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BRAZILIAN AGRICULTURAL RESEARCH CORPORATION — EMBRAPA
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BRS Parrudo: wheat cultivar from Embrapa.

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The release of BRS Parrudo aimed to offer farmers a wheat cultivar with a new plant ideotype, a plant with medium plant height; short, narrow, and upright leaves; solid stem at the basal internodes; and high spike fertility, which can be cultivated in the usual the Àeld conditions used by the farmers.

For some time, several breeding strategies were used in Brazil to improve wheat grain yield, focused mainly on lodging and disease resistance. Parallel to the development of cultivars by the conventional breeding methods described by Allard (1971) and used by various breeding institutions in the late 1970s and early 1980s (Riede et al. 2015; Caierão et al. 2016), an innovative method, the systemic approach (Scheeren et al. 2011) was introduced into wheat breeding. In co-evolution with the current production system, improvements in disease resistance were sought, while maintaining or even increasing the crop yield potential. As of 1990, the systemic selection was addressed in partnership between Embrapa Trigo and Embrapa Clima Temperado. In this approach, also used in the selection of BRS Parrudo, the selection is made in the Àrst generations, in a great number of crosses and backcrosses (4,000–5,000 combinations/year), with intense elimination of individuals. The method was improved by applying selection to multiple stresses already in the F_1 generation of multiple crosses (single double crosses including only four parents or in complex F_1, including F_1/F_1 crosses, using a large number of different parents), rather than initiating selection only in the F_2 population. After obtaining close to ideal plants, they were crossed to get desired new lines. ArtiÀcial inoculation of diseases (for example: powdery mildew, leaf rust, fusarium head blight) were used in order to obtain rapid solutions for several selected traits. Simultaneously, a new plant ideotype with industrial suitability characteristics of bread wheat was sought as key objective. Acting this way, a large number of highly resistant lines to several diseases were obtained in a short period of time and as a Ànal result of the breeding efforts of 30 years, cultivar BRS Parrudo was released. The purpose of this study was to describe the yield performance, main agronomic characteristics and industrial suitability for the end use of the Embrapa wheat cultivar BRS Parrudo.

BRS Parrudo was created using the principles of the systemic selection, as described above, and this work was made in a partnership between Embrapa Trigo and Embrapa Clima Temperado. To obtain the parents of BRS Parrudo, many selections were made in early generations, in a great number of populations derived from crosses and backcrosses (4,000–5,000 combinations/year), with intense elimination of individuals. In the F_1 generations, many traits for strong plant type were selected in screenhouse, like solid stem and short and erect leaves. Then, initiating selection in the Àeld in the F_2 populations and continuing until the F_7 generations, an intense selection for multiple stresses (most of the diseases occurred naturally in the Àeld and some were artiÀcially inoculated, like powdery mildew and leaf rust) was applied. During the process, after obtaining close to desired plants, new crosses were made to get desired new lines. Cultivar BRS Parrudo was derived from single cross F70465, made in summer 2000–01, in a screenhouse at of Embrapa Trigo, in Passo Fundo, Rio Grande do Sul (RS). As parents we used the lines WT 98108, originated from selections performed in Passo Fundo and in Warta, Londrina, Paraná (PR), and TB 0001, bred and selected at Embrapa Clima

Temperado, in Pelotas, RS. WT 98108 present high grain yield potential and TB 0001 has the desired characteristics of plant type. In 2001, the F_1 were self-pollinated in a screenhouse in Passo Fundo to produce F_2 seeds. Beginning in 2002, the segregating populations from F_2 to F_7, composed of 200 individuals selected in the previous generation, were space planted in the experimental Àeld under natural conditions to permit individual plant selection, without use of fungicides, or in screenhouse, at Embrapa Trigo. In all generations were selected individual plants. After threshing individually the selected plants, a strong visual selection of the grains was carried out keeping the best plants in terms of grain Àlling, red and glassy grains, and absence of yellow berry. In the winter of 2007, all the plants from one Àeld plot, already in the F_8 generation, were harvested and named PF 070478.

In 2008, line PF 070478 was evaluated in the preliminary test series of special lines of Embrapa. Thereafter, it was included in the tests of value for cultivation and use (VCU) in 2009, 2010 and 2011. All tests were arranged in a randomized complete block design with three replications. Each experimental unit, consisting of one genotype, was sown in Àve rows of 5 m long, spaced 0.2 m apart, resulting in a total evaluated area of 5 m^2. As recommended by the Brazilian government rules for registration of wheat cultivars (Brazilian Ministry of Agriculture, Livestock and Supply (MAPA) – Brazil (2010) two cultivars, from the Brazilian recommended list of wheat cultivars were chosen as checks, including BRS Guamirim, as an early cycle cultivar, and Quartzo, as a medium cycle cultivar, and both presenting high yield potential. All cultural treatments were applied according to the technical recommendations of the National Wheat and Triticale Commission (Fronza 2008, Castro 2009, Marchioro 2011). Prior to sowing, seeds were treated with triadimenol + imidacloprid. Tests were carried out in the states of RS, Santa Catarina (SC), and in southern PN, in the Wheat Adaptation Regions 1 (cold/wet/high altitude) and 2 (moderately hot/humid/low altitude; Embrapa Trigo (2006)). In RS, the tests were carried out in Vacaria (28°30'44" S, 971 m; Latossolo Bruno Aluminoférrico); Passo Fundo (28°15'46" S, 687 m; Latossolo Vermelho DistróÀco húmico) at two sowing dates, early and late, to avoid frost; São Borja (28°39'38" S, 123 m, Nitossolo Vermelho Distroférrico latossólico); Três de Maio (27°46'24" S, 343 m, Latossolo Vermelho Distroférrico); and Victor Graeff (28°15'46" S, 411 m; Latossolo Vermelho DistróÀco férrico); in SC in the counties of Abelardo Luz (26°33'53" S, 760 m, Latossolo Vermelho), Canoinhas (26°10'38" S, 839 m, Latossolo Bruno Aluminoférrico) and Chapecó (27°05'47" S, 674 m, Latossolo Vermelho Distroférrico); and in PN, in Guarapuava (25°25'36" S, 1,098 m; Latossolo Bruno Ácrico Húmico) and Ponta Grossa (25°05'42" S, 969 m; Latossolo Vermelho Distroférrico). In the VCU trials, cultivar BRS Parrudo was compared with the control cultivars BRS Guamirim and Quartzo (which are two cultivars from the recommended list, as postulated by Brazilian Ministry of Agriculture, Livestock and Supply (MAPA) – Brasil 2010. In terms of grain yield, BRS Parrudo produced 106% (2009), 102% (2010), and 103% (2011), when compared with the mean of the two control cultivars in each year, and a mean of 103% in relation to the controls in the three evaluation years. In 2010, cultivar BRS Parrudo produced 5,459 kg/ha, whereas the mean of the control cultivars was 5,367 kg/ha (Table 1).

Table 1. Grain yield (kg/ha) of BRS Parrudo and the control cultivars BRS Guamirim and Quartzo. % = percentage in relation to the mean of the control cultivars BRS Guamirim and Quartzo, MC = mean of the control cultivars BRS Guamirim and Quartzo. Locations in 2009: Passo Fundo, Rio Grande do Sul (RS) (two growing seasons, early and medium sowing date to avoid frost), São Borja (RS) (two growing seasons), Três de Maio (RS) (two growing seasons), Chapecó, Santa Catarina (SC) and Canoinhas (SC). Locations in 2010: Passo Fundo (RS) (two growing seasons), São Borja (RS) (two growing seasons), Três de Maio (RS) (two growing seasons), Vacaria (RS), and Abelardo Luz (SC). Locations in 2011: Passo Fundo (RS) (two growing seasons), São Borja (RS) (two growing seasons), Três de Maio (RS), Vacaria (RS), Victor Graeff (RS), Chapecó (SC), Canoinhas (SC), Ponta Grossa, Paraná (PR) and Guarapuava (PR).

Genotype	2009		2010		2011		Mean	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Number of locations	8		8		11		27	
BRS Parrudo	4.574	106	5.459	102	4.860	103	4.964	103
Quartzo	4.717	109	5.604	104	4.728	100	5.016	104
BRS Gurmirim	3.952	91	5.130	96	4.709	100	4.597	96
MC	4.334	100	5.367	100	4.719	100	4.807	100

BRS Parrudo (Fig. 1A, p. 9) is a low to medium-tall cultivar (mean of 85 cm in Passo Fundo, RS) and of a short cycle (average of 85 days-to-heading and 135 days-to-maturity in Passo Fundo). The stem is solid in the Àrst internode

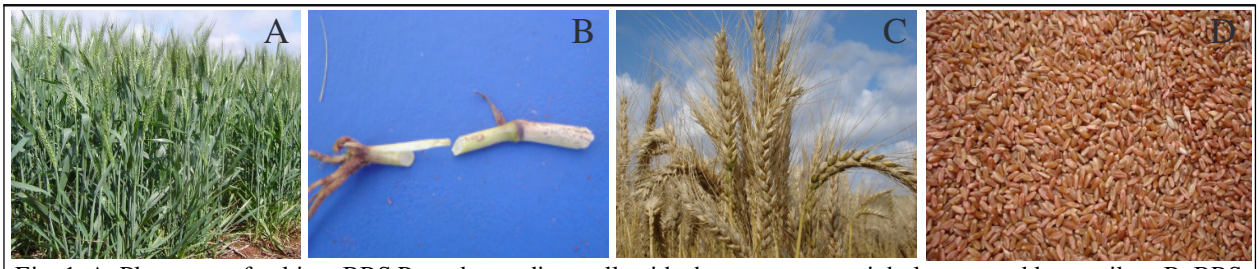

Fig. 1. A. Plant type of cultivar BRS Parrudo; medium-tall, with short, narrow, upright leaves, and long spikes. B. BRS Parrudo presents a solid stem at the basal internode until the flowering period. C. Spikes of BRS Parrudo at maturity. D. Seeds of BRS Parrudo are hard red vitreous. Passo Fundo, 2011. Photos by Pedro Luiz Scheeren.

during the early stages (Fig. 1B). The grains are hard red vitreous (Fig. 1D) is resistant to lodging and soil acidity and moderately resistant to frost in the vegetative phase. In relation to biotic stresses, it is resistant to soilborne wheat mosaic virus and powdery mildew (Blumeria graminis); moderately resistant to Fusarium head blight (Fusarium graminearum), Septoria glume blotch (Stagonospora nodorum), spot blotch (Bipolaris sorokiniana), wheat tan spot (Pyrenophora tritici-repentis, and leaf rust (Puccinia triticina); moderately susceptible to preharvest sprouting; and moderately tolerant to barley yellow dwarf virus.

Regarding the industrial suitability in the homogeneous wheat adaptation Regions 1 and 2 of RS and SC, cultivar BRS Parrudo was classified as strong gluten wheat suitable for bread making according to Regulation no. 38 (Brasil 2010) by the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA). Sixty percent of the samples from Region 1 and 62.5 percent of samples from Region 2 reached this classification. Samples of BRS Parrudo from the homogeneous adaptation Region 1 of RS and SC, analyzed between 2009 and 2011 at the Grain Quality Laboratory of Embrapa Trigo, had mean gluten strength (W) of 345 x 10^{-4} J in the Alveography test and a mean elasticity index (EI) of 60.4% (Table 2). Samples of BRS Parrudo from the homogeneous adaptation Region 2 of RS and SC, analyzed in the same period, had a mean gluten strength (W) of 324 x 10^{-4} J and a mean EI of 57.9%, with a variation of 46 to 65%. Classified as strong gluten wheat, this cultivar is recommended for the production of bread, dry pasta, cracker cookies, industrial baking and can be blended with weaker gluten wheat for baking in general.

Table 2. Industrial suitability traits of cultivar BRS Parrudo in the Brazilian Wheat Adaptation Regions. Samples = the number of samples per region; Region 1: Passo Fundo, Rio Grande do Sul (RS), Vacaria (RS), Victor Graeff (RS), Canoinhas, Santa Catarina (SC), Ponta Grossa, Paraná (PR), and Guarapuava (PR); Region 2: São Borja (RS), Três de Maio (RS), Chapecó (SC), and Abelardo Luz (SC).

Traits	Mean of Region 1	Mean of Region 2	Overall mean or sum
Number of samples/region	9	9	18
Mean of falling number	339	337	338
Mean of gluten strength (x10^{-4} Joules)	345	324	334
Mean of lightness (0 = black, 100 = white (Minolta))	93.1	92.2	92.6
Mean of color b (+ = yellow hues, – = blue hues (Minolta))	10.9	11.7	11.3
Mean of tenacity or resistance to extension	120	123	122
Mean of extensibility or average abscissa at dough rupture (mm)	77	71	74
Mean of tenacity/extensibility ratio	1.6	1.9	1.8

Wheat cultivar BRS Parrudo also responded with significant grain yield increase to the application of high nitrogen rate, without lodging in the farm fields. In 2013, in the mean of the best 22 fields (40 ha/farmer), BRS Parrudo produced more than 4 t/ha and reached 6.3 t/ha at the best site. In the Alveography test, the mean W value was 368 x 10^{-4} J and the mean stability 29 minutes (Farinography test); the highest values were 495 x 10^{-4} J and 62 minutes, respectively. In average of nine locations, BRS Parrudo presented a mean of 40.7 mg Fe/kg, 53.3% superior to the mean iron value of cultivar Quartzo (26.6 mg Fe/kg), which presented the largest acreage in the South Brazilian wheat region in 2013 (Table

3). Considering the high (level of) iron concentration in the grains, BRS Parrudo can be classiÀed as a natural biofortiÀed wheat cultivar. BRS Parrudo was registered and protected by the Ministry of Agriculture, Livestock and Supply (MAPA) under the numbers 29434 and 20120242, respectively.

Table 3. Iron concentration (mg/kg) in grains of BRS Parrudo in comparison with Quartzo and percentage of increase in nine locations in 2013. Quartzo is the most planted cultivar in the South Brazilian Wheat Region. [1] First sowing date (early June); [2] Second sowing date (late June) (RS = Rio Grande do Sul, SC = Santa Catarina, and PR = Paraná states).

Location	Quartzo	BRS Parrudo	% difference of increase
Três de Maio, RS	28.3	41.1	45.2
Passo Fundo, RS [1]	21.5	32.1	49.3
Passo Fundo, RS [2]	22.1	31.5	42.5
São Luiz Gonzaga, RS	31.8	46.3	45.6
São Borja, RS	30.5	53.1	74.1
Chapecó, SC	25.5	40.5	58.8
Canoinhas, SC	24.3	37.6	54.7
Campos Novos, SC	26.4	40.4	53.0
Ponta Grossa, PR	28.7	44.0	53.3
Mean	26.6	40.7	52.9

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Performance of wheat cultivars in the state of Rio Grande do Sul, Brazil, 2017.

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The Brazilian Commission of Wheat and Triticale Research (BCWTR) annually conducts the State Test of Wheat Cultivars in the state of Rio Grande do Sul (STWC–RS), aiming to support the indications of cultivars. This work had the objective to evaluate wheat cultivar grain yield performance of STWC–RS, in 2017. The grain yield performance of 30 wheat cultivars (Ametista, BRS Guaraim, BRS Marcante, BRS Parrudo, BRS Reponte, CD 1303, CD 1705, Celebra, FPS Certero, Inova, Jadeíte 11, LG Cromo, LG Oro, LG Supra, MarÀm, ORS 1401, ORS 1402, ORS 1403, ORS 1405, ORS Vintecinco, Quartzo, TBIO Alpaca, TBIO Iguaçu, TBIO Mestre, TBIO Noble, TBIO Sintonia, TBIO Sinuelo, TBIO Sossego, TBIO Toruk, and Topazio) was studied in 12 environments (Coxilha, Cruz Alta, Não-Me-Toque, Passo Fundo – season 1; Passo Fundo – season 2; Vacaria – season 1; Vacaria – season 2; and Augusto Pestana, Ijuí, Santo Augusto, São Borja and Três de Maio), in Rio Grande do Sul in 2017. The experiments were carried out in a randomized block design with three or four repetitions. Each plot consisted of Àve rows of 5 m in length with 0.2 m spacing between rows. The plant density was approximately 330 plants/m^2. Grain yield data (kg/ha) were subjected to individual analysis of variance (for each environment) and to grouped analysis of variance (for all environments). The grouped analysis of variance was performed employing the mixed model (Àxed cultivar effect and randomized environment effect). The grain yield performance of wheat cultivars was evaluated by analysis of adaptability and stability, employing the method of distance from the ideal cultivar, weighted by the coefÀcient of residual variation, proposed by Carneiro (1988). In this analysis, the ideal cultivar was considered as the cultivar with high grain yield, high stability, low sensitivity to adverse conditions of unfavorable environments and ability to respond positively to improvement of favorable environments. The general average of STWC–RS in 2017 was 3,544 kg/ha. The experiment conducted in Santo Auguto had the highest average of wheat grain yield: 4,845 kg/ha. The maximum wheat grain yield was 5,610 kg/ha, in Santo Augusto (cultivar CD 1303).