Crop Breeding and Applied Biotechnology 11: 370-374, 2011
Brazilian Society of Plant Breeding. Printed in Brazil

CULTIVAR RELEASE

Brisasul: a new high-yielding white oat cultivar with reduced lodging

Antônio Costa de Oliveira[1], Maraisa Crestani[1]*, Fernando Irajá Félix de Carvalho[1], José Antonio Gonzalez da Silva[2], Igor Pirez Valério[3], Irineu Hartwig[4], Giovani Benin[5], Douglas André Mallmann Schmidt[6] and Ivandro Bertan[7]

Received 27 September 2010

Accepted 08 April 2011

ABSTRACT – *The white oat cultivar Brisasul was developed from the cross OR 2 x UPF 18 at the Centro de Genômica e Fitomelhoramento, Faculdade de Agronomia 'Eliseu Maciel', Universidade Federal de Pelotas. The most important traits are high yield, low stature and high lodging resistance.*

Key words: Avena sativa *L.; plant breeding; yield; short stature.*

INTRODUCTION

The genetic gain in white oat (*Avena sativa* L.) depends entirely on the dynamics and efficiency of a plant breeding program that can detect variability for the development of genotypes well-adjusted to the distinct environmental conditions, associating grain quality and yield with disease and lodging resistance (Carvalho et al. 1987). These efforts have increased the importance of the crop throughout the country. White oat is being used for pasture, silage, hay, and as cover crop for soil protection and to improve the soil chemical, physical and biological properties. The grain is widely used in human nutrition and in industrial applications, where it serves as component of numerous processed products, due to its binding and emulsifying capacity (Walker 1993). Also, the species is particularly suitable for crop rotation systems, for blocking the cycle of many pathogens of standard crops and providing straw in no-tillage systems in Southern Brazil (Jacobi and Fleck 2000, Ceccon et al. 2004).

Oat (*Avena* spp.) is one of the world's major cereal crops, with a total yield of 23,032,118 tons of harvested grain in 2009. Russia is the major oat producer, with a total production of 5,401,200 tons (FAOSTAT 2010). In 2009, Brazil ranked second in oat production in South America, with an overall production of 238,831 tons of grain grown on 122,653 ha (FAOSTAT 2010). In 2009, Rio Grande do Sul was the largest oat-producing state of the country, with a harvest of 141,000 tons of grain, while Parana, the second largest, produced 91,200 tons of grain (CONAB 2010).

[1] Universidade Federal de Pelotas (UFPel), Faculdade de Agronomia 'Eliseu Maciel'(FAEM), Centro de Genômica e Fitomelhoramento, Departamento de Fitotecnia, Campus Universitário Capão do Leão, Rua Gomes Carneiro, 1, Centro, CP 354, 96.010-610, Pelotas, RS, Brasil. *E-mail: maraisacrestani@gmail.com
[2] Universidade Regional do Noroeste do Estado do Rio Grande do Sul, Departamento de Estudos Agrários, Rua do Comércio, 3000, Bairro Universitário, 98.700-000, Ijuí, RS, Brasil
[3] Biotrigo Genética Ltda., Rua João Batistti, 71, 99.050-380, Passo Fundo, RS, Brasil
[4] Syngenta Seeds Ltda, Rua Paraná, 1241, Centro, 85.812-010, Cascavel, PR, Brasil
[5] Universidade Tecnológica Federal do Paraná (UTFPR), Campus Pato Branco, Via do conhecimento, km 1, 85.503-390, Pato Branco, PR, Brasil
[6] Don Mario Sementes, Rua Garibaldi Leão, Quadra 28, Lote 10, s/n, 75.904-028, Rio verde, GO, Brasil
[7] Syngenta Seeds Ltda, Rodovia BR 452, KM 142, Zona Rural, 38400-974, Uberlândia, MG, Brasil

The increasing economic importance of this cool-season cereal has become a challenge for researchers, and genotypes with higher yield and better milling potential and grain chemical quality are called for. This has accelerated the dynamics of plant breeding programs to develop elite genotypes, superior to the ones currently used by farmers, with better adaptability and capable to respond to crop management improvement. In this sense, the white oat breeding program conducted at the Centro de Genômica e Fitomelhoramento, Faculdade de Agronomia 'Eliseu Maciel', Universidade Federal de Pelotas (CGF/FAEM-UFPel) is a contribution to the nationwide expansion of this crop. White oat has been intensively studied in the last 15 years, based on interrelated teaching and research, allowing the elaboration of dissertations and theses and consequently the publication of scientific papers in journals, and the participation of researchers in congresses and conferences focused on white oat. All these activities led to the release of genotypes developed by the program, of which the first were cultivars Albasul (in 2003) (Lorencetti et al. 2004) and Barbarasul (in 2008) (Carvalho et al. 2009).

PEDIGREE AND BREEDING METHOD

The white oat (*Avena sativa* L.) cultivar Brisasul was derived from the cross OR 2 x UPF 18, made in 2000. The artificial hybridizations were performed in a greenhouse of the above CGF/FAEM-UFPel, in Capão do Leão, Rio Grande do Sul. The F_1 generation was grown in a greenhouse in the 2000/2001, producing F_2 seeds. In the winter of 2001, the F_2 generation was grown in an experimental field of the Centro Agropecuário da Palma of the same university. The F_2 seeds were sown (plants and rows spaced 30 cm apart). The best F_2 plants were selected for their performance in important agronomic plant traits observed in the field and panicle and grain-related traits in the lab. In the summer 2001/2002, the selected F_3 seeds were grown without selection in the greenhouse, resulting in F_4 seeds. The selection followed a modified pedigree method, since no selection was performed in the F_3 generation. The F_4 generation was grown in the experimental field in the cold season of 2002, at commercial seeding density, i..e, a final stand of 66 plants m^{-2} and between-row spacing of 0.20 m (full density). At this point, the best F_4 lines were selected. These F_4 lines originated the F_5 generation, grown in the cold season of 2003, at full density. Similarly, the F_6 lines were obtained. The most uniform lines were evaluated in an internal preliminary grain yield test in 2004, together with three control genotypes (indicated by the Brazilian Oat Research Committee). The experiment was conducted in a randomized block design with four replications consisting of five 5- m long rows spaced 0.2 m apart, of which the three central rows (covering 3 m^2) were assessed. In this trial, the seeding density was 300 seeds m^{-2} and the line was named UFPel 03-012.

PERFORMANCE

Due to the good performance in the preliminary trial in 2004, line UFPel 03-012 was included in the Regional Line Trial (RLT), coordinated by the Brazilian Oat Research Committee (CBPA), in 2005. Based on the results in the RLT, line UFPel 03-012 was included in the Brazilian Line Trial (BLT), where its performance was evaluated in 2006, 2007 and 2008.

The approval by the CBPA (CBPA 2006) for the release of white oat cultivars is primarily based on the comparative performance of the lines and the best mobile control at several cultivation sites in least three years (the first year in the RLT and the second and third in the BLT). Lines with a three-year-average grain yield $\geq$ 105 % of the average grain yield of the best control can be released. A line can also be approved if the average yield is between 100 and 105 % of the best control associated to a particular trait of the line. Also, the release can be focused on a specific location if the grain yield of the candidate line is 10 % higher than of the best control at this location. Therefore, based on the performance at many locations, in 2005, 2006, 2007 and 2008, and following the CBPA criteria, UFPel 03-012 was released as white oat cultivar in 2009, under the name 'Brisasul'.

In 2007 and 2008, the DHS (differentiation, homogeneity and stability) tests were conducted in Capão do Leão-RS (lat 31º 46' S, long 52º 20' W; 12 m asl), using the cultivars Albasul, UPF 18 and URS 22 for comparison.

The average performance of cultivar Brisasul in comparison to the control cultivars in 2005, 2006, 2007 and 2008, at different sites, is shown in Table 1. In comparison, the grain yield of 2,726 kg ha^{-1} of Brisasul exceeded the white oat control cultivars UPF 18 (1,308 kg ha^{-1}) and UPFA 22 (1,958 kg ha^{-1}). Regarding the controls URS 21 (2,743 kg ha^{-1}) and URS Guapa (3,001 kg ha^{-1}), the performance of Brisasul was equivalent and slightly lower (90.8 %). However, there was no statistical difference between the grain yield of Brisasul and URS Guapa (best control), in the group of tested locations.

Table 1. Average performance of the white oat cultivar Brisasul and four control cultivars regarding agronomic traits, at different years and locations in Brazil

Cultivar	2005 (% BC)	2006 (% BC)	2007 (% BC)	2008 (% BC)	Mean	Mean BC (%)**
	Days from the emergence to physiological maturity (days)					
Brisasul	125 (107.8)	114 (105.6)	121 (106.1)	119 (104.4)	120	106.2
UPF 18 (C)	125 (107.8)	115 (106.5)	-	-	120	106.2
UPFA 22 (C)	116 (100.0)	108 (100.0)	114 (100.0)	114 (100.0)	113	100.0
URS 21 (C)	121 (104.3)	111 (102.8)	117 (102.6)	117 (102.6)	117	103.5
URS Guapa (C)	-	-	118 (103.5)	116 (101.8)	117	103.5
Tested locations	6	6	6	6	-	-
	Hectoliter weight (kg hl^{-1})					
Brisasul	39.4 (85.1)	39.0 (85.7)	42.9 (92.9)	42.1 (90.0)	40.9	88.5
UPF 18 (C)	33.1 (71.5)	32.8 (72.1)	-	-	33.0	71.4
UPFA 22 (C)	38.2 (82.5)	39.1 (85.9)	43.7 (94.6)	42.2 (90.2)	40.8	88.3
URS 21 (C)	46.3 (100.)	45.5 (100.0)	46.2 (100.0)	46.8 (100.0)	46.2	100.0
URS Guapa (C)	-	-	43.5 (94.2)	42.7 (91 2)	43.1	93.3
Tested locations	9	9	8	8	-	-
	1000 grain weight (g)					
Brisasul	24.8 (86.7)	24.4 (88.4)	26.4 (84.3)	27.0 (84.4)	25.7	81.1
UPF 18 (C)	25.3 (88.5)	24.5 (88.8)	-	-	24.9	78.5
UPFA 22 (C)	28.6 (100.0)	26.8 (971)	29.5 (94.2)	31.0 (96.9)	28.8	90.9
URS 21 (C)	28.2 (98.6)	27.6 (100.0)	28.0 (89.5)	29.0 (90.6)	28.2	88.1
URS Guapa (C)	-	-	31.3 (100.0)	32.0 (100)	31.7	100.0
Tested locations	6	8	7	7	-	-
	Grain yield (kg ha^{-1})					
Brisasul	2578 (97.1)	2145 (98.4)	2772 (97.2)	3409 (100.7)	2726	90.8
UPF 18 (C)	1459 (55.0)	1158 (53.1)	-	-	1308	43.6
UPFA 22 (C)	1864 (70.2)	1404 (64.4)	2089 (73.2)	2477 (73.2)	1958	65.2
URS 21 (C)	2654 (100.0)	2180 (100.0)	2755 (96.6)	3385 (100.0)	2743	91.4
URS Guapa (C)	-	-	2853 (100.0)	3149 (93.0)	3001	100.0
Tested locations	9	9	8	8	-	-
	Average plant stature (cm)					
Brisasul	98.5 (94.1)	96.8 (93.7)	82.9 (101.0)	111.7 (96.7)	97.5	96.3
UPF 18 (C)	120.0 (114.6)	112.0 (108.4)	-	-	116.0	114.6
UPFA 22 (C)	104.7 (100.0)	103.3 (100.0)	82.0 (100)	117.9 (102.1)	102.0	100.8
URS 21 (C)	114.9 (109.7)	112.0 (108.4)	93.9 (114.5)	119.0 (103.0)	109.9	108.6
URS Guapa (C)	-	-	86.9 (106.0)	115.5 (100.0)	101.2	100.0
Tested locations	9	9	8	8	-	-
	Lodging (%)					
Brisasul	28.2 (143.1)	18.6 (62.4)	4.4 (58.7)	11.0 (71.9)	15.6	104.0
UPF 18 (C)	19.7 (100.0)	38.8 (130.2)	-	-	29.3	195.3
UPFA 22 (C)	48.7 (247.2)	29.8 (100.0)	16.2 (216.0)	21.0 (137.3)	28.9	185.3
URS 21 (C)	33.5 (170.1)	37.4 (125.5)	7.5 (100.0)	18.5 (120.9)	24.2	161.3
URS Guapa (C)	-	-	14.7 (196.0)	15.3 (100.0)	15.0	100.0
Tested locations	6	6	7	4		

BC = best control in the tested year.
BC** = best control in the group of years tested.

Brisasul was released based on its important agronomic traits, low plant stature and low lodging percentage, associated to a grain yield equivalent to the best control.

The average plant stature of Brisasul is low (97.5 cm), equivalent to 96.3 % of the best control cultivar, URS Guapa, with an average plant stature of 101.2 cm. The selection and development of white oat cultivars with short stature tends to increase lodging resistance and is an important step towards the development of cultivars better adapted to improved environments, especially in view of

the application of higher nitrogen levels to increase grain yield. Short-stature white oat cultivars with lodging resistance represent ideotypes to be used in environments with high N availability, due to natural fertility or artificial fertilization, or in other lodging-favorable environments. Therefore, for the overall lodging performance of Brisasul, a percentage of 15.6 % was observed at the trial level, which is slightly higher (104 %) than of the best control URS Guapa (15.0 %) (Table 1). A comparison with the control genotypes UPF 18, UPFA 22 and URS 21, with lodging indexes of 95.3 %, 85.3 % and 61.3 % higher than URS Guapa, respectively, clearly showed the better performance of cultivar Brisasul.

From emergence to maturity, Brisasul took on average 120 days, equivalent to 106.2 % of the best control. This indicates a longer cycle of cultivar Brisasul, similar to UPF 18 (Table 1). For the traits hectoliter weight and 1000 grain weight, the performance of Brisasul was 88.5 % and 81.1 %, respectively, of URS 21 and URS Guapa.

The milling quality and chemical properties of cultivar Brisasul and of four white oat control cultivars are shown in Table 2, with data from the cultivation in Capão do Leão-RS, in 2007 and 2008. It was observed that cultivar Brisasul has a very similar performance to the cultivars UPF 18, UPFA 22, URS 21, and URS Guapa for these properties. Regarding milling yield, the caryopses of about 52 % of grain produced by the cultivar Brisasul are suitable for industry.

For the character grain > 2 mm, the values of cultivar Brisasul were lower than of the other cultivars (73.03 %), being the highest value presented by the cultivar URS Guapa (88.2 %). The dehulling index ranged from 70.37 % (UPFA 22) to 74.49 % (UPF 18) and was 71.45 % for Brisasul; for this trait, the uniformity of UPF 18 was low, and the value for URS 21 was 74.22 %. Milling yield ranged between 52.22 % (Brisasul) and 62.89 % (URS Guapa). For crude protein, lipids and total digestible fiber, the performance of Brisasul was intermediate for the first and low for the latter two characters. The characters ash content and nitrogen-free extracts were equivalent for all genotypes.

With regard to shoot diseases under experimental conditions, Brisasul was moderately resistant to crown rust (*Puccinia coronata Cda.* f. sp. *avenae*), stem rust (*Puccinia graminis* Pers. f. sp. *avenae*) and leaf spots (*Pyrenophora avenae* and *Cochliobolus sativus*), the most common shoot diseases of white oat in Southern Brazil (CBPA 2006). It is worth pointing out that in regions where conditions favor the development of crown rust, the major white oat disease in Brazil, the fields must be a carefully monitored, with an eventual need for fungicide application, to avoid losses in grain quality and yield.

SEED MAINTENANCE AND DISTRIBUTION

Brisasul is registered in the Ministério da Agricultura, Pecuária e Abastecimento, number 21518 (MAPA 2010). The Universidade Federal de Pelotas is responsible for maintaining the genetic and basic seed of the cultivar, while trade is reserved for the Fundação Pró-Sementes de Apoio à Pesquisa.

Table 2. Analysis of characters related to the milling and chemical grain quality of cultivar Brisasul and four additional control cultivars grown in Capão do Leão, RS, in 2007 and 2008

Traits	Cultivar				
	Brisasul	**UPF 18 (C)**	**UPFA 22 (C)**	**URS 21 (C)**	**URS Guapa (C)**
Grains > 2 mm (%)	73.03±7.94	80.92±10.88	83.25±5.19	76.84±7.95	88.22±6.62
Dehulling index (%)	71.45±3.84	74.49±25.93	70.37±3.30	74.22±2.51	71.40±4.56
Milling yield (%)	52.22±6.62	58.47±11.80	58.64±5.33	57.07±6.56	62.89±4.90
Crude protein* (g $100g^{-1}$)	19.39±2.01	21.22±1.42	19.95±1.34	19.31±1.39	18.50±1.47
Lipids* (g $100g^{-1}$)	7.15±0.18	8.24±0.36	7.99±0.38	8.17±0.25	7.22±0.44
Total digestible fiber* (g $100g^{-1}$)	9.15±0.32	9.92±0.24	9.64±0.27	9.58±0.25	9.00±0.38
Crude fiber* (g $100g^{-1}$)	2.69±0.54	3.02±0.48	2.60±0.44	2.20±0.40	2.45±0.76
Ash content* (g $100g^{-1}$)	2.30±0.04	2.37±0.03	2.33±0.04	2.31±0.03	2.26±0.06
Nitrogen-free extracts* (g $100g^{-1}$)	67.61±3.45	63.96±1.99	66.13±2.08	67.50±2.28	68.52±2.91

C = control cultivars.
* Properties of the chemical grain composition determined by near infra-red spectroscopy (NIR), in the Laboratório de Cereais do Centro de Pesquisa em Alimentação (Cepa), Universidade de Passo Fundo (UPF), Passo Fundo, RS.

Brisasul: nova cultivar de aveia branca de reduzido acamamento e elevado rendimento de grãos

RESUMO - *A cultivar de aveia branca Brisasul foi desenvolvida pelo Centro de Genômica e Fitomelhoramento da Faculdade de Agronomia 'Eliseu Maciel', Universidade Federal de Pelotas, sendo resultado do cruzamento entre OR 2 e UPF 18. Caracteriza-se pelo elevado rendimento de grãos, porte reduzido e elevada resistência ao acamamento.*

Palavras-chave: Avena sativa *L.; melhoramento genético; produtividade; reduzida estatura.*

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