

THE DISSEMINATION OF THE BLACK SIGATOKA IN BRAZIL DISEMINACIÓN DE LA SIGATOKA NEGRA EN BRASIL

Luiz Alberto Lichtemberg¹, Luadir Gasparotto², Josiane Takassaki Ferrari³, Robert Harri Hinz⁴, Adriano Munhoz Pereira⁵, Wilson da Silva Moraes⁶, Luiz Augusto Martins Peruch⁷

RESUMEN

En febrero de 1998 investigadores de Embrapa Amazonia Occidental detectaron los primeros síntomas de sigatoka negra en bananos en Brasil, en la frontera con Colombia y Perú, en la región del Río Marañón. En mayo de 1998 se confirmó la presencia de la enfermedad en las ciudades de Benjamín Constant y Tabatinga, en el Estado de Amazonas. En Julio, la presencia de la enfermedad fue confirmada en Coari y hasta diciembre del mismo año en todo el Estado de Amazonas. Hasta 2000 toda la región Norte registró la presencia de la enfermedad, con excepción del Estado de Tocantins, donde fue confirmada solamente en 2010. En 1999, la sigatoka negra ya se encontraba en el Estado de Mato Grosso, en la región Centro Oeste de Brasil. En 2004, fue registrada en la región Sudeste de Brasil, en los Estados de Minas Gerais y São Paulo. En el mismo año, la sigatoka negra fue registrada en los tres Estados de la región Sur de Brasil. El trabajo describe la cronología y localización de los registros oficiales de la enfermedad en Brasil y discute las formas de diseminación y las diferencias de sintomatología y virulencia de la enfermedad en diferentes zonas bananeras de Brasil.

ABSTRACT

In February 1998, Embrapa Amazonia Ocidental researchers detected black sigatoka symptoms on bananas on the border with Colombia and Peru, in the Brazilian region of the Solimões river. In May of the same year was confirmed the presence of the disease in Benjamin Constant and Tabatinga cities, in the State of Amazonas. In July, black sigatoka presence was confirmed in Coari and until December of the same year in all Amazonas State. Until 2000, the entire Northern Brazilian region registered the presence of the disease, with the exception of the Tocantins State. In 1999, the black sigatoka was present in the Mato Grosso State, in the Centre Western Brazilian region. In 2004, it was registered in the Southeast region of Brazil, in the States of Minas Gerais and São Paulo. In the same year, black sigatoka was registered in the three States of the Southern region of Brazil. This work describes the chronology and location of the official records of the disease in Brazil and discusses forms of dissemination and the differences of symptoms and virulence of the disease in different banana areas of Brazil.

INTRODUCTION

In February 1998, José Clério Resende Pereira, Luadir Gasparotto and Ana Fabíola da Silva Coelho, plant pathologists from Embrapa Amazonia Ocidental detected the first black sigatoka symptoms on bananas in Brazil (Cordeiro et al.; 1998). The first official register of black sigatoka in Brazil was in Amazonas State, confirmed in 1998, May, in Tabatinga and Benjamim Constant cities, near the Brazilian frontier with Colombia

¹ Ing. Agr., MSc, Epagri/EEI, Caixa Postal 277, 88301-970 Itajaí, SC, Brasil, Telefono +55 (47) 3341-5212, licht@epagri.sc.gov.br

² Agr. Dr, Embrapa Amazônia Ocidental, Manaus, AM, Brasil, gasparotto@cmaa.embrapa.br

³ Ing. Agr. Dra, APTA-SP, Instituto Biológico, SP, Brasil, takassaki@biologico.sp.gov.br

⁴ Ing. Agr., MSC, Epagri/EEI, Itajaí, SC, Brasil, robert@epagri.sc.gov.br

⁵ Agr. SEAB/DEFIS/DDSV, Curitiba, PR, Brasil, amunhozp@seab.pr.gov.br

⁶ Ing. Agr., Dr, APTA-SP, Polo Vale do Ribeira, Pariquera-Açú, SP, Brasil, wilson@apta.sp.gov.br

⁷ Ing. Agr., Dr, Epagri/EEU, Urussanga, SC, Brasil, lamperuch@epagri.sc.gov.br

and Peru (Pereira et al., 1998 a; Pereira et al., 1998b). The entrance of the disease in the country was in the Solimões river region. According to regional people information, the disease was already current in the region for two years, and confirmed in Leticia, Colombian border city, since 1997 (Hinz & Ventura, 1998). On 1998, July, the disease was present in Coari town (Pereira et al., 1998 a). In de same year, the black sigatoka was detected in very cities in the Solimões and Amazonas rivers, and one year later was disseminated for full Amazonas State area (Gasparotto et al., 2001). Also in 1998, the disease was already present in the Acre State and in 2010 in fourteen Brazilian States. The chronology and location of the official registers of the disease in Brazil, possible dissemination forms and the differences of symptoms and virulence of the disease, in different banana areas of Brazil, are presented in this work.

BLACK SIGATOKA DISSEMINATION IN BRAZILIAN NORTH REGIÓN

After being confirmed in the whole Amazonas State, the entire Northern Brazilian region registered the presence of the disease until 2000, with the exception of the Tocantins State, where it was confirmed only in March 2010. The date of detection of black sigatoka in Brazilian Northern Region and location of the cities are listed in table 1.

Table 1. Detection dates of black sigatoka in Brazilian States and cities - Northern Region.

City	State	City coordinates	Date
Tabatinga	Amazonas	04° 15' 09" S and 69° 56' 17" W	February 1998
Benjamim Constant	Amazonas	04° 22' 58" S and 70° 01' 51" W	February 1998
Coari	Amazonas	04° 05' 06" S and 63° 08' 27" W	June, 1998
Rio Branco	Acre	10° 07' 18" S and 69° 21' 26" W	November 1998
Acrelândia	Acre	09° 49' 40" S and 66° 52' 58" W	1998/1999
Capixaba	Acre	10° 34' 22" S and 67° 40' 33" W	1998/1999
Brasiléia	Acre	11° 00' 36" S and 68° 44' 52" W	1998/1999
Tarauacá	Acre	08° 09' 39" S and 70° 45' 57" W	1998/1999
Cruzeiro do Sul	Acre	07° 37' 51" S and 72° 40' 12" W	1998/1999
Porto Acre	Acre	09° 35' 16" S and 67° 31' 58" W	1998/1999
Porto Velho	Rondônia	08° 45' 43" S and 63° 54' 14" W	February 1999
Machadinho do Oeste	Rondônia	09° 26' 38" S and 61° 58' 53" W	1999
Ouro Preto do Oeste	Rondônia	10° 44' 53" S and 62° 12' 57" W	1999
Rolim de Moura	Rondônia	11° 48' 31" S and 61° 46' 39" W	1999
Alta Floresta	Rondônia	11° 58' 05" S and 61° 57' 15" W	2004
Cujubim	Rondônia	09° 21' 46" S and 62° 35' 07" W	2005
Cabixi	Rondônia	13° 29' 52" S and 60° 33' 15" W	2006
Castanheiras	Rondônia	11° 25' 03" S and 61° 56' 19" W	2007
Almeirim	Pará	01° 31' 22" S and 52° 34' 55" W	2000
Porto de Moz	Pará	01° 44' 52" S and 52° 14' 16" W	2000
Belém	Pará	01° 27' 21" S and 48° 30' 14" W	2000-2002
Santarém	Pará	02° 26' 34" S and 54° 42' 28" W	2000-2002
Óbidos	Pará	01° 55' 04" S and 55° 31' 04" W	2000-2002
Juriti	Pará	02° 09' 07" S and 56° 05' 31" W	2000-2002
São Geraldo do Araguaia	Pará	06° 24' 03" S and 48° 33' 18" W	2007
Tartarugalzinho	Amapá	01° 30' 21" N and 50° 54' 43" W	July 2000
Caroebe	Roraima	00° 53' 02" N and 59° 41' 45" W	December 2000
São João da Baliza	Roraima	00° 57' 03" N and 59° 54' 39" W	2001
Rorainópolis	Roraima	00° 56' 45" N and 60° 25' 04" W	2001
Mucajá	Roraima	02° 25' 48" N and 60° 54' 00" W	2001
Araguaína	Tocantins	07° 11' 28" S and 48° 12' 26" W	2010

The second Brazilian State that detected the black sigatoka was Acre, in 1998, November, in Rio Branco city (Ritzinger et al., 1999). In a study realized from 1998, December to 1999, September, the disease was confirmed in ten municipalities, Acrelândia, Senador Guimard, Plácido de Castro, Capixaba, Brasiléia,

Tarauacá, Cruzeiro do Sul, Mâncio Lima, Rodrigues Alves e Porto Acre and Rio Branco (Cavalcante et al., 1999 e 2004).

The third Brazilian State that detected the black sigatoka was Rondônia, in 1999 February, in Extrema and Porto Velho cities (Cavalcante et al., 1999). In this year the disease was detected in the municipalities of Machadinho do Oeste, Ouro Preto do Oeste and Rolim de Moura (Garcia, 1999) and after this date in nineteen other Rondonian municipalities (Reis et al., 2008).

In 2000 July, the black sigatoka was detected in Amapá State, in Tartarugalzinho municipality (Gasparotto et al., 2001). In this State, wasn't studied the disease presence in other municipalities.

In 2000 year, the disease was detected in Pará State, in Monte Dourado district, in Almeirim city and in Porto Moz municipality (Trindade et al., 2002). After this, the black sigatoka was detected in every municipalities of Pará State, including São Geraldo do Araguaia, municipality located in the Tocantins State border, in 2007.

In 2000 December, the black sigatoka was confirmed in Roraima State, in the Caroebe municipality (Gasparotto et al., 2001). After this, the disease was detected in São João da Baliza, Rorainópolis and Mucajaí municipalities (Vieira, 2005 and Nechet et al., 2006).

Until 2000, all States of Northern Brazilian region registered the presence of the disease, with the exception of the Tocantins State, where it was confirmed only in 2010 March, in Araguaína city.

In the Brazilian Northern region, due to climatic conditions, especially temperature and rainfall, the system of cultivation and the absence of chemical control, the best solution was the replacement of local varieties by resistant varieties, from genetic improvement programs of Embrapa and FHIA. The disease is extremely virulent and destructive in conditions of Equatorial climate of the region (Figure 1).

Figure 1. Aggressiveness of black sigatoka in Amazonas State. Pictures: José Clério Rezende Pereira and Lúadir Gasparotto.

The official point of access of black sigatoka in Brazilian territory was in Tabatinga city, Amazonas State, from Colombia and Peru frontier areas (Hinz & Ventura, 1998; Pereira et al., 1998a e Pereira et al., 1998b). The disease entrance was before the 1998 year. It is estimated that black sigatoka was present in the region since 1996, two year before its detection. Other possible and secondary point of access was from Guyana frontier area to Amapá State and Northeast of Pará State (Trindade et al., 2002). The disease entrance was before the 2000 year. The entrance of black sigatoka in the Amazon Southeast occurred later than other areas of Brazilian North Region and inclusive than in Brazil Southern Region, despite the present climate very much favorable to disease development. The disease was only officially detected in 2007, in São Geraldo do Araguaia, and in 2010, in Araguaína (SECOM, 2010). This possibly occurred because the currents of Araguaia River basin run away to the region where the black sigatoka was already established, in the Amazon basin.

BLACK SIGATOKA DISSEMINATION IN BRAZILIAN CENTRAL WESTERN REGION

In the Central Western Brazilian Region, the first detection of black sigatoka was in Mato Grosso State (figure 2), in 1999, in Cáceres city. After this, the disease was confirmed in eighteen municipalities of West half of Mato Grosso State, including the frontiers with Bolivia country and with Rondônia, Amazonas, Pará and Mato Grosso do Sul Brazilian States (Souza e Feguri, 2004). The disease was confirmed in Cáceres, Lambari D'Oeste, Barra dos Bugres, Porto Estrela, Santo Antônio de Leverger, Acorizal, Nobres, Tangará da Serra, Rosário do Oeste, Rondolândia, Paranaíta, Juruena, Comodoro, Aripuanã, Nova Bandeirantes, Nova Monte Verde, Cotriguaçu and Apiacás, in Mato Grosso State (table 2).

A secondary probable point of access of the black sigatoka in Brazil, was from Bolivian frontier area to Mato Grosso State, with the first detection in the Cáceres municipality (Souza e Feguri, 2004). The disease entrance was, probably, before the 1999 year.

In Mato Grosso do Sul State, the black sigatoka was detected in 2004, August, only in Pedro Gomes municipality (table 2), in the border of Mato Grosso State (Nogueira e Ferrari, 2005 e Nogueira et al., 2005). In this State, wasn't studied the disease dissemination in other municipalities.

In Goiás State, despite border cities of other states have confirmed the disease occurrence for several years, until 2010 year has not confirmed the black sigatoka presence in its territory. The spread of the disease in the East half of Mato Grosso State and in Goiás State may have been disadvantaged by dry climate conditions of the region.

Table 2. Detection of black sigatoka in Brazilian States and cities – Central West Region.

City	State	City coordinates	Date
Cáceres	Mato Grosso	16° 04' 16" S and 57° 40' 44" W	1999
Santo Antônio de Leverger	Mato Grosso	15° 51' 57" S and 56° 04' 37" W	1999-2000
Porto Estrela	Mato Grosso	15° 19' 26" S and 57° 13' 40" W	1999-2000
Lambari D'Oeste	Mato Grosso	15° 19' 22" S and 58° 00' 14" W	1999-2000
Acorizal	Mato Grosso	15° 12' 18" S and 56° 21' 57" W	1999-2000
Barra dos Bugres	Mato Grosso	15° 04' 22" S and 57° 10' 51" W	1999-2000
Rosário do Oeste	Mato Grosso	14° 50' 09" S and 56° 25' 40" W	1999-2000
Nobres	Mato Grosso	14° 43' 12" S and 56° 19' 40" W	1999-2000
Tangará da Serra	Mato Grosso	14° 37' 08" S and 57° 29' 09" W	1999-2000
Comodoro	Mato Grosso	13° 39' 46" S and 59° 47' 09" W	1999-2000
Rondolândia	Mato Grosso	10° 52' 15" S and 49° 30' 14" W	1999-2000
Juruena	Mato Grosso	10° 19' 04" S and 58° 21' 32" W	1999-2000
Aripuanã	Mato Grosso	10° 10' 01" S and 59° 27' 32" W	1999-2000
Nova Monte Verde	Mato Grosso	09° 58' 55" S and 57° 32' 06" W	1999-2000
Cotriguaçu	Mato Grosso	09° 51' 28" S and 58° 24' 50" W	1999-2000
Nova Bandeirantes	Mato Grosso	09° 48' 50" S and 57° 51' 43" W	1999-2000
Paranaíta	Mato Grosso	09° 39' 54" S and 56° 28' 37" W	1999-2000
Apiacás	Mato Grosso	09° 32' 38" S and 57° 26' 56" W	1999-2000
Pedro Gomes	Mato Grosso do Sul	18° 06' 03" S and 54° 33' 07" W	August 2004

Figure 2. Aggressiveness of black sigatoka in Silk banana, in Mato Grosso State. Pictures: Robert Harri Hinz

BLACK SIGATOKA DISSEMINATION IN BRAZILIAN SOUTHEASTERN REGION

In Southeastern Brazilian Region, the first detection of black sigatoka was in Miracatu city, in São Paulo State (Ferrari et al., 2005b). In study realized in 2004 and 2005 years, the disease was confirmed in 246 municipalities of São Paulo State, including in the borders of Paraná, Mato Grosso do Sul, Goiás, Minas Gerais and Rio de Janeiro States (Nogueira and Ferrari, 2005 and Brito et al., 2006). Some cities where the disease was confirmed are listed in table 3.

In Minas Gerais State, the black sigatoka was detected in 2004 July, in Gonçalves and Piranguçu municipalities (Ferrari et al., 2005 a) and in 2004 August in Cristina and São José do Alegre, everyone in South of Minas Gerais State, and in 2004 August in Coronel Pacheco municipality, in Southeast State Zone (Castro et al., 2005). Although the disease has been detected in 2004, in Minas Gerais State, the disease presence was confirmed only in localities at South and Southeast of the State. The main region of banana production in this State is located in the northern area, where the climate is semi-arid. In this zone, the disease has not yet been officially registered.

In Minas Gerais State and in some areas of São Paulo State, the black sigatoka has been little aggressive, with low destructive power. But in part of Ribeira Valley, in São Paulo State, the disease has been very destructive (figures 3 and 4). Even in these areas, the chemical control has been efficient, at the present moment.

Figure 3. Aggressiveness of sigatoka disease in a fungicide treated Cavendish banana leaf and in no treated Cavendish and Bluggoe bananas, in Ribeira Valley, São Paulo State. Pictures: Eliane Cristina Müller

Figure 4. Aggressiveness of black sigatoka in Cavendish banana plantation, in the Guaraú locality, Ribeira Valley, São Paulo State. Pictures: Wilson da Silva Moraes

In Rio de Janeiro State, despite the areas de occurrence of black sigatoka in São Paulo State, in localities close to de border with that State, the presence of the disease has not yet been detected. The same occurs in Espírito Santo State, considered a black sigatoka Free State.

Table 3. Detection of black sigatoka in Brazilian States and cities – Southeastern Region.

City	State	City coordinates	Date
Cristina	Minas Gerais	22° 12' 43" S and 45° 15' 50" W	July 2004
São José do Alegre	Minas Gerais	22° 19' 44" S and 45° 31' 33" W	July 2004
Gonçalves	Minas Gerais	22° 39' 32" S and 45° 51' 21" W	July 2004
Piranguçu	Minas Gerais	22° 31' 40" S and 45° 29' 42" W	July 2004
Coronel Pacheco	Minas Gerais	21° 35' 16" S and 43° 15' 57" W	August 2004
Miracatu	São Paulo	24° 16' 51" S and 47° 27' 36" W	June 2004
Juquiá	São Paulo	24° 19' 15" S and 47° 38' 06" W	2004
Registro	São Paulo	24° 29' 16" S and 47° 50' 38" W	2004
Cajati	São Paulo	24° 44' 09" S and 48° 07' 22" W	2004
Itaí	São Paulo	23° 25' 04" S and 49° 05' 27" W	2004
Jacareí	São Paulo	23° 18' 18" S and 45° 57' 57" W	2004
Jaú	São Paulo	22° 17' 45" S and 48° 33' 28" W	2004
Paraguaçu Paulista	São Paulo	22° 24' 46" S and 50° 34' 33" W	2004
Altair	São Paulo	20° 31' 26" S and 49° 03' 32" W	2004
Batatais	São Paulo	20° 53' 28" S and 47° 35' 06" W	2004
Auriflama	São Paulo	20° 41' 08" S and 50° 33' 17" W	2004
Igarapava	São Paulo	20° 02' 16" S and 47° 44' 49" W	2004
Queluz	São Paulo	22° 32' 13" S and 44° 46' 26" W	2005
Mesópolis	São Paulo	19° 57' 57" S and 50° 38' 16" W	2005

BLACK SIGATOKA DISSEMINATION IN BRAZILIAN SOUTH REGION

In South Brazilian Region, the first register of black sigatoka was in 2004 August, in Alvorada do Sul, Carlópolis, Morretes, Matinhos and Paranaguá municipalities, in Paraná State (Nogueira and Ferrari, 2005 and Ferrari et al., 2005c). In a later study, realized in 2004, among July and November months, the disease was confirmed in 117 municipalities, including localities in Paraguay and Argentina frontiers (Pereira et al., 2006). From 2004 to 2010, 507 samples of banana leaves from different Paraná State regions were taken to disease diagnosis, on optical microscope. *Mycosphaerella fijienses* was present on 423 samples (83,4%), from 137 cities (Pereira et al., 2010), including localities in Paraguay and Argentina frontiers and Mato Grosso do Sul State border.

In Santa Catarina State, the black sigatoka was detected in 2004 October in various municipalities of State Coast (Nogueira and Ferrari, 2005). Among 2004 and 2005 years, the disease was confirmed in Garuva, Itapoá, Joinville, Araquari, Massaranduba, Barra Velha, São João do Itaperiú, Corupá, Guaramirim, Jaraguá do Sul, Schroeder, Itajaí, Nova Trento, Canelinha, Tijucas, São José, Treviso, Siderópolis, Criciúma, Jacinto Machado, Praia Grande, Turvo, Santa Rosa do Sul and Sombrio municipalities, from North to South Santa Catarina Coast, and in São José do Cedro, in West State Zone, in the Argentina frontier.

In the Rio Grande do Sul State, the black sigatoka was confirmed in 2004 October, in Northeast State Zone, in Dom Pedro de Alcântara, Três Cachoeiras, Três Forquilhas, Terra de Areia, Torres, Itati, Maquiné and Osório municipalities (Nogueira and Ferrari, 2005).

In southern Brazil, black sigatoka has been less destructive than in other regions of the country. This behavior can be associated with the subtropical climate of the region, with cold winter, especially in southern Santa Catarina and northeastern Rio Grande do Sul. In the Brazilian South region, six years after the confirmation of the disease, is still common the occurrence of yellow sigatoka symptoms along with black

sigatoka symptoms. Also common is the presence of different kinds of symptoms in the one same banana leaf (Figure 5). In plantations where is done the monitoring of the disease and the control by notice biological method, the control is efficient with 5 to 7 spraying of fungicide per year, in the State of Paraná and the North coast of Santa Catarina State and with 2 to 3 spraying in the South Coast of the Santa Catarina State and in the Northeast Coast of the Rio Grande do Sul State. In this two areas, the number of positive samples for black sigatoka was reduced from 67% to 23%, from 2004 to 2006, and was 0% from 2007, when all fungi analyses have negative results for black sigatoka (Peruch et al., 2010).

Table 4. Detection of black sigatoka in Brazilian States and cities – South Region.

City	State	City coordinates	Date
Alvorada do Sul	Paraná	22° 46' 48" S and 51° 13' 51" W	August 2004
Carlópolis	Paraná	23° 25' 30" S and 49° 43' 15" W	August 2004
Matinhos	Paraná	25° 49' 04" S and 48° 32' 34" W	August 2004
Morretes	Paraná	25° 28' 37" S and 48° 50' 02" W	August 2004
Paranaguá	Paraná	25° 31' 12" S and 48° 30' 32" W	August 2004
Andirá	Paraná	23° 03' 03" S and 50° 13' 44" W	2004
Londrina	Paraná	23° 18' 36" S and 51° 09' 46" W	2004
Alto Paraná	Paraná	23° 07' 44" S and 52° 19' 08" W	2004
Guaraqueçaba	Paraná	25° 18' 25" S and 48° 19' 44" W	2004
Porto Rico	Paraná	22° 46' 19" S and 53° 16' 01" W	2004
Umuarama	Paraná	23° 45' 57" S and 53° 19' 30" W	2004
Guaira	Paraná	24° 04' 48" S and 54° 15' 21" W	2004
Capanema	Paraná	25° 40' 19" S and 53° 48' 32" W	2004
Foz do Iguaçu	Paraná	25° 32' 52" S and 54° 35' 16" W	2004
Garuva	Santa Catarina	26° 01' 37" S and 48° 51' 18" W	October 2004
Schroeder	Santa Catarina	26° 24' 46" S and 49° 04' 22" W	October 2004
Corupá	Santa Catarina	26° 25' 30" S and 49° 14' 34" W	October 2004
Biguaçu	Santa Catarina	27° 29' 38" S and 48° 39' 21" W	October 2004
Treviso	Santa Catarina	28° 30' 57" S and 49° 27' 28" W	October 2004
Santa Rosa do Sul	Santa Catarina	29° 08' 09" S and 49° 42' 00" W	October 2004
São José do Cedro	Santa Catarina	26° 27' 18" S and 53° 29' 38" W	October 2004
Torres	Rio Grande do Sul	29° 20' 06" S and 49° 43' 37" W	October 2004
Dom Pedro De Alcântara	Rio Grande do Sul	29° 22' 08" S and 49° 51' 00" W	October 2004
Três Cachoeiras	Rio Grande do Sul	29° 27' 21" S and 49° 55' 26" W	October 2004
Itati	Rio Grande do Sul	29° 29' 20" S and 50° 06' 18" W	October 2004
Três Forquilhas	Rio Grande do Sul	29° 32' 13" S and 50° 03' 50" W	October 2004
Terra de Areia	Rio Grande do Sul	29° 35' 06" S and 50° 04' 15" W	October 2004
Maquiné	Rio Grande do Sul	29° 40' 30" S and 50° 12' 25" W	October 2004
Osório	Rio Grande do Sul	29° 53' 13" S and 50° 16' 12" W	October 2004

Figure 5. Yellow and black sigatoka lesions in Santa Catarina North Coast. Pictures: Robert Harri Hinz

BRAZILIAN NORTHEAST REGION AND BRAZILIAN BLACK SIGATOKA FREE AREAS

At this date the total States of Northwest Brazilian Region and the State of Goiás (Central West Region) and Rio de Janeiro and Espírito Santo (Southeast Region) are considerate Black Sigatoka Free Areas. In the Rio de Janeiro and Goiás States neighborhoods was detected black sigatoka in the States of São Paulo and Minas Gerais. In very much States don't was realized a serious study about the black sigatoka occurrence. The Brazilian phytosanitary laws are restrictive to domestic inter-states marketing of banana from black sigatoka areas. Than, don't is interesting for the States to detect the disease.

The majority of currently black sigatoka free Brazilian States are the States that present lower air relative humidity, in Brazilian Central Plateaus Region and in Brazilian Northeast Region. Some of these Northeast

Brazilian States have a semi-arid climate. The exceptions are the States of Rio de Janeiro and Espírito Santo, in the Brazilian Southeast.

SPREADING OF BLACK SIGATOKA ON BRAZILIAN TERRITORY

The physical difficulties of the Amazonian territory and the absence of official research in many Amazon regions became impossible the execution of surveys and studies on the spreading of the disease in the region. Another difficulty was the lack of surveys, in all the country, from 1998. Many states alone had detected the black sigatoka at the moment where some region presented serious problems of the disease. Of these states, some had not carried through posterior surveys, to verify the extension of the problem. Some Brazilian states had not carried through conclusive surveys until today, more than twelve years after the confirmation of the first occurrence of the black sigatoka in the country.

Although the wind to be considered the main way of dissemination of the fungi, in the spreading the black sigatoka in long distances, the transport of the infected planting material and the infected leaves (as material of protection for the fruits) also can have been determinative for the fast dissemination of the black sigatoka in Brazil (Hanada et al., 2002).

In the states of Amazon, Pará, Amapá and Roraima the aquatic way had much importance in the fast dissemination of the disease, either for way of banana plants pulled out for the currents of the rivers and lead until other places (Hinz & Ventura, 1998), either by the great importance of the fluvial transport in the region. Is very common the transport of banana fruit protected for leaves of banana plants to the centers of consumption and the transport of planting banana material of a locality to another one. The low technological level of the banana culture in the Brazilian North Region favored the fast dissemination of the black sigatoka in that region (Cavalcante et al., 2004).

In the states of the Acre, Rondônia and Mato Grosso this dissemination occurred by road way and by aquatic way. In the regions Southeast and South the road way had greater importance. Among others possibilities for this dissemination the long distances, we can enumerate: the transport of sick planting material and infected leaves; the fungi transport in clothes, packings, vehicles and in the fruits skin, among others material that permit the survival of conidia for a long time (Hanada et al., 2002).

Among these possibilities, the most effective it is the transport of planting material of a region for other, practical common on the part of truck drivers. In the 2003 end, Lichtemberg identified an area with suspicion of occurrence of the disease, in the West of Santa Catarina State, in the South of Brazil, where plants of the Silk variety, with one year of age, whose original suckers had been brought of gift for a local producer, since the State of Rondônia, in Brazilian North Region (about 3,000 kilometers of distance).

The fast dissemination of the disease inside of a region had as main way the winds and breezes, of every intensity and direction.

However, the dissemination the great distances, possibly, if gave for chains of winds. Amongst the air masses that act in Brazil, the continental equatorial air mass (mEc), possibly, had greater importance in the dissemination of the disease in the country. The dissemination in the Brazilian South Coast, probably, was sped up by the act of the Atlantic tropical air mass (mTa).

POSSIBLE PERFORMANCE OF mEc IN THE BLACK SIGATOKA DISSEMINATION

In the winter, the Intertropical Convergence Zone (ITCZ or ZCIT) is more to the north, near of 12°N. With this, the biggest part of the humidity that would have to be distributed by Brazil is accumulated only in the extremity north of the South America. In Brazil it only rains in Roraima. At this time, the Region Center-West of Brazil, also the part of the Amazonian center-south and the northwest/north of the South and Southeastern Brazilian Regions is, by large periods (weeks or more), sunny and with very dry air (maximum relative humidity of 60% and minims of 20 or 30% and, in some periods, until inferior to these values).

From Spring (September) the humidity of the north of the Amazon starts to flow off to south, advancing gradually for the Center-West and arriving at the Southeast and part of the South of Brazil, bringing much cloudiness, high humidity, storms and rain of isolated form. This advance also characterizes the gradual incursion of mEc from the Amazon to bigger South latitudes, that if installs definitively between the Amazon and the Brazilian Southeast in the months of summer through the strong instabilities (cloudiness, dark sky, persistent rain, strong thunderstorms, especially in the afternoon period, and high air humidity) that it characterizes the Zone of Convergence of the South Atlantic (ZCAS). Associated to this hot and humid air mass, the winds predominate of the northwest, with more significant intensity when occur strong rain

thunderstorms. This condition of time frequently reaches the north of the Paraná State, but, for times, it arrives to reach Santa Catarina State zones through Plateaus North, Valley of the Itajaí River and Litoral North of this State. In this case, the humidity of air increases and, associate to the heat, it forms a “sensation of characteristic Amazon sultry”.

The thunderstorms are dislocated from the northwest to Southeast (from the continent to the sea) and anyways come followed of hail. From the second half of March this condition of time gradually leaves to exist and the humidity more goes falling in the high latitudes, until that for May return dry air again in great part of Brazil. The humidity go back only to low latitudes. The fast dissemination inside of the Amazon region and for other regions of Brazil, especially Center West and Southeast, and part of the South, can have as responsible this displacement of mEc.

Also exists the possibility that the dissemination has occurred from Bolivia, therefore mEc also has act during the summer in that region, with the northwest winds, that arrive to reach the Southeast and the South of Brazil.

POSSIBLE PERFORMANCE OF mTc IN THE BLACK SIGATOKA DISSEMINATION

The dry air of the autumn and, mainly, the winter is dominated by the continental tropical air mass (mTc), therefore, by the conditions of time associates to this mass, the conidia do not have conditions of longer life, being small the possibility of its performance in the dissemination of the disease.

POSSIBLE PERFORMANCE OF mTa IN THE BLACK SIGATOKA DISSEMINATION

In the South Coast of Brazil, mTa can has acted decisively in the fast dissemination of black sigatoka, in view of that it is the responsible one for the origin of the winds north-east that carry much humidity and rain, mainly at the beginning of the day to the São Paulo, Paraná and Santa Catarina States coast, until the region of Florianópolis.

CONCLUSIONS

The lack of intensive surveys in banana production areas at national level made very difficult the study of the Brazilian black sigatoka dissemination.

It is necessary to perform complete surveys in all Brazilian States to conclude the real extension of black sigatoka issue in Brazil.

The black sigatoka virulence among regions and production zones present great variation.

The black sigatoka virulence is less intense in dry and in cold regions.

It is possible the occurrence of different strains of the fungus within and among banana regions.

It is necessary an intensive molecular biology study of the Brazilians sigatoka strains to investigate the possible modifications of the fungus in different banana production environments.

In North Brazil the best solution to black sigatoka problem was de replacement of local varieties by resistant varieties.

In South, Southeast and West Center Brazil, the chemical control has been effective, especially when combined with good cultural practices and biological monitoring of disease.

The transport of fruits, suckers and leaves by roads contribute to fast dissemination of the black sigatoka in Brazil.

The winds were the main way of dissemination of black sigatoka in Brazil.

In Amazon region the river currents and the fluvial transport were important ways of dissemination of the disease.

Is very probable that black sigatoka is present in Argentina and Paraguay countries, due the occurrence of the disease in the Brazilian border, in municipalities of Paraná and Santa Catarina States.

Is very probable that black sigatoka is present in Goiás and Rio de Janeiro States, due the occurrence of the disease in these States borders, in municipalities of São Paulo and Minas Gerais States.

REFERENCES

- BRITO, P. F. de; SPIR, B. B.; MENDONÇA, E. T. de. Monitoramento da incidência da sigatoka negra no Estado de São Paulo. In: Reunião Internacional da Acorbat, 17, 2006, Joinville, SC. Anais da XVII Reunião Internacional da Acorbat. Itajaí, SC: ACORBAT/ACAFRUTA, v. 2, p. 698-701, 2006.

- CASTRO, M. E. A .; PEREIRA, J. C. R.; GASPAROTTO, L. Primeiro relato da ocorrência da sigatoka-negra em Minas Gerais. *Fitopatologia Brasileira*, Fortaleza – CE, v. 30, n. 6, p. 668-668, 2005.
- CAVALCANTE, M. J. B.; GONDIM, T. M. S.; CORDEIRO, Z. J. M.; MATOS, A . P. HESSEL, J. L.; SAMPAIO, F. R. V. Ocorrência da Sigatoka-negra em dez municípios do Estado do Acre. Rio Branco, AC: EMBRAPA-CPAF/AC. 2 p. 1999 (Comunicado Técnico, 107)
- CAVALCANTE, M. J. B.; SÁ, C. P. de; GOMES, F. C. da R.; GONDIM, T. M. de S.; CORDEIRO, Z. J. M.; HESSEL, J. L. Distribuição e impacto da sigatoka-negra na bananicultura do Estado do Acre. *Fitopatologia Brasileira*, Fortaleza – CE, v. 29, n. 5, p. 544-547, 2004.
- CORDEIRO, Z. J. M.; MATOS, A . P. de; SILVA, S. de O e. Black sigatoka confirmed in Brazil. *Infomusa*, Montpellier, FR, v. 7, n. 1, p. 31, 1998.
- FERRARI, J. T.; HARAKAVA, R.; NOGUEIRA, E. M. de C.; CASTRO, M.E. A . Ocorrência de sigatoka negra da bananeira no Sul de Minas Gerais. *Summa Phytopathologica*, v. 31, supl., p. 34, 2005 a. Resumo 74.
- FERRARI, J. T.; NOGUEIRA, E. M. de C.; GASPAROTTO, L.; HANADA, R. E.; LOUZEIRO, I. M. Ocorrência da sigatoka negra em bananeiras no Estado de São Paulo. *Arquivos do Instituto Biológico*, São Paulo, v. 72, n. 1, p. 133-134, 2005b.
- FERRARI, J. T.; TOMAZ, R.; HARAKAVA, R.; NOGUEIRA, E. M. de C. Sigatoka negra da bananeira no Estado do Paraná. *Summa Phytopathologica*, Botucatu, v. 31, supl., p. 102, 2005c. Resumo 229.
- GARCIA, A . A sigatoka negra (*Mycosphaerella fijiensis* Morelet): mais uma ameaça à produtividade da bananeira (*Musa sp*) em Rondônia. *Circular Técnica*, 46, Embrapa CPAF/RO, 15p., 1999.
- GASPAROTTO, L.; PEREIRA, J. C. R.; TRINDADE, D. R. Situação atual da sigatoka negra da bananeira. *Fitopatologia Brasileira*, v. 26, supl., p. 449, 2001. Resumo 692.
- HANADA, R. E.; GASPAROTTO, L.; PEREIRA, J. C. R. Sobrevivência de conídios de *Mycosphaerella fijiensis* em diferentes materiais. *Fitopatologia Brasileira*, Fortaleza – CE, v. 27, n. 4, p. 408-411, 2002.
- HINZ, R. H.; VENTURA, J. A . Relatório de viagem técnica para conhecer e dimensionar a ocorrência da sigatoka negra no Estado do Amazonas. MA/DAS/DDIV: Manaus, AM. 6p. 1998.
- NECHET, K. L.; HALFELD-VIEIRA, B. A.; PEREIRA, P. R. V. S.; CALIARI, C. C. Distribuição de sigatokas na cultura da banana (*musa spp.*) no Estado de Roraima. In: SIMPOSIO BRASILEIRO SOBRE BANANICULTURA, 6., 2004, Joinville, SC. Anais... Itajaí, SC: SBF/ACAFRUTA, 2006. p. 334.
- NOGUEIRA, E. M. de C.; FERRARI, J. T. Situação e dispersão da Sigatoka Negra da bananeira no Estado de São Paulo. *Summa Phytopatologica*, Botucatu, v. 31, supl., p. 33-34, 2005. Resumo 073.
- NOGUEIRA, E.M.de C.; FERRARI, J. T. ; HARAKAVA, R. Sigatoka negra *Mycosphaerella fijiensis* em bananeira no Mato Grosso do Sul. *Summa Phytopathologica*, v. 31, supl., p. 34, 2005. Resumo 75.
- PEREIRA, A . M.; TOMAZ, R.; KANDA, N. E.; PAIVA, P. G.; PIAN, C. A . Situação da sigatoka negra em bananeiras no Estado do Paraná. In: REUNIÃO INTERNACIONAL DA ACORBAT, 17, 2006, Joinville, SC. Anais da XVII Reunião Internacional da Acorbat. Itajaí, SC: ACORBAT/ACAFRUTA, 2006. v. 1, p. 383.

- PEREIRA, A. M.; MATYAK, E.; TOMAZ, R.; SCREMIN, R. M.; SADE, M. C. Situação da sigatoka negra em bananeiras do Estado do Paraná, Brasil. In: Simpósio sobre a cultura da bananeira nos subtrópicos do Cone Sul. Joinville, SC, 2010. Anais... Itajaí: ACAFRUTA/EPAGRI, 2010, p. xxx-xyy.
- PEREIRA, J. C. R.; GASPAROTTO, L.; COELHO, A. F. da S. Ocorrência da Sigatoka negra no estado do Amazonas. Informativo SBF, Brasília- DF, v. 17, n. 2, p. 11-13, 1998 a.
- PEREIRA, J. C. R.; GASPAROTTO, L.; COELHO, A. F. da S.; URBEN, A. Ocorrência de Sigatoka negra no Brasil. Fitopatologia Brasileira, v. 23, p. 295, 1998b.
- PERUCH, L. A. M.; SÔNEGO, M.; FERREIRA, J. V.; MACARINI, D.; SILVA, F. P. Situação da sigatoka-negra no Sul de Santa Catarina e Norte do Rio Grande do Sul. In: Simpósio sobre a cultura da bananeira nos subtrópicos do Cone Sul. Joinville, SC, 2010. Anais... Itajaí: ACAFRUTA/EPAGRI, 2010, p. xxx-xyy.
- REIS, N. D.; FERNANDES, C. de F.; VIEIRA JÚNIOR, J. R.; SILVA, D. S. G. da; GUEDES, M. L. A. ; MIRANDA, S. L. V. de; FERNANDES NETO, A. ; COSTA, J. N. M.; HOLANDA FILHO, Z. F. Ocorrência da sigatoka negra em bananais do Estado de Rondônia. In: XX Congresso Brasileiro de Fruticultura, 2008, Vitória – ES. XX Congresso Brasileiro de Fruticultura. Vitória – ES: INCAPER, v. único. P. 1-5, 2008.
- RITZINGER, C. H. S. P.; RITZINGER, R.; CORDEIRO, Z. J. M.; CAVALCANTE, M. J. B. Ocorrência de sigatoka negra da bananeira em Rio Branco, AC, Brasil. Fitopatologia Brasileira, v. 24, p. 450, 1999.
- SECOM/ASCOM/ADAPEC. Bananal com a praga Sigatoka negra é destruído em Araguaína. <http://secom.to.gov.br/noticia/banana-com-a-praga-sigatoka-negra-e-destruido-em-araguaina/29562> . Access in 2010 May 25
- SOUZA, N. S. de; FEGURI, E. Ocorrência de Sigatoka negra em bananeira causada por *Mycosphaerella fijiensis* no Estado do Mato Grosso. Fitopatologia Brasileira, v. 29, n. 2, p. 225, 2004.
- TRINDADE, D. R.; POLTRONIERI, L. S.; MENEZES, A. J. E. A. Sigatoka negra da bananeira no Estado do Pará. Fitopatologia Brasileira, v. 27, n. 3, p. 323, 2002.
- VIEIRA, B. de A. H. Sigatoka negra: situação atual em Roraima. Manchetes Embrapa, 2006. Disponível em: http://www.cpafr.embrapa.br/index.php/cpafr/manchetes/sigatoka_negra_situa_o_atual_em_roraima . Access in 2008 December 11.