

all environments). The grouped analysis of variance employed the mixed model (a fixed cultivar effect and randomized environment effect). Grain yield performance of the wheat cultivars was evaluated by analysis of adaptability and stability, employing the method of distance from the ideal cultivar, weighted by the coefficient 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 the ability to respond positively to improvement of favorable environments. The general average of STWC-RS in 2014 was 3,136 kg/ha. The experiment in São Borja had the highest average for wheat grain yield, 4,925 kg/ha. The maximum wheat grain yield was 5,780 kg/ha, in Coxilha (TBIO Sinuelo cultivar). The Ametista, TEC Vigore, LG Oro, TBIO Celebra, and Topazio cultivars had adaptability and stability in favorable environments (environments with average of wheat grain yield higher than the general average). The cultivars Ametista, Topazio, TBIO Sinuelo, LG Prisma, and LG Oro had adaptability and stability in unfavorable environments (environments with average of wheat grain yield lower than the general average). In general, averaged for all environments, cultivars Ametista (3,671 kg/ha), Topazio (3,522 kg/ha), TBIO Sinuelo (3,557 kg/ha), LG Oro (3,545 kg/ha), and LG Prisma (3,517 kg/ha) were the closest to the ideal cultivar.

#### Reference.

Carneiro PCS. 1998. New methodologies for analyzing the stability and adaptability of behavior. Ph.D. Thesis in Genetics and Breeding, Federal University of Viçosa. 168 pp.

### ***Wheat crop in the state of Rio Grande do Sul, Brazil, in 2014.***

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Rio Grande do Sul is one of the main wheat-producing states in Brazil. This study analyzed the wheat crop in Rio Grande do Sul in 2014. That year, Rio Grande do Sul harvested 1,180,817 ha of wheat (41.7% of the total area harvested in Brazil), producing 1,670,623 tons of wheat (26.7% of the Brazilian production), with an average of grain yield of 1,415 kg/ha (794 kg/ha above the Brazilian average of 2,209 kg/ha). Among the geographical mesoregions of Rio Grande do Sul (Fig. 1), the RS Northwest mesoregion harvested the largest wheat area, 937,231 ha (79.4% of the cropped area in the state) and had the largest production, 1,141,342 tons of grain (68.3% of state production) (Table 2). However, the average grain yield obtained in this mesoregion was the lowest of the state, 1,218 kg/ha (197 kg/ha below the state average) (Table 2). The RS Northeast mesoregion harvested 53,127 ha of wheat (4.5% of the cropped area in the state), produced 161,595 tons of wheat grain (9.7% of the state production), and had the highest grain yield average in the state, 3,042 kg/ha (1,627 kg/ha above the state average) (Table 2). The 2014 wheat crop in Rio Grande do Sul had unfavorable weather conditions, with average temperature above normal and an excess of rain in the spring. In Passo Fundo, in the Northwest mesoregion, for example, the total rainfall was 586.1 mm in the months of September, October and November. Consequently, the average wheat grain yield, in 2014, was very low in Rio Grande do Sul, especially in the Northwest mesoregion. Comparing the wheat crop data with the results

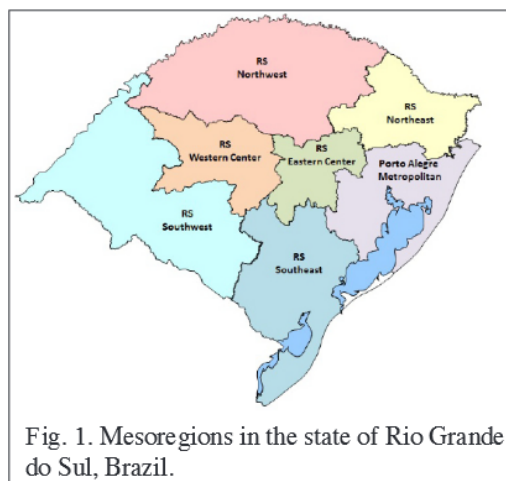


Fig. 1. Mesoregions in the state of Rio Grande do Sul, Brazil.

Table 2. Area harvested, production, and average of grain yield of wheat in each of the mesoregions (see Fig. 1) of the state of Rio Grande do Sul, Brazil, in 2014 (Source: IBGE. 2016).

Mesoregion	Area harvested		Production		Grain yield (kg/ha)
	ha	%	tons	%	
RS Northwest	937,231	79.4	1,141,342	68.3	1,218
RS Northeast	53,127	4.5	161,595	9.7	3,042
RS Western Center	97,782	8.3	160,689	9.6	1,643
RS Eastern Center	20,289	1.7	33,038	2.0	1,628
Porto Alegre Metropolitan	3,068	0.3	6,026	0.4	1,964
RS Southwest	55,050	4.6	136,990	8.2	2,488
RS Southeast	14,270	1.2	30,943	1.8	2,168
Rio Grande do Sul state	1,180,817	100.0	1,670,623	100.0	1,415

of the State Test of Wheat Cultivars in Rio Grande do Sul in 2014, we observed that the average grain yield of commercial crops was 1,721 kg/ha below the average of 3,136 kg/ha.

#### Reference.

IBGE. 2016. Sistema IBGE de Recuperação Automática – SIDRA. Available at: <<http://www.sidra.ibge.gov.br/bda/tab-ela/listabl.asp?z=t&o=11&i=P&c=1612>>. Accessed 28 March, 2016. Note: aggregate data studies and research carried out by the IBGE (In Portuguese).

## ITEMS FROM GERMANY

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### *Genome-wide association mapping of anther extrusion in hexaploid spring wheat.*

In a number of crop species, hybrids are able to outperform the conventionally bred varieties. The anthers of the autogamous bread wheat plant are normally extruded post anthesis, a trait that is unfavorable for the production of  $F_1$  hybrid grain. Higher anther extrusion (AE) promotes cross fertilization for higher hybrid seed production. Therefore, this study aims to genetically dissect the AE trait by genome-wide association mapping and determine the main effect QTL. The association mapping approach was used to identify DArT markers potentially linked to AE to unfold the genetic basis of AE in a panel of spring wheat cultivars. Phenotypic data were collected in field trials for three consecutive years (2013–15) and the best, linear, unbiased estimations (BLUEs) were calculated across all years. The extent of the AE correlation between growing years and BLUEs ranged from  $r = 0.56$  (2013 vs 2015) to 0.91 (2014 vs BLUEs). The level of repeatability was 0.95 for 2013 and 2014 and 0.97 for 2015. The broad sense heritability was 0.84 across all years. Six accessions displayed an AE >80%, and the trait was stable across the years. Genotyping data included 2,575 DArT markers (with minimum of 0.05 minor allele frequency applied) covering the A, B, and D genomes, unevenly, with 409 unmapped markers. Anther extrusion was influenced both by genotype and by the growing environment. In all, 131 significant marker trait associations (MTAs) ( $|\log_{10}(P)| \geq \text{FDR}$ ) were established for AE. Anther extrusion behaved as a quantitative trait, with each consistent MTA (across at least two years and BLUEs) contributing a minor to modest proportion (4.29% to 8.61%) of the overall phenotypic variance. The five consistently significant MTAs mapped to chromosomes 5A, 5B, and 6A. The association mapping analysis showed that AE is controlled by many genetic loci, which can affect the trait both positively or negatively. For that reason, gene pyramiding may have potential for breeding for improved AE. The highly significant markers linked to AE could be helpful for marker-assisted selection to transfer AE to high-yielding cultivars, allowing the exploitation of hybrid heterosis in the key crop wheat.