



The distribution of the materials, as indicated in Figure 1, shows a large demand coming from the state of Amazonas, followed by Pará, indicating a special concern of governmental authorities, farmers and Embrapa, aiming reduction of damages caused by the disease in the region. Sending more than 2 million plantlets and almost 1.5 million plantlets to Amazonas and Pará, respectively, during a period of 12 years, is indeed a considerable task!

Resistant materials sent to the northern states mentioned above are those shown in Figure 2. Thap Maeo, FHIA 18 and Caipira, together, accounted for almost 2.4 million plantlets and meristems out of the 4.2 million units delivered in the period 2002-2015.

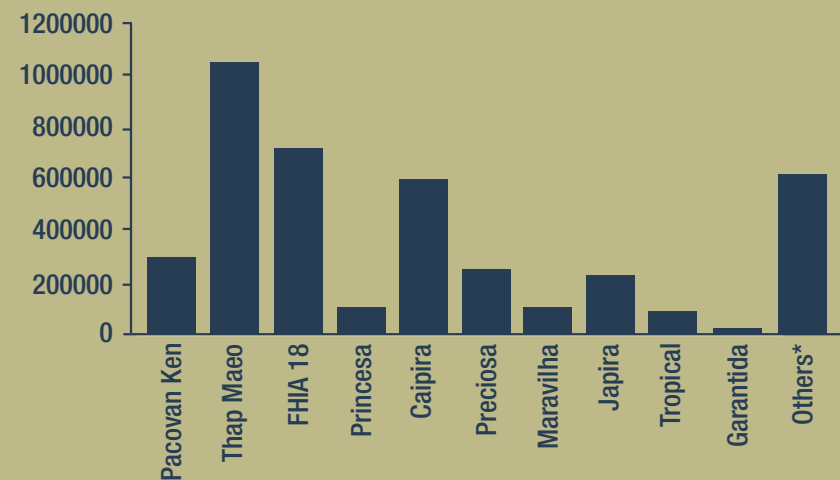


Figure 2. Banana varieties sent to states of Northern Brazil (2002-2014)*

*Others: Grande Naine, Prata Anã, Pacovan, BRS Garantida, FHIA 01, FHIA 02, FHIA 21, YB4221, PA4244 (BRS Platina), BRS Vitória, D'Angola, Calypso, Ambrosia, Buccaneer, others YB.

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Research Highlights

Outstanding Technologies that must be known

**PREVENTIVE BREEDING
SEARCHING FOR RESISTANCE
TO BLACK SIGATOKA IN BRAZIL**



Photo: Léa Cunha



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Research Highlights has been created by Embrapa Cassava and Fruits as a communication channel aimed at disseminating important results of the work performed by researchers dedicated to solve the production constraints faced by the crops which are part of our mandate.

Embrapa Cassava & Fruits was created in 1975. It has the national mandate to coordinate research programs involving mainly six tropical fruits (banana, citrus, mango, passion fruit, papaya, pineapple, Barbados cherry), and cassava. The research center has its headquarters in the city of Cruz das Almas, State of Bahia, with advanced posts located in the States of Paraná and Santa Catarina (South), São Paulo, Espírito Santo and Minas Gerais (Southeast), Mato Grosso (CenterWest), Rio Grande do Norte (Semi-Arid Northeast) and two other locations in Bahia. The center has a staff comprising 147 researchers and analysts, 57% of them with a doctoral or post doctoral degree, and the remaining 37% with a M.Sc. degree. Additional administrative, laboratory and field staff completes the total number of employees, equal to 224 staff members. A considerable number of post graduate students are also performing thesis studies and participating in the research activities of the center.

Over the years, Embrapa Cassava & Fruits has obtained research results that certainly contributed to improveth the agricultural sector, as a result of the work done by its scientists and staff members in general. There are dozens of technologies, products and processes that deserve the title of “good research”, but also those that can be pointed as “Research Highlights”, with an outstanding performance, and with a strong impact in the field and in the market.

This publication reports successful cases of our research history, and aims to inform our partners and/or potential partners about outstanding results obtained by the research Center. It is important to say that we seldom work alone; our research highlights were generated by teams of researchers composed by our staff members

and representatives of many partner institutions across the country, and across the world.

By publishing Research Highlights Embrapa Cassava & Fruits expects to point out contributions to the splendid growth of the agricultural sector in Brazil in recent decades. We expect that new partners are found and share their experience with us, establishing new partnerships, and that those who generated and disseminated our research results are given the right recognition for their good work!

Preventive Breeding searching for resistance to Black Sigatoka in Brazil

Bananas are produced in all geographic regions of Brazil, with an area of over 500 thousand hectares and total production above seven million tons of fresh fruits per year. Consumption of banana in Brazil is the highest in the world and the crop has an enormous social importance, due to strong participation of smallholder farmers in its production. Brazil appears as the world's fourth banana producing country, with a production of approximately 6.9 million tons and 485 ha planted to the fruit. The gross producing value was estimated to be 4.3 billion US dollars (FAOSTAT, 2016). Black Sigatoka, caused by *Mycosphaerella fijiensis* and *Fusarium* Wilt disease, caused by *Fusarium oxysporum* f. sp. *cubense* (Foc), are the two most important diseases limiting banana cultivation and economic production in the country. Black Sigatoka was firstly described in 1963, in the Fiji islands, and identified in 1972, in Honduras, rapidly spreading to other producing countries of the Americas. In Brazil, the disease was detected in 1998, in banana plants growing in the cities of Tabatinga and Benjamin Constant, both located in the state of Amazonas.

A Preventive Breeding strategy has been adopted by Embrapa Cassava &Fruits since the early eighties,

in order to minimize the potential damages that could be caused by the eventual introduction of Black Sigatoka. The basis of the strategy was the establishment of a banana breeding program in the early eighties, with the substantial support of Embrapa Genetic Resources and Biotechnology (CENARGEN). The first step followed by the program was to enrich Embrapa’s germplasm collection by organizing germplasm collection expeditions to different countries, including those located in the center of origin of Musa species in Asia (Malaysia, Philippines, Thailand, Papua New Guinea, Hawaii and Indonesia); and in the Americas and the Caribbean (Colombia, Ecuador, Honduras, Costa Rica, Jamaica, Saint Lucia, and French colonies). The collection was also enriched with genotypes provided by the Agronomic Institute of Campinas (IAC) and regional collections maintained mainly in Northeast Brazil (Pernambuco, Paraiba, Piauí and Bahia), and also in the Northern Region Almost simultaneously the first controlled pollinations begun in Cruz das Almas, state of Bahia.

The breeding program aimed yield increases, size reduction and especially resistance to diseases such as Yellow Sigatoka, *Fusarium* Wilt and black Sigatoka. As mentioned above, the latter was only identified in Brazil in 1998, but since the beginning of the breeding program, in 1982, pollinations were targeted to obtain genotypes resistant to the disease. Development of protocols to evaluate resistance to yellow Sigatoka and *Fusarium* Wilt started after the production of the first hybrids in 1983. Evaluation for resistance to black Sigatoka remained as a problem, just because the disease was not present within national territory.

Field Evaluations against the disease, using a group of 10 genotypes, started with an agreement between CATIE and INIBAP, the International Network for the Improvement of Banana and Plantain. The first information was obtained in 1990, indicating three diploids (Heva), and the improved diploids 003004-02 and 003005-05), plus two other improved diploids (M58

and M48), and also three tetraploid hybrids (PV03-76 (later released as BRS Pacoua), PV03-44, and JV03-15) as resistant to the disease. Cultivars Prata Anã and Pacovan were also evaluated, and identified as susceptible to the disease. In the second batch of evaluations, four of the eight genotypes tested were considered as resistant (JV42-29; Nam (later released as BRS Belluna); PV42-53 and PV42-129) For the third and last batch of evaluations a new agreement was signed by Embrapa, Corbana (Corporación Bananera Nacional) and Inibap. Eleven diploid hybrids were then evaluated and the majority performed as resistant to Black Sigatoka. Among those, 2803-01 hybrid performed satisfactorily and is still considered as one of the best improved materials produced by Embrapa, showing resistance to several diseases, also with short height and good fruit characteristics.

In 1992 Embrapa provided Inibap with a group of ten genotypes (PV03-44, PV03-76, JV03-15, JV42-34, JV42-29, PA03-22, PA12-03, PV42- 129, PV42-53, and PV42-114), as a contribution to the IMTP (International Musa Testing Program), which had, as one of its tasks, the evaluation against black Sigatoka in several countries in the Americas (Costa Rica and Honduras), Africa (Cameroon, Nigeria and Uganda), and Asia/Pacific (Philippines and Tonga)).Only two (PV03-44 and PA03-22) out of the ten genotypes were part of the material evaluated by the project.

During the period described above, banana cultivars were also introduced from the Fundación Hondureña de Investigación Agrícola (FHIA). With these introductions and other information already known, it was possible to select a number of genotypes (PV03-76, PV03- 44, JV03-15, Nam (BRS SCS Belluna), Caipira, Thap Maeo, Gian Hui, FHIA 01 and FHIA 18) which were sent, for evaluations, to other Embrapa research units located in the North of Brazil. The presumption, later, proved to be true, was that the disease would enter Brazil by the Northern region, and this justified the introduction of genotypes with several levels of resistance and varying

organoleptic characteristics.

Black Sigatoka was firstly detected in Brazil in the year 1998. One year later Embrapa recommended two varieties (Caipira and Thap Maeo), followed by the recommendation of FHIA 18 for the Sigatoka-infested North. Following these recommendations, several other cultivars were released, such as BRS Pacovan Ken, BRS Preciosa, Maravilha (FHIA 01), BRS Garantida, and BRS Caprichosa, all evaluated and selected even before the appearance of black Sigatoka in the country.

Figure 1 shows the number of banana plantlets or meristems of materials with different levels of resistance to black Sigatoka that were sent from Embrapa's biofactory to the North of Brazil. The massive delivery was: one million plantlets of Thap Maeo; 729,885 of FHIA 18; 608,765 of 'Caipira' and 436,456 of 'BRS Pacovan Ken'. This represents the basis for survival of the crop in a region where the disease was already installed.

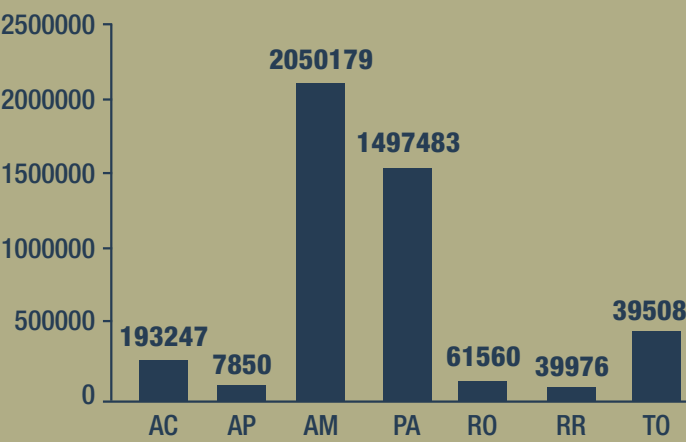


Figure 1. Banana plantlets and meristems sent to Northern Brazil (2002-2014)