The Black-head Disease of Bananas (*Musa acuminata*)

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Cobb (1893) found males of the nematode, *Tylenchus similis* (a synonym of *Radopholus similis* (Cobb, 1893) Thorne, 1949) in soil around diseased banana roots in Fiji. In 1915 he described both sexes and recorded the pest from banana rhizomes in Jamaica, W.I. and sugar cane roots in the Hawaiian Islands. Leach (1958) recorded the pest on Lacatan bananas in Jamaica, W.I. Scarseth and Sharvelle (1950) reported on "head rot" and "short roots" of bananas in Honduras, two maladies they attributed to nematode injury, though the nematode was not identified. Taylor and Loegering (1953) found *Pratylenchus musicola* (Cobb, 1919) Filipjev, 1936 in frequent association with root lesions of abaca or Manila hemp (*Musa textilis* Née); *R. similis* was found but less commonly. Anon. (1957) and Loos (1957) described the symptoms associated with *R. similis* infection of Gros Michel and Cocos banana roots and rhizomes. Loos (1959) demonstrated, in pot experiments, that severe infection with this nematode, while causing a highly significant reduction in the root system of the banana, shortened the period between inocula- of young Gros Michel plants with the fungus, *Fusarium oxysporum* f. *cubense*, and symptom expression of fusarium wilt disease. Loos and Loos (1960) reported that the inadequate anchorage afforded by a depleted and severely lesioned root system, the result of *R. similis* infection, was responsible for tipping over and consequent loss in crop of first ratoon banana plants. Stover and Fielding (1958), in a limited survey of banana areas in Honduras, recorded the nematodes found in association with *Musa* spp.

Diseases caused by *R. similis* infections are better known as "spreading decline of citrus" in Florida, U.S.A. and "yellows disease of pepper" in Banka, Indonesia. "Black-head disease of bananas," suggested by Ashby (1915), appropriately describes the symptoms in banana heads or rhizomes.

Banana plants are generally spaced 11 ft. by 11 ft. apart but, in recent years on commercial plantations, closer spacings for higher plant populations have been attempted. Bananas are herbaceous perennials with a sympodial rhizome system in which horizontal growth of the sympodium is slight. This tendency for rhizome sprouts to turn up to form new aerial stems close to the parent plant results in a clumped "mat" or congregate of plants. Generally two plants are encouraged to a mat, the others being pruned back occasionally.

Primary roots are fleshy, up to two-thirds of one inch thick, and originate usually in groups of four at the junction between the central cylinder and cortex of the rhizome. These roots are restricted mainly to the upper foot of soil and may reach 17 feet in length (Simmonds, 1959). Fleshy lateral or secondary roots, of smaller diameter than primaries, are formed mainly at their distal portions (Summerville, 1939) and at damaged roots. Large numbers of fine rootlets, seldom over two inches long, which have a relatively short life and are continuously replaced, are produced on these thick fleshy roots. They originate at the junction between the tough central stele and cortex and pass through the width of the root cortex before being externally borne.

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DISEASE SYMPTOMS ASSOCIATED WITH *R. similis*

INFECTIONS IN ROOTS: The nematode enters a fleshy primary or secondary root close behind a root tip or via a rootlet. In the later mode of entry the nematode moves through and along the rootlet to pass into the cortical tissues of the large root, immediately above the tough central stele, near the rootlet origin. The track is clearly visible as a pink-red streak (Fig. 1-G). With growth of the colony and extension of its feeding area the pink-red coloration extends parallel with the stele and laterally through the width of the fleshy cortical tissues. Brown to black lesions, with slightly sunken centers and longitudinal cracks, up to four inches long and girdling the root are common on roots of heavily infected plants (Fig. 1-E).

The characteristic internal symptoms of *R. similis* infections are best observed in lesions over one inch long if the root is split centrally and longitudinally through the infected region. Discolored tissue is restricted to the cortex and the central stele is white and healthy (Fig. 1-F). The advancing edge or perimeter of the lesion is pink-red or wine color, with the aging center brown to black. A streak of reddened tissues may extend one-half inch beyond the lesion, in close contact with and parallel to the stele. While the internal structure of the discolored cell is destroyed the cell wall remains intact for some considerable time and the normal form of the root is retained. Final breakdown of the infected cortical tissues exposes the central stele to infection with rot-causing organisms and the root beyond the lesioned area is killed. This damage stimulates production of a number of secondary roots immediately above the damaged area (Fig. 1-B). Increased root formation, may, at first, be beneficial to the plant but in time, with a build-up of the pest population these new roots in turn become infected and are destroyed.

Steiner and Buhrer (1933) described *R. similis* in the xylem tissue of a tea root. In banana roots the nematodes often lie so close to the central cylinder that their position may be interpreted erroneously in a fairly thick tangental section.

Infection generally spread from the "seed" rhizome and, since all roots originate from rhizomes, the majority of infections are confined to the vicinity of the plant bowl. This results in shortened roots, 3 inches to 2 feet long, a symptom which Searseth and Sharvelle (1950) mentioned. These shortened roots are inadequate anchorage to the plant, which tips over easily under wind pressure or from the leverage exerted by weight of developing fruit (Fig. 1-D). The depth of the plant bowl in the soil has, however, a bearing on proneness to tip over; plants with deep-seated bowls stand up more satisfactorily than shallow-set ones.

INFECTIONS OF RHIZOMES: *R. similis* infections of rhizomes cause blackening of the epidermal tissues above the lesioned area. In large rhizomes this blackening may extend up to 4 inches in width and in small material, such as "sword" suckers, the entire rhizome epidermis may be involved. Epidermal blackening is most conspicuous in the Lacatan banana and it was this symptom which Ashby (1915) termed "black-head disease."

The root of a banana plant, in a large rhizome, may pass through 3 to 4 inches of rhizome cortex before being externally borne. *R. similis* enters the rhizome via a root (Fig. 1-H) or through a wound in the epidermis. Nematodes in a root infected close to a rhizome, pass along the root and into the rhizome cortex where they spread laterally and in depth to form the typical diffuse rhizome lesion. The lesion surrounding embedded roots is clearly visi-

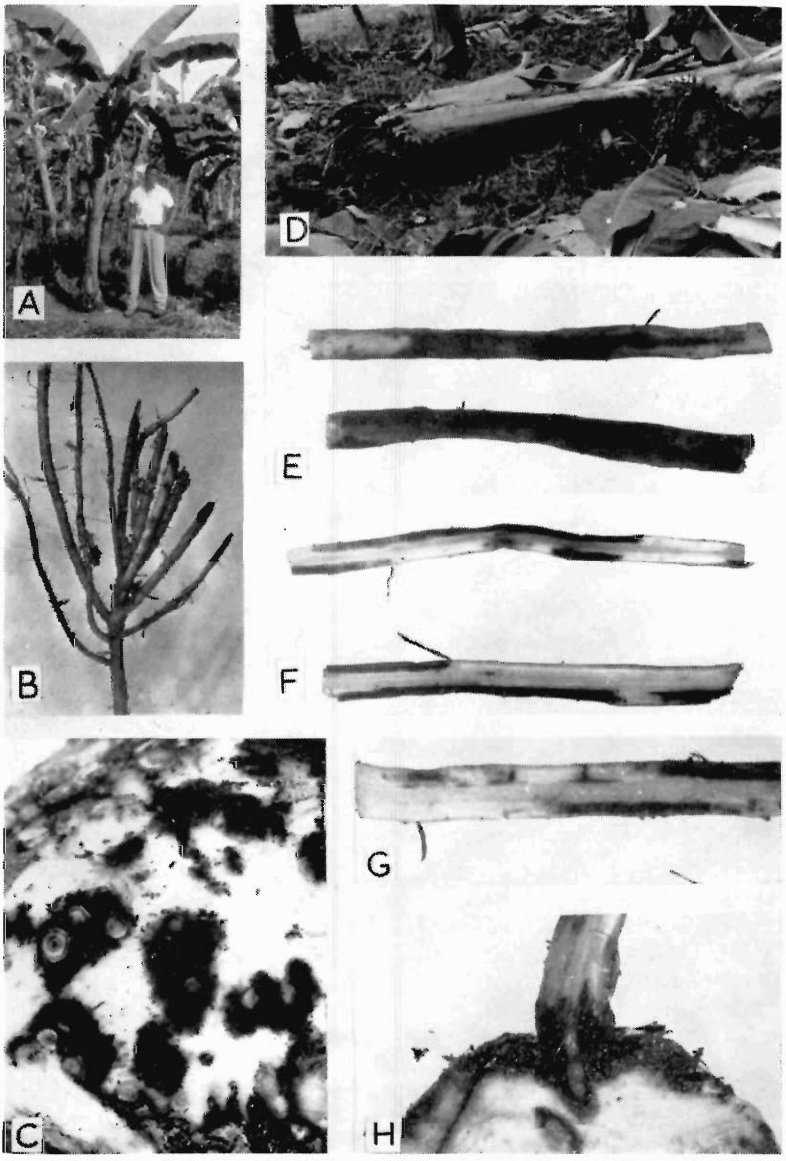

Fig. 1: A. *Radopholus similis* infected banana plant. Such plants are easily pushed over or topple over under wind pressure; B. Root proliferation above point girdled with the nematode infection; C. Rhizome lightly pared of outer cortical tissues to show diffuse R. similis lesions surrounding the root origins; D. Banana plants toppled by wind pressure. Note complete uprooting of the plant bowl; E. Lesioned primary roots of Lacatan banana; F. Split Lacatan roots showing death of cortical tissues; G. *R. similis* infection of a primary root. Note ⊥ shaped discoloration of the split root. The stem of the ⊥ is the rootlet through which the nematodes passed before turning at right angles to infect tissues parallel and close to the stele; H. Infection of rhizome cortex. The nematodes pass through the root and into the rhizome.

ble on lightly paring the outer cortical tissues of an infected rhizome (Fig. 1-C). The lesion gradually becomes brown to black in the center but edges retain the characteristic pink-red colorations. The central black tissues often disintegrate with age, forming cavities suggestive of borer (*Cosmopolites sordidus* Germar) galleries. The lesions are generally confined to the outer inch of the rhizome cortex though occasionally they may go down as deep as 2½ inches. Frequently an infection may continue below the diffused lesion as a pink-red streak inside the cortex of the embedded root.

The reddened areas are infected with all stages of the nematode whereas the blackened central tissues contain bacteria and fungi. Saprophagous nematodes become abundant in tissues which are in the process of distintegration.

All types of rhizomes, ranging from "button seed" to large "bull-heads" (Loos and Loos, 1960) are liable to infection. Dormant button buds, formed above ground level, are infected through roots which develop around their base during prolonged spells of wet weather and die back under drier conditions.

Under adverse weather conditions lesions may become water soaked and tissues prematurely invaded by rot-causing organisms. When this occurs the nematodes evacuate the lesion and the pink-red perimeter disappears.

LOCATION AND EXTRACTION OF *R. similis*

All stages in the development of this nematode are colonized in the reddened tissues of the lesion and never beyond it. Large numbers may be obtained by teasing reddened tissues in a dish of water or by washing material, comminuted for about 20 seconds in a Waring blendor, through sieves. The specimens are found in residues on 200- and 300-mesh sieves. Larvae, juveniles and females removed in this manner are sluggish but may be induced to activity if the water, in which they are suspended, is aerated for a few hours. Males, on the other hand, are very active. Comparatively few specimens are recovered from banana soils but those in soil are generally active.

DISCUSSION

The behaviour of *R. similis* in different locations indicated the existence of physiological races of this nematode. The Gros Michel banana was grown, almost exclusively over the last few decades, in Almirante, Republic of Panama; infection was widespread and tip-overs abundant. During the writers' stay there a consignment of Lacatan rhizomes was imported from Jamaica, W.I., to replant an old Gros Michel area which had succumbed to fusarium wilt disease. This Lacatan material was severely infected with *R. similis,* and, as was expected, there was widespread infection throughout the planted area 12 months later. After 20 months many mats had toppled over during wind storms (Fig. 1-D) and surviving heavily infected plants could be recognized from the small stems (fruits) they bore. Those weak-looking plants could be toppled over with a slight push or pulled down with a light tug on a leaf. During a series of laboratory experiments the writers failed to obtain satisfactory infections of Gros Michel plants with *R. similis* obtained from those Lacatan rhizomes. Similarly *R. similis* from Gros Michel failed to infect Lacatan. On the other hand, using the same nematode concentrations, there was no difficulty in obtaining severe infections on Lacatan with the Lacatan strain and on Gros Michel with the Gros Michel strain. Similar specializations are evident on the banana fields in Jamaica, though definite experimental

proof is still lacking. DuCharme and Birchfield (1956) considered there were at least 3 physiological races of *R. similis* in Florida, U.S.A.

Although sandy soils may favor the spread of *R. similis* from plant to plant there were no apparent differences in the intensity of attack in heavy clay and sandy soil. This is understandable since most infections originate at the "seed" rhizome and the spread is around the plant bowl.

SUMMARY

"Black-head disease" of bananas is caused by the burrowing nematode *R. similis*. Nematodes enter a rootlet and pass through it into the cortical tissues of the fleshy primary root where they form lesions up to 4 inches long, which may girdle the root. Lesions are brown to black with slightly sunken centers and longitudinal cracks. A root split centrally and longitudinally through the lesion shows that discoloration of the tissues is confined to the cortex; the central stele is unaffected. Edges of the lesion are pink-red while the center turns brown to black with age. Although the stele is not invaded by the nematode the breakdown of the cortex exposes it to infection with rot-causing organisms and the entire root beyond the lesioned area is killed. Root infection lies mainly in the vicinity of the plant bowl as infection usually originates from the "seed" rhizome. This results in shortened roots, a typical symptom of *R. similis* infection on bananas. The rhizome is infected via a root and the lesions are diffuse patches up to 4 inches wide and occasionally 2½ inches deep. Nematodes, in all stages of development are present in the pink-red tissues; the blackened tissues contain bacteria and fungi.

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