CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

Germplasm the key factor for development of oat cultivars URS OLADA And URS POENTE

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Abstract: *Cultivars URS OLADA and URS POENTE, with superior agronomic performance were bred by the Oat Breeding Program of UFRGS. These cultivars were developed using germplasm from the Quaker Oat International Nursery, a long-term collaborative program of open exchange of oats superior germplasm among breeders in a global scale.*

Keywords*:* Avena sativa*, grain yield, resistance to crown rust, ION*

INTRODUCTION

Oat is an important crop during winter months for the subtropical region of Brazil usually following a crop of soybeans grown in the summer. In the subtropics an oat cultivars to be successful it needs to have a cycle that perfectly fit the windows between two summers crops (Pacheco and Federizzi 2020). Oats grain are used as humans' diet because of its proprieties associated with health benefits; and they are used on the farm as animal feed. The development of oat cultivars takes time and requires a lot of resources, but the principal factor is access to superior germplasm. Since the domestication of crops began 8,000–10,000 yr ago the exchange from one country or region to another of crop cultivars and germplasm has been an enduring hallmark of agricultural food systems (Smith et al. 2021). But, more recently the free exchange of germplasm has been diminished as nonintentional consequence of implementation of policies by the Convention on Biological Diversity. As a result, monetary benefit sharing has been very low, the exchange of germplasm has been reduced, adding and decreasing breeding progress (Bretting 2018, Brink and van Hintum 2020). The same discussion is occurring now with genetic sequence data (Gaffney et al. 2020).

Oat breeders in Brazil have capitalized on the existence of a long program of free exchange of oat germplasm. In that respect oats are a good example of free exchange of superior germplasm, there is a program denominated Quaker Oat International Nursery (QOIN) with the objective of providing new elite germplasm to oat breeders worldwide that will allow them to create news cultivars that fit better the environment and season disponible with better and stable yield, have better disease and insect resistance and cultivars more suitable for the oat industry and consumers. This nursery originated at University of Wisconsin in 1974 when professor H. L. Shands approved a project with funding provided by a grant from the United States Agency for International Development (USAID). The project which was entitled "Breeding Oat Cultivars Suitable for Production in Developing Countries" run through

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1976. From 1977 to 2020 Quaker Oats company assumed funding responsibilities for the project (Fosberg and Shands 1989). The nursery each year is distributed to 20+ locations around the world and contains between 250 and 300 new lines and segregating populations.

The project currently has a 48-year history. In 2020 the USDA assumed funding of the "International Oat Nursery (ION)" coordinated by Professor Stephen Harrison of the Louisiana State University and as the only global oat germplasm sharing cooperative include germplasm from all countries participating. The objectives of the ION to develop improved new cultivars of oat around the world, share innovative methods and ideas and improve the feasibility of local crops worldwide. The ION includes advanced breeding lines and early-generation segregating populations (F_2, F_3 and F_4). Germplasm is submitted by ION participants for use by other participants, if advanced lines are used directly as a new cultivar the understanding that their Intellectual Property Rights (IPR) will be honored. Each year a different set of advanced lines and segregating population are included in the ION. The segregating populations from different oat breeding programs are intended to be used as a selection population for development of locally adapted varieties. All recipients are free to select within the segregating populations and release new improved varieties from them with no Intellectual property or financial obligations to the originator of the populations (http://wheat.pw.usda.gov/OG).

The objective of this work is to report how the exchange of germplasm facilitate the creation of two new oat cultivars by the UFRGS oat breeding program with superior agronomic and quality attributes adapted for the sub-tropical environment of Brazil.

MATERIAL AND METHODS

Development of URS OLADA

URS OLADA was developed by the Federal University of Rio Grande do Sul between 2013 and 2016, at the Agronomic Experimental Station of UFRGS (EEA/UFRGS). In the selection process is utilized the pedigree modified as breeding method as described by Nava et al. (2016). The cross was carried out at the University of Louisiana, having as parents the lines SD 031128-330 (from University of South Dakota)/ UFRGS 079002-1 (from UFRGS). The population F_3 was introduced at the Federal University of Rio Grande do Sul as Quaker International Oat Nursery of 2013 (QION), which is an international germplasm exchange program, conducted between 1976 and 2020, under the sponsorship of Quaker oats / PepsiCo, when 'accession 204' received the experimental code 'Q204/2013'. The development of the line 'UFRGS 16Q6010-1' was carried out through the pedigree method, where only one panicle was collected from each plant selected in the field. The grains of each panicle were threshed, kept separated by panicle and submitted to visual selection, where characters such as panicle fertility, grain filling, uniformity and grain health were evaluated. The seeds of each panicle, selected in the previous year, were sown in a plot consisting of 2 (two) rows, with 2 m length each, spaced 0.20 between them and 0.40 m of other plots of segregating lines. In 2013, about 6 g of seeds of the F_3 population 'Q204/2013' were sowed in the experimental field, in two lines of 2 m in length, separated by 0.20 m. From this population, 18 panicles were selected in the field and after evaluation for the physical quality of the grains, only 8 (eight) panicles remained, which gave rise to the family 'UFRGS 14Q4006' in 2014. In 2014, the F_4 family 'UFRGS 14Q4006' consisted of 8 (eight) $F_{3:4}$ lines, called 'UFRGS 14Q4006-1' to 'UFRGS 14Q4006-8'. From the $F_{3:4}$ lines 'UFRGS 14Q4006-6' 8 (eight) panicles were selected in the field, and 6 (six) were maintained after visual inspection of grain quality, forming the family 'UFRGS 15Q5010' in 2015. The line 'UFRGS 14Q4006-6' presented precocity in flowering, good resistance to lodging. In 2015, the $F_{3:5}$ family 'UFRGS 15Q5010' consisted of 6 (six) $F_{4:5}$ lines, called 'UFRGS 15Q5010-1' to 'UFRGS 15Q5010-6'. The $F_{4:5}$ line 'UFRGS 15Q5010-1' presented early flowering, with excellent biomass in the vegetative stage and resistant to leaf rust, and 4 (four) panicles were selected, of these, 3 (three) were maintained, after visual selection, constituting the seeds of the family 'UFRGS 16Q6010' of 2016. In 2016, the $F_{4:6}$ family 'UFRGS 16Q6010' consisted of 3 (three) $F_{5:6}$ lines, called 'UFRGS 16Q6010-1' to 'UFRGS 16Q6010-3'. The three lines of this family were uniform, super early in flowering, resistant to leaf rust, with good resistance to leaf spots and barley yellow dwarf virus, with their seeds harvested in bulk and taken for testing in the 'Preliminary Oat Test' of 2017, 2018 and during the years 2019, 2020 and 2021 it was tested in regional trials (Figure 1).

Development of URS POENTE

URS POENTE was developed by the Federal University of Rio Grande do Sul between 2013 and 2017, at the Agronomic Experimental Station of UFRGS (EEA/UFRGS). The cross was carried out at the University of Louisiana, having as parents the lines UFRGS 105064-1 (line from UFRGS) / SD 081085 (line from the University of South Dakota). 'QION 2013' was introduced at the Federal University of Rio Grande do Sul in 2013, when 'accession 211' received the experimental code 'Q211/2013'. The development of the line 'UFRGS 16Q6031' was carried out through the pedigree selection method, similarly the development of the line 16Q6010-1 above. In 2013, about 6 g of seeds of the F_3 population 'Q211/2013' were sowed in the experimental field, in two lines of 2 m in length, separated by 0.20 m. From this population, 6 (six) panicles were selected in the field, and after selection for the physical quality of the grains, there were 5 (five) panicles left, which gave rise to the family 'UFRGS 14Q4011' in 2014. In 2014, the F_4 family 'UFRGS 14Q4011' consisted of 5 (five) $F_{3:4}$ lines, called 'UFRGS 14Q4011-1' to 'UFRGS 14Q4011-5'. From the $F_{3:4}$ line 'UFRGS 14Q4011-2' 8 (eight) panicles were selected in the field, and 3 (three) were maintained after visual selection of grain, forming the family 'UFRGS 15Q5027' in 2015. In 2014, the line 'UFRGS 14Q4011-2' presented intermediate cycle, relative to other late populations evaluated together, excellent resistance to lodging, medium plant height and resistance to crown rust. In 2015, the $F_{3:5}$ family '15Q5027' consisted of 3 (three) lines, named '15Q5027-1' to '15Q5027-3'. The $F_{4:5}$ line '15Q5027-1' presented semi-prostrate habit, excellent agronomic type, late cycle, and resistance to crown rust. Of this line, in the field, 3 (three) panicles were selected, and only 1 (one) panicle was maintained, after visual selection of the grains, constituting the seeds of the family 'UFRGS 16Q6031' in 2016. In 2016, the $F_{5:6}$ family 'UFRGS 16Q6031' was formed by only 1 (one) line, receiving the same family name, i.e., 'UFRGS 16Q6031', which showed a late flowering cycle in 2016. Their seeds were harvested in bulk and taken for testing in the 'Preliminary Oat Test 12', 2017,2018 and it was tested in regional trails during the years 2019, 2020 e 2021.

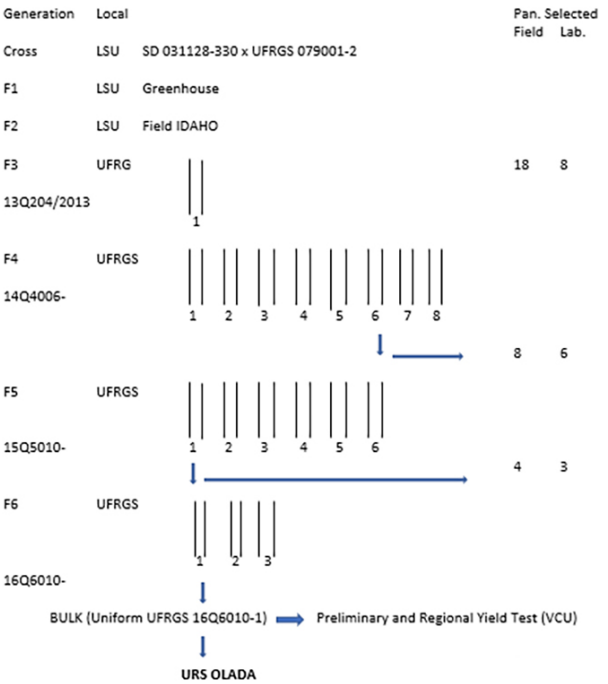

Figure 1. The pedigree method with locations and selection procedure for the development of the cultivar URS Olada.

The regional trails were planted from 6 to 8 locations each year with plots of 5 rows 5-meter longs spaced of 0.20 m with 3 to 4 replications with no application of fungicide. In all trials, URS OLADA and URS POENTE were compared with check cultivars that are important oat cultivars in the market. The T-test for paired observations (Steel and Torrie 1980) was used for comparing the mean of URS OLADA and URS POENTE with the check's cultivars.

RESULTS AND DISCUSSION

These two new oat cultivars are the most evident results of the free exchange of oat superior germplasm. The crosses were made at LSU University using two distant geographically and genetics parents, one from the oat breeding of South Dakota University program typically summer line and another from the UFRGS oat breeding typically of the Brazilian cultivars grown the winter-spring type. The F_2 generations was grown at IDAHO and F_3 seeds sent to Brazil where the selection was made for several years.

The two new oat cultivars had on average better yield than the checks cultivars when compared in different locations and years without any application of fungicide (Table 1, Figures 2 and 3) and they showed less variation than the checks among environment as shown at Figure 2 and Figure 3. This is an important characteristic of a success oat cultivar, because the enormous variation in temperature, rainfall, solar radiation, and number of days with frost, shown in the subtropical environments (Leite et al. 2012).

The two cultivars have an excellent test weight compared to URS Altiva the best cultivar for the trait in the Brazilian market (Nava et al. 2016). For the other traits as thousand kernel weight, plant height and lodging the new cultivars have no difference from the checks (Table 1).

For number of days from germination to flowering the two cultivars were different from the checks, URS OLADA was earlier with average 65 days and URS POENTE was latter with 83 days (Table 1). URS OLADA has more days from flowering to maturation than the checks cultivars and URS POENTE has a long cycle with on average 120 days from germination to maturation (Table 1). The succession of crops utilized by farmers in the subtropics require that for an oat cultivar to be successful it needs to perfectly fit the windows between two summers crops. Oat in the region is cultivated for grain production during the winter/spring seasons in no-tillage crop system as a pre-soybean crop and earliness is an important trait for fitting the oat cultivars to the length of the season disponible (Locatelli et al. 2007, Nava et al. 2016, Pacheco and Federizzi 2020). In the other hand there is a need for cultivars with longer cycle, since the soybean cultivars are more and more early with harvest as soon as February, so URS POENTE can be planted at end of April to first days of May and it would be harvested as the others oat cultivars at end October-November.

Table 1. Mean grain yield, test weight, thousand kernel weight, days from emergence to flowering, days from flowering to maturation, days from emergence to maturation, plant height, lodging and crown rust of oat cultivars grown in different environments (years and locations) of South Brazil

Nº Tr.	Cultivar	Yield	Test W	TKW	DEF	DFM	DEM	PH	Lodging	Crown rust
		kg ha^{-1}	kg hL^{-1}	g	days	days	days	cm	%	%
1	URS Brava (C)	2557	47.3	26.2 NS	77	37	110	114 NS	26 NS	71
2	URS Altiva (C)	2284	50.1	29.4	71	38	105	108	24	76
3	IPR Artemis (C)	3871	42.9	28.0	76	41	112	108	46	27
17	URS OLADA	4032 *	51.7&	28.2	65 **	50 **	112 a	115	26	8 **
20	URS POENTE	4159**	50.1#	27.0	83 **	39	120 **	110	29	7 **
number of environments		19	18	16	19	13	13	17	11	18

* Mean different by T-test from URS Brava and URS Altiva. ** Mean different by the T-test of all check cultivars & Mean different by T-test of URS Brava and IPR Artemis. # Mean different by T-test of IPR Artemis. NS: Not significantly different by T-test from URS Altiva.

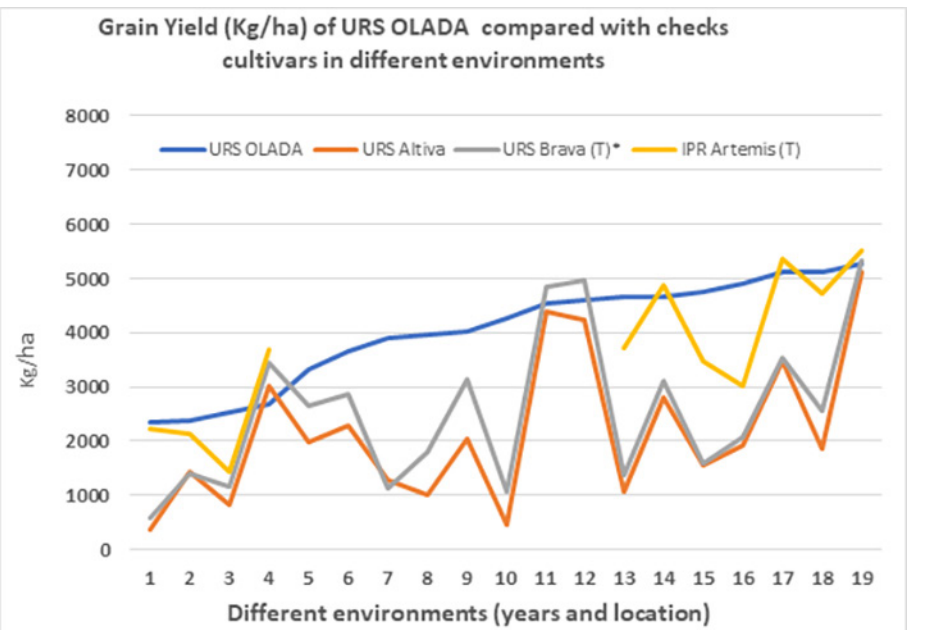

Figure 2. Grain yield of URS OLADA and the checks cultivars in different environment (years and locations).

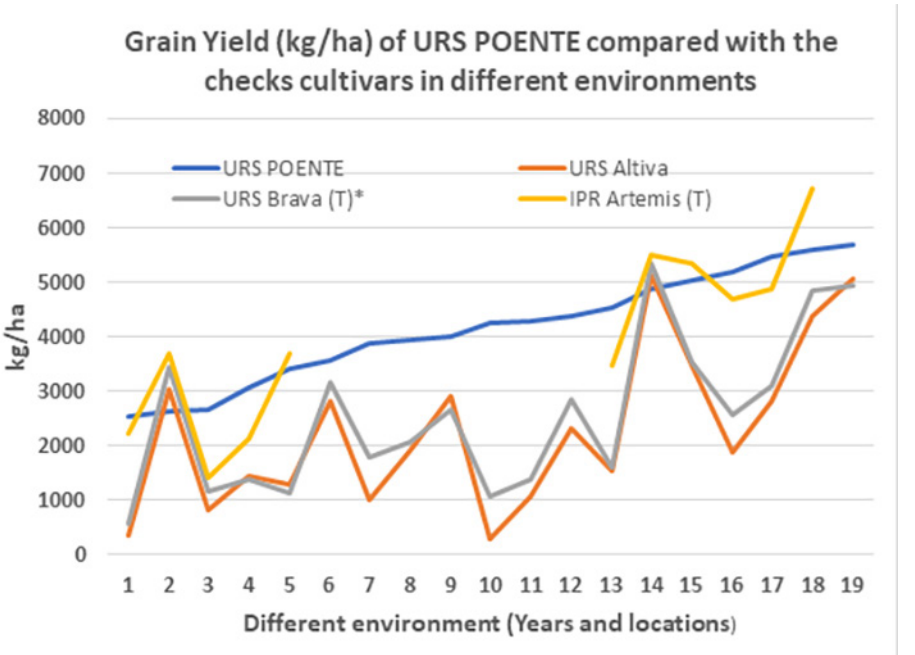

Figure 3. Grain yield of URS POENTE and the checks cultivars in different environment (years and locations).

The main and most destructive oat disease in Brazil, Argentina and Uruguay is crown rust, caused by *Puccinia coronate f. sp. avenae* Led. & Fraser (Leonard and Martinelli 2005). The devastating effects of disease was demonstrated by Lovatto et al. (2021) where every increase of 100 units in the crown rust AUDPC causes in average 3.2% reduction in grain yield and the final severity negatively correlated to all yield traits (Lovatto et al. 2021). In this respect, URS OLADA and URS POENTE represent two new sources of resistance genes to crown rust, and after 5 years of test they still given very low reading as compared the checks cultivars (Table 1).

The release of URS OLADA and URS POENTE as cultivars provides a new option for the farmers in the sub-tropical environments of Brazil beside the excellent grain yield, very good test weight, resistance to crown rust, very different cycle, they have excellent grain quality, very good dehulling, low grain breakage (less of 1%), and excellent milling yield (> 65%). The foundation seed will be produced by farmers in 2023.

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