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D. R. Reynolds
Florida Technological University

B. R. Pohlad
Florida Technological University

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D. R. REYNOLDS and B. R. POHLAD[1]

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Monographic work (Reynolds, 1970; Reynolds, 1971a; Reynolds, 1971b) suggests that sooty molds exhibit distinct cyclic patterns of growth and reproduction. Furthermore, a tally of collection data recorded in other monographic work (Batista and Ciferri, 1962; Batista and Ciferri, 1963a) suggests that the sexual fruit bodies of ascomycetous neotropical sooty molds are prevalent during the drier season of the year. Asexual sooty molds may also occur seasonally (Batista and Ciferri, 1963b). A study was begun approximately two years ago to determine the reproductive unit frequency of select sooty molds at various times of the year.
INDEX DESCRIPTORS: *Capnodiaceae,* Sooty Molds of Florida, Cyclic Patterns in Sooty Molds.

MATERIALS AND METHODS

Trees in two central Florida citrus groves were regularly sampled throughout the year. The leaves of a total of 20 trees were taken at breast height, at one-foot intervals from the center of the tree to the canopy edge. The sooty mold mycelium was removed from the leaf surface as a 10 mm wide strip from the midrib to the leaf margin. The mycelium was either teased from the leaf surface or, if sparsely growing, removed after embedding in a celluloid matrix. These strips were mounted on a microscope slide. Spore and fruit body counts were made by visually determining the numbers of reproductive units, including conidia, pycnidia, and ascocarps, present in the field of a Zeiss research compound microscope equipped with a 10X eyepiece and a 40X objective. The reproductive units were counted from five randomly selected fields on each mycelium strip. The species selected for counts were those which represented *Pithomyces, atro-olivaceus* (Cooke and Harkness) M. B. Ellis, *Podoxyphium citricolum* Bat, Vital, and Cif., and *Trichomerium didymopanacis* Bat. and Cif. An index of the prevalance of the fruiting structures for each fungus was determined by calculating the average of reproductive units per micrscope field per month. These data are represented for each species in Figure 1.

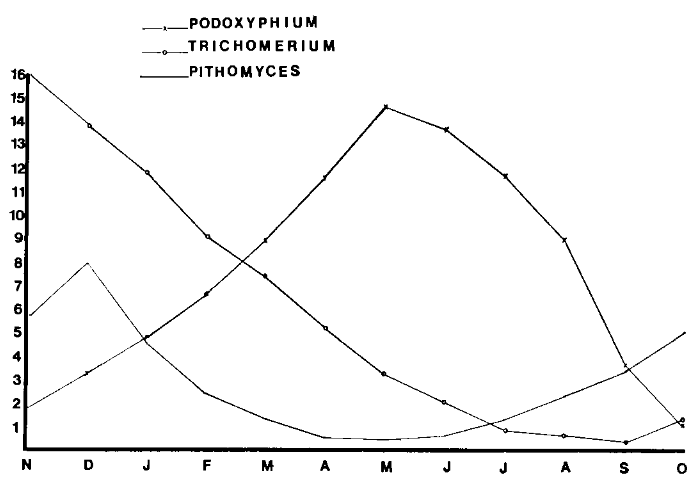

Figure 1. Index of prevalence of sooty mold fungi present in a central Florida citrus grove. The average number of reproductive units for *Podoxyphium citricolum, Trichomerium didymopanacis,* and *Pithomyces atro-olivaceus* (abscissa) measured each month. The annual cycle is represented as beginning with November (N).

RESULTS AND DISCUSSION

It appears that the reproductive units of the sooty mold fungi represented by the species reported on here are prevalent at different seasons of the year. Data are reported in Figure 1. In brief, the *Trichomerium* ascocarps abruptly appeared in late October and early November, and reached their lowest point in July. The *Podoxyphium* pycnidia slowly increased from October to April, and declined from June through September. *Pithomyces* conidia increased from May through January, and decreased until May.

Several observations made on the ecology of sooty molds in relation to these results deserve discussion. These include (1) a correlation of patterns of reproductive unit production with the presence of honeydew-producing insects, (2) mechanisms for survival from season to season, and (3) the role of pleomorphism in the annual cycle patterns.

A correlation of patterns of reproductive unit production with the presence of honeydew-producing insects. A broad pattern of sooty mold colony growth and development on citrus leaves is related to the presence of honeydew-producing insects. The major sources of honeydew on citrus are aphids, soft brown scale, wax scale, mealybugs, black scale, and the white fly. These insects undergo annual reproductive cycles which make honeydew available only during certain stages of the insect life cycle.

An illustrative example from central Florida is the white fly associated with the sooty molds on citrus (Webber, 1897). In

[1] Department of Biological Science, Florida Technological University, Orlando, Florida 32816.

late spring the overwintering mature larvae emerge as pupae; in mid-March the adults appear. Several broods develop until formation of the mature overwintering larval stage in October. Honeydew is secreted by adult larval and pupal stages, and thus is available only during limited times of the year.

Observations seem to corroborate the simultaneous occurrence of honeydew-producing insects and sooty molds. Dr. Bill Simanton from the University of Florida measured the seasonal development of sooty molds on newly formed leaves of citrus trees frequented by honeydew-producing insects for 16 years. He indicated that sooty mold growth began in late March or early April and leveled off by August (personal communication).

On Florida citrus trees sooty mold growth seems correlated with the presence of the white fly (Griffiths and Thompson, 1957). Fungal growth begins in late fall or early winter; by March little sooty mold growth occurs on the citrus leaves. These observations were confirmed in the groves utilized in this study.

Mechanisms for survival from season to season. The three species reported in this study may exhibit mechanisms for survival from season to season. Consider for example *Trichomerium* and *Podoxyphium.* The outermost part of the ascocarp wall of *Trichomerium* is composed of layers of darkly pigmented cells and an underlying hyaline tissue. Upon absorption of moisture, the hyaline inner wall of the ascus containing the ascospores expands and extrudes through the ostiole of the ascocarp. At this time the ascospores are ejected (Reynolds, 1971c). In *Podoxyphium* the pycnidiospores are produced in a mucilaginous matrix. Droplets containing the pycnidiospores form at the mouth of the pycnidium *in situ* on a citrus leaf during periods of moisture, or in a moist chamber. The droplets can eventually dry down and, upon rewetting, again become viscous. In agar culture, the pycnidia exude large amounts of spores which fill a petri dish with a white slime. The pycnidiospores will not germinate as long as they are in the undiluted mucilaginous matrix; however, upon dilution of the material, the small hyaline spores will produce hyaline hyphae which eventually develop dark walls. These reproductive mechanisms exhibited by *Trichomerium* and *Podoxyphium,* coupled with cyclic reproduction, may encourage the development of a sooty mold colony at the initiation of favorable conditions, such as the end of the dry winter season.

The three kinds of reproductive structure counted in this study may have adaptive value, too: (1) Possibly pycnidiospores, such as those produced by *Podoxyphium,* produced in a drier time of the year are kept moist by the mucilage within the pycnidium, thus facilitating germination when the rainy season begins; (2) The rapid appearance of ascocarps which contain mature ascospores, such as those of *Trichomerium,* and the apparent cessation of mycelial growth, may be correlated with the onset of adverse factors, such as the cooler and drier conditions in October-November, and a reduction in food when the honeydew-producing insects develop the overwintering stage. The ascospores would be protected in a fruit body within a bitunicate ascus. The ascospores from these ascocarps would easily be ejected during a rainy period from mycelium adhering to the leaf, or perhaps from mycelial flakes located near a honeydew source. Asexual spores produced directly from the mycelium, such as those of *Pithomyces,* might function to maintain the fungus.

The role of pleomorphism in the annual cycle patterns. The prevalence of asexual spore forms at certain times of the year, other than those during which a sexual spore form is prevalent, may suggest pleomorphism. McAlpine (1896) believed that the spore forms present in a sooty mold colony were pleomorphic variations of the same species. Other workers, including Fraser (1933), Fisher (1933), Batista and Ciferri (1963a), and Hughes (1972), also considered this possibility. The data reported in this paper could be interpreted as supporting the occurrence of pleomorphism in a sooty mold colony. Possibly asexual spores produced by hyphae allow a sooty mold to colonize a leaf even before the production of ascocarps. We have seen the germinated staurospores of *Tripospermum roupalae* (Syd.) Hughes on newly formed leaves, and phialides producing phialospores on many of the conidial arms and at regular intervals along the hyphal extensions from the tips of each germinated arm. Deuteromycetous and ascomycetous sooty molds can exist independently side by side. Evidence from experimental culture work is necessary for proof of pleomorphism.

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