Moko Disease of Banana and Bacterial Wilt of Heliconia
Ralstonia solanacearum Race 2
and
Blood Disease of Banana
Caused by Different Strains in the *Ralstonia solanacearum* Complex

Hosts: Banana (*Musa* sp.) and heliconia (*Heliconia* spp.).

Disease common names: Moko disease of banana and bacterial wilt of heliconia; blood disease of banana. In the Philippines, the disease is referred to as moko in plantation bananas but as bugtok for cooking bananas, where symptoms appear in the bunch bud.

Pathogen: *Ralstonia solanacearum*; syn.: *Pseudomonas solanacearum* and *Burkholderia solanacearum*. Different strains of race 2 cause moko disease since the movement from heliconia to banana occurred several times in widely separated areas of Central and South America. The strains have different epidemiological potentials in banana. The blood disease strains are phylogenetically distinct but are included in the *Ralstonia solanacearum* complex. They also can be distinguished from other *Ralstonia solanacearum* strains by phenotypic characteristics.

Disease Cycle

Inoculum: The pathogen resides in soil, infected rhizomes, and pseudostems or roots.

Transmission: In banana plantations, spread occurs mostly by means of machetes (knives) used in pruning suckers as workers go from plant to plant. The SFR strain (referring to the small fluidal round colonies) has high epidemiological potential due to its ease of transmission from bud to bud by insects (bees, wasps, and flies). Moko and blood diseases are similar in epidemiological parameters, both being transmitted from bud to bud by insects.

Infection: Root infection occurs when bananas are planted in soils near latently infected *Heliconia* spp.; symptoms occur a few months after planting. Bacteria from infected roots invade interlaced roots of healthy plants. Infection occurs through open vessels of pruned suckers by means of bacteria-laden machetes, used first on undetected root-infected plants. Subsequent pruning cycles transmit the pathogen further, initiating a localized disease outbreak. Sweeping epidemics occur via insect transmission to “cushions” on the peduncle at sites where male flowers have recently fallen, exposing open xylem vessels. Fresh, infectable cushions are exposed daily for up to 3 months before fruit is harvested. Bacteria enter the xylem through these natural openings and colonize the vascular tissues.

Symptoms and signs: Leaves of young banana plants wilt rapidly (Figs. 1 and 2), the petioles break at a sharp angle, and plants die while still green. In older plants, inner leaves are discolored and droop, starting from the second leaf. The leaves are typically chlorotic and wilted (Fig. 3). The disease progresses outward, the petioles collapse, and the entire plant wilts and dies (Fig. 4). During the fruiting stages, the disease often is seen on peduncles where scars left by fallen male flowers became infected (Fig. 5). This may be followed by blackening of the entire terminal bud (Fig. 6). Moko disease symptoms of a fruit bunch include arrested fruit development, premature ripening or splitting, internal fruit discoloration (Figs. 7–8), and rot. When infected pseudostems or stalks are cut, many discolored, yellowish brown or almost black vascular bundles can be seen, particularly in the inner leaf sheaths and in the true stem of the fruit stalk (Figs. 9 and 10). Symptoms on heliconia include browning and shriveling of leaves, wilting, and death (Fig. 11). Figures 12–

14 show infected heliconia spathes and stalks. Blood disease of banana in Indonesia and moko disease in the Americas are similar in symptomatology (Figs. 15–17).

Survival: The pathogen survives for short periods in soil and in roots of banana and heliconia.

Disease Management

Control practices include the use of pathogen-free propagative materials, disinfestion of pruning tools, prompt surveys after first detection, and injection of affected plants with the herbicide Roundup™ to rapidly kill them and reduce the spread of inoculum. Other methods include disking soils to enhance decomposition of infected plant parts and fallowing of infested soil for a year. Since insect spread from bud to bud is the most explosive means of spread, the most important practice is to break the peduncle to remove the male inflorescence just after exposure of the florets in the last female fruit "hand". This eliminates the infection sites on the peduncle cushions. The practice is needed to stop the spread of both blood disease and SFR-Moko. The ideal control for village cooking bananas is to plant recently discovered mutant plants that naturally abort the bud after the female hands are formed.

References

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Figure 1. Moko disease caused wilting and yellowing of young banana plants. (Courtesy I. Buddenhagen)

Figure 2. Banana plant with wilt and yellowing of leaves (Moko disease). (Courtesy APS)

Figure 3. 'Valery' banana with wilting and yellowing of leaves (Moko disease). (Courtesy I. Buddenhagen/M. Schroth)

Figure 4. Moko disease caused wilted and dead plants. (Courtesy I. Buddenhagen)

Figure 5. 'Bluggoe' banana with bacterial ooze on bracts (Moko disease). (Courtesy APS)

Figure 6. 'Bluggoe' banana, infected by SFR strain, with blackened terminal bud where male flowers have dehisced. (Courtesy I. Buddenhagen/M. Schroth)

Figure 7. Infected stalk with discolored fruit (Moko disease). (Courtesy I. Buddenhagen)

Figure 8. Fruit infected by SFR strain of Moko disease. (Courtesy I. Buddenhagen)

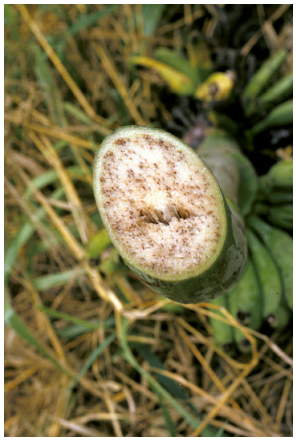

Figure 9. Fruit stalk with discolored vascular bundles (Moko disease). (Courtesy M. Schroth)

Figure 10. Cooking banana with discolored vascular bundles (Moko disease). (Courtesy A. Hayward)

Figure 11. Wilt of heliconia. (Courtesy I. Buddenhagen)

Figure 12. Heliconia spathes with wilt and leaf necrosis. (Courtesy I. Buddenhagen)

Figure 13. Heliconia with discolored stalk. (Courtesy I. Buddenhagen)

Figure 14. Heliconia with infected spathe on the right. (Courtesy I. Buddenhagen)

Figure 15. Wilted and yellowing of leaves (Blood disease). (Courtesy I. Buddenhagen)

Figure 16. Wilted and yellowing of leaves (Blood disease). (Courtesy I. Buddenhagen)

Figure 17. Cross sections of fruit with red discoloration (Blood disease). (Courtesy I. Buddenhagen)