Food and Agriculture Organization of the United Nations

International Plant Protection Convention

African Union

USDA

Survey Guidance for *Fusarium oxysporum* f.sp. *cubense* tropical race 4

Survey Guidance for *Fusarium oxysporum* f.sp. *cubense* tropical race 4

Figure 1. Adult banana plant infected with Foc TR4 exhibiting leaf yellowing and wilt. (Photo by Scot Nelson)

Scientific Name

Fusarium oxysporum f. sp. *cubense* tropical race 4 (E. F. Sm.) W. C. Snyder & H. N. Hansen

Common Name

Foc TR4, Fusarium wilt of banana, Panama disease

Type of Pest

Fungus

Taxonomic Position

Phylum: Ascomycota,
Class: Sordariomycetes,
Order: Hypocreales, **Family:** Nectriaceae

Known Hosts

Preferred hosts

Musa acuminata, *M. acuminata* subsp. *burmannica*, and *M. balbisiana*

Survey Protocol

Survey Site Selection

Survey where *Musa* species occur. This may include commercial production sites, landscaped areas, or natural areas with wild *Musa* plants.

Time of year to survey:

Year round however, the older leaves are more likely to express symptoms of the disease. Banana suckers that are less than about four months old (often used as planting material) do not develop visible symptoms.

Visual Survey

Signs and Symptoms:

The first above-ground symptoms are pale green streaks at the base of the leaf petioles at the base of the oldest leaves. After this, two types of syndromes can develop:

Figure 2. Early stage of Foc TR4 infection – leaf yellowing and edges turn brown (Source: Department of Agriculture and Fisheries, Queensland, Australia, CC BY 4.0)

- Yellow leaf syndrome:
  - Leaves begin to yellow, progressing from older (bottom) to younger (top) leaves. Leaves may turn brown at edges (**Fig. 2**)
  - Leaves gradually collapse, bend, and hang down, forming a skirt around the base of the plant (**Fig. 4**).
  - This process can take 1 to 3 weeks to occur.
- Green leaf syndrome:
  - The leaves remain mostly green until they bend and collapse; older leaves exhibit this syndrome before younger ones.

The pseudostems (the part of the banana that looks like a trunk) may split lengthwise and when cut open, a reddish-brown discoloration of the vascular tissue is typically seen (**Fig. 3**). A reddish-brown discoloration may also be seen in the roots and rhizomes. New leaves may be paler and shorter than normal. Fruit exhibit no symptoms.

Figure 3. Various stages of internal discoloration in banana pseudostems due to Foc TR4 (Source: CC BY-NC 4.0: George Mahuku/IITA; Department of Agriculture and Fisheries, Queensland, Australia; Miguel Dita/Alliance)

Figure 4. Advanced stage of Foc TR4 infection (A) Leaves wilt and start to collapse; (B) advanced yellowing and browning of leaves; (C) dead leaves form a skirt around the stem (Source: Department of Agriculture and Fisheries, Queensland, Australia; CC BY 4.0)

Associated Organism

The banana weevil, *Cosmopolites sordidus,* (**Fig. 5**) is a suspected vector of this pathogen. Presence of this insect could be an indication that the pathogen may be present.

Figure 5. Adult banana weevil, *Cosmopolites sordidus* (Germar). (Photograph by G. McCormack, Cook Islands Biodiversity Database)

Sample Collection

Disposable gloves are recommended for sampling. If sampling multiple plants, gloves and cutting tools should be sanitized (or gloves changed) between plants to avoid cross contamination. Sample the pseudostem of the plant where continuous discolored vascular areas (strands) are present. Sample as low as possible on the pseudostem (closer the ground) but not from areas where decay is advanced. Avoid sending only the outermost leaf bases of the pseudostem. A small (5 cm x 5 cm) piece of rhizome tissue showing discolored vascular strands can also be used but only if decay is not advanced. Banana tissues are very wet and can degrade quickly in hot weather. Plastic bags are

not recommended as it may quicken the deterioration of the sample. Place sample in clean, dry paper towel or newspaper in a heavy paper bag. Make sure sample is accurately labeled for follow-up. Keep the sample cool and dry in an ice chest, but do not freeze. If sampling between fields where Foc TR4 is suspected, clean footwear of soil or use disposable foot covers between fields to avoid spreading the pathogen.

Pictures of symptoms from the field can also be helpful to identifiers to see the location, overall plant health, and how the samples looked before they were removed from the host.

Pest Identification and Diagnostics

Pest Description

Fusarium oxysporum f. sp. *cubense* (Foc) has four races, three of which affect banana. Race 4 has two subgroups: TR4 and subtropical race 4 (SR4), that infect hosts in the tropics and subtropics, respectively. Cold-stressed banana plants grown in subtropical regions are predisposed to SR4 outbreaks, whereas TR4 is an aggressive strain that can infect banana plants that are healthy or unstressed.

F. oxysporum f.sp. *cubense* TR4 is a soil-borne and is found within the vascular tissues of host plants. The pathogen can survive in plant residue and can persist in soil for up to 40 years. Daughter plants can become infected through the connection to the mother plant. The total process, from the initial external symptoms to collapse and death, can take 3 to 6 weeks.

F. oxysporum f.sp. *cubense* TR4 is like other Foc races and produces three types of asexual conidia that can only be seen with a microscope. Microconidia (5-7 x 2.5-3 µm) are oval or kidney-shaped spores that can be produced under any conditions and are the most produced spore within infected plants. Macroconidia (22-36 x 4-5 µm) are larger, thin-walled spores, most frequently produced on the surface of infected plants. The third group, chlamydospores (9 x 7 µm) are round, thick-walled spores that are produced in macroconidia or are intercalary or terminal in older hyphae.

Identification and Diagnostic Resources

The different races of Foc cannot be distinguished by symptoms alone and therefore laboratory techniques are needed for identification. The recommended molecular method to screen for Foc TR4 is Polymerase Chain Reaction (PCR) using the W2987-F and W2987-R primers that amplify DNA specific to Foc TR4.

Mistaken Identities

Besides the other races of *Fusarium oxysporum* f. sp. *cubense* that occur on banana, this fungus causes symptoms that may also be confused with other bacterial diseases of banana such as *Xanthomonas campestris* pv. *musacearum* (banana xanthomonas wilt), Ralstonia *solanacearum* race 2 (moko disease of banana) and *Ralstonia syzgii* subsp. *celebesensis* (blood disease of banana). However, these pathogens cause symptoms on fruit (which Foc does not) and can have noticeable bacterial ooze from

freshly cut pseudostems (which Foc would not). Foc TR4 symptoms may also be confused with other biotic and abiotic factors, including water stress. Care should be taken to examine the plant for other external and internal symptoms.

The United States Department of Agriculture developed this datasheet in support of the Africa Phytosanitary Program (2023).

International Plant Production Convention Secretariat
ippc@fao.org | www.ippc.int

Food and Agriculture Organization of the United Nations
Rome, Italy