar each must stand on its own morphological characteristics; too often species have been described as " new " because they were found on previously unrecorded hosts. *H. halodes* is a case in point. Here there might have seemed ample reason for prejudice against using, for a form from foot-rotted wheat, a name given to a species from so different a substratum as *Distichlis spicata* (L.) Greene, growing in a salt-marsh subject to occasional inundation by sea water.

In this study, prune agar, Brown's standard agar, and autoclaved host tissues were the media used. Cultures were incubated at 25° C. Every species received in living condition was studied in pure culture as well as on the host. Measurements of conidia and other structures were taken from frequency charts compiled from at least one sample from each medium, and more where obtainable from the host. Up to 100 spores were measured in a sample, depending on the variability of the spore population.

My thanks are due to Mr. E. W. Mason of the Commonwealth Mycological Institute at Kew, Dr. Johanna Westerdijk of the Centraalbureau voor Schimmelcultures at Baarn, and Dr. Mitra of the Agricultural Research Institute at Pusa, India, for confirming my identifications of three of the species and for naming two others dealt with here.

Natural Subdivisions of Helminthosporium, and Associated Ascigerous Forms.

Mention has been made in the Introduction of natural groups within the large form-genus *Helminthosporium*. It will be convenient to examine in this section all available reports of ascigerous stages connected with *Helminthosporium* species, none of which have been known to develop the " perfect " state in South Africa. The reason for this may be that under our milder winter conditions there is no need for the fungus to pass into the more resistant sexual state; the conidia, especially thick-walled ones, are sufficiently resistant themselves. Alternatively Helminthosporia from cereal crops may be maintained between seasons on secondary wild grass hosts, or even on self-sown seedlings of the crop itself. This is known to happen in coastal and other districts where the winter is mildest.

Sometimes the mere beginnings of a perithecial body are laid down; there are many records of " immature perithecia ", " immature sclerotia " and " sclerotial bodies ". In culture, many species develop thick " knots " or mycelial complexes containing abundant anastomoses. Similar sclerotial growths occur naturally. But even if perithecia should be formed, and asci within them, it is well known that if suitable conditions intervene before the ascospores are mature, then further development of these spores may be suspended in favour of the immediate formation of conidiophores and conidia, even from the surface of the perithecium. Thus the influence of climate or environment on the life-cycle is profound, and it is partly this fact that has caused our understanding of the complete life-cycles of these fungi to develop so slowly.

Species of *Helminthosporium* are the conidial stages of some Pyrenomycetes. In the fact that they do not all pass into the same ascigerous form we have the most striking corroboration of the belief that *Helminthosporium* is a large composite genus, presently to be split up into more natural groups. A start has now been made. In 1929, Nisikado (43) proposed the division of *Helminthosporium* into two subgenera. He based his work on Drechsler's (15) observation that the conidial shapes and modes of germination fall into two main groups, and that this division corresponds with the possession of *Ophiobolus* or *Pyrenophora* perithecial stages so far as these are known. Thus Nisikado's *Eu-Helminthosporium* possesses fusiform conidia germinating from the poles only, together with an *Ophiobolus* stage; *Cylindro-Helminthosporium* is characterised by cylindrical conidia germinating from intermediate as well as polar cells, and by a *Pyrenophora* stage. Not all the species of *Helminthosporium* studied by Nisikado have yet been linked with a perithecial stage; but a glance at the summary below will show that if any one can be satisfactorily classified on conidial characters, its ascomycetous stage may be predicted with fair certainty.

With the heterogeneous nature of *Helminthosporium* thus exposed, the need for a special generic name under which to describe the full life-cycle of a fungus such as *H. teres—Pyrenophora teres* becomes insistent. That need was not met by Ito (28) when, in 1930, he raised Nisikado's *Cylindro-Helminthosporium* to generic rank under the name *Drechslera*, for apparently the term was to refer only to the conidial stage. In 1930, *Pyrenophora* was no more precise in meaning than *Helminthosporium*, thus Ito could have chosen to break away from both old generic names and describe the full life-cycle under a new genus of Ascomycetes. The genus *Pyrenophora* Fuckel became confused when Saccardo incorporated into it various non-sclerotioid forms previously known as species of *Chaetoplea*. However, in 1934, Drechsler (19) ably surveyed the field and pointed out that " through the elevation of *Chaetoplea* to generic

rank by Clements & Shear (7), *Pyrenophora* is automatically rehabilitated as a natural genus in the sense defined and applied by Fuckel, being reserved for the hard, sclerotioid perithecial forms having their asexual stages in *Helminthosporium*-forms such as *H. teres*, *H. bromi*, *H. tritici-repentis* with indiscriminate germination, and corresponding broadly with Nisikado's subgenus *Cylindro-Helminthosporium* and Ito's genus *Drechslera*". And further, "to this sense it would seem to be highly desirable that further usage and application should rigorously conform".

Species of *Pyrenophora* included by the authors discussed above comprise the following:—

P. phaeocomes (Reb.) Sacc. (19; 49, vol. 11). Type species.

P. relicina (Fuckel) Sacc.

P. teres Drechsl. (14, 19, 60). Connected with *H. teres*.

P. bromi (Died.) Drechsl. (14, 19). Connected with *H. bromi*.

P. tritici-repentis (Died.) Drechsl. (14, 19). Connected with *H. tritici-repentis*.

P. graminea Ito (28). Connected with *H. gramineum*.

P. avenae. Connected with *H. avenae*.

P. japonica Ito (28).

P. polytricha da Camara (9). Connected with *H. olisiponense*.

Forms possibly connected with the same series: *P. chaetomioides* Speg. (49, Vol. 16). Said to be connected with *H. penicillosum* Speg.

Forms not yet connected with *Pyrenophora*, but named by Ito as species of the genus *Drechslera* (28): *D. arundinis* (*H. arundinis*); *D. catenaria* (*H. catenarium*); *D. gigantea* (*H. giganteum*); *D. tritici-vulgaris* (*H. tritici-vulgaris*).

Forms connected with the same series by Drechsler: *H. erythrospilum* Drechsl. (19 a); *H. dictioides* Drechsl. (19 a); *H. siccans* Drechsl. (19 a); *H. vagans* Drechsl. (18).

The present use of the name *Pyrenophora* in preference to *Pleospora* of so many authors requires comment. *Pyrenophora* was erected in 1849 and *Pleospora* eight years later. Fuckel restricted the genus *Pyrenophora* to forms with hard sclerotioid perithecia. Saccardo, however (49, v. 11) distinguished *Pyrenophora* as "*Pleospora*, but with setose perithecia". The latter simple distinction has been generally adopted, though some authors, notably Winter, considered the possession of setae insufficient reason for the maintenance of a separate genus. Drechsler (19) discusses the point and concludes that "excessive emphasis on the presence or absence of setose outgrowths as a criterion for distinguishing *Pyrenophora* and *Pleospora* has obscured much more important differences in life-histories and structure". The type species of *Pleospora*, *P. herbarum* (Pers.) Rab., is associated with a *Macrosporium* conidial stage, while the restricted group of species referred definitely to *Pyrenophora* by Fuckel have all been associated with *Helminthosporium*. Stripped of non-sclerotioid forms, and distinguished also from *Pleospora*, Fuckel's genus *Pyrenophora* now stands out as a natural one. Under this name, therefore, we leave *Cylindro-Helminthosporium* Nisikado.

Turning now to *Eu-Helminthosporium* Nisikado, it is clear that a similar need exists here for a name which will indicate the occurrence of both *Helminthosporium* and *Ophiobolus* stages in this combination only. Drechsler has shown that the majority of species in the collective genus *Ophiobolus* are not connected with a *Helminthosporium* stage at all, but instead with a *Phoma* type of asexual stage. Further, those that do have a *Helminthosporium* stage agree among themselves (and differ from other *Ophiobolus* species) in having a pronounced helicoid arrangement of the ascospores within the ascus, and consequently unusually long ascospores and wide asci. The mutual relationship of forms with *Eu-Helminthosporium—Ophiobolus* life-cycles being

without doubt natural, the group may be removed from both genera and established independently. For these species, Drechsler (19) erected the new genus *Cochliobolus*.

So far the genus *Cochliobolus* includes the following species:—

C. heterostrophus Drechsl. (19) type species. Synonyms *Ophiobolus heterostrophus* Drechsl. (15, 16) and *Helminthosporium maydis* Nisikado & Miyake (44).

C. sativus (Ito & Kuribayashi) Drechsl. (31, 19). Connected with *H. sativum*.

C. kusanoi (Nisikado) Drechsl. (42). Connected with *H. kusanoi*.

C. miyabeanus (Ito & Kuribayashi) Drechsl. (29). Connected with *H. oryzae*.

C. setariae (Ito) Drechsl. (28). Connected with *H. setariae*.

C. stenospilus (Carpenter) Drechsl. Connected with *H. stenospilum*.

It is clear that the conidial stages of *Pyrenophora* and *Cochliobolus* account for a large number of the known graminicolous species of *Helminthosporium*, but there still remain other species from grasses that cannot be assigned to either genus, and these will now be considered.

H. dematioideum, which germinates by production of germ-tubes from the basal cell, is one of these. Another may be *H. miyakei* with conidia of unique form. There are also the species parasitic on *Meliola* in which the conidial shape is also different.

H. giganteum Heald & Wolf (17), produces a whorl of germ-tubes at each end of the conidium. In addition to producing normal conidia, it sporulates abundantly in a manner like *Hormodendrum*. A sexual stage has not yet been found, but these two features alone are enough to show that the affinities of this species lie in another direction.

Then there is the relationship between *H. sigmoideum* Cav. and *Leptosphaeria salvinii* Catt., demonstrated by Tullis (58). *H. sigmoideum* is unusual in having conidia with rather pointed, differently coloured end cells, and the sharp pointed " sterigmata " of the conidiophores are unique. Finally it produces the well-known sclerotial stage, *Sclerotium oryzae*, which is commoner than the conidial stage itself. Examination of the genus *Leptosphaeria* appears to justify the suspicion that *L. salvinii* is misplaced in this genus, and that its independence should be recognised by a new generic name. In the literature at her disposal, the author has found no other *Leptosphaeria* having a *Helminthosporium* stage. Several *Leptosphaeria* species have phomaceous conidial stages, while what appears to be the type species of the genus, *L. doliolum* (Pers.) de Not., is stated by Saccardo (49) to have a *Periconia* conidial stage. *Leptosphaeria* as it appears in the *Sylloge Fungorum* is a large assemblage in which smaller groups will certainly prove to be independent natural genera, and the fungus under discussion is probably one. We cannot, however, go further than this interesting speculation until we have seen authentic specimens and examined the work of da Camara (9) on the genus, neither of which is available to us at present.

Finally there is the related series of small-spored species for which Boedijn (2) erected the genus *Curvularia*, under which name they are discussed in this paper. Most of these develop more or less cylindrical stromata, but apparently perithecia have not yet been reported for any of them.

Species of Helminthosporium found in South Africa.

(1) **Helminthosporium teres** Saccardo, in Fung. Italici (1881) t. 833, Sacc. Syll. Fung. 4 (1886) 412.

Helminthosporium hordei Eid. in Der Landwirt, Bd. 27 (1891) 509.

Illustrations: FIG. 1.

Conidia cylindrical, straight or nearly so, usually with a slightly uneven contour, both ends rounded; basal septum often very slightly constricted so that the basal segment is characteristically rounded in outline. Mature conidia, especially when beginning to germinate, are frequently slightly constricted at the septa; walls thin; colour sub-hyaline or tinted faint smoky yellow-green, to deeper smoky yellow; hilum large, included in basal contour. Conidia 30–195 × 10–23 μ [over 200 μ long and with 1–11 septa fide Smith & Rattray (65)], borne on geniculations or swellings of the conidiophores. *Conidiophores* stout, septate, usually simple, yellowish-brown or olivaceous, usually 80–230 × (6)–7–9–(11) μ, wider across the swollen basal cell, emergent from stomata or between epidermal cells in groups of two or occasionally three, possessing large distinct scars left by fallen conidia.

Ascigerous stage: Pyrenophora teres Drechsl. Cultures of *H. teres* are characterised by abundant anastomoses and the consequent formation of small, round black sclerotia in large numbers. Sclerotial bodies form naturally on dead plants during autumn and if conditions are suitable, give rise to perithecia in the spring. Diedicke (11) originally suggested the name *Pleospora teres* for the perithecial stage, though perithecia had not then been found. The complete ascigerous stage was first described by Drechsler (14) under *Pyrenophora* and in view of the fact that Diedicke's fungus was purely hypothetical, Wakefield & Moore (60) have observed that the correct citation of the species is *Pyrenophora teres* Drechsl.

Drechsler (14) states that conidia of *H. teres* always have a slight constriction of the basal septum so that the basal segment is characteristically rounded. Smith & Rattray (53) have not found this feature constant in South African specimens; the present writer finds the feature well represented, if not quite constant in all specimens examined. In South Africa, the conidia seem to reach somewhat larger dimensions than those recorded elsewhere.

H. teres Saccardo (1881) was later described by its author in terms which make it impossible to be distinguished from either of the two other species of *Helminthosporium* common on barley. Ravn (47) taking into account differences in destructiveness, distinguished the then known leaf-stripe disease (which he attributed to *H. gramineum*) from what he called Helminthosporiosis (i.e. " net-blotch ") of barley. To the fungus causing the latter, he applied Saccardo's binomial, *H. teres*, an opinion later confirmed by Saccardo himself. Further comment differentiating these species will be found under *H. gramineum*.

Specimens examined: F. 693, on *Hordeum*, Pretoria, 6/10/09; 8411, *W. Fletcher*, on *Hordeum vulgare*, Elim, 20/10/14; 21787, *Krieger* Schädliche Pilze Exsicc., on *Hordeum distichum*, Europe; 25884, *N. J. G. Smith*, on *Hordeum*, Belmont Valley, Albany, 1929; 25885, *N. J. G. Smith*, on *Hordeum*, Grahamstown, June 1930; 25886, *N. J. G. Smith*, on *Hordeum*, Swellendam, July 1930; 25887, *N. J. G. Smith*, on *Hordeum*, Swellendam, 7/7/30; 30377, *J. Sellschop*, on *Hordeum vulgare*, Louis Trichardt, Sept., 1938; 30855 and 30856, *J. Sellschop*, on *Hordeum*, Louis Trichardt, Aug., 1939.

Pathological notes: *H. teres* causes " net-blotch " of barley, which, though common, is not so serious as leaf-stripe caused by *H. gramineum*. In primary infections the seed-borne fungus may infect the first leaf, as found with *H. gramineum*, resulting similarly in a pale stripe, which may turn brown. Severely infected young plants may closely resemble those suffering from leaf-stripe disease. The later leaves are not ordinarily infected by contact, so that the stripe form of the disease is rarely seen after the seedling stage. Instead, conidia blown from primary lesions cause secondary infections of the foliage, and the irregular blotches thus produced are by far the commonest symptoms to be seen. Typically these blotches or streaks are smallish, reticulate patches of narrow dark brown lines over a lighter background, and usually surrounded by a yellowish border. Very elongated lesions may resemble the stripes caused by *H. gramineum*, though their placing is more haphazard. The grain is similarly

contaminated by windblown conidia, but though secondary infections may reach epidemic proportions they rarely reduce the yield seriously. Ascospores maturing in spring cause infections of the secondary type.

" Net-blotch " is common wherever barley is grown. Because of the conditions necessary for secondary infections, it is most prevalent in damp places or seasons. Perithecia have not yet been recorded in South Africa. In this country it is not even necessary for the fungus to be seed-borne, for wherever the climate is suitable it may live on self-sown plants, or plant remains, all the year round.

(2) **Helminthosporium gramineum** Rabenhorst, Herb. Myc. No. 332 (1856); Saccardo, Syll. Fung. 10 (1892) 615.

Brachysporium gracile (Wallr.) Sacc. var. *gramineum* Rabenh., Sacc. Syll. Fung. 4 (1886) 430.

Napicladium hordei Rostrup, Sygdomme landbr. for. Snyl. (1893) 130–132.

Illustrations: FIG. 2.

Conidia nearly always straight, typically cylindrical, often somewhat narrower in the upper half, broadly rounded at each end, the hilum included in the basal contour, subhyaline to yellowish-brown; walls fairly thin; rarely slightly constricted at the septa. Conidia measure 20–120 × 11–22 μ, with 1–7–(8) septa. *Germination* from polar and intermediate segments. Smaller secondary spores are frequently formed on short processes from germinating primary conidia. In isolates containing secondary spores, these and the smaller primary spores are indistinguishable, so that the range of spore size is extended at the lower end. The larger spores in an isolate are thus to be regarded as more characteristic of the species and more important in its identification.

Conidiophores: light yellowish-brown, lighter in the upper part, simple, septate, bearing successive conidia on moderate-sized geniculations leaving distinct scars after separation. Conidiophores 30–200 μ long, and 5–9 μ wide above the swollen basal cell; arising singly or in groups of 2–6 from stomata or between epidermal cells.

Ascigerous stage: Pyrenophora graminea Ito. Diedicke (10, 11) reported an ascigerous stage of *H. gramineum*, referring it to *Pleospora trichostoma* (Fr.) Wint. He regarded this as a collective species and later split it up, naming the form from barley *P. graminea*. Drechsler (14) considered that the fungus thus described by Diedicke was actually the perfect stage of *H. teres*. Ito & Kuribayshi (30) agreed with Drechsler's conclusion. Although Drechsler mentioned that Paxton had found the mature perithecial stage of *H. gramineum* neither of these workers described the fungus. Ito (28) first published a description of *Pyrenophora graminea* as a new species.

H. gramineum was one of the first parasitic graminicolous Helminthosporia to be described but it was many years before it was clearly distinguished from other species of *Helminthosporium* on the same host. Ravn (47) first differentiated *H. gramineum* and *H. teres* and correctly observed the disease symptoms attributable to each. In 1910 a third parasite of barley, *H. sativum*, was described by Pammel, King & Bakke. Early descriptions of *H. gramineum* and barley leaf-stripe are therefore confused.

Ravn pointed out that microscopically the conidia and conidiophores of *H. teres* and *H. gramineum* are hardly distinguishable from one another. The writer has found that Drechsler s distinctions (14), though useful, do not invariably hold good. It was found that " typical " conidia of *H. gramineum* attained a greater maximum length and breadth than recorded by Drechsler and others, and may have up to 8 septa, while the conidiophores were not markedly narrower than those of *H. teres*. As Smith (53) states: " the two are best distinguished from one another by the commonness of spores in *H. teres* samples which are superior in length to any conidia developed by the other species ". *H. sativum* is easily distinguished microscopically from the above two species, by its conidia.

Specimens examined: 21785, 21786, *Krieger: Schädliche Pilzen*, on *Hordeum vulgare;* 25888, *N. J. G. Smith*, on *Hordeum*, Grahamstown, 27/6/30; 25889, *N. J. G. Smith*, on *Hordeum*, Aylesbury, Albany, C.P., Aug. 1929; 30861, 30862, *J. Sellschop*, on *Hordeum*, Branddraai, Lydenburg, Tvl., Sept. 1939.

Pathological notes: *H. gramineum* causes leaf-stripe disease of barley, which is one of the most widespread and destructive maladies of this crop, especially in colder climates. Many workers in colder countries have claimed that infected plants cannot recover. In South Africa the disease does not ordinarily cause great losses, for conditions are such that the host plant is able to outstrip the parasite. Smith has described leaf-stripe very fully, both in its typical form (50) and as it occurs in South Africa (53).

Leaf-stripe is most easily recognised if the manner of formation of the strip is clearly understood. The disease is seed-borne, and Smith (50, 53) has shown that the fungus does not grow up with the plant by maintaining itself in a smut-like fashion in the growing point, as Ravn (47, 48) claimed. Instead the coleoptile becomes infected by the seed-borne fungus and transfers its infection to the first small enclosed leaf, which, as it grows itself enwraps and so infects the second young leaf. Each successive leaf, and finally the young ear, become infected in turn from its wrapping. As the elongating leaves and sheaths brush past the source of infection continuous vertical strips become infected and show the typical stripe. At first the stripes are yellow but later turn brown. The leaves may split along the stripes. The development of a typically striped plant depends on the relative growth rates of the host and parasite. A vigorous plant which outstrips the fungus may show only a partially developed form of the disease. If the fungus reaches the ear it may prevent normal seed formation, while if it invades growing points the plant may be killed before maturity, as happens in severe outbreaks of the disease.

It is evident that symptoms of this disease may be confused with elongated secondary lesions caused by *H. teres* or *H. sativum*. In these latter species, however, the lesions are caused by wind-blown conidia and are usually entirely haphazard. Wind-blown conidia of *H. gramineum* do not seriously affect plants during the growing season.

Under certain conditions *H. gramineum* has been known to cause foot-rot of barley. It has also been isolated from wheat, oats and maize.

(3) **Helminthosporium mediocre** sp. nov.

Illustration: FIG. 3 a.

Conidia brownish-yellow, 40–108 × 13–18 μ, with 2–10 septa, sub-cylindrical or long elliptical, usually straight, sometimes slightly curved, widest in the middle or slightly below it, narrowing somewhat towards the ends both of which are broadly and similarly rounded; walls of medium thickness, hilum included in the basal contour. *Germination* bipolar.

Conidiophores: light olive-brown, 80–150 μ long and 5·5–8 μ wide, usually with a swollen basal cell; emerging singly from the epidermis.

Ascigerous stage: unknown.

Helminthosporium mediocre sp. nov.

Conidia: flavo-fusca, 40–108 × 13–18 μ, 2–10 septatis, subcylindrica vel longe ellipsoidea, crassitudo maxima ad vel paullo infra medio, fere recta, interdum leviter curvata, plerumque attenuata, ad basin et apicem late et similiter rotundata; membranae mediocres, hilum in extrema basalis inclusum. Germinatio bipolaris. Conidiophora: pallide olivacea, 80–150 μ longis et 5·5–8 μ latis; cellulis basalis fere incrassatis, ex epidermi singulariter emergens. Typus No. 30756.

H. mediocre, both in culture and on the host plant, is devoid of any extraordinary distinguishing feature. No record of any similar species of *Helminthosporium* on *Pennisetum* could be traced. A portion of the type was sent to the Commonwealth Mycological Institute but no name for it could be suggested.

H. leucostylum Drechsl. and *H. nodulosum* B. & C. have been found capable of attacking *Pennisetum typhoideum* under experimental conditions (39), but both of these differ from *H. mediocre* in the size and shape of their conidia. Other records of species of *Helminthosporium* on *Pennisetum* occur in phytopathological literature, but none were found to include a description of the fungus.

In culture on prune agar, the conidia (Fig. 3 b) were found to be smaller, darker, with thicker walls and with the end cells often somewhat lighter. The end cells were sometimes emphasised. The conidia measured only 33–82 × 12–15 μ. The conidiophores appeared longer in culture as they merged gradually into long, narrow hyphae below.

Specimens examined: 30756, *L. C. C. Liebenberg*, on *Pennisetum clandestinum*, Schagen, Tvl., June, 1939.

Pathological notes: The fungus occurred on discoloured basal sheaths and leaf blades of *Pennisetum clandestinum* in numerous brown spots about 0·2–1·5 mm. × 1–2 mm., or larger by coalescence. The spots were slightly elongated lengthwise. As other fungi were also growing in these lesions, and no inoculation tests were made, it is not known whether this species was parasitic.

(4) **Helminthosporium sativum** Pammel, King & Bakke in Iowa Agr. Expt. Sta. Bull. 116 (1910) 178–190; Saccardo Syll. Fung. 25 (1931) 822.

Helminthosporium acrothecioides Lindfors. Svensk. Bot. Tidskr. 12 (1918) 227.

Illustrations: FIGS. 4a & 4 b.

Conidia: Long-elliptical, widest near the middle, tapering towards the rounded ends, typically slightly or distinctly curved, greenish or brownish-olivaceous when mature, often opaque, lighter at the ends, 26–120 × 12–26 μ, with 3–10 septa; wall thick, thinning towards the ends; hilum well marked. *Germination* bipolar.

Conidiophores: Erect, simple, septate, 6–8 μ wide, 60–300 μ long, olivaceous, paler at the apex; arising from dead host tissue from between epidermal cells or stomata, either singly or in groups of 2–4, bearing about 6 conidia. Variable in culture, sometimes branching irregularly and bearing many conidia.

Ascigerous stage: Cochliobolus sativus (Ito & Kuribayashi) Drechsl. (19).

The perfect stage of this fungus was unknown until 1929, when it was described by Kuribayashi (31) as *Ophiobolus sativus*.

Helminthosporium sativum was first described (Pammel *et al.* loc. cit.) from barley. Its presence undoubtedly caused a great deal of confusion in descriptions of other congeneric cereal parasites before that date.

H. sativum is most difficult to define satisfactorily. Its astonishing variability in morphology and parasitic behaviour has been extensively studied by many workers (6, 14, 37). The species has been found to comprise many races, which, though morphologically inseparable, differ greatly in pathogenicity and cultural behaviour. Morphological characters may vary widely under different conditions. New races arise with ease as saltants in culture, and apparently also in nature. The large-spored species of *Helminthosporium*, as Drechsler (20) observes, offer the greatest possibilities for variation in their length and septation with the consequent tendency for such species to be divided into new races or strains.

The writer found that conidia produced in cultures of *H. sativum* differed greatly from those occurring naturally (Fig. 4 b). In culture the conidia were often irregularly shaped, bent rather than merely curved, and sometimes showing bifurcate ends. Many were scarcely longer than wide, and had none or few septa, which were often irregularly

spaced or set at odd angles. Conidia formed on greenhouse plants, and occasionally under natural conditions, tended to show the same peculiarities. It is thus hardly possible to define a typical conidium, but we may assume that the most typical are those from cultures.

Specimens examined: 25890, *N. J. G. Smith*, on *Hordeum*, Grahamstown, 27/6/30; 30421, *J. Pons*, on *Triticum vulgare*, Lydenburg, Tvl., 17/10/38; 30493, *J. Sellschop*, on *Triticum vulgare*, Bethlehem, Nov. 1938; 30857, 30858, 30859, *J. Sellschop*, on *Hordeum*, Louis Trichardt, 10/8/39; 30860, *J. Sellschop*, on *Hordeum*, Lydenburg, Tvl., Sept. 1939; 30990, 30991, *J. Pons*, on *Triticum vulgare*, Lydenburg, Tvl., Oct. 1939.

Pathological notes: *H. sativum* is parasitic on barley, wheat, rye and other cereals and wild grasses, on which it causes more than one type of damage. It appears to be world-wide in distribution (6, 13, 14, 22, 24–27, 33, 36, 37, 38, 40, 53, 54). It is especially severe on wheat and barley in the United States. In South Africa it is common on both wheat and barley, and has also been isolated from oats and wild grasses.

The nature and severity of the disease symptoms vary with the mode of infection, environment, strain of the fungus and the host concerned. This variability is noticed even on a single host. Strains from different hosts have been found to be interchangeable. The types of damage described below occurred on barley and wheat, but though a set of experiments with a single strain cannot be typical of all cases, it applies roughly throughout the host range.

The fungus may be carried in the grain, where, for example, it causes " black point " of wheat. In such cases, if germination is not prevented, seedling blight may result. Plants which survive or escape this may be attacked by root- or foot-rot caused by the same fungus. Such plants display marked discolouration round the base and sometimes a bronzing of the foliage. Similar rots may be caused in plants from clean seed by conidia that have lodged in the soil. Severely affected plants die or are dwarfed, and may be prevented from tillering. If infection is less severe, or the host plant withstands the infection, the parasite may actually stimulate the plant to excessive tillering. The heads, if formed, rarely fill properly, and the grain may be shrivelled.

H. sativum may also cause a disease known as " spot-blotch ". Here, conidia formed on the diseased parts cause secondary infections of the later foliage or stems in the form of small spots or blotches. These are up to 10 mm. long, or longer on the stems, at first yellow but later turning brown with or without a yellowish margin. The ears and grain may also be infected by the conidia. Where the foliage is much reduced by disease, the grain usually ripens prematurely if it is formed at all.

Though it has been found (e.g. Mitra & Bose, 38) that the optimum conditions for damage are plentiful moisture and warmth this result may be misleading. Plants weakened by drought may fall prey to parasites which they might otherwise have resisted. Foot-rot occurs in dry as well as in moist areas. Mourashkinsky (40), working on the control of cereal diseases in arid districts in Russia, states that seedling wilts of cereals, caused by *H. sativum* and other species of *Helminthosporium* and *Fusarium*, are of some importance in dry regions. He finds it erroneous to believe that drought is so unfavourable for disease development that control measures may be relaxed. The longevity of the thick-walled conidia of *H. sativum*, together with its ability to grow saprophytically on dead or dying tissue of the Gramineae, makes this fungus difficult to control.

South African conditions are seldom such as to encourage the development of serious disease from secondary infections. The writer's experience has been that although the " spot-blotch " form of the disease is common in the summer-rainfall areas, the foot-rot form is much more destructive.

Examination of numerous plants affected by foot-rot in different parts of the country has shown that *H. sativum* occurs commonly in company with a fairly constant set of other fungi. These fungi have been isolated from the bases of many living plants

showing foot-rot, but not from dead material. Species of *Fusarium* (especially *F. avenaceum*) and *Curvularia* (e.g. *C. spicifera*) were the most constant and important associates. Other fungi that were isolated more than once were: *H. bicolor* Mitra, *H. halodes* var. *tritici* Mitra, *H. rostratum* Drechsl. and *H. dematioideum*. As many as seven such associates were isolated on one occasion from a single plant which was not particularly reduced. Sometimes *H. bicolor* or *H. halodes* was associated with a *Fusarium* and/or a *Curvularia* on plants attacked by foot-rot, though *H. sativum* was not present. No doubt there are other fungi which may participate.

In the writer's opinion, foot-rot of wheat in South Africa is very often attributable to the combined action of a complex of fungi, rather than to *H. sativum* alone. If so it would explain why *H. sativum* isolated from foot-rot specimens often proves to be feebly parasitic on re-inoculation. But the tendency of this species to produce saltants in culture should not be overlooked. The point can only be established by a series of experimental inoculations of these fungi singly and in combinations. Hynes (24, 26), in Australia, has undertaken just such a series of experiments. He found damage to be greatest when plants were inoculated simultaneously with *H. sativum*, *Fusarium culmorum* and *Curvularia ramosa*—a remarkably close parallel with what the writer has found in South Africa. Hynes did not, however, find in Australia all the large-spored species of *Helminthosporium* named in the present paper, though most of these have been associated with foot-rot elsewhere. Hynes concluded that " the large-spored species of *Helminthosporium* associated with foot-rot throughout Australia is predominantly, if not exclusively, *H. sativum* ". This conclusion does not find support in South Africa.

(5) **Helminthosporium N** Henry in Minn. Agr. Expt. Sta. Tech. Bull. 22 (1924).

Illustrations: FIG. 5.

Conidia: Long-elliptical, widest near the middle, tapering somewhat towards the rounded ends, slightly or distinctly curved, sometimes straight; wall fairly thick, thinner towards the ends; hilum well-marked, not protruding, but flat rather than included in the rounded basal contour; conidia fuliginous or greyish-olivaceous, lighter at the ends, 16–82 × 8–16·5 μ, with 1–10 septa. *Germination* bipolar.

Conidiophores: variable, often branching below the conidium-bearing part, geniculate, up to 7 μ wide. Only seen in culture.

Ascigerous stage: unknown.

This species has conidia very similar to those of *H. sativum*, but rather more uniform in shape. The most pronounced difference is in the width of the conidia, although differences in length and colour are also apparent. Henry (22, p. 35) gives a table comparing variations and constants for the conidia of the two species. Both he and Drechsler considered *Helminthosporium N* sufficiently distinct from *H. sativum* to be regarded as a new species but neither named it specifically. Both noted a resemblance in the spores of *Podosporiella verticillata* O'Gara (45).

Specimens examined: 30497, *J. Sellschop*, on *Triticum vulgare*, Bethlehem, Nov. 1938.

Pathological notes: *Helminthosporium N* was originally reported on wheat, where it produced symptoms similar to those caused by *H. sativum*. It was, however, less virulent. It is probably more common than it appears from the records, being very liable to be identified as one of the many variants of *H. sativum*.

The South African isolation was made from the culm bases of wheat attacked by foot-rot. No inoculation experiments were done, so its relationship to the host and to other foot-rotting fungi present remains in doubt.

(6) **Helminthosporium bicolor** Mitra in Trans. Brit. Myc. Soc. 15 (1930) 286.

Illustrations: FIG. 6.

Conidia: roughly cylindrical with bluntly rounded ends, or long-elliptical and widest near the middle then narrowing towards the rounded ends, straight or slightly curved; wall thick, thinning towards the end segments; hilum included in the basal contour or occasionally showing slightly outside; olivaceous-brown or yellowish- to smoky-brown to dark brown, sometimes opaque, paler in the end segments; 20–90–(108) × 8–18 μ; septa 1–12, the terminal septa thicker and darker. *Germination* bipolar.

Conidiophores: brownish, variable in culture, from 160 μ long; the short fertile region markedly geniculate, sometimes forked, 5–7 μ wide, narrower below; conidia borne at short intervals on the geniculations.

Ascigerous stage: unknown.

All the South African isolates of this taxonomic species agree well with the description of *H. bicolor* Mitra, except that the majority of their conidia are longer and have marked end-septa. In view of this discrepancy, two isolates (Nos. 30496, 30432) were sent to Dr. Mitra, who confirmed their identity as *H. bicolor*, but noted that accentuated septa are not shown in the type. In these two strains isolated from Wheat and sorghum respectively, and from different localities, conidia up to 108 μ in length occurred. The maximum length in other South African isolates was 75–90 μ, and 79 μ in the type specimen. These unusually long conidia were slender, sometimes distinctly curved, and much lighter in colour (see three conidia figured at top of Fig. 6) than the usual conidia for this species. They occurred only in the fresh specimens and in the first culture isolations from fresh material, but by means of monospore cultures it was proved that subcultures from the long conidia later produced only average conidia. The two extremes thus belonged to the same species, which showed many intermediate forms in culture. In addition, examination of standing conidiophores in culture showed that the first-formed conidia were of the long, light-coloured type, and that the shorter, darker conidia were formed later and more abundantly.

Cultures of this species were among the most rapidly staling of any encountered in this study (cfr. introduction), and staling was apparently accompanied by a decrease in the size of the conidia. Measurements of conidia in staling cultures of No. 30496 agreed well with those for *H. euchlaenae* Zimm. In the description of the latter there is no mention of emphasied terminal septa or lighter end cells. While it is possible that *H. bicolor* and *H. euchlaenae* are synonymous this point requires further investigation, and at present the South African material is better disposed under *H. bicolor*. A summary of measurements relevant to this discussion is given in Table 1, below.

TABLE 1.

Fungus.	Measurements of Conidia in μ.	No. of Septa.	Authority.
H. euchlaenae Zimm.	50–60 × 13–15	7	Saccardo, Syll. Fung. 18, p. 592.
H. euchlaenae strain Sideris, Hawaii	32–62 × 11–14	5–7	C.B.S., Baarn, in litt.
H. bicolor Mitra.	16·5–79 × 10–20	1–9	Mitra.
No. 30496 (fresh)	20–108 × 8–16	3–11	Present studies.
No. 30496 (staling)	44–63 × 12·7–15	5–7	
No. 30432	20–105 × 10–17	1–12	
No. 30458	13–75 × 10–18	2–9	

Specimens examined: 30432, *L. Codd*, on *Sorghum halipense*, Pretoria; 30458, *J. Sellschop*, on *Triticum*, Clarens, O.F.S., Nov. 1938; 30496, *J. Sellschop*, on *Triticum*, Bethlehem, Nov. 1938.

Pathological notes: *H. bicolor* was described as the cause of foot-rot and root-rot of barley and wheat seedlings in India. In South Africa it has been isolated from wheat showing foot-rot, grown in various parts of the country. This fungus has also been found associated with lesions surrounded by dull-red borders, on leaves of *Sorghum halipense* and *S. verticilliflorum*. In some cases *Helminthosporium turcicum* was also present.

(7) **Helminthosporium halodes** Drechsler in Journ. Agric. Res. 24 (1923) 707.

Illustration: FIG. 7.

Conidia long-elliptical, straight or slightly curved, widest at or above the middle, narrowing somewhat towards the broadly-rounded apex and more markedly towards the narrowly-rounded or roughly triangular basal cell; walls fairly thick, becoming thinner towards the ends; hilum protruding, large, conspicuous; septa 1–11, the terminal septa thick and dark; colour greenish- or yellowish-brown to dark or smoky-brown, lighter in the end segments; 20-85 × 10–21 μ. *Germination* bipolar. *Conidiophores* (in culture) simple, usually long, 5–8 μ wide in the enlarged fertile region.

Ascigerous stage: unknown.

The above description is based on material in culture. It is evidently identical with *H. halodes* Drechsl. var *tritici* Mitra (36, p. 287), which Dr. Mitra himself kindly confirmed. The variety differs from Drechsler's species in spore size and septation. Mitra gives the extreme spore measurements as 23–73 × 13–20 μ, with 2–9 septa, while the extreme measurements for Drechsler's type are 20–105 × 10–14 μ with 1–12 septa. In length and septation the conidia of the South African strain thus fall between the two, and the conidia may attain a slightly greater width than Mitra claimed.

The present description, like Mitra's, was based on cultures obtained from foot-rotted wheat, and no naturally occurring conidia were seen. Drechsler found that *H. halodes* showed a tendency towards the production of shorter, thicker and darker conidia in culture. This is a variation towards the form shown in *H. halodes* var. *tritici*, and it is thus not improbable that the latter is an ill-founded variety. In view of the known cultural irregularities and abnormalities of *H. halodes*, as striking as those found in *H. sativum*, the author would minimise the seemingly important difference in the width of the conidia and dispose her material under *H. halodes* rather than under the variety *tritici*.

Specimens examined: 30434, *K. M. Putterill*, on *Triticum*, Brits, Oct., 1938.

Pathological notes: *H. halodes* was originally described on *Distichlis spicata* in the United States of America. The symptoms it produced resembled those caused by *H. sativum*. It has been reported as a parasite of sugar-cane seedlings, maize, sorghum, wheat and barley in India (55). The variety *tritici* associated with foot-rot of wheat in India (Mitra, 36) was found to infect barley seedlings as well. In South Africa, *H. halodes* was isolated from foot-rotted wheat.

(8) **Helminthosporium rostratum** Drechsler in Journ. Agric. Res. 24 (1923) 722.

Illustrations: FIG. 8.

Conidia long-elliptical, straight or slightly curved, widest near the middle, with a broadly rounded to subconical base; apex broadly rounded in the shorter conidia but narrowing markedly in the longer conidia, often elongated into a rostrate extension; walls thick, thinning towards the ends; hilum large and strongly protruding; septa 3–21 (usually more than 10), the terminal septa usually accentuated except the apical septum in rostrate conidia; greenish-yellow when young, olivaceous- or yellowish-brown, dark olivaceous or blackish-brown at maturity, more dilutely coloured in the end

segments and with a very light area round the hilum and the extreme apex; 20–180 × 10–26 μ, usually 13–20 μ wide. *Germination* bipolar. *Conidiophores* (in culture) variable, simple, 160 μ long, or longer, the fertile region expanded, 6–9 μ wide, geniculate, olivaceous.

Ascigerous stage: unknown.

Both isolations made of this fungus showed extreme conidial variation in culture. Drechsler (loc. cit.) states, " on artificial media, the fungus produces conidiophores bearing conidia altogether similar to those found in nature ". In the author's material, rostrate conidia agreeing well with *H. rostratum* were produced in the first set of cultures, but appeared less readily in the second set and were absent from subsequent cultures. In being half their original length and tending to become obovate in the shortest conidia, the later conidia strongly resembled those of *H. halodes*. In a private communication Dr. Westerdijk confirmed the author's identification of No. 30456 as " *H. rostratum* Drechsl. with typical rostrate conidia ", but within two months on subcultures the same fungus, still in pure culture, was indistinguishable from *H. halodes* Mitra, a fact which Dr. Mitra kindly confirmed. In view of these facts and the variability of this fungus in culture, which is paralleled by the cultural behaviour of *H. sativum* and *H. bicolor*, the South African isolations are best assigned to *H. rostratum*.

Specimens examined: 30456, *J. Sellschop*, on *Triticum*, Bethlehem, Nov. 1938; 30460, *J. Sellschop*, on *Triticum*, Ferraira, Nov. 1938.

Pathological notes: *Helminthosporium rostratum* was described (loc. cit.) from the dry leaves of *Eragrostis major* in the U.S.A. Its author stated, " the mature condition of the grass precluded any inquiry into the biological relation of the fungus to its substratum ".

The South African isolations were made from the base of wheat plants affected by foot-rot. One isolate (No. 30456) was found in association with *H. sativum*, *H. bicolor*, *Helminthosporium N*, *Curvularia spicifera*, *Curvularia* sp., and *Fusarium avenaceum*. Five of these fungi have been found on grasses affected by foot-rot. The second isolate was associated with *H. sativum*, *H. dematioideum*, *Fusarium* sp. (probably *F. avenaceum*) and *Curvularia* sp. No inoculations were made to test the ability of *H. rostratum* to cause foot-rot alone.

(9) **Helminthosporium turcicum** Passerini in Bol. Comiz. Agr. Parmense 10 (1876); Saccardo Syll. Fung. 4 (1886) 420.

Helminthosporium inconspicuum Cooke & Ellis in Grevillea 6 (1878) 88.

Illustrations: FIG. 9.

Conidia long elliptical, straight, less often slightly curved; broadest near the middle and narrowing decidedly towards the ends; apex rounded; basal cell conical, often more rounded; thin-walled; hilum prominent, characteristically protruding. Septa 1–8–(11). Subhyaline with a grey-green tint, to light yellow-brown. 50–140–(154) × 15–26 μ. *Germination* bipolar. *Conidiophores* simple, few-septate, fertile region moderately geniculate, light olivaceous; 100–280 × 7–10 μ; emerging in small groups from the stomata.

Ascigerous stage: unknown.

Specimens examined: F. 890, *H. G. Mundy*, on *Zea mays*, Rhodesia, Feb. 1910; 1134 *May Varney*, on *Sorghum vulgare*, Kansas, U.S.A., Oct. 1889; 7913, *Briosi & Cavara* on *Zea mays*, Pavia, Italy, 1889; 2187 *J. Fisher*, on *Zea mays*, Cedara, Natal, March 1912; 9729, *Angus & Co.*, on *Sorghum verticilliflorum*, Dalton, Natal, March 1916; 10099, *J. Pope-Ellis*, on *Sorghum halipense*, Ashburton, Natal, April 1919; 15448, *Th. Eruleben*, on *Sorghum sudanense*, Pietermaritzburg, March 1922; 15462

R. R. Staples, on *S. sudanense*, Cedara, Apr. 1922; 20354, *Entomologist*, on *Zea mays*, Belgian Congo, March 1935; 20386, *McKay*, on *Zea mays*, Naboomspruit, Apr. 1935; 28600, *L. C. C. Liebenberg*, on *S. halipense*, Prinshof, Pretoria, March 1936; 30431, 30432, *K. M. Putterill*, on *S. halipense*, Prinshof, Pretoria, Dec. 1938; 30708, *K. M. Putterill*, on *Sorghum verticilliflorum*, Prinshof, Pretoria, Jan. 1939; 30709, *K. M. Putterill*, on *S. sudanense*, Prinshof, Pretoria; 30710, *K. M. Putterill*, on *S. halipense*, Prinshof, Pretoria, Jan. 1939.

Pathological notes: *Helminthosporium turcicum* is the cause of leaf blight or " white-blast " of maize, a conspicuous and often serious disease. It occurs in all maize-growing countries. The same disease has also been described on various species of *Sorghum*.

In South Africa, Doidge & Bottomley (12) found that leaf blight " causes considerable damage (to maize) in Natal in wet seasons, but appears to have slight ill effects elsewhere ". In the summers of 1937–39 entire plantings of *Sorghum sudanense* at Prinshof, Pretoria, were rendered useless by the disease. In Rhodesia (23), and Madagascar it completely destroyed maize crops, especially of newly introduced varieties, while it is regarded as important enough in Kenya to justify extensive work on the breeding of resistant varieties.

The symptoms of this disease are evident as small straw-coloured lesions, often surrounded by a darker outline, which may later merge into one large blotch covering almost the entire surface. Fully grown plants are not usually much affected, but where the infection occurs early in the wet season on young plants, the destruction of large leaf-areas with considerable subsequent damage to the crop, may result. On species of *Sorghum* the symptoms resemble those on maize, except that the smaller lesions have reddish-brown borders, or may consist of yellowish blotches turning reddish or blackish later.

Elsewhere *H. turcicum* has been found capable of infecting barley, oats, rice, sugar-cane and wheat, under experimental conditions. Although various workers have found the strains on these hosts interchangeable, it is suspected that the strains from maize and *Sorghum* may be biologically different.

Drechsler (15) believes that leaf blight caused by *H. turcicum* may often have masked the simultaneous appearance of leafspot caused by *Cochliobolus heterostrophus* (*H. maydis* Nisi. & Miyake) on maize plants. Thislatter fungus would otherwise have been more widely known in maize areas. It has not yet been recorded in South Africa.

(10) **Helminthosporium leucostylum** Drechsler in Journ. Agric. Res. 24 (1923) 710.

Illustrations: FIG. 10.

Conidia usually straight, widest about one-third from the base, tapering evenly and characteristically towards the narrow apex; base paraboloid or sometimes broadly rounded; wall thick, thinning in the terminal cells to conspicuous thin areas at the extreme apices and around the hilum which is conspicuous but not protruding; medium to dark olivaceous, or olive-brown, lighter in the terminal cells; 1–8 septate, not constricted at the septa; 15–80 × 8–17 μ. *Germination* bipolar. *Conidiophores* simple, very short, the fertile region markedly geniculate, the tip somewhat flattened; typically subhyaline to light fuliginous, darkening lower down; 25–105 × 5–6·5 μ; emerging in groups from the stomata. Well-spaced conidia leave prominent scars on separation from the conidiophores.

Ascigerous stage: unknown.

Drechsler named this species *leucostylum* because of the characteristic colourless or light-fuliginous conidiophores. According to his description and figures, the conidiophores are as light at the base as at the apex. Drechsler's figures show the conidiophores to be of even thickness throughout, and rounded at the top. The conidiophores in South African material differed somewhat in being subhyaline at

the apex but deeper in colour towards the base. The most typical conidiophores were fairly light fuliginous, but others (e.g. in No. 23689) were not much lighter in colour than the olive-brown conidia.

Mitra & Mehta (39) described an isolate from *Eleusine coracana* which differed from the type in having slightly larger, olive-brown conidia and conidiophores which were " conspicuously slender at the basal part, gradually becoming broader at the top which is flat or anvil-shaped ". These features are not mentioned by Drechsler, but they agree well with what was seen in South African material.

There is a noticeable variation in the conidiophores in recorded isolations of *H. leucostylum*, but conidial features have remained characteristic. Taking this into consideration, and despite the fact that *H. leucostylum* was named for the lack of coloration in the conidiophores, the South African material is too typical to be assigned to any other species.

Specimens examined: 23689, *P. Cazelet*, on *Eleusine indica*, White River, Tvl., Jan. 1929; 25908, *L. Doidge*, on *Eleusine indica*, Ladysmith, Natal, March 1931; 10036, *L. C. Turner*, on *E. indica*, Vereeniging, Feb. 1917.

Pathological notes. Drechsler (loc. cit.) in describing *H. leucostylum* from *Eleusine indica*, also found it common on *Eragrostis major* in the U.S.A. It has been reported, too, on *E. coracana* in India and Uganda, and on *E. aegyptiaca* in India. It was found in India (39) to be capable of infecting maize, sorghum, *Panicum frumentaceum* and *Pennisetum typhoideum*. On *E. coracana* and *E. aegyptiaca* it is stated to cause leaf-blight or leaf-spot, seedling-blight and head-blight.

In South Africa this species was recorded on *Eleusine indica* by Smith & Putterill (52), who stated that diseased plants were " characterised by a black-dusted withering of the extremities ". Tips of inflorescence branches showed empty, discoloured spikelets; tips of leaves withered and tended to split lengthwise, while the lower parts were green and apparently healthy. Black, dusty stripes parallel to the veins on the brown, withered parts resulted from abundant spore formation. Wind-blown conidia may also cause a brown-spotting of the lower parts of the older green leaves. Seedling plants may be killed by this fungus.

Drechsler described similar symptoms on *Eleusine indica*, though their significance was obscured by a considerable overgrowth of other fungi.

(11) **Helminthosporium cynodontis** Marignoni in Micromiceti di Schio (1909); Saccardo Syll. Fung. 22 (1913) 394.

Illustrations: FIG. 11.

Conidia usually long-elliptical, slightly curved, often straight, widest near the middle and tapering gradually to the rounded ends; wall fairly thin; hilum included in the basal contour; subhyaline to light fuliginous; 20–83 × 8–15 μ, with 3–11 septa. *Germination* bipolar. *Conidiophores* simple, dark brown, 60–200 × 4–6·5 μ, arising from stomata or between epidermal cells singly or in pairs.

Ascigerous stage; unknown.

The South African material agrees well with that from America dealt with by Drechsler (14).

Specimens examined: 27359, *R. Gardner*, on *Cynodon dactylon*, Pilgrims Rest, Feb. 1934; 29976, *B. Wilson*, on *C. bradleyi*, Redan, March 1938; 30242, *A. M. Bottomley*, on *C. bradleyi*, Pretoria, March 1939.

Pathological notes: The type of *H. cynodontis* occurred on dry leaves of *Cynodon dactylon* in Italy. The species has also been recorded by Drechsler (14) in the U.S.A. on *Cynodon dactylon* and *Eleusine indica*, on *C. dactylon* in Kenya (41) and on *C. dactylon* in South Africa (51). The author has found it to be fairly common on *C. dactylon* and *C. bradleyi* in the Transvaal, and on *C. dactylon* in the Eastern Cape

Province. Drechsler also regarded this fungus as common, so that lack of records probably indicates a comparative unimportance of the hosts rather than rarity of the fungus.

The author has found this fungus on dark brown lesions on living leaves and stems, but it is most plentiful on dying or withered parts. In wet seasons, during February and March it was abundant on lawns turning brown and in brown patches on lawns. Species of *Curvularia*, *Rhizoctonia* and also *Helminthosporium dematioideum* have sometimes been found on the same plants with *H. cynodontis*. Although the relationship of the last-named to the host has not been determined it appears to be often secondary to some other agent (e.g. nematodes or *Rhizoctonia*) only becoming conspicuous in unusually wet weather.

(12) **Helminthosporium brizae** Nisikado in Berichte Ohara Inst. für Landw. Forsch. 4 (1929) 122.

Illustrations: FIG. 12.

Conidia subcylindrical or long-elliptical, straight, only exceptionally curved, widest near the middle, tapering gently towards the abruptly rounded ends; hilum large, conspicuous, included in the basal contour; walls fairly thin, thinner over the ends; subhyaline or light fuliginous at first, later becoming yellowish or yellow-brown, lighter in the basal or both end cells; 26–75 × 9·5–15 μ, with 2–7 septa. *Conidiophores* simple, light to dark brown or olivaceous, lighter above; 40–150 × 4·5–7·5 μ above the bulbous basal cell; emerging from between epidermal cells singly or in groups of 2–3.

Ascigerous stage: unknown.

In Nisikado's description of *H. brizae*, some discrepancies are evident. Although he described the conidia as " usually sub-cylindrical, but widest at a point near the middle and tapering towards both ends ", his illustrations are of conidia mostly widest below the middle while tapering decidedly more towards the apex than the base. Because of the lack of material for comparison, the writer decided to accept Nisikado's description rather than his figures.

The South African material differed from the description in only two respects. Firstly, Nisikado made no mention of a rather noticeable hilum. Then, the conidia in the author's material had a shorter average length (40 μ instead of 55 μ) than the Japanese material, although the range in conidial length was the same in both instances. Conidia were not plentiful in the South African material though abundant conidiophores were present. It seems possible, therefore, that most of the riper, heavier spores had been lost, leaving behind an unrepresentative spore population. Despite these differences there is a good general agreement between the South African material and Nisikado's description of *H. brizae*.

Specimens examined: 28530, *K. M. Putterill*, on *Briza maxima*, Port Elizabeth, Oct. 1935.

Pathological notes: *H. brizae* was described from the leaves of *Briza minor* in Japan. On this host it was found to cause rectangular or elliptical lesions at first 2–3 mm. × 1–2 mm. with a scaled appearance, later bleached and up to 10–20 mm. × 3–5 mm. in size, the leaf at last shrivelling up. The host in South Africa, *Briza maxima*, showed small purplish-black spots on the leaf blades and sheaths. The larger oblong or elliptical lesions, 1–5 mm. × 0·5–2 mm., each had a minute bleached spot in the centre. There is thus a difference in the symptoms on *Briza maxima* in South Africa and *B. minor* in Japan. Whether this difference is significant is unknown as the host and conditions may determine the appearance of the disease as much as the parasite does.

(13) **Helminthosporium sacchari** (Breda de Haan) Butler in Mem. Dept. Agric. India Bot. ser. 6 (1913) 204–208, Pl. 6; Saccardo Syll. Fung. 25 (1931) 823.

Cercospora sacchari Breda de Haan in Meded. Proefsta. Suikerriet West-Java 3 (1892) 15–21.

Helminthosporium ocellum Faris in Phytopathology 18 (1928) 753–773.

Illustrations: FIG. 13.

Conidia long-elliptical or elliptic-fusiform, with a slight or marked crescentic curve, or sometimes straight, widest at the middle tapering slightly to each rounded end; walls thin; hilum included in the basal contour; yellowish or sub-hyaline with a faint smoky greenish to smoky olivaceous-brown tint; (33)–50–105–(125) × 11·5–17–(18) μ, with 3–11 septa. *Germination* bipolar. *Conidiophores* medium smoky olive-brown colour, lighter at the tips, frequently swollen at the base, with geniculate fertile regions, showing distinct conidial scars; 100–260 × 4–10 μ; arising from brown mycelium on the surface of the leaf or below it.

Ascigerous stage: unknown.

The causal organism of eye-spot disease of sugarcane was first described (3) as *Cercospora sacchari* under which name it was later recorded from many other sugarcane-growing areas. Butler (4) noted that the fungus was better classified in *Helminthosporium*, and made the transfer. Van der Byl (59) recorded *Cercospora sacchari* from Natal, but also noted that it was more properly a *Helminthosporium*. Faris (20) claimed that in Cuba the eye-spot fungus of de Haan and others differed from Butler's *H. sacchari*, and distinguished the former as *Helminthosporium ocellum* n. sp. Mitra (37) showed that " *H. sacchari* Butler and its saltants have a range of variation in spore dimensions sufficiently wide to include all the forms of *Helminthosporium* causing eye-spot of sugarcane ". The same may be said of the range of symptoms on different varieties of cane under different conditions. McRae (34, 35) in reporting Mitra's work, stated, " The conclusion drawn so far is that *H. sacchari* Butler and *H. ocellum* Faris are identical, though they are different strains, and the name *H. sacchari* Butler with its amplified description (Mitra 36, p. 290) should be maintained for the eye-spot disease in Cuba." This is now generally accepted, and *H. sacchari*, like *H. sativum*, is recognised as a species composed of many different strains.

The conidia of the South African strains are large and resemble those of *H. ocellum* as described by Faris.

Specimens examined: 30245, 30988, *A. McMartin*, on *Saccharum officinarum*, Mt. Edgecombe, July 1939; 32708, on *Pennisetum* sp., Honolulu, Hawaii.

Pathological notes: Eye-spot disease of sugarcane, caused by *H. sacchari*, is recognised by lesions of a dull red colour, usually with a light-brownish centre, formed on the leaves. Young lesions are often surrounded by a pale halo. These spots often spread or coalesce into long streaks with or without a definite eye.

The disease occurs in sugar-belts all over the world. In South Africa it has not been serious. It is most prevalent in cool, damp weather.

The frequency of leaf-spotting and the acuteness of the attack vary with the variety of sugarcane. An Indian cane, Co. 419, was badly attacked, the fungus causing a rot of the unfolded leaves and even attacking the stems which dried and became light in weight.

H. sacchari has not been found on hosts other than sugarcane in South Africa, but elsewhere has been recorded on Napier grass, *Pennisetum* sp. It has been found capable of infecting wheat and barley under experimental conditions.

(14) **Helminthosporium leersii** Atkinson in Bull. Cornell Univ. (Sci.) 3 (1897) 47; Saccardo Syll. Fung. 14 (1899) 1087.

Illustrations: FIG. 14.

Conidia curved, occasionally straight, widest at or just below the middle, tapering evenly towards the rounded ends; walls very thin and not constricted at the septa; hilum inconspicuous and included in the basal contour; light fuliginous; 52–124 × (13)–16·5–(20) μ, with 2–12 septa. *Germination* bipolar. *Conidiophores* simple, thick-walled, rigid; basal cell swollen; fertile region straight or moderately geniculate; light to medium brown becoming dark brown, lighter near the apex; 130–375 × 6·5–8·5–(10) μ; emerging singly from the host epidermis.

Ascigerous stage: unknown.

In Atkinson's description the conidiophores were characterised as " amphigenous, brown, irregularly nodulose or flexuous, 200–350 × 4–6 μ ". Drechsler, who noted the peculiar growth of *H. leersii* in culture, illustrated simple, straight conidiophores taken direct from the host. In South Africa the conidiophores are stout and stiff rather than " irregularly nodulose or flexuous ". Though Drechsler did not mention the dimensions of the conidiophores, he indicated the size of the conidia as 50–95 × 11–14 μ, thus narrower than the average of 16·5 μ in the South African isolations. The South African form is apparently not exactly the same as the American. There seems to be a significant difference in conidial width, if not in length, for although conidial length may fluctuate considerably in many species of *Helminthosporium*, the width usually remains rather characteristic.

Nisikado's figures for the conidial measurements of the Japanese form of *H. leersii* (45–125 × 12–20 μ), agree well with the South African form, but no mention was made of conidiophores.

Although the South African fungus agrees very well with the type in general conidial features (shape, colour, unusual thinness of wall) and appears to match *H. leersii*, there is at least a possibility that it is a distinct strain. However, it must be admitted that the comparatively meagre information available on this species might make it appear more limited than it really is. Until proper comparison of material should demonstrate constant differences it is not advisable to add confusion with a new species, and the South African fungus is provisionally referred to *H. leersii*.

In conidial size and general appearance the author's material bears a resemblance to *H. sacchari*, but the former is recognised by the stiff, dark conidiophores.

Specimens examined: 33115, *A. P. D. McClean*, on *Leersia hexandra*, Nottingham Road, March 1939; 33116, *A. P. D. McClean*, on *Setaria* sp., Nottingham Road, March 1939.

Pathological notes: *H. leersii* was described from leaves of *Leersia virginica* in the United States of America. Drechsler (14) later redescribed it from the same host. Nisikado (43) recorded it from Japan on *Leersia hexandra*. In South Africa this fungus was collected on *L. hexandra* and *Setaria* sp. at the same time and place.

The symptoms on the two South African grasses are small indefinite brown spots 1–3 mm. long, elliptical or elongated, which later develop into irregular dark brown eye-spots 8–10 × 2–3 mm. in size, with a straw coloured or bleached ashen centre. Lesions occur chiefly on the leaf-blades of both grasses and are less definite in form on *Setaria*. Fructifications are found on these spots and also on the withered lower leaves. The brown and gray eye-spots are exactly like Drechsler's description of those on *L. virginica*.

(15) **Helminthosporium urochloae** sp. nov.

Illustrations: FIG. 15 A & B.

Conidia usually straight but sometimes with a slight or pronounced crescentic curve, occasionally slightly sigmoid; widest one third to one half the distance from the

base, tapering towards the rounded ends, often more tapered towards the apex; about half the conidia slightly narrowed near the first or second basal septa, these conidia having a characteristically narrowed proximal part; wall thick, thinner at the ends; hilum not projecting; yellow-brown to olive-brown, later opaque; (62)–90–160–(189) × (13)–18–(21) μ, with 6–16 septa. *Germination* bipolar. *Conidiophores* simple, with swollen basal cell; fertile region slightly geniculate; dark olive-brown or olivaceous at the base, becoming lighter towards the tips which are light coloured or subhyaline; 160–300 × 5–10 μ; mostly emerging singly.

Ascigerous stage: unknown.

Helminthosporium urochloae sp. nov.

Conidia: flavo-fusca vel olivacea, deinde opaca, (62)–90–160–(189) × (13)–18– (21) μ, 6–16 septatis, fere recta sed interdum leviter vel manifeste curvata, nonnunquam leviter sigmoidea (crassitudo maxima $\frac{1}{3}$–$\frac{1}{2}$ supra basin), plerumque attenuata (praecipue ad apicem) et rotundata; conidia dimidia pars leviter contracta ad septis basalis primae et secundae, istae septae pars proxima proprie attenuata; membrana crassa, ad extremitatis tenuioris; hilum non eminens. Germinatio bipolaris. Conidiophora: simplices, cellulis basalis incrassatis; regio fertilis subgeniculata, basin versus obscure olivacea, apicem versus pallidiora, apices pallidis vel subhyalinis, fere singulariter emergens. Typus No. 26148.

Some features of *H. urochloae* suggest comparison with *H. oryzae* B. de H. as described by Drechsler (14), which it resembles in the general shape, colour and size of the conidia. *H. urochloae* differs from the latter species in having a large proportion of conidia with characteristically narrowed basal ends and in the absence of a mycelial crust anywhere on the host. Its conidiophores are somewhat wider than those of *H. oryzae* and in the latter branched conidiophores also occur. *H. urochloae* is easily distinguished by its conidial features from other Helminthosporia on grasses.

Specimens examined: 26148, *V. A. Wager*, on *Urochloa helopus*, Barberton, March 1932; 26182, *L. C. C. Liebenberg*, on *Urochloa helopus*, Nelspruit, March 1932.

Pathological notes: *H. urochloae* was found on *Urochloa helopus* in the Transvaal. No inoculations were made but it is suspected that the fungus was parasitic and responsible for an eye-spot disease. The symptoms were very numerous brown to black lesions varying in size from pinpoints to irregular blotches about 2 × 6 mm. or larger, on the leaf blades. Some remain as ill-defined brown stains, but most develop into irregular eye-spots each with a small straw-coloured or dirty white centre, surrounded by a very dark zone. This peripheral zone is lighter towards the outside and may fade off into the surrounding tissue of the leaf. The fungus was plentiful on all affected parts but especially on the lower withered leaves. No other possible parasites were found.

(16) **Helminthosporium ravenelii** Curtis in Amer. Journ. Sci. ser. ii, 6 (1848) 349–353; Saccardo Syll. Fung. 4 (1886) 412.

Helminthosporium hoffmanni Berk. & Curt., Intro. to Crypt. Bot. (1857) 298.

Helminthosporium tonkinense Karst. & Roum. in Rev. Myc. 12 (1890) 78.

Helminthosporium crustaceum P. Henn. in Hedwigia 41 (1902) 147.

Illustrations: FIG. 16.

Conidia straight or with a slight crescentic or sigmoid curve, widest near the middle, narrowing slightly to either end, often decidedly narrower towards the base; wall thin; hilum inconspicuous and included in the basal contour; light smoky-yellow to smoky brownish-yellow; 25–82 × 12–18 μ with (1)–3–4–(7) septa. *Germination* bipolar. *Conidiophores* very distinctive, long, much branched, torulose; light fuscous yellow; 550 × 5–11·5 μ; arising close together from a velvety basal layer of interwoven hyphae encrusting the affected parts of the host.

Ascigerous stage: unknown.

H. ravenelii differs from other species in the unusual conidiophores rather than in conidial characters. These torulose, much branched conidiophores, crowded into a compact crust, are very distinct from the usual simpler, separate conidiophores of many other species. Only one other species, *H. miyakei*, studied by the author displayed similar features.

Specimens examined:

On *Sporobolus capensis*: 1453, *I. B. Pole Evans*, Harden Heights, 11/4/11; 1826, *E. M. Doidge*, Zoutpansberg, 14/8/11; 2201, *T. Parkins*, Eshowe, 5/4/12; 6692, *E. Baker*, Cedara, 15/5/13; 6921, *A. Pegler*, Kentani, 26/5/13; 9764, *I. B. Pole Evans*, Tweedie, 4/7/16; 9769, *P. v. d. Byl*, Illovo, Natal; 10065, *A. O. D. Mogg*, Tweedie, 13/4/17; 10097, *P. J. Pienaar*, Nelspruit, 17/4/17; 11643, *A. O. D. Mogg*, Tweedie; 20371, *C. N. Campbell*, Mooi River, Apr. 1925; 31783, *H. Power*, Illovo, 20/5/16.

On *Sporobolus fimbriatus*: 6667, *A. Pegler*, Kentani, 14/5/13; 23390, *A. O. D. Mogg*, Balgowan, 3/4/19.

On *Sporobolus pyramidalis*: 13995, *F. Eyles*, Salisbury, 20/2/19; 26093, *L. C. C. Liebenberg*, Lydenburg, Apr. 1931; 29835, *E. M. Doidge*, Donnybrook, 5/9/37.

Pathological notes: *Helminthosporium ravenelii* is the cause of "false smut" of *Sporobolus* spp. in most warm countries where it is widely distributed. In South Africa the commonest host is *S. capensis*. As the popular name of the disease indicates, the inflorescences of the grass are attacked. It appears at first as a velvety, olive or brown coating on the floral parts, and later turns into a dense black crust which often cakes the separate parts together.

This fungus may not be as economically unimportant as is usually stated. Investigators have proved that ravenelin, a metabolic product of the parasite (46) causes cattle poisoning, of which false smut of *Sporobolus* has been suspected in South Africa and elsewhere (32).

(17) **Helminthosporium miyakei** Nisikado in Berichte Ohara Inst. für Landw. Forsch. 4 (1929) 122.

Illustrations: FIG. 17.

Conidia bent, or with a crescentic or irregular sigmoid curve, sometimes straight, widest just below the middle, tapering suddenly and often irregularly to a narrow apex, narrowing gradually towards the abruptly rounded base; basal cell often out of alignment; immature conidia mostly without a tapering apex, obovate long-elliptic or irregular; wall thin; hilum included in the basal contour; light yellow-fuliginous; 25–113 × 11·5–18 μ, with (2)–3–5–(8) septa. *Condiophores* torulose, profusely branched, arising close together from a mat of interwoven hyphae; up to 260 × 4–11·5 μ.

Ascigerous stage: unknown.

H. miyakei approaches the genus *Cercospora* in the shape of its conidia, but in every feature except conidial shape it is closely allied to *Helminthosporium ravenelii*. The genus *Helminthosporium* seems the most suitable for its disposal at present. Although the conidial shape in *H. miyakei* differs from that of the other species discussed in this paper, it does find a parallel in some of the conidia of *H. rostratum*. Many conidia of the latter however, do not taper, while the tapering of others is never as marked as in *H. miyakei*.

With only the conidial stage known, it seems unlikely that *H. miyakei* will fall into either of the two main groups *Cylindro-* and *Eu-Helminthosporium*. Further work may reveal *H. miyakei* and *H. ravenelii* as members of another group possessing conidia of the *Helminthosporium* type.

Specimens examined: 7761, *T. R. Sim*, on *Eragrostis curvula*, Pietermaritzburg, 26/4/14.

Pathological notes: *H. miyakei* forms an olivaceous, later black, crustose growth on the inflorescences of its graminaceous hosts, much like *H. ravenelii*. It has been found only once in South Africa but has been recorded as common on *Eragrostis* tef in Western Ethiopia (5). Nisikado described his type from *Eragrostis pilosa* in Japan. No other records of this interesting and distinctive species have been traced.

(18) **Helminthosporium dematioideum** Bubak & Wroblewski in Hedwigia 57 (1916) 337; Saccardo Syll. Fung. 25 (1931) 821.

Illustrations: FIG. 18.

Conidia straight, oblong-cylindrical, widest near the middle, hardly tapering towards the rounded apex but narrowing decidedly towards the rounded or sub-conical base; walls thin, sometimes somewhat constricted near the basal septum; hilum included in the basal contour; light yellowish-brown; (20)–30–36–(43) × (6)–8–10–(13) μ, with 3–5–(7) septa. *Germination* basal. *Conidiophores*: Simple, septate, usually swollen at the base; medium brown, paler at the tips; emerging singly or in small groups from the host epidermis; 50–100 × (3)–4–6–(7) μ.

Ascigerous stage: unknown.

In his discussion of the American isolates, Drechsler (14) states, " the principal circumstance suggesting a possible lack of identity of the European and American forms, is the recorded occurrence of the former only on the inflorescence of *Anthoxanthum odoratum* while the latter is much more abundant on the foliage ". He suggests that this might be due to a poor original specimen. From the writer's experience it would seem that Drechsler attached too much importance to this slight possible difference in substratum. The South African form fits the description of *H. dematioideum* so well that it must be assigned to this species despite its occurrence on hosts different from the type. The strain from wheat was morphologically indistinguishable from the rest. The identity of Nos. 30241 and 30498 was confirmed by Dr. Westerdijk.

In culture it was found that there was a tendency towards greater variation in conidial size (8–50 μ), conidial colour (darker and more olivaceous) and longer conidiophores. Such variations were also found in other species of *Helminthosporium*.

It is notable that the mode of germination of conidia in *H. dematioideum* is not typical of either of the two main classes in which most graminicolous Helminthosporia fall, namely those connected with *Pyrenophora* or *Cochliobolus* perfect stages.

Specimens examined: 27358, *Naudé*, on *Cynodon dactylon*, Pretoria; 27359, *R. Gardner*, on *Cynodon dactylon*, Pilgrims Rest, 8/2/43; 28779, *v. d. Merwe*, on *Cynodon bradleyi*, Pretoria, 18/12/36; 30241, *K. M. Putterill*, on *Cynodon bradleyi*, Pretoria, 20/2/39; 30243, *K. M. Putterill*, on *Cynodon transvaalensis*, Pretoria, 30/4/39; 30250, *J. Roderick*, on *Cynodon transvaalensis*, Johannesburg, 15/4/39; 30492, *J. Sellschop*, on *Triticum*, Ferreira, O.F.S., Nov. 1938.

Pathological notes: *H. dematioideum* was described from Galicia on *Anthoxanthum odoratum*; it was later found by Drechsler (who amplified the description, 14, p. 683) on the same host in the United States of America. Drechsler also found it on *Agrostis* spp. often accompanied by fructifications of larger-spored species of *Helminthosporium*.

In South Africa this fungus was found to be common on withering or dead leaves of *Cynodon transvaalensis*, *C. bradleyi* and *C. dactylon*. On *Cynodon* lawns it was frequently found mixed with *Helminthosporium cynodontis*, species of *Curvularia*, and occasionally with *Rhizoctonia*. These fungi are known to be responsible for causing browning of lawns in summer, thus it is not known what part was played by

H. dematioideum in producing this condition. Drechsler was similarly unable to decide, from the specimens found, whether *H. dematioideum* was present as a parasite or saprophyte, but he seemed to believe that it was more saprophytic on *Agrostis* and possibly parasitic on *Anthoxanthum*. The relationship of *H. dematioideum* to its *Cynodon* hosts can be established only by inoculation experiments. At present it may be said that the circumstances under which it appears suggest that it may be saprophytic, or a weak parasite capable of attacking plants already weakened by other fungi. This view is supported by the fact that this fungus was unexpectedly isolated from foot-rotted wheat, in company with a number of foot-rotting fungi.

Although there are not many records of this fungus, the writer's experience suggests that it is common.

Species of Curvularia found in South Africa.

The genus *Curvularia* was erected by Boedijn (2) to accommodate a number of small-spored species that had unnaturally been placed in *Helminthosporium*, *Brachysporium*, *Brachycladium* and *Acrothecium*.

Species of *Curvularia* are characterised by unequally-sided or strongly bent conidia, with 3–4 septa. At least one of the central cells is larger and darker than the others. Most species form branched cylindrical stromata in pure culture. These have a black rind, often with white growing points, and are white inside. No perfect stage has yet been found for any *Curvularia* species.

Boedijn divides the genus into three groups:—

(A) Maculans group: characterised by straight or merely asymmetrical, 3-septate conidia, with the two middle cells larger and darker than the end cells. Stromata are never formed in culture.

(B) Lunata group: characterised by 3-septate conidia, more or less strongly bent, with only one of the middle cells enlarged and darker than the end cells. Most species form stromata.

(C) Geniculata group: characterised by 4-septate conidia and forming stromata in culture.

Boedijn noted that the species of *Curvularia* often consisted of several strains showing minor morphological differences. This is well illustrated in the South African isolations of *C. spicifera* in which a strain from *Cynodon* has very much larger conidia than one from wheat. Host differences cannot be regarded as important among these fungi, which may possibly live in the soil.

The species of *Curvularia* described here belong to the Maculans and Lunata groups, but there are doubtless many other species in South Africa.

(19) **Curvularia spicifera** (Bainier) Boedijn in Bull. Jard. Bot. Buitenzorg, ser. iii, 13 (1933) 81.

Brachycladium spiciferum Bainier in Bull. Soc. Myc. de Fr. 24 (1908) 81.

Helminthosporium tetramera McKinney in U.S.A. Dept. Agr. Bull. 1347 (1925).

Illustrations: FIG. 19.

Conidia oblong or ellipsoid, straight, with broadly rounded ends; walls fairly thick, thinner towards the ends; hilum protruding slightly outside the basal contour; greenish-fuliginous or brownish, lighter over the ends; (11)–25–35–(43) × (7)–9–11–(13) μ, with 3 septa, occasionally 2 or 4 septa. *Conidiophores* erect, of variable length; fertile region long and geniculate, olivaceous or brownish, 5–7 μ diam. Conidia borne freely in long clusters.

Ascigerous stage: unknown.

Boedijn placed *C. spicifera* in the Maculans group. Hynes (25) found that McKinney's (33) *Helminthosporium tetramera* was synonymous with *C. spicifera*. However, McKinney reported that his fungus formed stromata in culture, a phenomenon described by Boedijn as specifically non-existent in the Maculans group.

In the writer's material of *C. spicifera* the central cells of the conidia were not as noticeably darker and larger than the end cells as in other material she saw, or as figured by Boedijn. The terminal cells were slightly paler where the wall thinned out over the end cells. Bainier and McKinney did not mention this feature, while Hynes described his conidia as " of a uniform straw brown colour ".

Apart from this difference in colour, the strain from *Cynodon* yielded much larger and darker conidia in culture than in nature. In culture the length of the conidia might be up to 54 μ, and the diameter up to 14·5 μ. This strain was indistinguishable from that on wheat except for conidial size. A culture sent to the Imperial Mycological Institute was identified as " *C. spicifera* except in spore measurements ".

Although the South African material differs from the description of the type in some respects, there is a good general agreement between the two. Differences observed and recorded by various workers indicate that this species is composed of a number of strains of varied character.

Specimens examined: 30246, *J. Roderick*, on *Cynodon transvaalensis*, Johannesburg, Apr. 1939; 30494, *J. Sellschop*, on *Triticum* sp., Bethlehem, Nov. 1938.

Pathological notes: *Curvularia spicifera* has been isolated from foot-rotted parts of wheat, oats, barley, rye and rice. Its recorded distribution is The United States of America (8), India (57), Australia (25), Angola (1), and South Africa. The writer has also found it on withering leaves and stems of *Cynodon transvaalensis* in South Africa, occurring among brown patches on lawns of this grass.

C. spicifera has so far only been found by the writer in association with other fungi known to be capable of causing foot-rot. Its relationship to its host and its associates is unknown. Neither McKinney nor Hynes regarded it as an important pathogen.

(20) **Curvularia** species.

Illustration: FIG. 20.

Conidia straight or unequal-sided to slightly curved; broadly rounded at the apex and tapering towards the base; base somewhat triangular, squared off in the well-marked hilum; yellowish-brown to brown; 3-septate, with the third cell larger and darker than the others, and with thicker walls; most strongly curved in the third cell; (15)–24–30–(36) × (8)–10–14–(16) μ. *Conidiophores* brownish, very variable in length in culture, 3–6μ diam. in the fertile region. Conidia borne spirally on the geniculate protuberances.

Ascigerous stage: unknown.

This species apparently belongs to the Lunata group, with its curved, 3-septate conidia having the third cell from the base larger than the others. But it differs from the Lunata group in that the third cell is not markedly darker than the end cells, and the conidia are seldom strongly bent, often being straight.

A specimen of this fungus was sent to Mr. E. W. Mason, who commented as follows: " It strongly resembles *Brachycladium ramosum* as figured by Bainier [Bull. Soc. Myc. de Fr. 24 (1908) Pl. 4], the only differences being that Bainier said his fungus formed elongated black stromata, covered with conidiophores, and that the conidia were 3 or 4 septate. However, Dr. Boedijn has applied the name *Curvularia ramosa* (Bain.) Boedijn to a distinctly more variable form isolated from wheat in Australia, with longer conidia, 2–5 septate, and with one or more of the central cells often distinctly darker than the two end cells. I would prefer to refer this to *Curvularia lunata* group, at any rate until more is known about the South African species ".

The writer has observed white, branched " roots " of fungous tissue growing down into the agar in month-old tube cultures of this species. These structures were probably an arrested stromatic development. Such positively geotropic stromata were seen by Boedijn in cultures of the Geniculata group. Especially in old cultures, the conidia sometimes became 4-septate. These septa, which were thinner than the rest and divided the large third cell, were obviously late additions. The addition of further septa in the conidia was one of the variations observed by Boedijn, who found it particularly in the Lunata group.

From the above evidence it seems best to follow Mr. Mason's advice and place this species provisionally in the Lunata group, until more is known about it.

Specimens examined: 30495, *J. Sellschop*, on *Triticum*, Bethlehem, Nov. 1938.

Pathological notes: This species was isolated from foot-rotted wheat plants in association with other fungi known to be capable of causing foot-rot. No inoculation tests were made. It is possible that the fungus was a secondary invader.

LITERATURE CITED.

(1) Bensaude, M..... Comptes Rendus Soc. de Biol. 103 (1930) 1265–1266.

(2) Boedijn, K. B..... Bull. Jard. Bot. Buitenzorg, ser. iii, 13 (1933) 120–134.

(3) Breda de Haan, J. van..... Meded. Proefsta. Suikerriet, West-Java 3 (1892) 15–21.

(4) Butler, E. J. & A. Hafiz Khan.. Mem. Dept. Agr. India, Bot. ser. IV (1913) 204–208.

(5) Castellani, E. & Ciccarone, A... Reg. Ist. agron. per l'Africa italiana (1939) 32 pp. (Seen Abstract in Rev. Appl. Myc. XIX: 85.)

(6) Christensen, J. J..... Univ. Minn. Agric. Expt. Sta. Tech. Bull. 37 (1926).

(7) Clements, F. E. & Shear, C. L... The Genera of Fungi (1931).

(8) Crosier, W. & Weimer, D..... Proc. Ass. Off. Seed Anal. N. Amer., 1939. (1940) 120–124. (Seen Abstract in Rev. Appl. Myc. XIX: 601.)

(9) da Camara, E. de S..... Rev. Agron 20 (1932) 5–63. (Seen Abstract in Rev. Appl. Myc. XII: 725.)

(10) Diedicke, H..... Centralbl. Bakt. Abt. 11, Bd. 9 (1902) 317–329.

(11) Diedicke, H..... Centralbl. Bakt. Abt. 11, Bd. 11 (1903) 52–59.

(12) Doidge, E. M. & Bottomley, A. M. Bot. Survey of S. Africa, Mem. No. 11 (1931).

(13) Dosdall, L..... Univ. Minn. Agr. Expt. Sta. Tech. Bull. 17 (1923).

(14) Drechsler, C..... Journ. Agric. Res. 24 (1923) 641–740.

(15) Drechsler, C..... Journ. Agric. Res. 31 (1925) 701–726.

(16) Drechsler, C..... Phytopathology 17 (1927) 414.

(17) Drechsler, C..... Journ. Agric. Res. 37 (1928) 473–492.

(18) Drechsler, C..... Journ. Agric. Res. 40 (1930) 447.

(19) Drechsler, C..... Phytopathology, 24 (1934) 953–983.

(19a) Drechsler, C..... Phytopathology 25 (1935) 334–361.

(20) Faris, J. A..... Phytopathology 18 (1928) 753–754.

(21) Hansford, C. G..... Imp. Myc. Inst. Mycol. Pap. No. 15 (1946) 213–214.

(22) Henry, A. W..... Univ. Minn. Agr. Expt. Sta. Tech. Bull. 22 (1924).

(23) Hopkins, J. C..... Rept. Plant Path. for 1929. Rept. of Secy., Dept. Agric. S. Rhodesia for 1929, (1930) 84–86.

(24) Hynes, H. J..... Sci. Bull. Dept. Agric. N.S.W. 47 (1935).

(25) HYNES, H. J..... Journ. Roy. Soc. N.S.W. 70 (1937) 378–391.

(26) HYNES, H. J..... Jour. Aust. Inst. Agric. Sci. iii, 4 (1937) 212–218.

(27) HYNES, H. H..... Sci. Bull. Dept. Agric. N.S.W. 61 (1938).

(28) ITO, S..... Proc. Imper. Acad. Tokyo 6 (1930) 352–355. (Seen Abstract in Rev. Appl. Myc. X: 232.)

(29) ITO, S. & KURIBAYASHI, K..... Ann. Phytopath. Soc. Japan 11 (1927) 1–8. (Seen Abstract in Rev. Appl. Myc. VII: 54.)

(30) ITO, S. & KURIBAYASHI, K..... Journ. Fac. Agric. Hokkaido Imper. Univ. Sapporo, Japan 29 (1931) 85–125. (Seen Abstract in Rev. Appl. Myc. X: 514.)

(31) KURIBAYASHI, K..... Trans. Sapporo Nat. Hist. Soc. 10 (1929) 138–145, 162. (Seen Abstract in Rev. Appl. Myc. VIII: 438.)

(32) MARCHIONATTO, J. B..... Bol. Min. Agric. Nac., Buenos Aires 29 (1930) 457–462.

(33) MCKINNEY, H. H..... U.S. Dept. Agric. Bull. 1347 (1925).

(34) MCRAE, W..... Scient. Repts. Imper. Inst. Agric. Res. Pusa (1931–2) 122–140.

(35) MCRAE, W..... Scient. Repts. Imper. Inst. Agric. Res. Pusa (1932–3) 134–160.

(36) MITRA, M..... Trans. Brit. Myc. Soc. 15 (1930) 254–293.

(37) MITRA, M..... Trans. Brit. Myc. Soc. 16 (1931) 115–127.

(38) MITRA, M. & BOSE, R. D..... Indian Journ. Agric. Sci. 5 (1935) 449–484.

(39) MITRA, M. & MEHTA, P. R..... Indian Journ. Agric. Sci. 4 (1934) 943–975.

(40) MOURASHKINSKY, K. E..... (Abstract seen in Rev. Appl. Myc. XIX: 391.)

(41) NATTRASS, R. M..... Rept. Dept. Agric. Kenya for 1938 (1939) 42–47. (Seen Abstract in Rev. Appl. Myc. XIX: 71.)

(42) NISIKADO, Y..... Japan. Jour. Bot. 4 (1928) 99–112. (Seen Abstract in Rev. Appl. Myc. VII: 519.)

(43) NISIKADO, Y..... Ber. Ohara Inst. für Landw. Forsch. 4 (1929) 111–126.

(44) NISIKADO, Y. & MIYAKE, C..... Ber. Ohara Inst. für Landw. Forsch. 3 (1926) 221–266.

(45) O'GARA, P. J..... Phytopathology, 5 (1915) 323–326.

(46) RAISTRICK, H..... Rept. London. Sch. Hyg. 1934–5, (1935) 27–30. (Seen Abstract in Rev. Appl. Myc. XV: 170.)

(47) RAVN, F..... Bot. Tidsskrif Bd. 23 (1900) 101–322.

(48) RAVN, F..... Zeits. Pflanzenkr. 11 (1904) 1.

(49) SACCARDO, P. A..... Sylloge Fungorum, 25 volumes (1882–1931).

(50) SMITH, N. J. G..... Ann. Appl. Biol. 16 (1929) 236–260; Ibid. 17 (1930).

(51) SMITH, N. J. G. & PUTTERILL, K. M. S. Afr. Journ. Sci. 29 (1932) 286–295.

(52) SMITH, N. J. G. & PUTTERILL, K. M. S. Afr. Journ. Sci. 30 (1933) 198–205.

(53) SMITH, N. J. G. & RATTRAY, J. M. S. Afr. Journ. Sci. 27 (1930) 341–351.

(54) STEVENS, F. L..... U.S.A. Dept. of Reg. & Educ. Div. Nat. Hist. Survey Bull. 14 (1922) 77–185.

(55) SUBRAMANIAM, L. S..... Indian Journ. Agric. Sci. 6 (1936) 11–16.

(56) SYDOW, H., MITTER, J. H. & TANDON, R. N. Ann. Myc. 35 (1937) 239.

(57) THOMAS, K. M..... Rept. Govt. Mycologist, Madras, 1938–39 (1939). (Seen Abstract in Rev. Appl. Myc. XIX: 258.)

(58) TULLIS, E. C..... Journ. Agric. Res. 47 (1933) 675.

(59) VAN DER BYL, P. A..... Union of S. Afr. Dept. Agric. Sci. Bull. 10 (1918).

(60) WAKEFIELD, E. M. & MOORE, W. C. Trans. Brit. Myc. Soc. 20 (1936) 97–109.

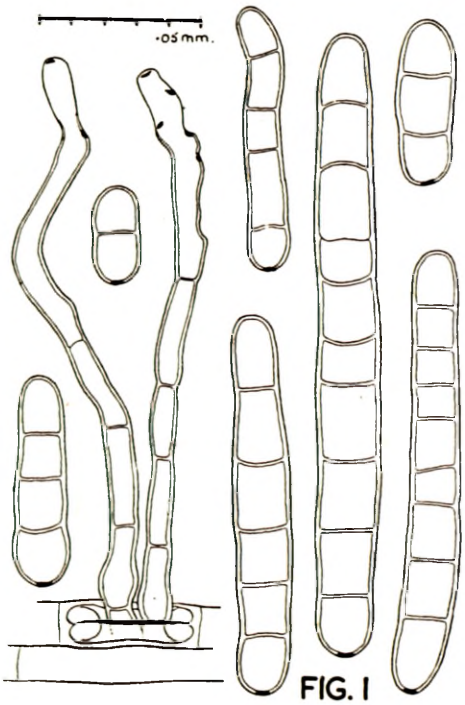


FIG. 1

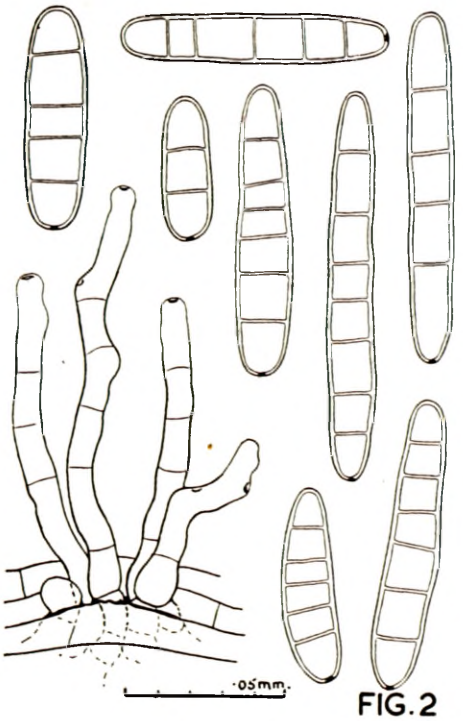


FIG. 2

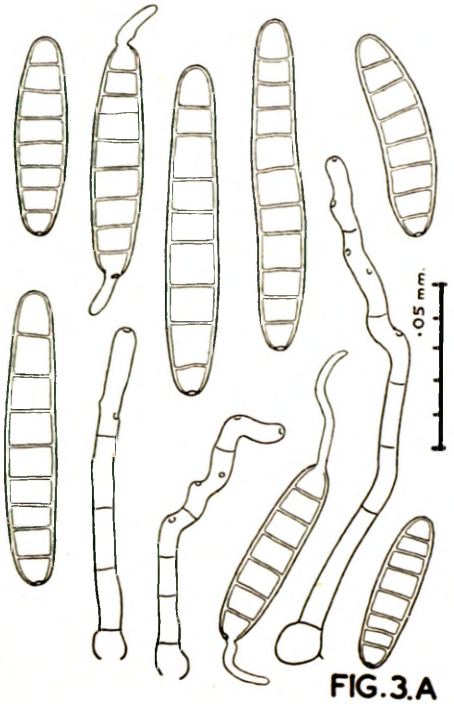


FIG. 3.A

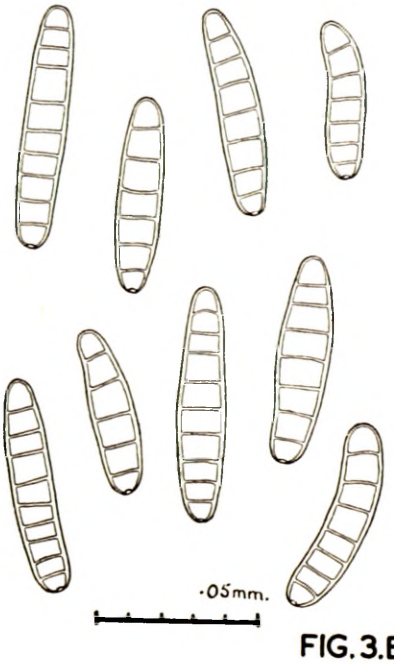


FIG. 3.B

FIG. 1.—*H. teres.* FIG. 2.—*H. gramineum.* FIG. 3a, 3b.—*H. mediocre.*

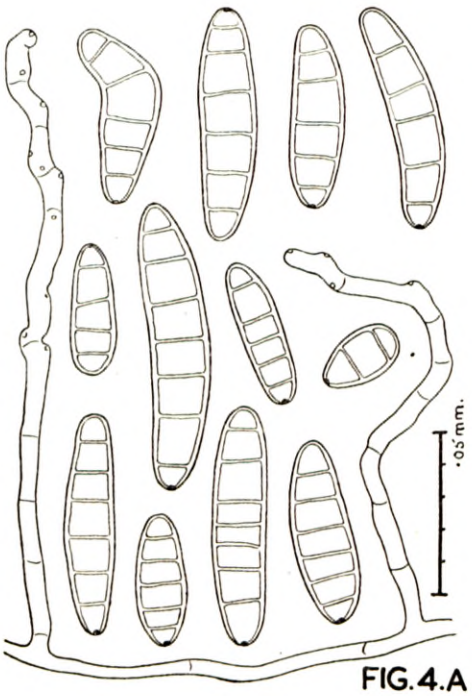


FIG. 4.A

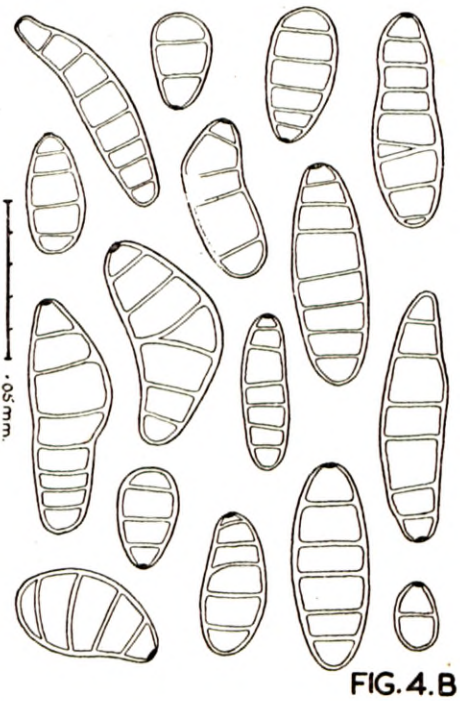


FIG. 4.B

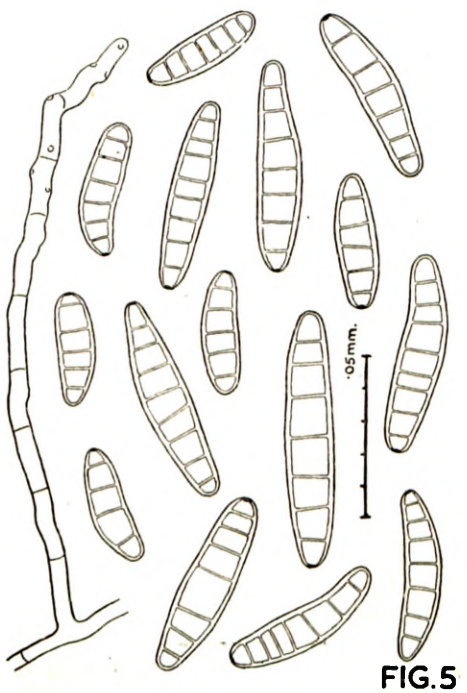


FIG. 5

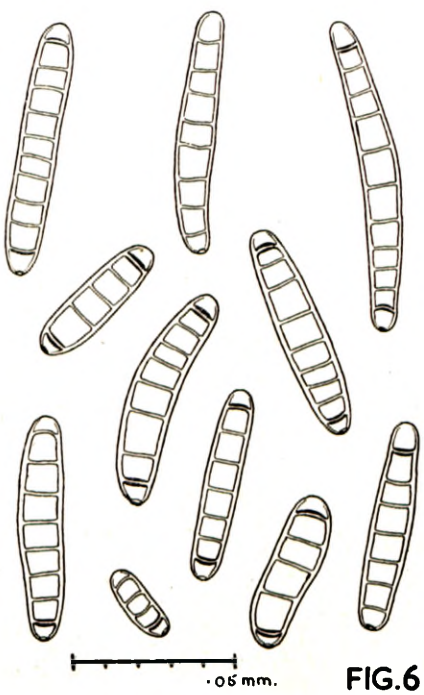
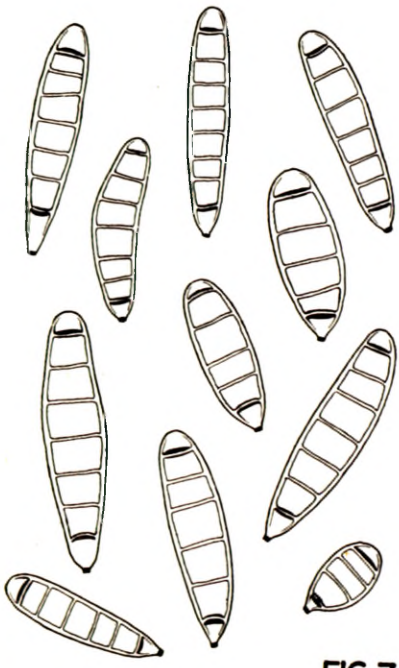
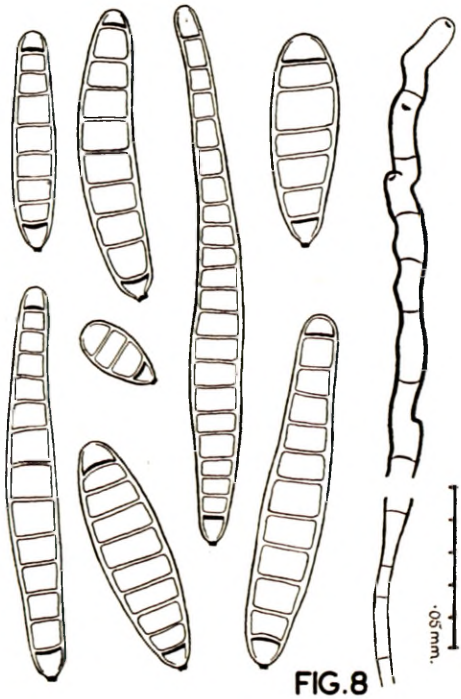
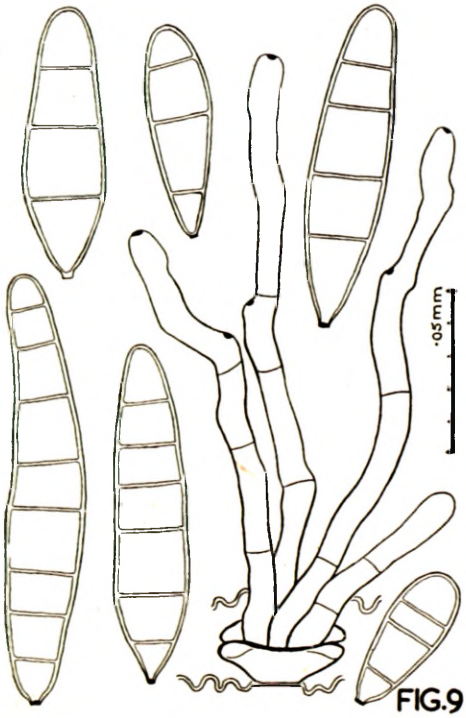


FIG. 6

FIG. 4a, 4b.—*H. sativum.* FIG. 5.—*Helminthosporium N.* FIG. 6.—*H. bicolor.*







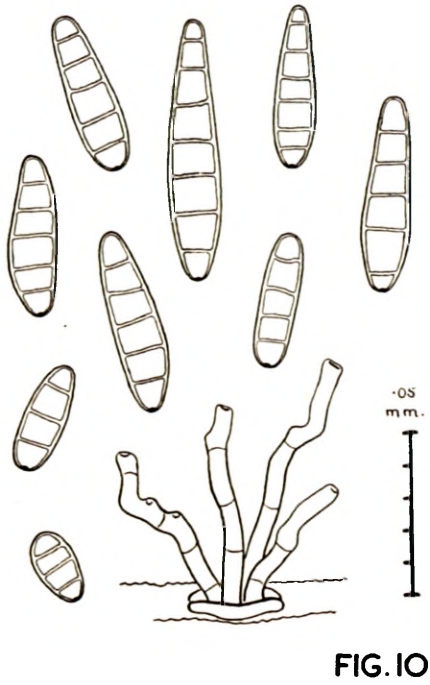


FIG. 7.—*H. halodes*. FIG. 8.—*H. rostratum*. FIG. 9.—*H. turcicum*. FIG. 10.—*H. leucostylum*.

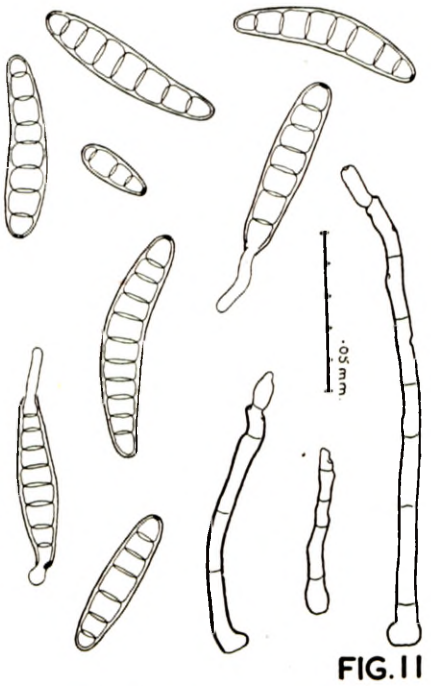


FIG. 11

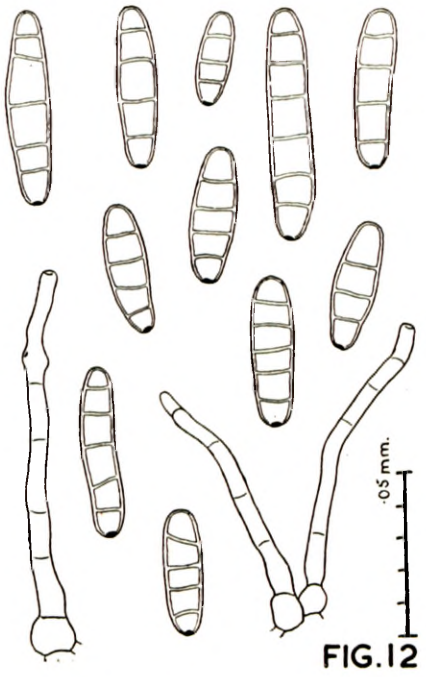


FIG. 12

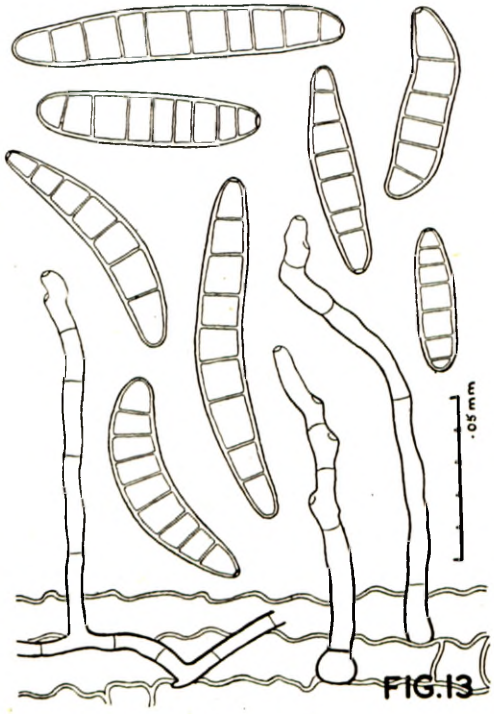


FIG. 13

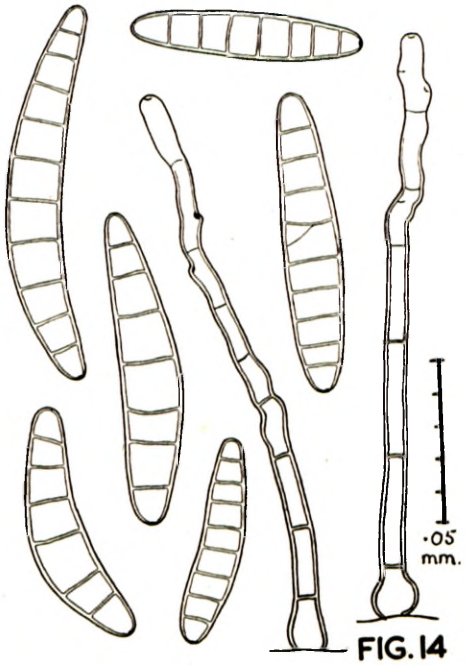


FIG. 14

FIG. 11.—*H. cynodontis.* FIG. 12.—*H. brizae.* FIG. 13.—*H. sacchari.*
FIG. 14.—*H. leersii.*

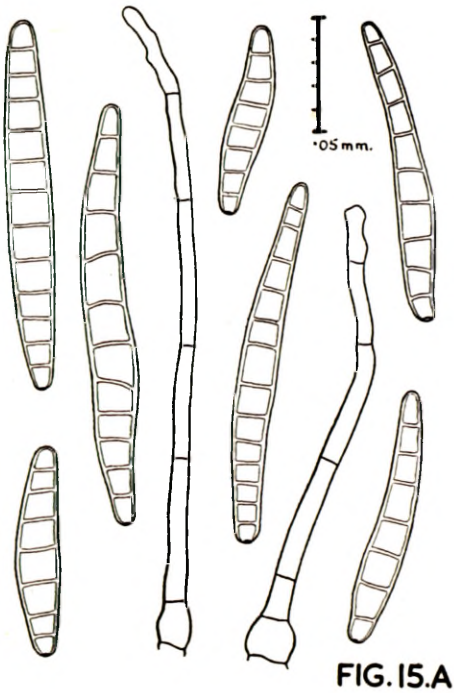


FIG. 15.A

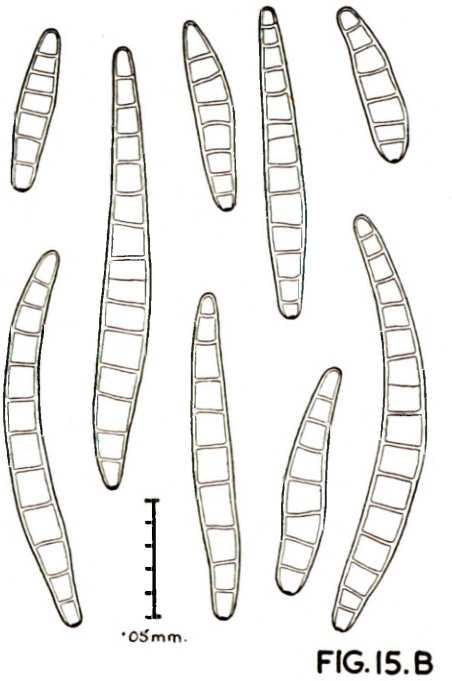


FIG. 15.B

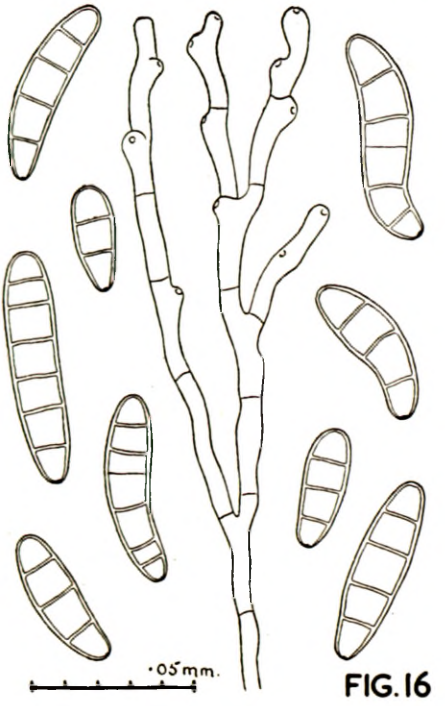


FIG. 16

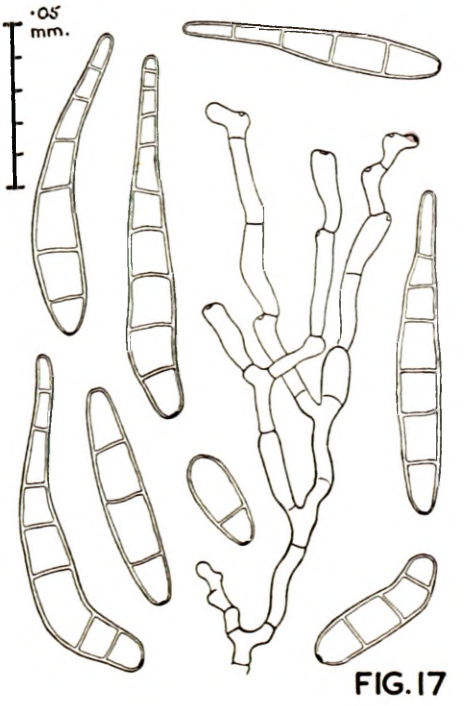


FIG. 17

FIG. 15a, 15b.—*H. urochloae*. FIG. 16.—*H. ravenelii*. FIG. 17.—*H. miyakei*.

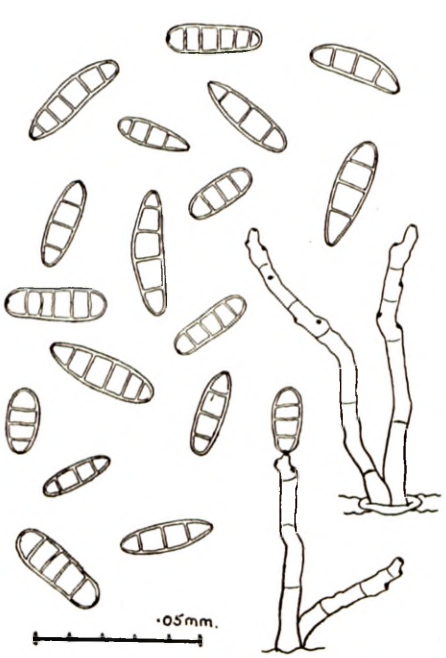


FIG. 18

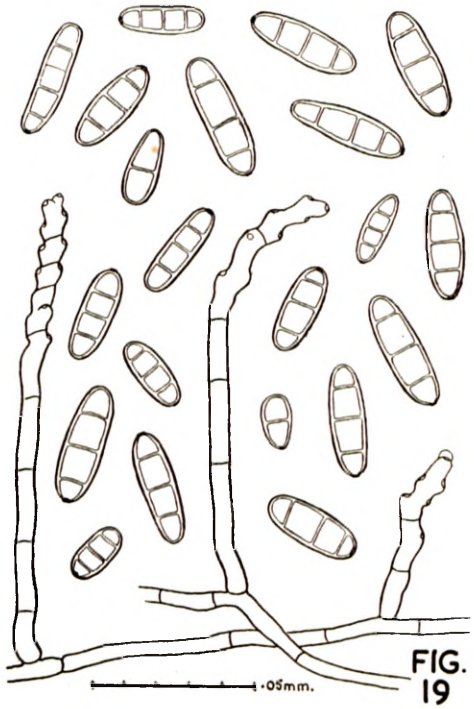


FIG. 19

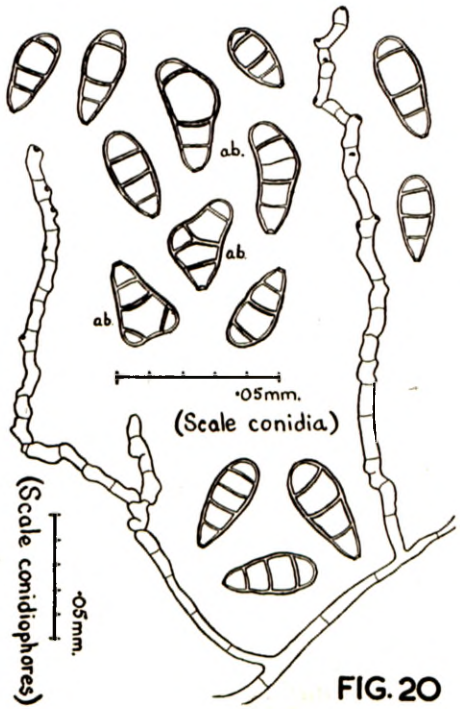


FIG. 20

FIG. 18.—*H. dematioideum.* FIG. 19.—*Curvularia spicifera.*
FIG. 20.—*Curvularia* species.