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Evaluation of *Musa* spp. for resistance to Moko disease (*Ralstonia solanacearum*, race 2)

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The Moko disease of banana, caused by *Ralstonia (Pseudomonas) solanacearum* race 2 (Smith), induces wilting of the leaves, starting from the young ones, and necrosis of the candle leaf as well. Immature fruits of infected plants show yellowish color and dry rot of the pulp. Early infection, prior to flowering, causes abnormal development of the bunch, fruit rot before ripening, and some plants may not yield a bunch. The Moko disease can be disseminated either by insects, through infested soil or by root contact. These characteristics associated with unavailability of resistant cultivars and low production technology make the Moko disease a very serious problem for the banana crop (Buddenhagen 1961, Stover 1972, Takatsu 1986, Matos *et al.* 1996).

R. solanacearum, race 2, was first reported in Brazil in the Amazon Region, State of Amapá (Tokeshi 1976). Currently this disease is also present in the States of Amazonas, Para and Acre, all of them located in the Amazon Region (Takatsu 1986). According to diagnostic surveys the number of banana orchards affected by the A strain of *R. solanacearum*, race 2, in the Amazon Region has been increasing in the past years (Matos *et al.* 1996, Pereira *et al.* 1997).

Several recessive genes are involved on the banana resistance to Moko (Vakilii 1965, Rowe and Richardson 1975). Results reported by Stover (1972) showed several levels of susceptibility to Moko in banana cultivars, pointing out that the cultivar Pelipita (ABB) is highly resistant to the pathogen, thus indicating the genetic resistance as a viable control measure for Moko in regions where the banana crop is grown under very low production technology (Jones 1995).

Despite that possibility, no Moko-resistant germplasm was found when tetraploids (AAAB), such as PV03-44, JV03-15, PA03-22, Pioneira; triploids (AAA) Caipira, Nam, Nanica and Nanic‹o, (AAB) Pacovan, Prata, Prata An‹, Mysore, Thap Maeo and Ouro da Mata; and plantains (AAB) Pacovi, Pacovan and Bluggoe, (ABB) Figo, were planted in naturally infested soil (Silva *et al.* 1998).

The objective of this paper was to evaluate the reaction of 31 diploid (AA) genotypes to the inoculation with *R. solanacearum*, race 2, aiming at selecting resistant ones to be used as male parents in the banana breeding programme under conduction at the Embrapa Cassava and Fruit Crops (CNPMF).

Material and methods

A total of 31 diploids (AA) genotypes - 21 natural germplasm and 10 hybrids - from the Banana Germplasm Bank of CNPMF, Cruz das Almas, State of Bahia, were evaluated. The experiment was carried out under greenhouse conditions, at the Embrapa Occidental Amazon (CPAA), located in the municipality of Manaus, Amazonas, North of Brazil, where the Moko disease is endemic.

Eight plants of each diploid (AA) genotype were inoculated with the Biovar 1 of *R. solanacearum*, race 2, by injecting 1mL of a bacterial suspension, at a concentration of 10^8 CFU.mL^{-1}, into the pseudostem, at 10 cm from the soil level.

External symptoms were evaluated at weekly intervals, based upon the following disease rating scale:

- No symptoms
- Necrosis of the candle leaf
- Yellowing of 2-3 leaves
- Buckle of the petiole
- Death of the plant

Plants without symptoms eight weeks after inoculation were considered resistant to Moko disease.

Results and discussion

Six weeks after inoculation the plants started showing external symptoms characteristics of the Moko disease. All plants that expressed external symptoms also showed vascular discoloration characteristic of infection by *R. solanaceraum*, race 2. These results indicate the efficiency of the inoculation technique used to evaluated diploid (AA) banana genotypes.

The natural germplasm Berlin, Buitenzorg, Fako Fako, Jambi, Jaran, Jari Buaya, Khai, Khi Maeo, Lidi, Microcarpa, NBA 14, NBF 9, N⁄118, Ouro, P. Serum, Pipit, Pa Phathalung, Tongat, Tambi and Zebrina and the hybrids 1304-04, 1318-01, 4223-06, F3P4, M-48 and M-61 showed susceptible reaction to the Biovar 1 of *R. solanacearum*, race 2. On the other hand, the diploid (AA) hybrids F2P2, 1319-01, 1741-01 and SH3362, and Babi Yadefana, a diploid cultivar from New Guinea, expressed resistance to the pathogen. Some characteristics of the five Moko-resistant genotypes are presented in Table 1.

Although resistance to Moko disease has not been detected in triploid and tetraploid commercial varieties so far (Vakilii 1965, Silva *et al.* 1998), the results presented in this paper show the occurrence of genetic variability among diploid (AA) banana genotypes able to express resistance to *R. solanacearum*, race 2.

The detection of resistance to Moko disease in diploid (AA) genotypes

Table 1. Some characteristics of diploids (AA) banana genotypes resistant to Moko disease. Embrapa Occidental Amazon, Manaus, Amazonas, Brazil, 1998.

Genotype[1]	Height	Fruits /bunch	Length of fingers (cm)	Reaction to diseases[2]		
				Fusarium wilt	Yellow Sigatoka	Black Sigatoka
Babi Yadefana	Low	60	12	_	S	-
F_2P_2	Medium	96	12	-	-	-
1319-01	Medium	200	13	R	R	
1741-01	Medium	112	14	-	R	-
SH3362	High	192	15	-	-	S

[1] Babi Yadefana: cultivar from New Guinea; F_2P_2: hybrid from Ecuador; 1319-01: cross between Malaccensis x Tjau Lagada, selection 01; 1741-01: cross between Jary Buaya x hybrid (Calcutta x Madang); SH3362: hybrid from Honduras.
[2] R: resistant; S: susceptible.

opens up a real possibility of creating resistant commercial varieties, through conventional breeding techniques. Considering that only a small number of genotypes was evaluated, it is expected that new sources of resistance to *R. solanacearum*, race 2 would be detected as evaluations continue. ■

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Multilocational evaluation of FHIA hybrids in Ghana

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Plantain and banana (*Musa* spp.) are very important starchy staples in Ghana. They are consumed both as energy-yielding food and as dessert. Plantain contributes about 13.1% of the Agricultural Gross Domestic product and its *per capita* annual consumption of 85 kg per head is higher than other staples such as maize and yam. Plantain and banana are also very important sources of rural income (Ortiz and Vuylsteke 1996).

Despite their high value, production has been affected by growing pest and disease pressures, the most notable being the fungal disease black Sigatoka *(Mycosphaerella fijiensis*). The disease was first observed at Assin-Fosu in the Central region of Ghana in the early 1980s and has since spread to all the plantain-growing regions of the country. Yield losses due to the disease are highly significant, ranging from 20 to 50%. Under very severe conditions yield losses may be as high as 80% (Hemeng and Banful 1994).

The black Sigatoka disease can be controlled with appropriate fungicides but the cost is prohibitive. Furthermore, the fungicides are not environmentally-friendly and thus threaten the fragile ecosystem. Consequently, the best viable alternative for the control of black Sigatoka is through the use of high-yielding resistant hybrids.

The Crops Research Institute introduced in 1994 some black Sigatoka-resistant/tolerant tetraploid hybrids of *Musa* from *Fundación Hondureña de Investigación Agrícola* (FHIA) in Honduras. The introduction was against the background that all the local landraces are susceptible to black Sigatoka disease. The hybrids included one dessert banana (FHIA-01), one cooking banana (FHIA-03) and one French plantain (FHIA-21).

Materials and methods

Tissue culture plantlets of FHIA-21 and FHIA-01 were received from the *Fundación Hondureña de Investigación Agrícola* (FHIA) in Honduras for evaluation. The plantlets were hardened under a hardening shed for six weeks before field planting.

The trials were established at three locations, namely Fumesua in the Ashanti region, Assin-Fosu in the Central region and Bunso in the eastern region. The locations were selected on the basis of the variation in the soil types and the severity of black Sigatoka incidence. The design was a randomized complete block with three replications. Three kilograms of poultry manure were applied as soil amendment at planting. The planting spacing was 3 m x 2 m (1667 plants/ha).

The disease evaluation was carried out using the Stover scale of 1 to 10 as observed on the third leaf.