

IPR Alvorada – Dwarf Arabica coffee cultivar with high yield

Gustavo Hiroshi Sera^{1*}, Tumoru Sera¹, Valdir Mariucci Junior^{1,2} and Luciana Harumi Shigueoka¹

Abstract: *IPR Alvorada* is a *Coffea arabica* cultivar with *C. canephora* introgression, developed from a cross between IAPAR 59 and Mundo Novo IAC 376-4. This cultivar has a dwarf-medium size, high yield, good cup quality, strong vegetative vigor, a medium fruit ripening cycle, and slight resistance to coffee leaf rust.

Keywords: *Breeding, Coffea arabica, IAPAR 59, Mundo Novo IAC 376-4, Sarchimor*

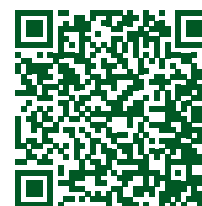
INTRODUCTION

Brazilian coffee breeding programs have registered a total of 148 *Coffea arabica* (Arabica coffee) cultivars; however, only 124 are currently available in the Ministério da Agricultura, Pecuária e Abastecimento (MAPA) (Sera et al. 2022b, Brasil 2022, 2024). Most Brazilian coffee crops are cultivated with varieties from the Catuaí and Mundo Novo groups, which are pure *Coffea arabica* genotypes, characterized by dwarf and tall sizes, respectively. Despite their high yield potential, cultivars from these two groups are susceptible to various diseases, such as coffee leaf rust (CLR) and bacterial halo blight (BHB) (Andreazi et al. 2015, Sera et al. 2022a).

In recent decades, several *C. arabica* cultivars with introgressions of *C. canephora* and *C. liberica* diploid species have been developed in Brazil. Commonly used germplasms, such as Híbrido de Timor, Sarchimor, Catimor, Icatu, and BA-10, have been utilized as parent plants to transfer beneficial traits from *Coffea* diploid species. Derivative genotypes from these germplasms serve as valuable sources of resistance to CLR (Fazuoli et al. 2019, Sera et al. 2022a), BHB (Ito et al. 2008, Sera et al. 2017a), and nematodes like *Meloidogyne paranaensis*, *M. incognita* (Sera et al. 2017b, Sera et al. 2020), and *M. exigua* (Botelho et al. 2021).

To date, eight dwarf cultivars from the Sarchimor x Mundo Novo group have been developed by the Instituto de Desenvolvimento Rural do Paraná - IAPAR-EMATER (IDR-Paraná) and Fundação Procafé. These cultivars are noted for their high yield across several coffee-growing regions and their high resistance to CLR (Sera and Sera 2013, Botelho et al. 2021, Pereira et al. 2022). The eight cultivars registered with MAPA include Acauã, Acauãma, Acauãново, Asabranca, Graúna, IPR 107, IPR Pérola, and IPR Alvorada (Sera et al. 2022b). Registered across the 2000s (e.g., Acauã and IPR 107), 2010s (e.g., Acauãново and Asabranca), and 2020s (e.g., Acauãma, IPR Pérola, IPR Alvorada, and Graúna), these cultivars are relatively new and still unfamiliar to many Brazilian coffee growers. Acauã

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*Corresponding author:

E-mail: gustavosera@idr.pr.gov.br

 ORCID: 0000-0002-5372-6169

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¹ Instituto de Desenvolvimento Rural do Paraná – IAPAR-EMATER, Rodovia Celso Garcia Cid, km 375, 86047-902, Londrina, PR, Brazil

² Universidade Estadual de Londrina, Rodovia Celso Garcia Cid, PR-445, km 380, Campus Universitário, 86057-970, Londrina, PR, Brazil

and IPR 107 are the most recognized due to their earlier registration. These cultivars inherited their dwarf size and high resistance to CLR from their Sarchimor parent, while both parents contributed to their high yield potential.

IPR 107, derived from a cross between IAPAR 59 and Mundo Novo IAC 376-4, has a similar average yield to Catuaí Vermelho IAC 81. In addition to its high resistance to CLR, it has an earlier ripening cycle compared to Catuaí cultivars (Sera and Sera 2013). Due to these traits, IPR 107 has been widely planted by coffee growers in Paraná (PR), Brazil, since 2010. In many cases, it has been chosen to replace older crops from the Catuaí and Mundo Novo groups as well as other highly resistant Sarchimor cultivars, such as IAPAR 59 and Tupi IAC 1669-33. To meet the demand for cultivars from the Sarchimor x Mundo Novo group with desirable traits, including higher yield rates, IDR-Paraná has developed a new Arabica coffee cultivar: IPR Alvorada.

PEDIGREE AND BREEDING METHODS

The pedigree method was employed to develop the IPR Alvorada cultivar. At IDR-Paraná in 1988, an artificial hybridization was conducted between IAPAR 59 and Mundo Novo IAC 376-4, resulting in F_1 hybrid plants designated H8818. IAPAR 59 belongs to the Sarchimor group and is derived from a cross between Villa Sarchi CIFC 971/10 and Híbrido de Timor CIFC 832/2. While Villa Sarchi CIFC 971/10 is a pure *C. arabica*, Híbrido de Timor CIFC 832/2 is an *C. arabica* cultivar with an introgression of *C. canephora* genes ranging from 14.2% to 37.9%, according to Herrera (2014). Mundo Novo IAC 376-4, on the other hand, is a pure Arabica coffee cultivar, originating from a cross between Sumatra and Bourbon Vermelho (Sera et al. 2022b). Notably, the H8818 plants that gave rise to IPR Alvorada are the same F_1 hybrids that produced IPR 107 and IPR Pérola.

The H8818 F_1 hybrid plants were planted in 1990 in a field in Londrina, PR, Brazil. Seeds from the F_1 population were harvested in 1993 and advanced to the F_2 generation in 1994 in Tamarana, PR. In 1997, an F_2 plant (R3C10) was selected, and its seeds were harvested to advance to the F_3 generation in 1998 in Londrina. While IPR 107 and IPR Pérola originated from the F_2 plant R8C12, IPR Alvorada was derived from a different F_2 plant, R3C10. The F_3 plant (E9803 25-7) was selected in 2002 and advanced to the F_4 generation in Londrina in 2003. By 2005, the F_4 plant (E0319 16-22) was selected, which exhibited a later ripening cycle compared to IPR 107.

In 2006, the F_5 generation was conducted in Londrina, and the F_5 plant (E0626 20-1-54) was selected in 2009. This plant exhibited high yield, strong vegetative vigor, a later ripening cycle than IPR 107, intermediate resistance to CLR, and large-sized fruits and beans. In 2010, the F_6 generation was planted in two experimental fields located in Londrina and Congonhinhas, both in the state of Paraná. Agronomic traits of IPR Alvorada were evaluated during the 2013 to 2016 crops, where it demonstrated yield superiority over IPR 107 and Catuaí Vermelho IAC 99.

In 2016, seeds from all plants in the F_6 generation were harvested, and a composite sample was used to establish the genetic seed field in 2017. The Distinguishability, Homogeneity, and Stability (DHS) assay for the cultivar's protection rights was conducted at IDR-Paraná, in Londrina. IPR Alvorada was officially registered with MAPA in 2021, and its protection rights began on November 16, 2021, set to expire on November 16, 2039.

YIELD

The yield evaluation of IPR Alvorada was conducted in two field experiments using seeds from the same F_5 plant (E0626 20-1-54), which was selected in 2010 to advance the generation to F_6 . The experiments were established in Paraná, with a planting spacing of 2.5 × 0.50 m. The first experiment was planted in September 2010 in Londrina (lat 23° 21' 41.46" S, long 51° 09' 44.35" W, alt 583 m asl), and the second in October 2010 in Congonhinhas (lat 23° 30' 22.74" S, long 50° 33' 12.37" W, alt 758 m asl). The average annual temperatures at these locations were 21.2 °C in Londrina and 20.1°C in Congonhinhas. Relative humidity ranged between 70.1% and 75%, with annual rainfall varying from 1600 to 1800 mm in Londrina and 1400 to 1600 mm in Congonhinhas.

Both experiments followed a randomized block design with four replications and 10 plants per plot. Fungicides, insecticides, and acaricides were applied as needed to control pests and diseases. Fertilization was performed based on soil analysis and following recommendations for Paraná. The Arabica coffee cultivars Catuaí Vermelho IAC 99 and IPR 107 served as controls in both experiments.

Yield was evaluated by harvesting coffee cherries during the 2013, 2014, 2015, and 2016 crops. Harvests were conducted in June in Londrina and July in Congonhinhas. A 2 kg sample of harvested coffee was taken to determine the weight of green beans per plot. Yields were estimated in 60 kg bags of green coffee beans based on the plant spacing and number of plants per hectare.

The need for data transformation was determined using Bartlett's test for homogeneity of variances and the Shapiro-Wilk normality test. Data were transformed using \sqrt{x} , after which an analysis of variance (ANOVA) and Tukey's means test at a 5% significance level were performed. These statistical analyses, including Bartlett's test, the Shapiro-Wilk normality test, ANOVA, and Tukey's test, were carried out using R software version 3.3.0 (R Core Team 2016) with the agricolae package (Mendiburu 2015).

In both Londrina and Congonhinhas, IPR Alvorada demonstrated higher productivity compared to IPR 107 and Catuaí Vermelho IAC 99, with statistically significant differences (Table 1). On average, across the two sites, IPR Alvorada exhibited a 24.77% yield increase compared to Catuaí Vermelho IAC 99, highlighting its high productive potential. However, further studies are necessary to evaluate the adaptability and stability of IPR Alvorada in other coffee-growing regions with varying environmental conditions.

OTHER TRAITS

IPR Alvorada is well-suited for cultivation in regions favorable for *Coffea arabica* growth, particularly in the state of Paraná, where average annual temperatures range between 20 and 22 °C. With a dwarf-medium size similar to Catuaí cultivars, it is recommended for both low- and high-density planting.

IPR Alvorada shows broad adaptability for cultivation in Paraná and demonstrates moderate tolerance to soils with low fertility, surpassing the tolerance typically observed in Sarchimor group cultivars. Additionally, IPR Alvorada exhibits high vegetative vigor and a plagiotropic branching pattern comparable to that of Catuaí cultivars.

The ripening cycle of the fruit is considered medium, similar to Mundo Novo cultivars. The fruits are red and medium-large in size (between Mundo Novo and Acaí cultivars), making them suitable for both manual and mechanical harvesting. The cup quality of IPR Alvorada is good, comparable to that of Catuaí cultivars.

The recommended planting spacing within rows is between 0.5 and 0.6 m, depending on the average annual temperatures at the cultivation site and the technologies employed, such as fertilizers, irrigation, and pruning. The inter-

Table 1. Mean yields of the 2013 to 2016 crops, in 60 kg of green coffee bags, of the cultivars IPR Alvorada, IPR 107 and Catuaí Vermelho IAC 99, planted at 2.5 x 0.5 m spacing in September 2010 in Londrina, PR, and in October 2010 in Congonhinhas, PR

Cultivar	Yield ¹		Relative yield ² (%)
	Londrina	Congonhinhas	
IPR Alvorada	69.78 a	69.40 a	124.77
IPR 107	56.64 b	55.98 b	100.96
Catuaí Vermelho IAC 99	56.49 b	55.06 b	100.00
Overall	60.97	60.14	
CV (%)	4.54	5.00	

¹ Means followed by the same letters did not differ from each other by the Tukey means test at 5% significance. Data were transformed in \sqrt{x} . ² Yield in relation to Catuaí Vermelho IAC 99 and considering the average yield of Londrina and Congonhinhas.

Table 2. Morphological traits of IPR Alvorada with the respective descriptions

Traits	Descriptions
Canopy architecture	Cylindrical (~ Catuaí)
Internode length	Medium (~ Catuaí)
Leaf length	Medium (~ Mundo Novo)
Leaf width	Medium (~ Mundo Novo)
Leaf shape	Elliptical
Undulation of the leaf margin intensity	Medium-high wavy (superior to Catuaí)
Fruit shape	Oblong (~ Mundo Novo)
Color of leaves not fully expanded	Bronze
Grain length	Medium-long (between Mundo Novo and Acaí)
Grain width	Large (~ Catuaí)
Grain thickness	Medium (~ Mundo Novo)

row spacing should be selected based on the size of the farm and the technology or machinery being used. Typically, IPR Alvorada should be planted with inter-row spacing similar to that recommended for Catuaí cultivars.

IPR Alvorada shows slight resistance to CLR and is susceptible to the nematodes *Meloidogyne paranaensis* and *M. incognita*. Its resistance to *M. exigua* has not yet been tested. Additional traits, based on the coffee descriptors from the MAPA, are listed in Table 2.

SEED MAINTENANCE AND DISTRIBUTION

IPR Alvorada is registered with the Brazilian Federal Database of Cultivars (Registro Nacional de Cultivares - RNC) of MAPA under registry number 48400. It was granted protection by the National Cultivar Protection Service (SNPC) in November 2021 (nº 20220059). The Instituto de Desenvolvimento Rural do Paraná – IAPAR-EMATER (IDR-Paraná) is responsible for maintaining the genetic and basic seeds, while certified seeds are distributed by private seed producers registered with MAPA.

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DATA AVAILABILITY

The datasets generated and/or analyzed during the current research are available from the corresponding author upon reasonable request.

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