



CULTIVAR RELEASE

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IPR AFRODITE – new oat cultivar with nematode resistance

Carlos Roberto Riede¹, Deoclecio Domingos Garbuglio^{*}, Andressa Cristina Zamboni Machado¹, Jose Nilvado Póla¹, Renan Carvalhal¹ and Klever Márcio Antunes Arruda¹

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Abstract – The oat cultivar IPR Afrodite, resulting from a cross between CFT 2 and the inbred line ER 88144-1, is high-yielding, has grain quality traits that are relevant for food processing and industry, and is resistant to the root-knot nematode species *Meloidogyne incognita*, *M. javanica*, *M. paranaensis* and *M. enterolobii*.

Key words: *Avena sativa*, breeding, grain processing quality.

INTRODUCTION

In Brazil, oat is being cultivated for a number of purposes, for example, agricultural diversification, as well as grain production for the food industry. The increase in the number of derivatives from this species may be due the fact that oat can be a food source of iron, calcium, antioxidants, proteins, vitamins, carbohydrates, and soluble and insoluble fibers. In addition, it is considered a functional food, for preventing or contributing to treatments of diseases when consumed routinely, aside from the well-documented nutritional functions.

According to CONAB (2014, <http://www.conab.br>), an output of 358 thousand tons of oat grain was expected in 2014, from an approximate acreage of 143 thousand hectares, corresponding to a grain yield of 2493 kg ha⁻¹. The significant rise in total production shows the increasing relevance of this crop in Brazil. In relation to 1976, with a production of 37.4 thousand tons, the increase was 9.6 fold, based on the estimated production volume for 2014.

According to Barbosa Neto et al. (2000), until the early 1980s, oat cultivars (*Avena sativa* L.) from Uruguay and Argentina were used. These had adaptation problems, mainly in relation to late cycle and tall height, which stimulated breeding programs at institutions such as Universidade Federal do Rio Grande do Sul (UFRGS) and Universidade de Passo Fundo (UPF). Currently, research on oat breeding has been intensified in the South of Brazil, especially in

many research institutions and universities of the States of Paraná and Rio Grande do Sul.

The Instituto Agronômico do Paraná-IAPAR initiated an oat breeding program with industrial focus, in 1999, by introductions of inbred lines for crosses, stimulated by other breeding programs of institutions such as UFRGS, UPF, Universidade Federal de Pelotas (UFPEL), Universidade Tecnológica Federal do Paraná (UTFPR) and Fundação Agrária de Pesquisa Agropecuária (FAPA).

The objective of the IAPAR oat breeding program is the development of new oat cultivars with high yield, wide adaptability and stability, tolerance to biotic and abiotic stresses, aside from grain quality traits that meet the standards of the food processing industry.

BREEDING METHOD

The oat cultivar IPR Afrodite was developed from a single cross between cultivar CFT 2 (of the UTFPR breeding program) and the inbred line ER 88144-1 (FAPA breeding program), in the 2000 growing season, with the genealogy IP2000248-0L-0L-4G-3L-0L, i.e., the cross was number 248, in the chronological order of IAPAR oat crosses. Letter L indicates Londrina and G Ponta Grossa, both in the State of Paraná, where the crosses and selection processes were conducted. The numbers refers to the breeding method (0=bulk or mass selection, and 4G and 3L indicate the number of plants selected by the pedigree method)

¹ Instituto Agronômico do Paraná (IAPAR), Rod. Celso Garcia Cid, km 375, 86.047-902, Londrina, PR, Brazil. * E-mail: ddgarbuglio@iapar.br

The modified pedigree method was used for breeding (Riede et al. 2001), by which panicles of the best F₂ plants were selected and threshed in bulk, forming the F₃ bulk. This generation was grown in Ponta Grossa, and four individual plants were selected to continue the process. In F₄, three individual plants were selected in Londrina. In F₅, the best of these selected plants, were sown on experimental plots (5.1 m²), and harvested as superior line and labeled AL 0548.

AL 0548 was evaluated in Preliminary Grain Yield Tests and compared with three control cultivars. The Preliminary Tests - Year I were carried out in 2006, in Londrina and Ponta Grossa, and the Preliminary Tests - Year II in 2007, in Londrina, Ponta Grossa and Palotina. The grain processing quality was analyzed during three growing seasons in a food quality laboratory.

The performance of inbred line AL 0548 was superior in these evaluations, and it was chosen in 2008 for the Test of Regional Inbred Lines and in 2009 and 2010 for the Test of Brazilian Inbred Lines, to determine the Value for Cultivation and Use. These VCU tests provide data underlying the registration of new cultivars. Both tests were carried out in a cooperative effort of institutions of the Brazilian oat research committee (CBPA), mainly of the states RS, PR and SP. In this partnership model, each

institution is responsible for tests at a certain number of locations (Table 1).

After three years of testing, the inbred line AL 0548 was assessed in an internal ranking of IAPAR and subsequently approved at the 31st annual meeting of CBPA. The decision was taken to release IPR Afrodite as new oat grain cultivar and, thereafter, initiate the request of registration by the Ministry of Agriculture, Livestock and Food Supply (MAPA) in 2011.

PERFORMANCE

In the mean of the evaluations, the cultivar proved suitable for all producing regions in Brazil, with a medium cycle (85 days from emergence to silking and 124 days to maturation), intermediate plant height (114 cm), and moderate lodging resistance at a seeding rate of 300 to 350 viable seeds per square meter (Table 2). The panicles have awns, with semi-erect and equilateral branching, medium density and decumbent position. The mean hectoliter weight ranged from 45 to 48 kg hL⁻¹, with a mean of 46 kg hL⁻¹, and 1000-seed weight from 27 to 29 g, with a mean of 28 g.

In relation to the grain yield in the Preliminary Tests, at three locations in 2006 and 2007, and in 28 Regional VCU

Table 1. Locations, responsible institutions and growing seasons of regional and nation-wide tests of oat inbred lines

State ¹	Locations	Responsible Institution ²	Growing season of tests
Paraná	Guarapuava	FAPA	2008, 2009 and 2010
	Londrina	IAPAR	2008, 2009 and 2010
	Mauá da Serra	IAPAR	2008, 2009 and 2010
	Pato Branco	UTFPR	2008
	Ponta Grossa	IAPAR	2009 and 2010
Rio Grande do Sul	Augusto Pestana	UNIJUÍ	2009 and 2010
	Eldorado do Sul	UFRGS	2008, 2009 and 2010
	Passo Fundo	UPF	2008, 2009 and 2010
	Pelotas	UFPEl	2008, 2009 and 2010
São Paulo	Vacaria	FEPAGRO	2008 and 2009
	Capão Bonito	IAC	2009 and 2010
	São Carlos	Embrapa	2009

¹ States of Brazil

² FAPA - Fundação Agrária de Pesquisa Agropecuária; IAPAR - Instituto Agrônomico do Paraná; UTFPR - Universidade Tecnológica Federal do Paraná; UNIJUÍ - Universidade Regional do Noroeste do Rio Grande do Sul; UFRGS - Universidade Federal do Rio Grande do Sul; UPF - Universidade de Passo Fundo; UFPEl - Universidade Federal de Pelotas; FEPAGRO - Fundação Estadual de Pesquisa Agropecuária; IAC - Instituto Agrônomico de Campinas; Embrapa - Unidade Embrapa Pecuária Sudeste.

Table 2. Means of different agronomic traits of cultivar IPR Afrodite, evaluated in regional and nation-wide tests of oat inbred lines, from 2008 to 2010

Growing season	HW (kg hL ⁻¹)	TGW (g)	DEH (days)	DEM (days)	PH (cm)	LP (%)
2008	44.6	26.9	88	123	119	6
2009	45.4	27.2	88	128	120	48
2010	48.5	28.8	80	122	103	2
Mean	46	28	85	124	114	19

HW: Hectoliter weight; TGW: 1000-grain weight; DEH: Days from emergence to heading; DEM: Days from emergence to maturation; PH: Plant height; LP: Lodging percentage.

Table 3. Means of grain yield (kg ha⁻¹) of the new oat cultivar IPR Afrodite, compared to the two best controls of five years, at different test locations in Brazil

	Preliminary 2006 2 Locations	Preliminary 2007 3 Locations	Regional 2008 8 Locations	Nationwide 2009 11 Locations	Nationwide 2010 9 Locations	Mean	Controls (%)
IPR AFRODITE	5941	1011	3050	4382	2572	3391	112
URS 21	4785	1162	3197	3839	2417	3080	101
UPF 18/URS Guapa	5007	1237	3143	3317	2289	2999	99
UPFA 22/Barbarasul	3823	851	1253	2542	2228	2139	70
Means of two controls	4896	1200	3170	3578	2353	3039	100

Tests, in the main oat-producing regions of Brazil from 2008 to 2010, cultivar IPR Afrodite performed with a superiority of 12% over the means of the two best controls (Table 3).

With regard to grain processing, the grains were classified as flint with good uniformity, light color and low presence of malformed grains. The percentage of grains retained in 2mm-sieves of cultivar IPR Afrodite was also over 85%. The threshability was 98%, superior to the control cultivar IAC 7 (93%), with a percentage of broken grain of 5%. The husk percentage was 33% and mean protein content 14.3%.

In relation to the main diseases in the evaluation regions, cultivar IPR Afrodite was moderately resistant to moderately

susceptible to rust leaf (*Puccinia coronata* f.sp. *avenae*), stem rust (*Puccinia graminis* f.sp. *avenae*), and the leaf spot complex (Table 4), aside from moderately resistant to blast (*Pyricularia grisea*). The data of resistance to BYDV and scab (*Gibberella zeae*) were not conclusive.

In greenhouse experiments, cultivar IPR Afrodite proved superior over others (Table 5), for being moderately susceptible to *Pratylenchus brachyurus*, but highly resistant to four root nematode species of the genus *Meloidogyne* (*M. incognita*, *M. javanica*, *M. paranaensis*, and *M. enterolobii*). This motivated more detailed studies about the type of resistance of this cultivar.

Comparative penetration tests of *M. incognita* were performed with the cultivars IPR Afrodite (resistant) and URSFAPA Slava (susceptible). After germination, seedlings were inoculated with 1000 units of *M. incognita* and the root color was evaluated 3, 9, 15, and 30 days after inoculation (DAI). The number of nematodes within the roots indicated nematode penetration in both cultivars 3, 9 and 15 DAI, and the penetrated amount was lower in IPR Afrodite. Furthermore, juveniles stage J2, J3 and J4 were formed in

Table 4. Percentage of mean incidence of leaf rust (LR), stem rust (SR) and leaf spot (LS) on cultivar IPR Afrodite, evaluated for 3 years at 28 locations

Years of evaluation	LF (%)	SR (%)	LS (%)
2008	16.8	6.6	11.8
2009	19.3	0.7	28.4
2010	39	3	24
Means	25	3	21

Table 5. Reproduction factor (RF) and number of nematodes per grams of root (NGR) in oat genotypes, inoculated with *Meloidogyne incognita*, *M. javanica*, *M. paranaensis*, *M. enterolobii*, and *Pratylenchus brachyurus*, in means of greenhouse tests with 10 replications

Genotypes	<i>Meloidogyne incognita</i>		<i>Meloidogyne javanica</i>		<i>Meloidogyne paranaensis</i>		<i>Meloidogyne enterolobii</i>		<i>Pratylenchus brachyurus</i>	
	RF [†]	NGR [†]	RF [†]	NGR [†]	RF [†]	NGR [†]	RF [†]	NGR [†]	RF [†]	NGR [†]
IPR Afrodite	0 e	0 d	0 g	0 f	0 d	0 f	0 b	0 b	4.16 cde	285 abc
URS Corona	0 e	0 d	0.09 g	23 de	0.04 d	12 ef	0 b	0 b	8.19 bc	500 abc
URS Tarimba	0.02 e	16 cd	0.03 g	21 e	0.11 d	57 d	0 b	0 b	9.66 b	1151 a
URS Taura	0.03 e	32 c	1.76 f	816 c	0.18 d	130 c	0 b	0 b	2.33 efg	199 bc
URS Guria	0.04 e	32 c	0.07 g	45 d	0.06 d	27 d	0 b	0 b	2.47 def	246 abc
AL0509	0.06 e	41 c	0.07 g	31 de	0.03 d	14 e	0 b	0 b	4.5 cd	432 ab
URSFAPA Slava	3.2 d	2012 b	8.4 c	3233 b	0.89 c	368 bc	0 b	0 b	1 g	62 d
URS Torena	4.36 c	2737 b	4.09 d	1785 b	1.03 bc	619 b	0 b	0 b	2.33 efg	234 cd
IAPAR 61	4.48 c	1801 b	12.4 b	2675 b	-	-	0 b	0 b	-	-
URS Charrua	4.55 c	2971 b	2.01 e	1142 bc	1.09 bc	458 b	0 b	0 b	-	-
IPR 126	7.23 b	1591 b	16.8 b	3159 b	1.4 b	561 b	0 b	0 b	2.16 fg	48 d
Pattern*	54.4 a	23006 a	178 a	35793 a	12.35 a	5407 a	5.36 a	1129 a	59.5 a	588 a

*Tomato for *Meloidogyne* spp. and sweet pepper for *P. brachyurus*.[†] Means of RF and NGR, followed by same letters in a row, do not differ statistically by Tukey test at 5% probability.

both cultivars 15 DAI. Obese females and egg masses were formed only in URSFAPA Slava, 30 DAI. No nematodes were found in the roots of IPR Afrodite at 30 DAI, indicating the death of juveniles between 15 and 30 DAI.

In conclusion, cultivar IPR Afrodite represents an excellent contribution to the oat production chain, with potentially high returns for farmers. The food industry will be supplied with high-quality grain for processing of many derivate products from this cereal, while consumers will have

access to products with better quality, uniformity and flavor.

SEED PRODUCTION AND DISTRIBUTION

The oat cultivar IPR Afrodite is registered by the Brazilian registry of cultivars of MAPA, under number 28645 and a plant patent was issued by the Brazilian Plant Variety Protection service (SNPC, no. 20130221), initiating the protection period as of 04/01/2013; IAPAR is in charge of seed production and marketing.

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