

Rust Resistance in Arabic Coffee Cultivars in Northern Paraná

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ABSTRACT

The objective of the study was to evaluate the resistance to rust in coffee cultivars developed by research institutes of Brazil in Paraná state. Resistance to the local leaf rust races was assessed in high disease intensity field conditions at Londrina and Congonhinhas in 2009 and 2010. The cultivars were developed by the EPAMIG/UFV, IAPAR, IAC and MAPA/Procafé. The resistant standard 'IAPAR 59' and the susceptible standards Catuaí Vermelho IAC 144' and 'Bourbon Amarelo' were used. A randomized block design with three replications and plots with 10 plants was used. A scale from 1 to 5 based on the rust intensity was used to evaluate the resistance. The Catiguá MG 1, Catiguá MG 2, IAPAR 59, IPR 98, IPR 104, Palma II, Paraíso H-419-10-6-2-5-1, Paraíso H-419-10-6-2-10-1, Paraíso H-419-10-6-2-12-1, Pau Brasil MG 1 and Sacramento MG 1 cultivars presented complete resistance to rust at Londrina and Congonhinhas. The cultivars derived from the Catuaí germplasm were susceptible or showed different levels of partial resistance. Partial resistance to the rust was observed in several coffees derived from "Híbrido de Timor". 'Acauã' and 'Obatã IAC 1669-20' presented complete resistance at Londrina, but at Congonhinhas, they were partially resistant, indicating that different rust races have occurred at these two locations.

Key words: Breeding, *Coffea*, *Hemileia vastatrix*, Híbrido de Timor, SH genes

INTRODUCTION

Coffee leaf rust, caused by the *Hemileia vastatrix* Berk. et Br. fungus, is considered as the main disease in this crop. The disease can be efficiently controlled with chemical and genetic control (Zambolim et al. 1999).

In spite of the efficiency of the fungicides, the development and use of resistant cultivars is economically the best alternative to control the disease (Waller et al. 2007). However, obtaining the resistant cultivars has been a constant challenge for the breeders because over the time,

the plants can become susceptible to new races of the pathogen (Várzea and Marques 2005), thus making the control of the disease difficult by the use of these cultivars (Zambolim et al. 2005).

To date, nine major resistance genes have been identified in coffee plants of different genotypes, characterized by the sign SH. These resistance genes were found mainly in *C. arabica* (SH1, SH2, SH4, SH5), *C. canephora* (SH6, SH7, SH8, SH9) and *C. liberica* (SH3). The SH6, SH7, SH8, and SH9 genes were also found in Híbrido de Timor derivatives and Icatu, both interspecific hybrids between *C. arabica* and *C. canephora*

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(Bettencourt and Noronha-Wagner 1971, Bettencourt and Rodrigues Júnior 1988, Noronha-Wagner and Bettencourt 1967, Rodrigues-Júnior et al. 1975). The existence of other resistance genes in “Híbrido de Timor” derivatives and “Icatu” has been confirmed because the resistance was maintained to new rust races that defeated *SH5*, *SH6*, *SH7*, *SH8* and *SH9* genes (Rodrigues-Júnior et al. 2000).

The break in the resistance by the new rust races in many cultivars before considered resistant, such as the “Catimor” germplasm, has occurred in various regions of the world. The existing physiological rust races have already broken almost all the *SH* resistance genes (Várzea et al. 2002). Currently, more than 45 physiological rust races have been characterized in the world as the carriers of the nine virulence genes (*v1* to *v9*), alone or in combination. Some races have a wide virulence spectrum such as the XXXIX race, with seven virulence genes, isolated from the samples from India (Várzea and Marques 2005).

Genetic breeding for rust resistance has been carried out by several research institutes in Brazil using as resistant sources coffee trees, including the “Sarchimor”, “Catimor”, “Catindu”, “Icatu” and “Catucaí” germplasm. Many cultivars of these germplasm presented complete resistance to rust but currently have different resistance levels or have shown susceptibility due to the appearance of new races.

The objective of the present study was to assess the resistance to rust in the coffee cultivars developed by the research institutes in Brazil at two locations in Northern Paraná.

MATERIALS AND METHODS

The experiments were set up in the field in the municipalities of Londrina and Congonhinhas in the Paraná (Brazil). In Londrina, the experiment was set up at Experimental Station of the Paraná Agronomic Institute (23° 22' S, 51° 10" W) in red distroferic latosol type soil at 585 m altitude, with 20.8 °C mean annual temperature. In

Congonhinhas, the experiment was set up at Experimental Farm Serinha II (23° 30' S, 50° 10" W) in red distroferic latosol type soil at 750 m altitude, with 19.5 °C mean annual temperature.

The cultivars assessed were developed by the Empresa de Pesquisa Agropecuária de Minas Gerais/ Universidade Federal de Viçosa (EPAMIG/UFV), Agricultural Research Institute of Paraná (IAPAR), Instituto Agronômico de Campinas (IAC) and MAPA/ PROCAFÉ (Table 1). ‘IAPAR 59’ was used as resistance standard and ‘Catuaí Vermelho IAC144’ and ‘Bourbon Amarelo’ were used as susceptible cultivars.

The experiments were set up in October and November 2006, in Congonhinhas and Londrina, respectively, in the spacing 2.50 x 0.75m, in a randomized block design with three replications and plots of 10 plants. In Congonhinhas, the resistance to rust was assessed only in 2010 while in Londrina, the assessments were made in 2009 and 2010.

The resistance assessments were for the local population of rust races present in Londrina and Congonhinhas under the conditions of high disease intensity in the field. In the experiment in Congonhinhas, an assessment was made in July 2010 (46 months after the planting). The assessments in Londrina were made in July 2009 (33 months after the planting) and July 2010 (46 months after the planting). A scale of scores was used to assess the rust intensity ranging from 1 to 5, where: score 1 = plant without chlorotic lesions on the leaf; score 2 = number of lesions per leaf, on average, between 1 and 4, without sporulation; score 3 = number of lesions with between 1 and 10 spores per leaf and with 1 to 10 % leaves with sporulation; score 4 = number of lesions with between 11 and 20 spores per leaf and with 11 % to 35 % of the leaves with sporulation; score 5 = more than 20 lesions with spores per leaf at more than 35% leaves with sporulation. The lower third to the upper third of the coffee tree was assessed.

The data was submitted to the analysis of variance and the means were compared by the Scott-Knott test at 5% significance. The genes statistical program was used (Cruz 2001).

Table 1 - Description of arabic coffee cultivars assessed in the experiments set up in the north of Parana state, Brazil, to assess resistance to rust.

Cultivars	Description	Institute
Araponga MG 1	“Catuaí” x “Híbrido de Timor”	Epamig/ UFV
Catiguá MG 1	“Catuaí” x “Híbrido de Timor”	Epamig/ UFV
Catiguá MG 2	“Catuaí” x “Híbrido de Timor”	Epamig/ UFV
Oeiras MG 6851	“Catimor”	Epamig/ UFV
Paraíso H-419-10-6-2-5-1	“Catuaí” x “Híbrido de Timor”	Epamig/ UFV
Paraíso H-419-10-6-2-10-1	“Catuaí” x “Híbrido de Timor”	Epamig/ UFV
Paraíso H-419-10-6-2-12-1	“Catuaí” x “Híbrido de Timor”	Epamig/ UFV
H-419-3-3-7-16-4-1	“Catuaí” x “Híbrido de Timor”	Epamig/ UFV
Pau Brasil MG 1	“Catuaí” x “Híbrido de Timor”	Epamig/ UFV
Sacramento MG 1	“Catuaí” x “Híbrido de Timor”	Epamig/ UFV
Bourbon Amarelo	“Bourbon Vermelho” x “Amarelo de Botucatu”	IAC
Catuaí Vermelho IAC 144	“Mundo Novo” x “Caturra”	IAC
Obatã IAC 1669-20	“Sarchimor” x “Catuaí”	IAC
Tupi IAC 1669-33	“Sarchimor”	IAC
IAPAR 59	“Sarchimor”	IAPAR
IPR 98	“Sarchimor”	IAPAR
IPR 99	“Sarchimor”	IAPAR
IPR 100	“Catuaí” x (“Catuaí” x “series BA-10 coffee”)	IAPAR
IPR 103	“Catuaí” x “Icatu”	IAPAR
IPR 104	“Sarchimor”	IAPAR
Catuaí Amarelo 2 SL	“Icatu” x “Catuaí”	MAPA/Procafé
Catuaí Vermelho 20/15 cv 476	“Icatu” x “Catuaí”	MAPA/Procafé
Catuaí Amarelo 20/15 cv 479	“Icatu” x “Catuaí”	MAPA/Procafé
Catuaí Amarelo 24/137	“Icatu” x “Catuaí”	MAPA/Procafé
Catuaí Vermelho 785/15	“Icatu” x “Catuaí”	MAPA/Procafé
Acauã	“Sarchimor” x “Mundo Novo”	MAPA/Procafé
Palma II	“Catuaí” x “Catimor”	MAPA/Procafé
Sabiá 398	“Catimor” x “Acaíá”	MAPA/Procafé

RESULTS AND DISCUSSION

The mean rust intensity was high in the two locations, as could be observed in the susceptible standards ‘Bourbon Amarelo’ and ‘Catuaí Vermelho IAC 144’. The highest susceptibility of ‘Bourbon Amarelo’ was observed at Congonhinhas, where it was statistically more susceptible than ‘Catuaí Vermelho IAC144’ (Table 2).

Generally, the cultivars descended from the “Catuaí” germplasm were susceptible or presented different levels of partial resistance (incomplete resistance). ‘Catuaí Amarelo 24/137’ was statistically equal to the susceptible standard in Londrina, but in Congonhinhas, the rust intensity was less than in the susceptible standards, indicating that there was still partial resistance to the rust races existing in this location. In Londrina, the rust intensity was less in the Catuaí Vermelho 20/15 cv 476, Catuaí Vermelho 785/15 and

Catuaí Amarelo 2SL cultivars than in the susceptible standard, but statistically equal to the IPR 100, considered susceptible in the state of Paraná by Sera et al. (2010b). ‘Catuaí Vermelho 20/15 cv 476’, ‘Catuaí Amarelo 20/15 cv 479’, ‘Catuaí Vermelho 785/15’ and ‘IPR 100’ were statistically equal to the susceptible standard ‘Catuaí Vermelho IAC 144’ in the municipality of Congonhinhas, while ‘Catuaí Amarelo 2SL’ presented incomplete resistance similar to that of ‘IPR 103’. In Londrina, ‘Catuaí Amarelo 20/15 cv 479’ was partially resistant not different from the IPR 103 cultivar (“Catuaí”) that had presented a good level of partial resistance in a previous study by Sera et al. (2010b). The resistance found in ‘IPR 103’ and ‘Catuaí Amarelo 20/15 cv 479’ probably came from “Icatu”, because different partial resistance levels had been frequently detected in “Icatu” plants (Monaco and Carvalho 1975, Eskes and Carvalho 1983, Eskes and Costa 1983, Eskes et al. 1990). Inheritance studies in “Icatu” plants and “Híbrido de Timor”

descendants with different levels of incomplete resistance indicated the presence of one or a few minor partially dominant genes. These genetic factors when in homozygosis condition or associated, confer almost complete resistance (Eskes et al. 1990). Other authors have also reported that ‘Catucaí Amarelo 24/137’, ‘Catucaí Vermelho 20/15 cv 476’, ‘Catucaí Amarelo 20/15 cv 479’, ‘Catucaí Vermelho 785/15’ and ‘Catucaí

Amarelo 2SL’ have partial resistance to rust (Matiello et al. 2010), but it was seen in the present study that in some locations these genotypes were as susceptible as ‘Catuaí Vermelho IAC144’ and ‘IPR 100’, depending on the location. Matiello et al. (2005) reported that “Catucaí” lines are attacked by rust at different levels, but several do not lose leaves sharply and chemical control is easy using copper fungicides.

Table 2 - Mean scores of rust intensity on coffee cultivars assessed under field conditions in the municipalities of Londrina (2009 and 2010) and Congonhinhas (2010).

Cultivars ⁽¹⁾	Londrina ⁽²⁾	Congonhinhas ⁽²⁾
Bourbon Amarelo	3,200 a	5,000 a
Catucaí Amarelo 24/137	2,950 a	3,166 c
Catuaí Vermelho IAC 144	2,866 a	3,666 b
Catucaí Vermelho 20/15 cv 476	2,616 b	3,666 b
Catucaí Vermelho 785/15	2,616 b	3,833 b
Catucaí Amarelo 2 SL	2,450 b	2,666 c
H-419-3-3-7-16-4-1	2,366 b	2,333 c
IPR 100	2,316 b	3,333 b
Oeiras MG 6851	1,950 b	3,166 c
IPR 103	1,700 c	2,666 c
Catucaí Amarelo 20/15 cv 479	1,616 c	3,333 b
Tupi IAC 1669-33	1,583 c	2,333 c
Sabiá 398	1,500 c	2,000 d
Araponga MG 1	1,466 c	2,166 d
IPR 99	1,233 d	1,666 d
Acauã	1,200 d	2,666 c
Catiguá MG 2	1,183 d	1,000 e
IAPAR 59	1,150 d	1,000 e
Pau Brasil MG 1	1,150 d	1,333 e
IPR 104	1,133 d	1,333 e
Obatã IAC 1669-20	1,100 d	2,500 c
Palma II	1,100 d	1,000 e
IPR 98	1,083 d	1,000 e
Paraíso H-419-10-6-2-12-1	1,083 d	1,000 e
Sacramento MG 1	1,083 d	1,333 e
Catiguá MG 1	1,016 d	1,000 e
Paraíso H-419-10-6-2-5-1	1,000 d	1,000 e
Paraíso H-419-10-6-2-10-1	1,000 d	1,000 e

¹Cultivars ranked decreasingly according to rust intensity occurred in Londrina.

²Means followed by the same letters did not differ statistically by the Scott-Knott test at 5%. Scale of scores at from 1 to 5 for rust assessment.

‘IPR 100’ was originated from a crossing between “Catuaí” and one hybrid (“Catuaí” x series BA-10 coffee) carrying *Coffea liberica* genes, but it was probably not a carrier of the *SH3* gene, because in Londrina coffee trees with this gene were completely resistant to the rust (Sera et al. 2007a, 2010b). ‘IPR 100’ is resistant to race II (gene v5) of *H. vastatrix*, while the cultivars from the “Catuaí” germplasm, carriers only of *SH5*, are susceptible (Capucho et al. 2007). As ‘IPR 100’

was susceptible at Congonhinhas, statistically equal to the susceptible standard Catuaí Vermelho IAC144, some resistance gene from ‘IPR 100’ was broken by some race, different from race II.

‘Oeiras MG 6851’ was statistically equal to ‘IPR 103’ at Congonhinhas, indicating that the resistance had not yet been completely broken in this cultivar from “Catimor”. At Londrina, the resistance of this cultivar was completely broken, because it was statistically equal to ‘IPR 100’.

Pereira et al. (2010) reported that ‘Oeiras MG 6851’ presented predominantly vertical resistance reaction to the *H. vastatrix* races prevalent in the coffee regions of Minas Gerais and that the infected plants presented horizontal resistance. Other authors have also observed the occurrence of partial resistance in coffees derived from “Híbrido de Timor” with resistance broken in the ‘Colombia’ (“Catimor”) (Alvarado 2005) and ‘IPR 108’ (“Sarchimor” x “Catucaí”) cultivars (Sera et al. 2010b).

This break in resistance in “Híbrido de Timor” derivatives observed in ‘Oeiras MG 6851’ also seemed to be occurring in ‘Acauã’ (“Sarchimor” x “Mundo Novo”), ‘Araponga MG 1’ (“Catuaí” x “Híbrido de Timor”), ‘H-419-3-3-7-16-4-1’ (“Catuaí” x “Híbrido de Timor”), ‘IPR 99’ (“Sarchimor”), ‘Obatã IAC 1669-20’ (“Sarchimor” x “Catuaí”), ‘Sabiá 398’ (“Catimor” x “Acaíá”) and ‘Tupi IAC 1669-33’ (“Sarchimor”). Costa et al. (2007) also identified “Catimor” progenies with complete resistance and others with partial resistance to the rust. These authors also reported that ‘Catucaí Vermelho 36/6’, ‘Oeiras MG 6851’ and ‘Palma I’ (“Catimor” x “Catuaí”) presented quantitative resistance to race II of *Hemileia vastatrix*. Matiello et al. (2005) reported that ‘Palma I’, ‘Palma II’ and ‘Sabiá 398’ have already presented some plants attacked by rust, but with less intense of leaf-shedding.

Selection might be made on these cultivars with partially broken resistance to obtain the progenies with a higher frequency of the plants with complete resistance (scores 1 and 2). Sera et al. (2010a) identified the progenies of the IPR 99 and IPR 107 (‘IAPAR 59’ x ‘Mundo Novo IAC 376-4’) cultivars with a higher percentage of the plants with complete resistance by the test crosses (progeny to be tested x susceptible genotypes). Using the same method, Sera et al. (2007b) selected the progenies from the IAPAR 59 and Tupi IAC 1669-33 cultivars with a higher number of resistance genes not broken by the local population of rust races.

‘Acauã’, ‘Araponga MG 1’, ‘Obatã IAC 1669-20’ and ‘Tupi IAC 1669-33’ have been normally mentioned as being resistant by various authors (Carvalho et al. 2008, Matiello et al. 2005, 2010), but in the present study it was observed that resistance had been broken in these cultivars. It was interesting to note that ‘Acauã’ and ‘Obatã IAC 1669-20’ were completely resistant in Londrina, statistically equal to the standard

IAPAR 59, but were only partially resistant at Congonhinhas, at the same level as ‘IPR 100’, indicating that at the latter location, there were rust races with more virulence genes. The same occurred for ‘Catucaí Amarelo 20/15 cv 479’ that was partially resistant at Londrina and susceptible at Congonhinhas.

However, it could be possible that this partial resistance was not durable as occurred in the Cauvery (“Catimor”) cultivar where partial resistance was observed only at the start. In a short time, the susceptibility of these coffee trees and the aggressiveness of the rust increased and this cultivar was susceptible under field conditions in India (Várzea and Marques 2005). It could be probable that the partial resistance observed in these cultivars derived from “Híbrido de Timor” and “Catucaí” was durable, depending on the races present at the location. In Paraná state ‘IPR 103’ has presented the same level of partial resistance for more than 12 years (Sera T. 2010, personal communication).

The cultivars that presented complete resistance at the two locations and in the two assessment years were: Catiguá MG 1, Catiguá MG 2, IAPAR 59, IPR 98, IPR 104, Palma II, Paraíso H-419-10-6-2-5-1, Paraíso H-419-10-6-2-10-1, Paraíso H-419-10-6-2-12-1, Pau Brasil MG 1 and Sacramento MG 1. All these cultivars were “Híbrido de Timor” derivatives and confirmed the resistance reported by other authors (Carvalho et al. 2008, Matiello et al. 2010, Pereira et al. 2010, Sera et al. 2010b), except for ‘Palma II’ that had already presented some susceptible plants with less leaf shedding (Matiello et al. 2005). The “Híbrido de Timor” population has at least five dominant genes *SH5*, *SH6*, *SH7*, *SH8*, *SH9* (Bettencourt et al. 1992), and *SH6* to *SH9* came from *C. canephora* (Bettencourt and Rodrigues-Júnior 1988). In addition to these already identified, it might be likely that other resistance genes could be present in “Híbrido de Timor” (Várzea and Marques 2005). Two monogenetic resistant factors, different from *SH6* to *SH9*, were detected in Brazil; one in *C. canephora* cv. Kouillou and another in “Icatu” (Eskes 1989). In another study in Londrina, it was observed that the *SH1*, *SH2*, *SH4*, *SH5* and *SH8* genes had already been broken by the local population of rust races. Furthermore, it was observed that coffee tree carriers of *SH3*, Híbrido de Timor CIFC 832/1 and CIFC 832/2 had complete resistance (Sera et al. 2007a). It could be probable that these cultivars that presented

complete resistance at two locations were the carriers of the *SH5*, *SH6*, *SH7*, *SH8* and *SH9* genes and other resistance genes to rust in different combinations.

CONCLUSIONS

The cultivars Catiguá MG 1, Catiguá MG 2, IAPAR 59, IPR 98, IPR 104, Palma II, Paraíso H-419-10-6-2-5-1, Paraíso H-419-10-6-2-10-1, Paraíso H-419-10-6-2-12-1, Pau Brasil MG 1 and Sacramento MG 1 presented complete resistance to rust in Londrina and Congonhinhas.

The cultivars derived from the Catucaf germplasm were susceptible or showed different levels of partial resistance.

Partial resistance to the rust was observed in several “Híbrido de Timor” derivatives as in the case of the ‘Tupi IAC 1669-33’.

‘Acauã’ and ‘Obatã IAC 1669-20’ presented complete resistance in Londrina but were only partially resistant in Congonhinhas, indicating that different rust races occurred at these two locations.

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