

IPR 100 – Rustic dwarf Arabica coffee cultivar with resistance to nematodes *Meloidogyne paranaensis* and *M. incognita*

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Abstract: ‘IPR 100’ was derived from a crossing between “Catuai” and a hybrid (“Catuai” x BA-10 coffee). ‘IPR 100’ is a medium size dwarf cultivar with high rusticity, with late ripening cycle, and with resistance to *Meloidogyne paranaensis* and to some *M. incognita* populations.

Key words: BA-10, *Coffea arabica*, breeding, root-knot nematode.

INTRODUCTION

Brazilian coffee growers have nematodes as main constraints, since they reduce the production, besides being a limiting factor for the implementation of new coffee plantations in these infested areas. Many Brazilian regions with great potential for coffee cultivation cannot be exploited due to the presence of these pathogens.

Several species have been found in association with coffee plant roots in Brazil. However, *Meloidogyne* and *Pratylenchus* genera are the most important. The most damaging nematodes to coffee crops in Brazil are *M. exigua*, *M. incognita* and *M. paranaensis* (Gonçalves and Silvarolla 2007).

The use of resistant coffee cultivars is a viable alternative for infested areas, since it represents an efficient, economically viable and environmentally correct management method to control nematodes. However, currently, there are few coffee cultivars available with resistance to nematodes. Hypocotyledonary grafting, using the rootstock cultivar Apoatã IAC 2258 (*C. canephora*) resistant to *M. exigua* (Salgado et al. 2005, Fonseca et al. 2008), *M. incognita* (Sera et al. 2006, Fonseca et al. 2008), and *M. paranaensis* (Sera et al. 2006, Fonseca et al. 2008) has been the widely recommended strategy for nematode management in coffee-growing infested areas since 1987. Nevertheless, there are some problems in using rootstock cultivars compared to ungrafted, such as: a) segregation for susceptibility to nematodes (10 to 15%) due to the cross-pollinated reproductive system of *C. canephora*; b) breakage in the grafting region; and c) need of replanting (about 10 to 15%) (Gonçalves and Silvarolla 2007), due to susceptible segregating plants. Besides, grafted seedlings are more expensive than ungrafted ones.

‘IPR 100’, released in 2012, is a medium size dwarf cultivar, with late ripening, and resistant to *M. paranaensis* and some *M. incognita* populations. This cultivar

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is recommended for semi-dense and dense planting systems in lower and higher temperature areas with annual average between 19 °C and 23 °C in the state of Paraná.

PEDIGREE AND IMPROVEMENT METHOD

'IPR 100' was developed using the genealogical method. 'IPR 100' was originated from a crossing between "Catuaí" and a hybrid ("Catuaí" x BA-10 coffee). It was introduced by the Instituto Agronômico de Campinas (IAC) and named H8721-8 C1420 EP166. In 1977, seeds of this plant in F₂RC₁ generation were introduced by IAPAR and named PR 77041. Three selection generations were carried out, and selected plants were called PR 77041-62, PR 77041-62-6 and PR 77041-62-6-10. F₄ and F₅ plants that originated 'IPR 100' were selected in areas highly infested with nematodes. In these areas, these F₄ and F₅ plants presented high yield, whereas susceptible genotypes died or almost died in few years. F₆ genetic seeds field was originated using a composite sample of seeds of the F₅ plants IAPAR 77041-62-6-10-3 and IAPAR 77041-62-6-10-4. F₇ basic seeds field was planted at IAPAR (Londrina-PR-Brazil) with a composite sample of seeds of the F₆ plants originated from genetic seeds field. 'IPR 100' was released in 2012.

PERFORMANCE

This cultivar can be cultivated in regions with annual average temperature between 19 °C and 21 °C, such as in the municipalities of Londrina (lat 23° 21' 37" S, long 51° 09' 50" W, alt 586 m asl) and Congonhinhas (lat 23° 30' 22" S, long 50° 33' 13" W, alt 758 m asl), and in regions with annual average temperature between 22 °C and 23 °C, such as the municipalities of Itaguajé (lat 22° 37' 04" S, long 51° 57' 57" W, alt 350m asl). 'IPR 100' was evaluated in three locations of the state of Paraná, with 16 annual harvests, and presented higher yield than 'IAPAR 59' and 'Catuaí Vermelho IAC 81' (Table 1).

'IPR 100' is a medium size dwarf plant (~ "Catuaí") recommended in the spacing between plants varying from 0.50m to 0.80m, depending on the annual average temperature of the cultivation site and on the technologies adopted, such as fertilization, irrigation and pruning. In hot regions without irrigation, spacing should be narrower, since usually, canopy diameter and branching are smaller. In farms with fertirrigation, spacing between rows and between plants can be wider. In farms where pruning are frequently used, these spacings can be narrower. Using wider spacing between plants, yield per plant will be higher, and adequate nutrition is necessary. Spacing between rows can vary from 2.5 to 3.0 m, according to the coffee crop area and to the level of mechanization.

RESISTANCE TO NEMATODES

IPR 100 was evaluated for resistance to *Meloidogyne paranaensis* and *M. incognita* under greenhouse conditions, in the Instituto Agronômico do Paraná (IAPAR) (lat 23° 21' 20" S, long 51° 09' 50" W, alt 574 m asl), in Londrina, state of Paraná, Brazil. Two experiments were carried out between January to May, 2014, with temperatures ranging from 31.1 °C to 19.2 °C. Cultivar Mundo Novo IAC 376-4 was used as susceptible control in all experiments. Experiments were arranged in a completely randomized design, with one plant per plot, and 15 replications (experiment with *M. paranaensis*), or 20 replications (experiment with *M. incognita*).

Nematode populations collected from coffees in Apucarana, PR (*M. paranaensis*) and Altônia, PR (*M. incognita*) were identified, and each species was cultured from a single egg mass (isolates). Species identification was carried out with α -esterase phenotypes (Carneiro et al. 2000) and morphological approaches (Hartman and Sasser 1985). Both isolates were routinely multiplied in coffee cv. Mundo Novo IAC 376-4 under greenhouse conditions. Approximately 60 days before inoculation, nematodes were extracted from coffee roots (Boneti and Ferraz 1981) and inoculated in tomato cv. Santa Clara for inocula multiplication.

Seeds of coffee cultivars were sown directly in germinators containing sand. At the cotyledonary stage, seedlings

Table 1. Annual mean yield per hectare (bags of 60 kg ha⁻¹) of 'IPR 100' in comparison with other cultivars (state of Paraná, Brazil)

Cultivar ¹	Yield ²	Relative yield (%) ³
IPR 100 (late ripening)	58.79	114.29
Catuaí Vermelho IAC 81 (late ripening)	51.45	100.00
IAPAR 59 (semi early ripening)	47.10	91.55

¹ With chemical control for coffee leaf rust.

² Mean of three locations of the state of Paraná with 16 annual harvests (spacing 2.75 x 0.60m).

were transplanted to tubes in order to complete their development. Seedlings with 4-6-leaves pairs were transplanted (one per pot) to 700 cm³ plastic pots containing 600 cm³ of sterilized (160 °C for 5 h) substrate (58% sand, 8% silt, and 34% clay). Plants in pots were watered as required, and fertilized once with 3 g Osmocote® Plus (15% N, 9% P₂O₅, 12% K₂O, 1% Mg, 2.3% S, 0.05% Cu, 0.45% Fe, 0.06% Mn, 0.02% Mo). Seedlings were cultivated during one month prior to inoculation.

After extracting eggs using the NaCl method (Boneti and Ferraz 1981) from tomato roots, a suspension (2 ml) containing 2,000 eggs was poured in each pot (Pi = initial population) into two small 3.5-4.5 cm deep holes beside the root system of the coffee seedlings.

After the experimental period, 121 and 130 days after inoculation of *M. paranaensis* and *M. incognita*, respectively, roots were washed, and dried on absorbent paper. Fresh weight was determined and nematode extraction was carried out according to Boneti and Ferraz (1981). Nematode final population (Pf) was estimated by counting the eggs and the second-stage juveniles (J2) on the suspension obtained after nematode extraction from the entire root systems only, not from the soil. Reproduction factor (RF = Pf/Pi) values were subsequently determined (Oostenbrink 1966). After that, number of nematodes per gram of roots (Nematodes g⁻¹) was calculated for each replication.

Data of Nematodes g⁻¹ were submitted to the Lilliefors (Kolmogorov-Smirnov) test for normality of errors, and to the Levene's test, for homogeneity of variances at 5% of probability. Log (x + 1) transformation was used for Nematodes g⁻¹ data. Analysis of variance (ANOVA) and Tukey test at 5% of probability were used. Cultivars were classified as resistant when RF ≤ 1.0, and as susceptible, when RF > 1.0.

High RF values (29.85 and 30.81) obtained from the control (cultivar Mundo Novo IAC 376-4) confirm the viability of the inocula and the appropriate experimental conditions. On the basis of RF values, IPR 100 was classified as resistant to *M. paranaensis* (0.40) and *M. incognita* (0.24) (Table 2). In general, Nematodes.g⁻¹ data on both experiments are in agreement with RF values.

IPR 100 resistance observed in the present study for both nematodes confirmed previous results, in which 'IPR 100' showed resistance to nematodes *M. paranaensis* (Sera et al. 2007b, Ito et al. 2008, Andreazi et al. 2015) and to *M. incognita* races 1 (Kanayama et al. 2009) and 2 (Ito et al. 2008). Besides, 'IPR 100' presents good agronomic performance in comparison with susceptible controls Catuaí IAC 64 and Mundo Novo IAC 379/19 in areas infested with *M. paranaensis* in the state of Minas Gerais, Brazil (Salgado et al. 2014).

IPR 100 has not been tested for all races of *M. incognita* yet. Thus, this cultivar is resistant to some *M. incognita* populations. IPR 100 has not been evaluated to *M. exigua* yet. However, detailed studies are in progress in order to know the host reaction of IPR 100 to *M. exigua*.

Table 2. Means of the number of eggs and second-stage juveniles per gram of roots (Nematodes g⁻¹) of *Meloidogyne paranaensis* and *M. incognita*, reproduction factor (RF), and resistance reaction (RR) of IPR 100 and Mundo Novo IAC 376-4 (M. Novo) coffee cultivars

Cultivar	<i>M. paranaensis</i>			<i>M. incognita</i>		
	Nematodes g ⁻¹ (2)	RF	RR ⁽³⁾	Nematodes g ⁻¹ (2)	RF	RR ⁽³⁾
IPR 100	58 a	0.40	R	55 a	0.243	R
M. Novo ⁽¹⁾	6605 b	29.85	S	7170 b	30.81	S

⁽¹⁾ M. Novo = susceptible control.

⁽²⁾ Means followed by the same letter did not differ by the Tukey test at 5% significance. Data were transformed by log (x + 1).

⁽³⁾ RR = resistance reaction based on RF. R = resistant; S = susceptible.

OTHER TRAITS

Ripening is late, similar to "Catuaí". At lower temperatures, with annual average between 19 °C and 21 °C, ripening usually occurs in August. At higher temperatures, with annual average between 22 °C and 23 °C, ripening usually occurs in June.

'IPR 100' shows rusticity and better adaptation to high temperatures and poor soils than other compact cultivars, such as "Catuaí". 'IPR 100' was selected in coffee regions with poor and sandy soils, low altitudes and higher temperatures

with annual average between 21 °C and 23 °C in the state of Paraná. In Paraná, this cultivar is the most indicated for cultivation in the west and northwestern region (Arenito Caiuá), and in lower altitudes of argillaceous soils regions. 'IPR 100' could be planted in areas of lower temperature and with annual average between 19 °C and 20 °C in Paraná. However, it must be planted in areas with reduced frost risk, since this cultivar presents late ripening.

The cultivar is susceptible to rust physiological races present in the state of Paraná (Sera et al. 2010), and chemical control is necessary.

'IPR 100' presents good level of partial resistance (moderate resistance) to the symptoms of necrosis and mummification of fruits (Sera et al. 2005, Sera et al. 2007a). These symptoms have been associated with the attack of *Colletotrichum* spp. or *Colletotrichum gloeosporioides* Penz (Juliatti and Silva 2001, Paradela-Filho et al. 2001).

Coffee quality is similar to "Catuai".

These traits and others are described in Table 3.

SEED MAINTENANCE AND DISTRIBUTION

'IPR 100' is registered by the National Cultivar Registry (Registro Nacional de Cultivares - RNC) of the Ministry of Agriculture, Livestock and Food Supply (Ministério da Agricultura Pecuária e Abastecimento – MAPA), under the number 09948, in Brazil. IAPAR is in charge of genetic and basic seeds. Seed producers of private companies which are registered in MAPA are responsible for certified seeds.

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Table 3. Morphological, physiological and agronomic traits of 'IPR 100' with the respective descriptions

Traits	Descriptions
Size (tree height)	Medium (~ "Catuai")
Canopy radius	Medium (~ "Catuai")
Canopy architecture	Cylindrical (~ "Catuai")
Internode length	Medium (~ "Catuai")
Secondary plagiotropic branching	High (~ "Catuai")
Young leaf colour	Bronze
Leaf size	Medium (~ "Mundo Novo")
Undulation of the leaf margin	Medium wavy (~ "Mundo Novo")
Colour of ripe fruits	Red
Fruit shape	Oblong (~ "Mundo Novo")
Fruit size	Small (~ 'Bourbon Amarelo')
Grain length	Short (~ "Catuai")
Grain width	Large (~ "Catuai")
Ripening cycle	Late (~ "Catuai")
Resistance to rust	Absent
Resistance to nematodes	Present
Coffee quality	Similar to "Catuai"

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