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Resistance to red mite in *Coffea arabica* genotype introgressed with *Coffea racemosa* genes

Fernando Cesar Carducci[1,2], Inês Cristina de Batista Fonseca[2], Willian Gabriel dos Santos[1,2], Carlos Theodoro Motta Pereira[1], Valdir Mariucci Junior[1], Tumoru Sera[1], Gustavo Hiroshi Sera[1*]

[1]Instituto Agronômico do Paraná (IAPAR), Plant Breeding Department, Rodovia Celso Garcia Cid, km 375, 86047-902, Londrina-PR, Brazil
[2] Universidade Estadual de Londrina (UEL), Agronomy Department, Rodovia Celso Garcia Cid, km 380, 86057-970, Londrina-PR, Brazil

***Corresponding author: gustavosera@iapar.br**

Abstract

The aim of this study was to assess the resistance to red mite (*Oligonychus ilicis*) in *Coffea arabica* genotypes with introgression of genes from a different species (*Coffea racemosa*). The experiment was conducted in a greenhouse at IAPAR (Londrina, PR, Brazil), between January 2016 and January 2017. The experiment was conducted in a completely randomized design with five genotypes, 12 replications of one plant per plot. The *C. arabica* cultivars IPR 100, IPR 99 and IPR 103 were evaluated as well as an F_4 Arabica coffee line IAPAR H0113-40-26-10 with introgressed *C. racemosa* genes. Catuaí Vermelho IAC 99 cultivar, which is a pure *C. arabica*, was used as a susceptible control. In conditions of high natural infestation of red mite, the resistance of coffee genotypes was evaluated using a standard visual evaluation in January 2017. This evaluation was based on the percentage of leaf area with typical symptoms caused by this mite. Only one genotype, the F_4 line IAPAR H0113-40-26-10 showed resistance to the red mite because present less leaf area with symptoms compared to other genotypes. The Arabica coffee cultivars IPR 99, IPR 100 and IPR 103 are as susceptible to red mite as to the susceptible control Catuaí Vermelho IAC 99.

Keywords: Aramosa; breeding; IAC1195-5-6-2; cultivars; *Oligonychus ilicis*.
Abbreviations: IAPAR_ Instituto Agronômico do Paraná.

Introduction

Coffea arabica L. and *C. canephora* Pierre. are the main coffee species cultivated in the world representing, about 65 and 35% of the total production, respectively (ICO, 2017). The red mite (*Oligonychus ilicis*) is considered an important pest for *C. canephora*, which causes economic losses more frequently in hotter and drier regions (Matiello et al., 2016). This pest also occurs in *C. arabica* and it can cause losses of up to 50 % in productivity in areas with high infestation and without chemical control (Franco et al., 2009).

O. ilicis is a small arachnid of approximately 0.5 mm in length, with females with dark red coloration and males lighter and smaller (Malavolta et al., 1993). They attack the leaves of the coffee tree, especially on the tip of the branches and it can be seen with the naked eye, moving quickly on the leaves. The attacked plants presented leaves with tan color, without luster, where is observed thin webs woven by the mites and their ecdises on the upper face of the leaves. If there is no control, the mites can infest the entire crop. The leaves decrease in size and the photosynthetic activity, leaf fall and losses in the production (Franco et al., 2009). The attack of the red mite usually occurs in clumps of plants. They may also rarely attack the whole plantation, being more affected the plants with higher potential yield (Matiello et al., 2016).

The major infestation of the red mite occurs in winter and summer (dry periods), because in rainy periods *O. ilicis* mites can be washed from the leaves, which decreases the population of this pest (Abreu, 2014). The extra use of copper fungicides and also pyrethroids has contributed to the population increase of this mite, although some of the pyrethroids are also acaricidal and do not provoke this imbalance (Fragoso, 2002). The use of insecticides from the neonicotinoids group, even via soil, especially for the active ingredient Thiamethoxam, causes a major attack of the red mite, probably by altering the content of amino acids or hormones in the coffee (Matiello et al., 2016).

O. ilicis can be chemically controlled by sulfur-based products, insecticides and acaricides mainly by abamectin and emamectin, which are selective for controlling phytophagous mites (Reis et al., 2004). However, this increase costs coffee farmers' and cause environmental damage and damage to the applicator's health.

The use of genetic resistance to mites would be important in the management of this pest, but so far there are few studies on the resistance of coffee plants. According to Reis

et al. (2004) the *C. canephora* var. *kouillou* is more attacked than cultivars of *C. arabica*. In laboratory conditions with artificial infestation, resistance to *O. ilicis* was observed in some cultivar Vitória clones of *C. canephora* var. *kouillou* when compared to other clones of the same cultivar (Silva et al., 2015). Resistance to *O. ilicis* in different coffee species was evaluated in laboratory conditions with artificial infestation, where high resistance to *C. racemosa*, *C. salvatrix*, *C. dewevrei* and *C. liberica* was identified. *C. stenophylla* and genotypes IAC 1195-5-6-1 and IAC 1195-5-6-2 showed intermediate resistance (Oliveira et al., 1987). The same study reported that *C. canephora*, *C. congensis*, *C. arabica* cv. Mundo Novo and Icatu were highly susceptible.

In the IAPAR's breeding program, genotype IAC 1195-5-6-2, which is an Arabica coffee with introgressed *C. racemosa* genes, has been used to transfer resistance to leaf miner (*Leucoptera coffeella*) (Andreazi et al., 2015) and drought tolerance (Carvalho et al., 2017). In addition, IAPAR was developed by crossing Arabica coffee cultivars with introgression of genes of different species such as *C. canephora* and *C. liberica.* The source of resistance to red mite is not known in these cultivars and genotypes yet.

The aim of this study was to evaluate the resistance to red mite in *Coffea arabica* genotypes with introgression of genes of different species.

Results and discussion

The mean values showed that the cultivars IPR 99, IPR 100 and IPR 103 did not differ from the susceptible control Catuaí Vermelho IAC 99. Only the line IAPAR H0113-40-26-10 differed from this control and presented resistance to the red mite (Table 1).

The F_4 line IAPAR H0113-40-26-10 was originated from the cross between the cultivar IPR 104 with a complex hybrid ('Tupi IAC 1669-33' x ("IAPAR 81185" x 'Tupi IAC 1669-33')] (Fig 1). Genotype IAPAR 81185 is an F_2 plant derived from an F_1RC_2 plant called IAC 1195-5-6-2 c.950 Ep209. The origin of the latter was from a spontaneous hybrid between *Coffea arabica* and *C. racemosa* (IAC 1195) named C1195-5. This hybrid was naturally backcrossed twice with *C. arabica* originating from F_1RC_2 progeny named IAC 1195-5-6-2 (Guerreiro-Filho, 2007). In IAPAR, an F_2 plant (IAPAR 81185) from F_1RC_2 genotype (IAC 1195-5-6-2 c.950 Ep209) was identified as a possible resistance source to leaf miner and cold, and three more backcrosses were carried out with the cultivars Tupi IAC 1669-33 and IPR 104, originating from F_1RC_5 IAPAR H0113. In this study, this genotype was advanced by pedigree method to generate the F_4RC_5 line IAPAR H0113-40-26-10. "IAC 1195-5-6-2" is an important genotype used in Brazil's breeding programs to transfer resistance to *Leucoptera coffeella* (Medina-Filho et al., 1977b) and drought tolerance (Medina-Filho et al., 1977a), inherited traits from species *C. racemosa*. It is probable that IAC 1195-5-6-2 is the resistance source to red mite because of both cultivars Tupi IAC 1669-33 and IPR 104 originated from the same hybridization of IPR 99 (Villa Sarchi CIFC 971/10 x Timor Hybrid CIFC 832/2), which was susceptible in our study. In addition, this partial resistance of IAPAR H0113-40-26-10, with 21.52% of leaf affected area was also found in IAC 1195-5-6-2, on which 25.9% of the red mites completed their life cycle (Oliveira et al., 1987). In the same study, we verified that Icatu, *C. canephora*, *C. arabica* cv. Mundo Novo were highly susceptible and the % of mites that completed the life cycle were 88.0%, 84.6% and 77.8%, respectively, while *C. racemosa* was highly resistant with 14.8% of completed mite life cycle. Thus, this lower percentage of leaf area with symptoms can be explained by the lower reproduction of the red mite in leaves of IAPAR H0113-40-26-10. It is also possible to speculate that *C. racemosa* is likely to be the source of resistance of genotype IAC 1195-5-6-2.

IPR 100 was susceptible to red mite and is an Arabica coffee cultivar with *C. liberica* genes. Oliveira et al. (1987) reported it as highly resistant, but this resistance was not selected along the several generation and backcrossing advances with *C. arabica*. Both IPR 99 and IPR 103 were Arabica coffee plants containing *C. canephora* genes and were probably susceptible because both genitors were susceptible.

Materials and methods

Experimental set up

The assessment of resistance to red mite was carried out in an experiment that conducted only to test the tolerance to drought in coffee genotypes. However, there was a high natural infestation of this mite in January 2017. Thus, this experiment was used to assess the resistance to *O. ilicis*, because it was observed that there was variability among the genotypes. The experiment was conducted in a greenhouse at the IAPAR, in Londrina, PR, Brazil (23º23'S; 51º11'W, 585m asl), between January 2016 and January 2017. The means of maximum, minimum and average temperatures during the experiment period were 27.4ºC, 16.5ºC and 21.1ºC, respectively. Seedlings of five coffee genotypes with six pairs of leaves were transplanted into PVC tubes of 0.30 m in diameter x 1.2 m in height, with a total volume of 0.2826 m^3 of substrate in a 1:1 ratio of soil and sand. The substrate was previously oven sterilized at 100 ^{o}C for three hours at field capacity moisture. To each 1000 liters of soil 417 g of single super phosphate, 100 g of potassium chloride, 42 g of urea and 111 g of dolomitic limestone were added. Fertilization and pH correction were performed as a result of soil chemical analysis. The plants were irrigated directly in the soil, without the contact of the water on the leaves. The experiment was set up in a completely randomized design with five treatments and 12 replications of one plant per plot.

Plant materials

The cultivars of *C. arabica* IPR 100, IPR 99 and IPR 103 were evaluated, first with introgression of *C. liberica* genes and the last two of *C. canephora*. An Arabica F_4 line named IAPAR H0113-40-26-10 with introgression of *C. racemosa* (Fig 1) was also evaluated. The cultivar Catuaí Vermelho IAC 99, which is a pure *C. arabica*, was used as susceptible control.

Table 1. Percentage of leaf area with red mite symptoms in *Coffea arabica* genotypes with introgression of genes of different species.

Genotype	Mean[2]
IPR 103	60.02 a
IPR 100	59.62 a
Catuaí Vermelho IAC 99 (susceptible control)[1]	54.76 a
IPR 99	53.08 a
IAPAR H0113-40-26-10	21.52 b
General mean	49.80
CV (%)	24.64

(1) Pure *C. arabica*. (2) Means followed by the same letter do not differ by the Tukey test at 1% probability.

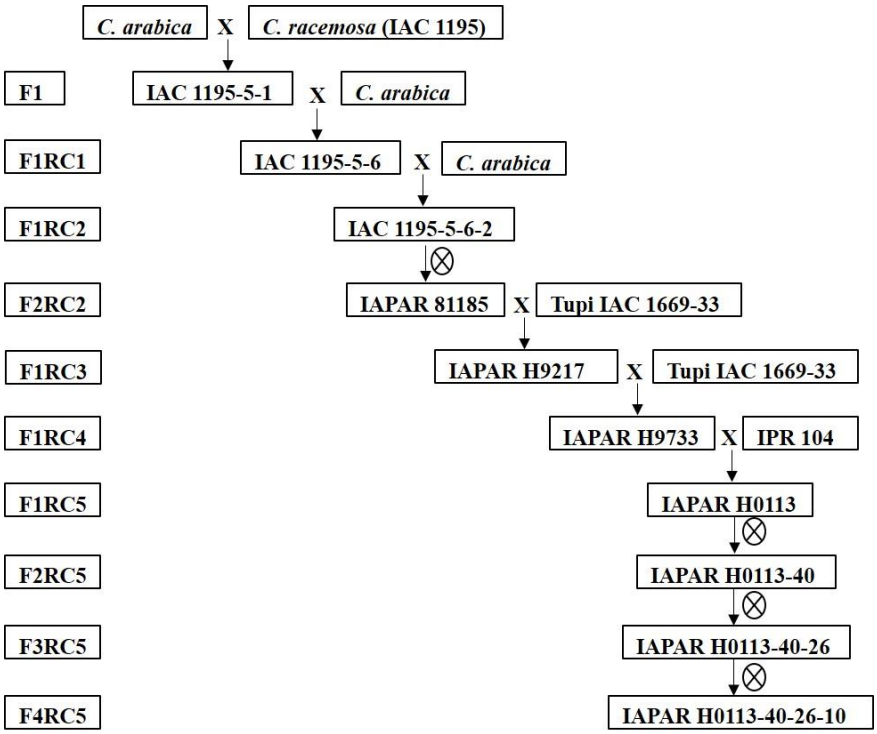

Fig 1. Backcrosses of Arabica coffee genotypes with *Coffea racemosa* and pedigree method used to develop the line IAPAR H0113-40-26-10.

Resistance evaluation

The resistance of genotypes to red mite was evaluated by a visual evaluation in January 2017. This evaluation was based on the percentage of leaf area with the typical symptoms caused by this mite (Franco et al., 2009), represented by the tanning of the upper face of the leaves. For each plant or plot, all leaves of three branches of the middle third were evaluated, varying from 8 to 20 leaves per branch; and therefore, with variable number of leaves per plot. Thirty leaves of the experiment were collected at random with symptoms of tanning of the upper face of the leaves, in which the presence of *O. ilicis* was identified in all leaves.

Statistical analysis

The data of the percentage of the leaf area with symptoms were submitted to the Shapiro-Wilk normality test and to Bartlett test of homogeneity of variances. The data were not transformed to make the analysis of variance and the Tukey's test at 1% of significance. The analyzes were carried out using the R software version 3.3.0 (R Core Team, 2016), package agricolae (Mendiburu, 2015).

Conclusion

The line IAPAR H0113-40-26-10 presented partial resistance to red mite. The Arabica coffee cultivars IPR 99, IPR 100 and IPR 103 are as susceptible to the red mite as to the susceptible control Catuaí Vermelho IAC 99.

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References

Abreu FA, Reis PR, Marafeli PP, Silva RA, Bernardi LFO, Carvalho CF (2014) Influência da precipitação pluvial na abundância de ácaros em cafeeiro. Coffee Sci. 9:329-335.

Andreazi E, Sera GH, Faria RT, Sera T, Shigueoka LH, Carvalho FG, Carducci FC, Chamlet D (2015) Desempenho de híbridos F1 de café arábica com resistência simultânea a ferrugem, mancha aureolada e bicho mineiro. Coffee Sci. 10:375-382.

Carvalho FG, Sera GH, Andreazi E, Sera T, Fonseca ICB, Carducci FC, Shigueoka LH, Holderbaum MM, Costa KC (2017) Tolerância ao déficit hídrico em mudas de genótipos de café portadores de genes de diferentes espécies. Coffee Sci.12:156-163.

Fragoso DB, Jusselino-Filho P, Pallini-Filho A, Badji CA (2002) Ação de Inseticidas Organofosforados Utilizados no Controle de *Leucoptera coffeella* (Guérin-Mèneville) (Lepidoptera: Lyonetiidae) Sobre o Ácaro Predador *Iphiseiodes zuluagai* Denmark & Muma (Acari: Phytoseiidae). Neotrop Entomol. 31:463-467.

Franco RA, Reis PR, M. Zacarias S, Altoé BF, Barbosa JPRAD (2009) Influência da infestação de *Oligonychus ilicis* (McGregor, 1917) (Acari: Tetranychidae) sobre a taxa de fotossíntese potencial de folhas de cafeeiro. Arquivos do Instituto Biológico. 76:205-210.

Guerreiro-Filho O (2007) Cafeeiros resistentes ao bicho-mineiro. O Agronômico. 59: 46-47.

ICO (International Coffee Organization) (2017) Total production by all exporting countries. Available in: <http://www.ico.org/prices/po-production.pdf>.

Malavolta E, Fernandes DR, Casale H Romero JP (1993) Seja o doutor do seu cafezal. Potafos 64:18-19.

Matiello JB, Santinato R, Almeida S, Garcia AWR (2016) Cultura de café no Brasil: Manual de recomendações, ed. 2015. PROCAFÉ, Varginha. 585 p.

Medina-Filho HP, Carvalho A, Medina DM (1977a) Germoplasma de *Coffea racemosa* e seu potencial no melhoramento do cafeeiro. Bragantia. 36:43-46.

Medina-Filho HP, Carvalho A, Monaco LC (1977b) Melhoramento do cafeeiro. XXXVII - Observações sobre a resistência do cafeeiro ao bicho mineiro. Bragantia. 36:131-137.

Mendiburu F (2015) Agricolae: Statistical Procedures for Agricultural Research. R package version 1.2-3.

Oliveira CAL de, Mauro SMZ, Lupoli ST (1987) Estudo comparativo da biologia de *Oligonychus ilicis* (Mc Gregor, 1917) (Acari: Tetranychidae) em diferentes cultivares de cafeeiro. Paper presented at the 14th Congresso brasileiro de pesquisas cafeeiras, COTEC/DIPRO/IBC, Rio de Janeiro, 110-112.

R Core Team (2016) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna.

Reis PR, Pedro-Neto M, Franco RA, Teoforo AV (2004) Controle de *Brevipalpus phoenicis* (Geijskes, 1939) e *Oligonychus ilicis* (McGregor, 1917) (Acari: Tenuipalpidae, Tetranychidae) em cafeeiro e o impacto sobre ácaros benéficos. I - abamectin e emamectin. Ciênc e Agrotecn. 28:269-281.

Silva RS, Ribeiro FR, Queiroz OS, Santos IB, Oliveira MGA, Pereira RR, Picanço MC (2015) Trypsin protease inhibitor activity is not a good proxy for defence against *Oligonychus ilicis* (Acari: Tetranychidae) in *Coffea canephora* (Gentianales: Rubiaceae). Int J Acarol. 41:189–194.