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Adaptability and Stability of Yield and Industrial Grain Quality with and without Fungicide in Brazilian Oat Cultivars

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Abstract

The use of productive cultivars with adaptability and stability and less demanding to fungicide use are critical to the sustainability of production factors. The objective of this work was to determine the *per se* performance of white oat cultivars and parameters of adaptability and stability on yield and grain quality in the proposition of cultivars more responsive in reducing the use fungicide. The study was conducted in Augusto Pestana, RS, Brazil, between the years 2010 and 2013. The experimental design was randomized blocks with six replicates, three with and three without fungicide. The study evaluated 14 white oat cultivars for yield and industrial capability. The white oat cultivars FAEM 4 Carlasul and URS Corona indicate high grain yield with stability and general adaptability, independent of chemical control. The cultivar URS Corona shows together high yield and thousand grain weight and hectoliter with general adaptability and stability in the absence of fungicide. Although no stability has been detected in industrial yield without the use of fungicides, cultivars of URS Charrua, URS Corona and URS Taura show high means with general adaptability.

Keywords

***Avena sativa* L., Grain Quality, Fungicide, Climatic Variations**

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1. Introduction

The white oat (*Avena sativa* L.) is a species of cool season multipurpose. It's used in succession and rotation of crops breaking the cycle of pests and diseases and excellent ground cover to the till system [1] [2], and in addition, to the animals providing feed, hay, silage and forage of quality [2] [3]. For human consumption, the grains stand out as a functional food rich in protein and fiber. Among these, the dietary fiber beta glucan assists in lowering cholesterol LDL [4] [5].

The inclusion of oats in the diet has grown tremendously in recent years due to more demanding population and seeking more nutritious and healthy foods [6] [7]. On the other hand, oat consumption is based product "in natura" that after peeling is directed production bran, flour or flakes, implying greater care in the production process, especially in the use of agrochemicals to control fungal diseases.

The pattern of targeted oat requires high grain yield cultivars with technological standards desired by industry. Therefore, the high percentage of caryopsis, the high weight of hectoliter and the grain size have been increasingly required [6]-[8]. These characteristics are not always obtained due to climatic factors and the prevalence of fungal diseases [9] [10]. Among the diseases, leaf rust (*Puccinia coronata* C da. f. sp. *avenae*) and helminthosporiosis [*Drechslera avenae* (Eidam) El Sharif] have received special attention [11] [12].

Reference [13] reported that diseases are not satisfactorily controlled by resistant cultivars, because the resistance level is not long lasting and sufficient to reduce the damage. Thus, besides genetic resistance, the use of fungicides show the fastest and most efficient measure in disease control, improving the yield and grain quality [12]-[14]. These conditions justify an unsustainable model of agriculture, because of increasing production costs and the contamination of the products [12]-[15].

Sensitivity to environmental conditions and susceptibility to foliar diseases may be associated with large variability of edaphoclimatic conditions in Brazil and the indication of cultivars of reduced adaptability and stability to different microclimates [16] [17]. In modern agriculture, the recommendation of cultivars with high grain yield and with stability to climatic variations is decisive, by taking advantage of improved environments or that showing adequate performance under adverse conditions [6]-[18]. Like this, the identification of genotypes of oats of high performance in characters of agronomic interest and industry, less demanding the use of fungicide and with adaptability and stability, may favor a more sustainable production of oat cultivation.

The objective of this work was to determine the *per se* performance of white oat cultivars and parameters of adaptability and stability on yield and grain quality in the proposition of cultivars more responsive in reducing the use fungicide.

2. Materials and Methods

The work was developed between the years 2010 to 2013 in the municipality of Augusto Pestana, RS, Brazil (28˚26'30" South latitude and 54˚00'58" West longitude). The soil of the area is classified as Oxisol Distroferric Typical and the climate, according to Köppen classification, is Cfa, with hot summer without a dry season. In the study, ten days before the sowing, was performed soil analysis and identified the following chemical characteristics of the local: pH = 6.2; P = 33.9 $mg \cdot dm^{-3}$; K = 200 $mg \cdot dm^{-3}$, Organic Matter = 3.4%; Al = 0.0 $cmol_c \cdot dm^{-3}$; Ca = 6.5 $cmol_c \cdot dm^{-3}$ and Mg = 2.5 $cmol_c \cdot dm^{-3}$. The sowings were performed in the second fortnight of May with seeder-fertilizer, where each parcel was formed of 5 lines of 5 m in length and line spacing of 0.20 m to compose the experimental unit of 5 m^2. The density population used was determined in accordance with the technical indications of the culture, being of 300 viable seeds per square meter. In the experiments was applied at seeding 10, 60 and 50 $kg \cdot ha^{-1}$ of NPK, on the basis of the levels of these elements in the soil for grain yield expectation of 3 $t \cdot ha^{-1}$. The remaining nitrogen to the desired income expectancy was applied in coverage when the plants were in the stadium of fourth leaf visible.

The experiments were conducted in experimental design of randomized blocks with six repetitions, being three without fungicide and three with fungicide for the control the leaf rust and leaf spot. In condition with fungicide, three applications were made: at the end of the stretching, in flowering and in grain filling. These conditions represent the most common application of fungicides in crops of oats of Brazil. It was used fungicide of tebuconazole active ingredient (commercial name FOLICUR 200 EC®) at a dose of 0.75 $L \cdot ha^{-1}$.

In the study were evaluated the 14 major white oat cultivars recommended for growing in Brazil, being they: Barbarasul, Brisasul, FAEM 4 Carlasul, FAEM 5 Chiarasul, URS 21, URS Guapa, URS Tarimba, URS Taura, URS Guria, URS Charrua, URS Torena, URS Corona, IAC 7 and UPFA Gaudéria. These cultivars have high grain yield with good quality industrial, besides the traits presented in **Table 1**. Were analyzed the following characters of agronomic interest and industry: 1) Grain yield (GY, kg·ha^{-1}): estimated from the grain mass from the harvest of the three central rows of each plot; 2) Thousand grain weight: (TGW, g): by the count of 250 grain and weighing in balance of accuracy and multiplied by four; 3) Weight of hectoliter (WH, kg·hL^{-1}): estimated by the ratio of grain weight on a volume of known cube 250 cm^{-3}; 4) Number of Grains bigger than 2 mm (Grains > 2 mm, n): a sample of 100 grains were placed on a sieve with a mesh of 2 mm for the analysis of major and minor grains which this dimension; 5) Grain weight (GW, g): obtained by weighing 50 grains that were above 2 mm sieve; 6) Weight of caryopsis (WC, g): removal of the bark of 50 grains larger than 2 mm and weighing of caryopses; 7) Husking index (HI, g·g^{-1}): relationship obtained between the weight of caryopses and grain weight of 50 grains of a thickness greater than 2 mm (HI = WC/WG); 8) Industrial grain yield (IGY, kg·ha^{-1}): is the product obtained from the grain yield, number of grains bigger than 2 mm and the husking index (IGY = GY × Grain > 2 mm × HI).

To meet the assumptions of homogeneity and normality via *Bartlett* and *Lilliefors* tests, the data were submitted to variance analysis for detection of main effects and interaction of the sources of variation genotype and year in the presence and absence of fungicide. The comparison of means was performed by clustering method by [19]:

$$\lambda = \frac{\pi B_0}{2(\pi - 2)\hat{\sigma}_0^2}$$

where:

B_0 = maximum value of the sum of squares between groups;

$\hat{\sigma}_0^2$ = variance obtained through.

$$\hat{\sigma}_0^2 = \frac{1}{g+v}\left[\sum_{i=1}^{g}\left(\bar{Y}_i - \bar{Y}\right)^2 + v s_{\bar{y}}^2\right]$$

where:

Table 1. Main agronomic traits of the oat cultivars present in study.

Genotype	Main traits			
	Cycle	Stature	Lodging	Leaf rust
Barbarasul	Early	Short	MR	MS
Brisasul	Medium	Short	MR	MR
FAEM 4 Carlasul	Medium	Medium	MR	MR
FAEM 5 Chiarasul	Medium	Medium	MR	MR
IAC 7	Early	High	-	S
UPFA Gaudéria	Medium	High	MS	MS
URS 21	Early	High	S	MR
URS Charrua	Early	very High	MS	R
URS Corona	Medium	High	MS	R
URS Guapa	Early	Medium	MS	S
URS Guria	Early	High	S	S
URS Tarimba	Early	Medium	MS	MS
URS Taura	Early	Short	R	S
URS Torena	Medium	Medium	S	MS

MR = moderately resistant; MS = moderately susceptible; R = resistant; S = susceptible.

$\overline{Y}_i$ = the average treatment "*i*" ($i = 1, 2, \cdots, g$);

$\overline{Y}$ = overall average of treatments to be separated;

g = number of averages to be separated;

v = number of degrees of freedom of the residue;

$s_{\bar{y}}^2 = \frac{QMR}{r}$, being *QMR* = mean square of the residue and "*r*" the number of observations.

The decision rule to establish groups:

If $\lambda < \chi^2_{(\alpha, vo)}$, the averages are homogeneous;

If $\lambda \geq \chi^2_{(\alpha, vo)}$, medium groups differ significantly.

The estimation of the parameters of adaptability and stability by [20]. Based on linear regression, the regression coefficients of phenotypic values of each genotype were estimated from an environmental index, generating estimates of parameters of adaptability and stability by the equation:

$$Y_{ij} = \beta_{oi} + \beta_{1i} I_j + \delta_{ij} + \overline{\varepsilon}_{ij}$$

where:

Y_{ij} is the means of genotype *i* at environment *j*;

β_{oi}: overall means genotype *i*;

β_{1i}: linear regression coefficient which measures the response of the genotype to variation of the environment;

I_j: environmental index coded $\left(\sum_j I_j = 0\right)$;

δ_{ij}: deviations from regression;

$\overline{\varepsilon}_{ij}$: means experimental error.

A cultivar is stable when $\delta_{ij} = 0$ and unstable when $\delta_{ij} \neq 0$. According to this methodology, adaptability is the ability of genotypes in certain condition take advantage of advantageously the environmental stimulus. For a cultivar highlight wide adaptability, it follows that $\beta_{1i} = 1$; and adapted to favorable environments when $\beta_{1i} > 1$; and adapted to unfavorable environments when $\beta_{1i} < 1$. Adaptability and stability of genotypes was measured by parameters general means, linear regression coefficient and deviations from the regression. The hypothesis that regression coefficient does not differ from one was evaluated by the test *t*, and the hypothesis that the deviations from regression of each cultivar does not differ from zero was analyzed by the test *F*. All analyses were carried out with the aid of computational GENES program.

3. Results and Discussion

In **Table 2**, the summary of the analysis of variance shows genetic differences among the oat cultivars and the presence of interaction genotype x year on characters of agronomic interest and industrial quality, regardless of the condition with or without chemical control. The values of mean square for the year of cultivation were superior in the scenario with and without fungicide in the expression of grain yield, weight of hectoliter and industrial yield, signaling greater contribution of amendment.

The thousand grain weight in the absence of fungicide conditioned to a greater participation of genotypic effects, indicating effective genetic differences the possibility of identification of cultivars more responsive the reduction of chemical control. The means values observed in the different scenarios show that in the presence of fungicide, general means of the variables analyzed were superior, indicating the strong action of foliar diseases on productivity and industrial quality of oat grains in the absence of fungicide (**Table 2**).

Studying the culture of white oats, researchers have been observing effects pronounced of genotype x environment interaction, concluding that the year of cultivation is the principal factor contributing to the instability of production [6] [21] [22]. Therefore, in addition to the performance *per se*, the understanding of the effects of the interaction genotype *versus* environment becomes necessary [6]-[23]. An efficient analysis in describing this interaction requires more adjusted models in defining cultivars for recommendation [5]-[24]. The analysis of adaptability and stability detail the effects of this interaction enabling define predictable and responsive behavior cultivars to environmental variations [6]-[17].

In **Table 3**, adaptability and stability, means values (β_{0i}) expressive in grain yield without fungicide were

Table 2. Summary of the analysis of variance for oat cultivars in different years of cultivation with and without fungicide application.

Source of variation	DF	Mean Square/without Fungicide			
		GY	TGW	WH	IGY
		(kg·ha^{-1})	(g)	(kg·hL^{-1})	(kg·ha^{-1})
Block	2	343,621*	14.81	24.11	144,180*
Genotype (G)	13	1,520,636*	76.33*	39.43*	615,963*
Year (Y)	3	13,482,567*	5.93	1424.26*	3,704,306*
G × Y	39	326,740*	18.36*	19.12*	174,971*
Error	110	89,700	4.75	4.11	28,956
Total	167	-	-	-	-
Mean	-	2364	30.23	43.91	839
CV (%)	-	12.66	7.21	4.61	20.27
Source of variation	DF	Mean Square/with Fungicide			
		GY	TGW	WH	IGY
		(kg ha^{-1})	(g)	(kg hL^{-1})	(kg ha^{-1})
Block	2	320,892	0.10	12.61	152,493
Genotype (G)	13	1,404,390*	100.71*	22.83*	937,241*
Year (Y)	3	21,900,706*	160.05*	1184.51*	12,285,703*
G × Y	39	280,843*	11.78*	10.61*	161,292*
Error	110	103,034	3.83	6.04	44,210
Total	167	-	-	-	-
Mean	-	3111	33.23	47.64	1351
CV (%)	-	10.31	5.89	5.15	15.55

*Significant at 5% level of probability error; DF = degrees of freedom; GY = grain yield; TGW = thousand grain weight; WH = weight of hectoliter; IGY = industrial grain yield.

Table 3. Mean values and parameters of adaptability and stability in oat cultivars with and without fungicide on grain yield and thousand grain weight.

Genotype	Without Fungicide				With Fungicide			
	β_{0i}	β_{1i}	δ_{ij}	R^2	β_{0i}	β_{1i}	δ_{ij}	R^2
	Grain yield (kg·ha^{-1})							
Barbarasul	2406 b	0.71^{ns}	−10256^{ns}	0.92	3053 b	1.11^{ns}	−4336^{ns}	0.97
Brisasul	2481 b	0.96^{ns}	148,973*	0.71	3529 a	1.04^{ns}	60,575^{ns}	0.90
FAEM 4 Carlasul	2666 a	1.19^{ns}	−12984^{ns}	0.98	3615 a	0.85^{ns}	25,304^{ns}	0.91
FAEM 5 Chiarasul	2683 a	1.43*	280,632*	0.76	3141 b	0.77^{ns}	−22,486^{ns}	0.98
IAC 7	1602 c	1.01^{ns}	−17,652^{ns}	0.98	2375 d	1.43*	18,294^{ns}	0.97
UPFA Gaudéria	2568 b	1.27^{ns}	−28,927^{ns}	0.99	3072 b	1.05^{ns}	−31,017^{ns}	0.99
URS 21	2461 b	1.13^{ns}	−9477^{ns}	0.97	2935 c	0.65*	17,659^{ns}	0.87

Continued

URS Charrua	2754 a	0.62*	−21,872^{ns}	0.96	3160 b	0.65*	4461^{ns}	0.81
URS Corona	2710 a	0.71^{ns}	56,946^{ns}	0.74	3573 a	0.85^{ns}	48,725^{ns}	0.87
URS Guapa	1875 c	1.75*	41,082^{ns}	0.95	2729 c	1.22^{ns}	85,761*	0.91
URS Guria	2420 b	0.53*	34,675^{ns}	0.68	3072 b	0.57*	−22,699^{ns}	0.96
URS Tarimba	1966 c	0.89^{ns}	260,537*	0.57	3190 b	1.25^{ns}	104,567*	0.90
URS Taura	2482 b	1.21^{ns}	181,107*	0.77	3317 b	1.51*	178,964*	0.89
URS Torena	2015 c	0.55*	−1853^{ns}	0.84	2791 c	0.99^{ns}	−21,977^{ns}	0.98
Thousand grain weight (g)								
Barbarasul	25 d	1.94^{ns}	2.346^{ns}	0.66	28 e	1.13^{ns}	12.101*	0.65
Brisasul	28 c	5.85*	−1.131^{ns}	0.94	29 e	1.58^{ns}	0.173^{ns}	0.91
FAEM 4 Carlasul	30 c	−1.47^{ns}	1.494^{ns}	0.63	32 c	1.59^{ns}	1.163^{ns}	0.86
FAEM 5 Chiarasul	31 b	1.99^{ns}	−1.259^{ns}	0.72	32 c	0.32*	0.325^{ns}	0.67
IAC 7	27 d	6.06*	0.604^{ns}	0.78	30 d	1.85*	−0.503^{ns}	0.96
UPFA Gaudéria	31 b	0.19^{ns}	13.394*	0.50	35 b	0.61^{ns}	−0.871^{ns}	0.84
URS 21	28 c	−1.25^{ns}	−1.501^{ns}	0.80	31 d	1.02^{ns}	3.277*	0.67
URS Charrua	34 a	4.01^{ns}	1.808^{ns}	0.67	36 b	0.62^{ns}	3.811*	0.72
URS Corona	33 a	4.92*	14.344*	0.71	36 b	0.29*	1.711^{ns}	0.64
URS Guapa	29 c	−3.55*	−0.374^{ns}	0.68	35 b	1.54^{ns}	0.046^{ns}	0.91
URS Guria	28 c	0.31^{ns}	5.805*	0.77	31 c	0.21*	3.281*	0.65
URS Tarimba	29 c	−3.94*	2.673^{ns}	0.64	32 c	1.74*	0.114^{ns}	0.92
URS Taura	29 c	−6.01*	15.521*	0.71	33 c	−0.08*	1.525^{ns}	0.69
URS Torena	33 a	4.94*	1.501^{ns}	0.63	38 a	1.53^{ns}	0.496^{ns}	0.88

Means followed by the same letter do not differ significantly at 5% probability of error; * = significant at 5% probability by F test; ^{ns} = not significant; β_{0i} = overall mean genotype *i*; β_{1i} = Linear regression coefficient; δ_{ij} = regression deviations; R^2 = coefficient of determination.

obtained by cultivars FAEM 4 Carlasul, FAEM 5 Chiarasul, URS Charrua and URS Corona. In these cultivars, in addition to high performance *per se*, was obtained general adaptability with stability in cultivars FAEM 4 Carlasul and URS Corona. Also stands out the genotype URS Charrua, which shows high means values with stability and adaptability to specific unfavorable environments ($\beta_{1i} < 1$).

On application of fungicide (**Table 3**), the higher means values of grain yield were obtained by cultivars Brisasul, FAEM 4 Carlasul and URS Corona. These cultivars indicated also general adaptability with stability, characterized as qualified genotypes the recommendation in this scenario. Furthermore, the FAEM 4 Carlasul and URS Corona independent of use the fungicide, also presented high means with general adaptability and stability, standing out as ideal genotypes as recommended by the model. The model of [20] has been widely used in cereals, because, the adaptability and stability parameters by linear regression are more informative [6] [17] [21] [23]. Highlights that the grain yield due to the complex genetic control is usually the focus of the analysis of the interaction genotype *versus* environment [25] [26].

Reference [27] identified in oats favorable effect of greater stability of genotypes with the use of fungicide on the yield of grain. In this study, the use of fungicide is not increased the number of genotypes with stability, reinforcing the largest genetic stability of the current cultivars in different conditions of chemical control. Important to strengthen that studies with greater detail on the effects of the adaptability and stability in oats in the presence and absence of fungicide on the characters of industrial grain quality has not been found, highlighting the importance of this study about the research developed in this species.

In **Table 3**, the greatest expression of the thousand grains weight in the environment without fungicide highlighted the cultivars URS Charrua, URS Corona and URS Torena. The URS Charrua is characterized as an ideal genotype, of high performance *per se*, broad adaptability and stability. The URS Corona and URS Torena they showed specific adaptability to favorable environment ($\beta_{1i} > 1$), however, the URS Corona of unstable behavior differed from URS Torena which showed stability. In the analysis of the thousand grains weight in the presence of fungicide (**Table 3**), to cultivar URS Torena was the only that showed high mean value associated with the general adaptability and stability. Therefore, condition that qualifies as genotype higher expression of favorable alleles the grain filling in the presence of fungicide. On the other hand, the URS Corona even in group "b" highlighted specific adaptability the unfavorable environments with stability. Reference [28] highlights the importance of analyzing the thousand grain weight due to its high effect on the yield and quality of grain. In wheat, indirect effect and positive the thousand grain weight on the productivity of grain was also observed [22]. It is noteworthy that the thousand grains weight is a component linked to production in oats which shows the greatest damage by foliar diseases [9].

In weight of hectoliter (**Table 4**) most of the cultivars in the absence of fungicide showed high values with general adaptability. However, only cultivars FAEM 4 Carlasul, FAEM 5 Chiarasul, URS Charrua and URS

Table 4. Mean values and parameters of adaptability and stability in oat cultivars with and without fungicide on the weight of hectoliter and the industrial grain yield.

Genotype	Without Fungicide				With Fungicide			
	β_{0i}	β_{1i}	δ_{ij}	R^2	β_{0i}	β_{1i}	δ_{ij}	R^2
				Weight of hectoliter (kg·hL^{-1})				
Barbarasul	42 b	0.92^{ns}	0.768^{ns}	0.95	46 b	0.89^{ns}	-1.051^{ns}	0.97
Brisasul	42 b	0.79^{ns}	4.447^{*}	0.85	46 b	1.22^{ns}	1.215^{ns}	0.95
FAEM 4 Carlasul	44 a	1.08^{ns}	2.001^{ns}	0.95	47 b	1.08^{ns}	5.006^{*}	0.88
FAEM 5 Chiarasul	45 a	0.92^{ns}	2.379^{ns}	0.92	47 b	0.87^{ns}	1.896^{ns}	0.89
IAC 7	43 a	0.84^{ns}	4.339^{*}	0.87	47 b	1.06^{ns}	4.612^{*}	0.88
UPFA Gaudéria	45 a	1.18^{ns}	9.324^{*}	0.87	48 a	0.93^{ns}	6.139^{*}	0.82
URS 21	44 a	1.04^{ns}	4.099^{*}	0.91	48 a	0.97^{ns}	-0.966^{ns}	0.97
URS Charrua	45 a	0.91^{ns}	-1.253^{ns}	0.99	47 b	0.99^{ns}	0.041^{ns}	0.95
URS Corona	46 a	0.85^{ns}	7.781^{*}	0.80	47 b	0.85^{ns}	-0.063^{ns}	0.94
URS Guapa	39 c	1.34^{*}	30.489^{*}	0.74	45 b	0.96^{ns}	3.281^{ns}	0.88
URS Guria	44 a	0.96^{ns}	2.402^{ns}	0.93	48 a	1.14^{ns}	-1.916^{ns}	0.99
URS Tarimba	43 b	1.27^{*}	3.981^{*}	0.94	49 a	0.89^{ns}	5.688^{*}	0.81
URS Taura	44 a	1.06^{ns}	10.662^{*}	0.83	50 a	1.41^{*}	-1.544^{ns}	0.99
URS Torena	41 b	0.77^{*}	3.391^{*}	0.87	46 b	0.68^{*}	0.852^{ns}	0.87
				Industrial grain yield (kg·ha^{-1})				
Barbarasul	689 c	0.29^{*}	$47,220^{*}$	0.67	1246 c	0.66^{*}	$61,237^{*}$	0.72
Brisasul	691 c	0.16^{*}	4667^{ns}	0.69	1361 c	1.41^{*}	$29,831^{ns}$	0.95
FAEM 4 Carlasul	818 c	1.01^{ns}	3245^{ns}	0.91	1417 b	0.75^{ns}	$150,588^{*}$	0.64
FAEM 5 Chiarasul	891 b	1.26^{ns}	$110,584^{*}$	0.64	1191 c	0.91^{ns}	5941^{ns}	0.95
IAC 7	381 d	0.72^{ns}	-2872^{ns}	0.91	729 d	1.15^{ns}	$29,499^{ns}$	0.93
UPFA Gaudéria	986 b	1.64^{*}	$39,116^{*}$	0.88	1522 b	0.9^{ns}	$-14,673^{ns}$	0.99
URS 21	685 c	1.12^{ns}	-8799^{ns}	0.99	1139 c	0.87^{ns}	$-10,344^{ns}$	0.99
URS Charrua	1196 a	1.27^{ns}	$38,779^{*}$	0.82	1501 b	0.62^{*}	4917^{ns}	0.90
URS Corona	1125 a	0.75^{ns}	$79,926^{*}$	0.66	1822 a	1.04^{ns}	$48,017^{*}$	0.88
URS Guapa	813 c	1.81^{*}	8341^{ns}	0.96	1299 c	1.09^{ns}	$51,618^{*}$	0.89
URS Guria	694 c	0.66^{ns}	-8271^{ns}	0.98	1217 c	0.86^{ns}	8011^{ns}	0.94
URS Tarimba	660 c	0.94^{ns}	$45,197^{*}$	0.68	1137 c	1.02^{ns}	$13,840^{ns}$	0.94
URS Taura	1111 a	1.86^{*}	$103,405^{*}$	0.80	1685 a	1.64^{*}	1509^{ns}	0.99
URS Torena	1004 b	0.41^{*}	$30,287^{*}$	0.66	1654 a	1.01^{*}	$26,396^{ns}$	0.91

Means followed by the same letter do not differ significantly at 5% probability of error; * = significant at 5% probability by F test; ^{ns} = not significant; β_{0i} = overall mean genotype *i*; β_{1i} = Linear regression coefficient; δ_{ij} = regression deviations; R^2 = coefficient of determination.

Guria indicated stability. Provided with fungicide, the UPFA Gaudéria, URS 21, URS Guria, URS Tarimba and URS Taura highlighted values of greater magnitude. Among these, all with general adaptability, except the URS Taura that proved to be adjusted to favorable environments. It should be noted in this scenario, mean high in trait combined with general adaptability with stability obtained only by cultivar URS 21. Genetic and environmental differences are observed in the expression of the weight of hectolitre and grain. The grain weight by genotype and the weight of hectoliter by year of cultivation are the sources of variation that promote the biggest changes [22]. High temperatures increase the respiration rate and when combined with drought stress or excessive rainfall next the maturation, significantly reduce the weight of hectoliter [29] [30]. Furthermore, similar to the thousand grains weight, the weight of hectoliter in oats also shows the further damage by foliar diseases [9]. These damages are awarded by the reduction of area photosynthetic active and interference in translocation of photoassimilates from the leaves to the grains, consequently, lower deposition of reserves and reducing the commercial value of the final product [31].

In the industrial yield of grain (**Table 4**), the absence of fungicide excelled the cultivars URS Charrua, URS Corona and URS Taura the high performance *per se*. Both the URS Charrua as URS Corona showed general adaptability and the URS Taura, specific adaptability the favorable environments, although, none have shown stability. The genotype FAEM 4 Carlasul in the third group of performance ("c") indicated general adaptability with stability. Provided with fungicide (**Table 4**), all genotypes tested showed industrial output exceeding 1 $t \cdot ha^{-1}$, except to cultivar IAC 7. In this condition, the cultivars URS Corona, URS Taura and URS Torena obtained the most expressive values. Among these, the URS Torena showed high means values with general adaptability and stability. And even the URS Corona having evidenced expression instability, counts with ample adaptability, opposite of URS Taura, of stability and adaptability specifies the favorable environments.

In a globalized market achieve self-sufficiency and competitiveness of Brazilian oat is decisive. Soon, climate change on the planet have provided a new challenge in global agricultural production, as well as obtaining more productive cultivars, they are more resistant to disease and tolerant to environmental stresses, require greater adaptation and stability in agricultural crops [32]. However, the growing demand for higher quality oats industry processing and more nutritious and healthy consumption has been increasingly required [6], justifying the need for reduction in the use of agrochemicals to control foliar diseases [15]. The results of this research show the importance of understanding the effects the unfolding of the interaction genotype *versus* environment on yield and industrial quality of oat grains in the absence and presence of fungicide, highlighting this determination about the new elite genotypes for commercial launch and optimize the recommendation of cultivars for producers of oats in Brazil.

4. Conclusions

The white oat cultivars FAEM 4 Carlasul and URS Corona indicate high grain yield with stability and general adaptability, independent of chemical control.

The cultivar URS Charrua together shows high yield and thousand grain weight and weight of hectoliter with general adaptability and stability in the absence of fungicide.

Although no stability has been detected in industrial yield without the use of fungicides, cultivars URS Charrua, URS Corona and URS Taura show high means with general adaptability.

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