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Physical and physiological attributes of black oat seeds produced in southern Brazil

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Black oat crop occupies the largest area during winter. It is important for animal production, crop rotation and dry matter production of approximately 3.8 million hectares in Rio Grande do Sul State. To ensure sowing, seeds are produced which must have high quality standards and must be evaluated by seed testing laboratories. Given this, the present study evaluated the physical and physiological quality of oat seeds analyzed by the Seed Analysis Laboratory of UNIJUI from 2006 to 2014. 2,910 samples were evaluated; 2,229 were evaluated with seed production process; 357 were evaluated with seed analysis of own use and 324 were evaluated with tetrazolium analysis. The samples obtained through seed production process were analyzed in terms of their physical and physiological aspects, while the own seed and tetrazolium test used were evaluated only in terms of their physiological attributes, following the methodology described in the Seed Analysis Rules. The data were analyzed through descriptive statistics for each variable studied per year, and the averages, maximum and minimum standard deviation and coefficient of variation were identified. The data were also evaluated based on their dispersion, and compared to weather occurrences and national standards, in order to estimate the percentages of samples approved. Seeds produced according to the National Seed system had high levels of physical and physiological quality from 2006 to 2010. However, between 2011 and 2014, 14.0 and 14.5% of the samples were above the standard levels for seeds of other cultivated species and harmful prohibited species respectively. The own used seeds showed greater variability and dispersion, with 18.1 and 31.7% samples below the standards for germination in the years 2006 to 2010 and 2011 to 2014, respectively, while the samples analyzed through the tetrazolium test showed approved levels of 19.4 and 12.5%, respectively. The major physiological qualities were obtained in 2008, 2010 and 2011 and the lowest in 2009, 2012 and 2014. It is noteworthy that the seed quality is related to years with levels of rainfall and appropriate temperatures for vegetative development, physiological maturity and harvest.

Key words: *Avena strigosa* (Schreb.), purity, germination, tetrazolium.

INTRODUCTION

The use of seeds with high genetic, physical, physiological and health quality constitutes a decisive element for the implementation of crops with the potential to maximize the cultivars' performance. The seeds have a great deal of responsibility for agricultural development in normal times as well as for its recovery after the occurrence of shocking events such as droughts, floods and epidemics (Oliveira et al., 2013; Carvalho and Nakagawa, 2012; Peske et al., 2006).

Livestock production in the Northwest Region of Rio Grande do Sul was stimulated by the introduction of forage species, due to the wheat and soybean binomial crisis in the 70s and 80s. From this introduction, research that enabled the domain of seeds production technology was performed (Medeiros, 1976, 1987; Souza et al., 1992).

The knowledge generated led to the increase in seed production, either by producers, cooperatives or companies. The planting of introduced cultivars seeds remained for decades, thanks to natural selection processes and exchange of seeds between regions. This enabled natural crossings, causing the genetic basis of cultivated species such as annual ryegrass (*Lolium multiflorum* Lam.), oat (*Avena strigosa* Schreb.), white clover (*Trifolium repens* L.), red clover (*Trifolium pratense* L.), vetch (*Vicia* spp.), birdsfoot trefoil (*Lotus corniculatus* L.) and alfalfa (*Medicago sativa* L.) (Maia, 2013).

Currently, forage cultivation is the basis for feeding dairy and plays an important role in the development of this activity in RS Northwest Region. According to Agricultural Census of 2006, there were 204,000 establishments producing 2.7 billion liters of milk annually in the RS, and the North-west Region accounted for over 60% of production (Trennepohl, 2011). Currently, the state produces four billion liters of milk per year, the second Brazilian state production (Mello, 2013).

For a long period, there was great informality in the forage species seed sector, with few cultivars suitable for cultivation and multiplication (Pereira, 2013). This condition has been changing in recent years with greater organization and formalization of this industry, from the approval and implementation of national seed and seedling system (Brazil, 2003).

Among the cultivated species, oat occupies a prominent place in the state of Rio Grande do Sul. According to Del Duca et al. (2004), it is the species that has been occupying the largest growing area in winter, with an area estimated at 3,850,000 ha in 2013/14 crop (Abrasem, 2014). The recommended seeding rate ranges from 30 to 60 kg ha^{-1} (Flaresso et al., 2001; Debiasi et al., 2007), which can generate an effective demand for seeds to 231,000 tons (Abrasem, 2014).

The oat is a species of temperate climate, is rustic and resistant to small droughts; it has excellent ability of tillering, green mass production, is tolerant to animal trampling, and resistant to pests and diseases. With the evolution of tillage, crop rotation and training straw were used, with benefits to the successor species (Carvalho et al., 2010; BortolinI et al., 2000).

In support of seed production system, studies have been carried out to assess the physical and physiological quality in order to clarify the standards presented by the seeds produced. Nakagawa et al. (2004) showed that seed oats originating from soil with lower fertility had less storage capacity, especially in natural laboratory environment with zero percent germination after 48 months. The seeds produced in the most fertile soil germinated above 90% at 60 months, when stored in air-conditioned environments and greater storage capacity was enhanced in less favorable storage conditions.

Work performed by Fonseca et al. (1999) showed that only 47% of ryegrass seed samples showed standards of purity and germination according to the RS standards; 81% had standards for germination and 54% met the physical standards of purity.

Study on ryegrass seeds carried out in 2005 to 2007, in the state of Paraná showed that in the harvests of 2005 and 2006 most of the samples of pure seed had 86 to 96% below the National Standard, which is 97%. In 2007, 100% of the samples of Italian ryegrass were within the standard (Ohlson et al., 2008).

The same study showed in the germination test, that 46% of the samples had lower germination percentage than the standard in 2005 and 64% of the samples of Italian ryegrass had lower germination percentage than the standard in 2006. In 2007, 100% of the samples of ryegrass had germination percentage above the standard, which is 70%.

Studies performed in 2008 to 2010 concluded that from 50 to 100% depending on the year and cultivar, the samples of ryegrass were below the standard for the parameter of pure seeds. Regardless of the reporting year, the predominant cultivar was ryegrass (66 to 100%), and all samples belonging to the category S2 (Ohlson et al., 2011a).

Colonião grass analyses showed that all samples of cultivar Tanzania were below the standard in pure seed parameter; for the cultivar, Mombasa, from 50 to 82% depending on the season, they did not reach the standard. The same was observed in cultivar Aruana in 2007 season, when only 50% samples were framed in this parameter. In 2007, 100% of pearl millet samples of BRS 1501 cultivar were below the standard for pure seed in the State of Paraná (Ohlson et al., 2010).

In *Brachiaria brizantha,* Ohlson et al. (2011b) showed that from 97 to 100%, depending on the year and cultivar, the samples were class S2 (not certified seed of the second generation); and from 55 to 100%, depending on

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Table 1. Number of samples of oats seeds analyzed by the Seed Analysis Laboratory, Agronomy Course, Department of Agrarian Studies, Universidade Regional do Noroeste do Estado do Rio Grande do Sul, from 2006 to 2014, Santa Maria, 2016.

Category	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Seeds S1 and S2	256	281	260	394	547	116	139	184	52	2229
Own use	44	44	25	47	55	39	40	38	25	357
Tetrazolium analysis	84	42	42	46	38	31	20	11	10	324
Total	384	367	327	487	640	186	199	233	87	2910

S1; S2, Not certified seed, first and second generation, respectively.

the year, the samples reached the minimum for pure seeds in Paraná State.

In the analyses of seeds carried out with 106 samples of *B. brizantha* 11 *Brachiaria humidicola* and 38 samples of *Panicum maximum* in the State of Rondônia, 85.9, 72.7 and 94.7%, respectively were below the standards, and the main reason for the low quality was impurity (Parmejiani et al., 2014).

As it is observed, there is a great variability in the quality of forage seeds produced, a fact that may impact the establishment of appropriate plant stand and the productive potential of these species. Thus, it is important to characterize and categorize the physical and physiological attributes of the seeds produced and associate them with national quality standards in order to indicate the use of seeds with high quality standards.

Given this, the present study has the general objective of evaluating the physical and physiological quality of black oat seeds produced in Southern Brazil, and specifically, to characterize the physical purity levels presented in the samples, the percentage of pure seeds, other seeds and inert material, as well as studying the occurrence of other seeds. The study aimed also to associate the quality of seeds to the production profile either by companies or for their own use, and the possible effects caused by meteorological factors.

MATERIALS AND METHODS

This work was carried out by using Seed Analysis database from the Laboratory of Seeds Analysis – Agronomy Course, Agrarian Studies (DEAg), Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUÍ), located in the city of Ijuí, RS. The department was accredited in 1995 by the Ministry of Agriculture, Livestock and Supply.

The analysis results of black oat seeds were evaluated (Avena strigosa Schreb.), belonging to 2006 to 2014 crops (Table 1). 2,910 samples were considered. Out of these, 2,229 were members of the seed production process and all samples belonged to the categories S1 and S2 (not certified seed from first and second generations, respectively). It was also studied the results of 357 seed samples intended for their own use, as the current legislation assures Brazil (1997) and Brazil (2003) and 324 seed analysis evaluated by the tetrazolium test. The number of samples, for example, accounted for 5.1% of the total of 96,086.72 tons of oats seeds produced in the state of Rio Grande do Sul in 2013 (Rio Grande Do Sul, 2014).

Analyses of physical and physiological quality of the seeds were carried out following the methodology recommended by the Seed Analysis Rules (BRAZIL, 1992, 2009). Purity analysis determines the percentage composition by weight and the identity of the different species of seed and inert material present in the sample. The working sample is separated into three components: pure seed, other seeds and inert material, which are indicated in percentage by weight of the working sample. Purity analysis was performed on a sample of 100 g to 2010 and, from this year, in a sample of 50 g. This change was promoted due to the entry of Instruction No. 33/2010 in force, Ministry ... (2010), which abolished the Ministerial Order No. 381/1998 (Ministry, 1998).

The determination of harmful species, complementing the purity analysis was carried out until the year 2010, according to Ministerial Order No. 381/1998 (Ministry, 1998, 1992). This determination was changed to the determination of other seeds by number, including other cultivated species, wild and harmful tolerated and prohibited species, because the Instruction No. 33/2010 was in force (Ministry, 2010). These measurements were performed in samples of 500 g.

The completion of the germination test also followed the recommendations for the species. Pre-drying was done at 35°C for seven days. After that, the seeds were sown on roll paper, with four replications of 100 seeds and placed in a chamber at 20°C temperature. In the evaluation, the percentage of normal seedlings, abnormal seedlings and dead seeds was determined (Brazil, 1992, 2009). Work done by Grzybowski et al. (2015) showed that pre-drying may be carried out for five days. The tetrazolium test which determines the feasibility of seeds also followed the criteria established in the rules for seed testing.

Samples of seeds originating in the production process following the national system of seed production and seedlings were analyzed for purity and germination, while the samples of own use of seeds were analyzed only with germination test. The tetrazolium analysis is used in the seed production process, as previous analysis, or own use of seeds, with an effective test for the rapid assessment of the viability of oats seeds (Souza et al., 2009).

The standards used to compare the results of analyses carried out by the year 2010 are as follows: Minimum germination of 75%, minimum 95% of pure seeds, maximum of 50 seeds from other cultivated species, 40 seeds of wild species, 40 seeds of tolerated harmful species and zero of harmful prohibited species seeds, according to Ministerial Order No. 381/1998 (MINISTRY, 1998). From the year 2010, for seeds belonging to S1 and S2 categories, not certified seeds from first and second generation, respectively, the following standards were used: Minimum germination of 80%, minimum of 97% of pure seeds, maximum 1% of other seeds, up to 16 seeds of other cultivated species or 20 from the oat species, and a maximum of 48 seeds for the category S2, up to 20 wild seeds, six harmful tolerated seeds and zero prohibited harmful seeds as stated in Instruction No. 33/2010 for black oat (Ministry, 2010).

The results were submitted to descriptive statistical analysis based on the years studied and we identified the outliers from the mean, standard deviation and coefficient of variation, using the GENES program (Cruz, 2013). There was also the presentation of data in scatter plots, with the assistance of the Office Excel

Table 2. Descriptive statistics (ED), number of samples (N), mean ($\bar{x}$), standard deviation (SD), maximum (Mmax), minimum (Mmin), pure seeds (%), inert material (%) other seeds (%), number of other seeds by number, number of cultured species seeds, number of wild species seeds, number of harmful tolerated species and harmful prohibited in black oat seeds produced in crops from 2006 to 2014, by the national system of seed production, LAS / UNIJUI. Santa Maria, RS, 2016.

Variable	ED	Years/seed purity									
		2006	2007	2008	2009	2010	2011	2012	2013	2014	$\bar{x}$
Pure seeds (%)	N	256	281	260	394	547	116	139	184	52	247.7
	$\bar{x}$	99.3	98.9	99.3	99.4	99.5	99.4	99.5	99.7	99.7	99.4
	DP	0.59	0.73	0.76	0.45	0.45	0.44	0.43	0.21	0.28	0.48
	Mmáx	100	100	100	100	100	100	100	100	100	100
	Mmin	96.6	96.7	96.3	97.5	96	97.8	97.0	99	98.8	97.3
		Purity decomposition									
Inert matirial (%)	$\bar{x}$	0.60	0.92	0.45	0.44	0.42	0.48	0.43	0.23	0.25	0.47
	DP	0.49	0.72	0.44	0.28	0.40	0.37	0.43	0.18	0.24	0.39
	Mmáx	3.2	3.3	2.3	1.9	3.1	2.1	3.0	1.0	1.0	2.32
	Mmin	0	0	0	0	0	0	0	0	0	0
Other seeds (%)	$\bar{x}$	0.13	0.13	0.27	0.17	0.04	0.09	0.03	0.32	0.04	0.13
	DP	0.24	0.21	0.46	0.24	0.11	0.16	0.05	0.79	0.13	0.26
	Mmáx	1.1	1.10	2.30	2.20	0.90	0.80	0.20	0.50	0.90	1.11
	Mmin	0	0	0	0	0	0	0	0	0	0
		Purity decomposition, other seeds by number									
Number of other seeds by number	$\bar{x}$	10.5	8.5	14.6	8.6	6.3	32.9	7.5	9.5	5.2	11.5
	DP	19.6	12.2	24.4	9.7	39.6	55.1	5.87	12.9	7.3	20.74
	Mmáx	128.0	92.0	142.0	51.0	315.0	238.0	33.0	75.0	50.0	124.8
	Mmin	0	0	0	0	0	0	0	0	0	0
Cultured species	$\bar{x}$	8.3	7.3	13.5	7.4	5.9	27.7	3.3	7.5	3.2	9.3
	DP	15.9	11.0	24.0	9.2	29.6	51.0	4.5	12.9	6.8	18.3
	Mmáx	108.0	91.0	139.0	50.0	315.0	230.0	22.0	73.0	44.0	119.1
	Mmin	0	0	0	0	0	0	0	0	0	0
Wild species	$\bar{x}$	1.20	0.74	0.87	1.10	0.23	0.31	0.00	0.00	0.02	0.5
	DP	3.48	1.73	1.80	1.79	0.68	1.89	0.00	0.00	0.14	1.27
	Mmáx	26	10	16	15	6	19	0	0	1	10.3
	Mmin	0	0	0	0	0	0	0	0	0	0
Harmful tolerated species	$\bar{x}$	0.99	0.42	0.20	0.18	0.11	4.82	4.2	2.00	1.98	1.7
	DP	2.66	1.33	0.84	1.01	0.55	5.99	4.44	2.25	1.74	1.71
	Mmáx	28.0	14.0	10.0	14.0	5.0	31.0	21.0	13.0	6.0	15.7
	Mmin	0	0	0	0	0	0	0	0	0	0
Harmful prohibited species	$\bar{x}$	0.01	0	0	0	0	0	0	0	0	0.00
	DP	0.06	0	0	0	0	0	0	0	0	0.01
	Mmáx	1.00	0	0	0	0	0	0	0	0	0.11
	Mmin	0.00	0	0	0	0	0	0	0	0	0.00

application program, and the percentage of samples outside the recommended standards was determined, and we compared the physiological quality data with weather occurrences of maximum temperatures and rainfall.

RESULTS AND DISCUSSION

The average percentage of pure seed was 99.4% studied in nine years (Table 2). In every year there were samples with 100% pure seed. The standard deviation of the average was 0.48. These data indicate higher levels of quality than those obtained by Fonseca et al. (1999) in ryegrass. The data also show superiority when compared to data from other similar works with analysis of forage species seed (Ohlson et al., 2008, 2011a; Parmejiani et al., 2014). This is due probably to the efforts and investment made by the seed companies in order to obtain seeds with a high degree of physical purity.

The presence of inert material reached an average of 0.47% over nine years, with a maximum of 3.3% in 2007. These data, combined with an average standard deviation of 0.39, indicate a low degree of presence of these impurities, meaning that the seeds were harvested and processed efficiently in removing this material. In inert material, straw, soil particles, dust, part of caryopses, palea, lemma and culture remained was found.

The average presence of other seeds was 0.13% and the standard deviation was 0.26 (Table 2). This variable also has a low average value, since the maximum is 1% of the sample (Ministry, 2010). As for the presence of other seeds by number, the average was 11.5 seeds and the average standard deviation was 20.74 (Table 2). The data indicate that there was a great variability in the samples analyzed for this variable. Out of these, 9.3 seeds per sample were seeds of other cultivated species, wild seeds 0.5, 1.7 seeds harmful tolerated species and zero of harmful prohibited.

The presence of grown species seeds was on average 9.3 seeds per sample and a high standard deviation of 18.3 (Table 2). Data maximum numbers indicate samples with up to 315 seeds, in 2010, for a maximum permitted up to 16 seeds of other cultivated species and 20 seeds of the oat species (Ministry, 2010). The high seed values of other cultivated species was mainly due to the presence of *Lolium mulflotum* Lam presenting limitations of specific products for their management and control in areas of black oat.

Wild species of seeds occurred, on average, 0.5 seeds per sample, standard deviation of 1.27. The highest data occurred in 2006 with 1.2 seeds on average per sample (Table 2). The occurrence of wild species seed was low, since it is allowed up to 20 seeds per sample (Ministry, 2010).

The average presence of harmful species tolerated seeds was 1.7 seeds per sample, occurring more sharply in the years 2011 and 2012 in which 4.8 and 4.2 seeds occurred per sample, respectively. The average standard deviation was 1.71. The increased presence of harmful tolerated species of seed was given mainly due to the reframing of *Avena barbata* Pott ex Link that went from wild to harmful tolerated, and allowed only six seeds per sample (Ministry, 2010).

The presence of harmful prohibited species seeds was observed in a sample in 2006. This indicates that seeds produced had no seeds of harmful prohibited species expressing a high degree of purity regarding this physical attribute.

Figure 1 shows the samples of scatter plots for purity analysis, containing the percentage of purity, inert material and other seeds, the number of other seeds by number, the number of crop species seeds, the number of wild seed and the number of seeds of harmful tolerated species in oat seed samples produced in the seed production process following the national system of seeds and seedlings.

Analysis of the physical attributes found a high degree of physical purity over the years, as shown in Figure 1A. There were slight increases in levels of the percentage of inert material in 2007 and 2010 (Figure 1B), and percentage of other seeds in 2006, 2008 and 2009 (Figure 1C).

Regarding the number of other seeds by number, a significant increase in rates in 2010 and 2011 can be observed (Figure 1D). In these years, there was an increase in the number of other seeds of cultivated species, especially ryegrass (Figure 1E). A trend to reduce the number of seeds of wild species and the increase of seeds of harmful tolerated species from the year 2010 may be noted, also. This is due mainly to the changing frame of the species *A. barbata Pott* ex Link that went from wild species to harmful tolerated species, based on Instruction No. 33/2010 (Ministry, 2010).

The results of physiological analysis of black oat seeds evaluated by germination test are shown in Table 3. The average germination was 90.3% over the nine years of analysis, with mean maximum of 98.7%, average minimum of 59.3% and a standard deviation of 6.0. In 2008, 2010 and 2011 averages above 92% of normal seedlings were obtained, and in the years 2009, 2012 and 2014 the averages were below 90%.

Abnormal seedlings had an average of 5.6%, with 0.5% average of the minimum and 18.6% of average maximum and a low average standard deviation of 3.6. There was percentage of abnormal seedlings in the year 2012; an average of 8.2% (Table 3).

Dead seeds showed an average of 4.1%, ranging from zero to 30.5%, average of the maximum and average standard deviation of 3.7 (Table 3). The percentage of dead seeds was higher in 2014, with 7.5%, and this year was considered a year with a low average germination.

The physiological attributes of seeds, evaluated by the germination test, can be seen in Figure 2. The same shows that there was less dispersion of normal seedlings in the years 2011 and 2013 and increased dispersion in the year 2009, which was a year with lower germination means (Figure 2A).

Abnormal seedlings rates exhibited higher dispersion in the years 2007, 2009 and 2012 (Figure 2B) and dead seedlings indexes showed the highest dispersion in the years 2009 and 2014 (Figure 2C).

The results of the analysis of own use seeds germination are shown in Table 4. The average germination was 83.2%, the average maximum was 98.2%, average minimum was 26.2% and a standard deviation was 15.4. The averages were higher in 2007 and 2013, whereas in the years 2012 and 2014 averages were below 80%. The percentage of abnormal seedlings was 5.9%, while the percentage of dead seeds was 10%.

By comparing the data analysis of the germination

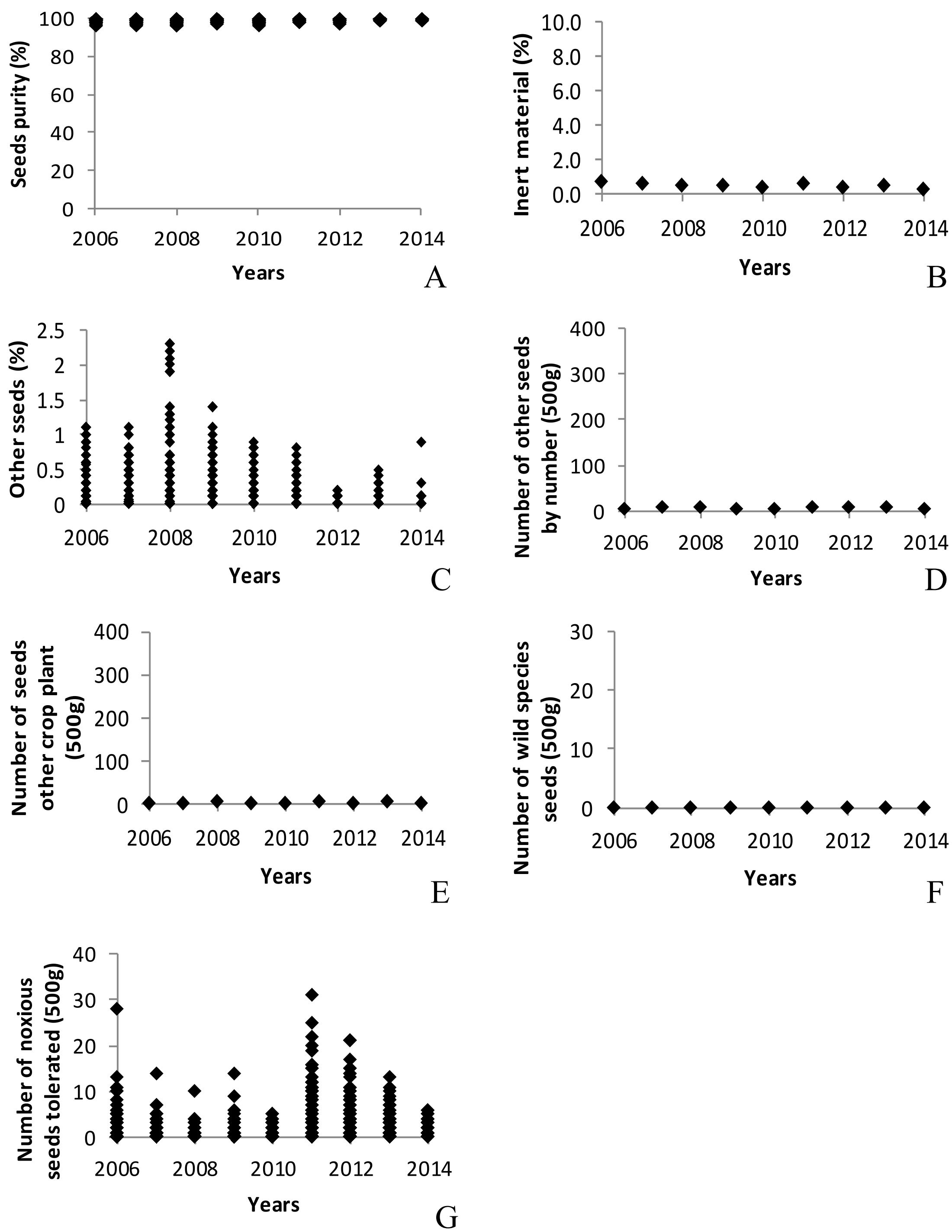

Figure 1. Scatter plots for physical purity (%), inert materials (%), other seeds (%) number of other seeds by number, other crop species, wild and harmful tolerated species in samples of black oat seeds, analyzed between 2006 and 2014, LAS/UNIJUI. Santa Maria, RS, 2016. A, Seeds purity (%); B, inert material (%); C, other seeds (%); D, number of other seeds by number; E, number of seeds other crop plant; F, number of wild species seeds; G, number of harmful tolerated seeds.

seeds produced in the seed production process with own use seeds, a reduction in average percentage of 90.3% germination was observed for 83.2%, increase in deviation standard from 6.0 to 15.4 and increase of the percentage of dead seeds from 3.7 to 10%.

The data presented above indicate that the physiological quality of own use seeds were lower than seed produced in the seed production process, possibly

Table 3. Descriptive statistics (ED), number of samples (N), mean ($\bar{x}$), Standard Deviation (SD), maximum (Mmax), Minimum (Mmin) to Normal Seedlings (%) Abnormal Seedlings (%) Dead Seeds (%) in oat seeds analyzed between 2006 and 2014, LAS / UNIJUI. Santa Maria, RS, 2016.

Variable	ED	Years/ germinated seeds									
		2006	2007	2008	2009	2010	2011	2012	2013	2014	x̄
Normal seedlings (%)	N	256	281	260	394	547	116	139	184	52	247.7
	x̄	91.2	91.6	92.0	88.6	92.1	92.1	87.5	90.6	87.6	90.3
	DP	9.40	5.08	4.85	5.9	5.16	3.88	5.2	6.01	8.67	6.0
	Mmáx	99	99	99	99	99	98	97	99	99	98.7
	Mmin	3	69	66	46	61	82	65	77	65	59.3
Abnormal seedlings (%)	x̄	3.2	5.9	4.1	5.9	5.8	5.9	8.2	6.3	4.9	5.6
	DP	2.16	3.99	2.83	5.94	2.27	3.69	3.60	4.53	3.64	3.6
	Mmáx	13	20	19	24	20	16	23	18	15	18.6
	Mmin	0	0	0	0	0	1	2	1	1	0.5
Dead seeds (%)	x̄	5.6	2.9	3.8	5.4	3.0	1.9	3.9	3.1	7.5	4.1
	DP	9.08	2.64	3.70	4.17	3.01	1.47	3.07	2.42	3.83	3.7
	Mmáx	94	26	33	24	32	8	19	11	28	30.5
	Mmin	0	0	0	0	0	0	0	0	0	0.0

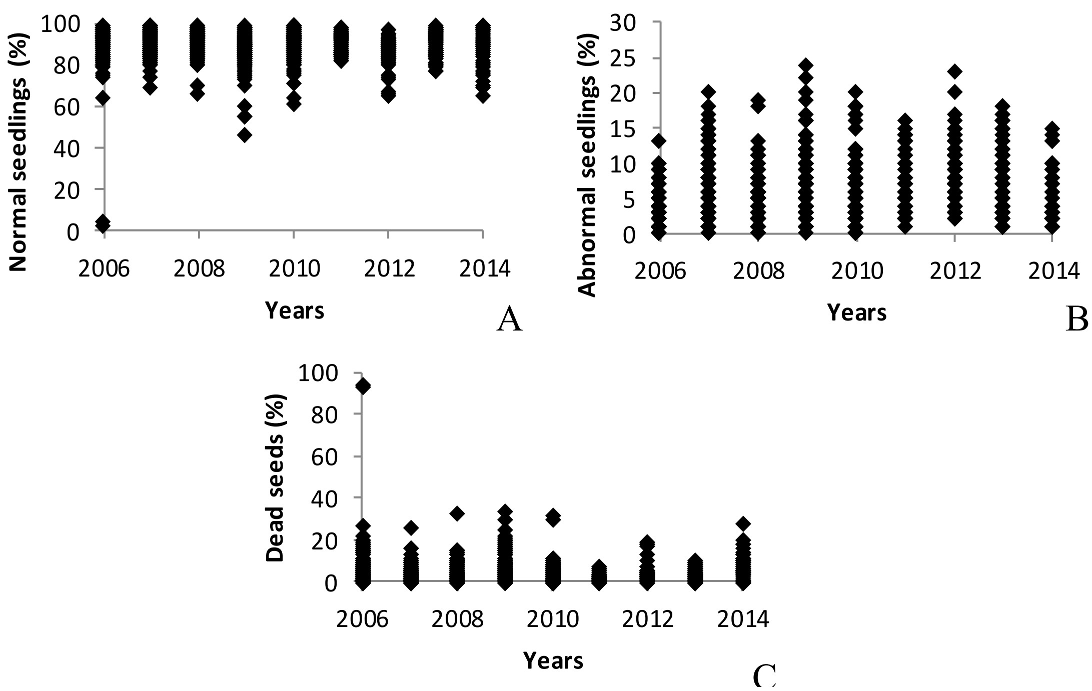

Figure 2. Scatter plots for normal seedlings (%), abnormal seedlings (%) and dead seeds (%) in samples of oats seeds, analyzed between 2006 and 2014, LAS / UNIJUI. Santa Maria, RS, 2016. A: Normal seedlings (%); B: Abnormal seedlings (%); C: Dead seeds (%).

because the seed producers can manage, harvest and process the seeds, making batches with better physiological standards.

Whereas own use seeds probably receive lower levels of investment in crops management, minor care in harvesting and processing. For both categories of seeds in the years 2012 and 2014, lower results were obtained in terms of physiological quality, due to adverse environmental conditions.

In Figure 3, it is presented the scatter plots for normal

Table 4. Descriptive statistics (ED), number of samples (N), mean (x̄), Standard Deviation (SD), maximum (Mmax), minimum (Mmin) to normal seedlings (%) abnormal seedlings (%) dead seeds (%) in own use seeds in black oat analyzed between 2006 and 2014, LAS / UNIJUI. Santa Maria, RS, 2016.

Variable	ED	Years/germination own use seeds									
		2006	2007	2008	2009	2010	2011	2012	2013	2014	x̄
Normal seedlings (%)	N	44	44	25	47	55	39	40	38	25	39.7
	x̄	83.9	87.4	84.9	83.1	82.9	84.2	79.7	86.4	76.5	83.2
	DP	15.4	13.3	18.1	12.4	15.1	13.8	20.0	10.1	20.2	15.4
	Mmáx	99	100	98	98	98	98	98	98	97	98.2
	Mmin	41	44	39	38	6	35	8	57	6	26.2
Abnormal seedlings (%)	x̄	4.3	4.9	5.4	6.7	7.3	7.6	9.0	6.9	8.5	5.9
	DP	3.6	4.6	4.2	6.2	5.8	7.0	5.3	4.9	5.7	5.3
	Mmáx	15	17	15	31	19	41	29	23	22	23.5
	Mmin	0	0	1	1	1	1	2	1	2	1.0
Dead Seeds (%)	x̄	11.8	7.7	10.0	10.1	9.7	8.2	11.3	6.6	14.9	10.0
	DP	14.2	12.0	14.5	9.7	11.9	10.5	12.2	6.8	18.7	12.3
	Mmáx	57	54	47	55	75	57	85	24	88	60.2
	Mmin	0	0	0	0	0	0	0	0	1	0.1

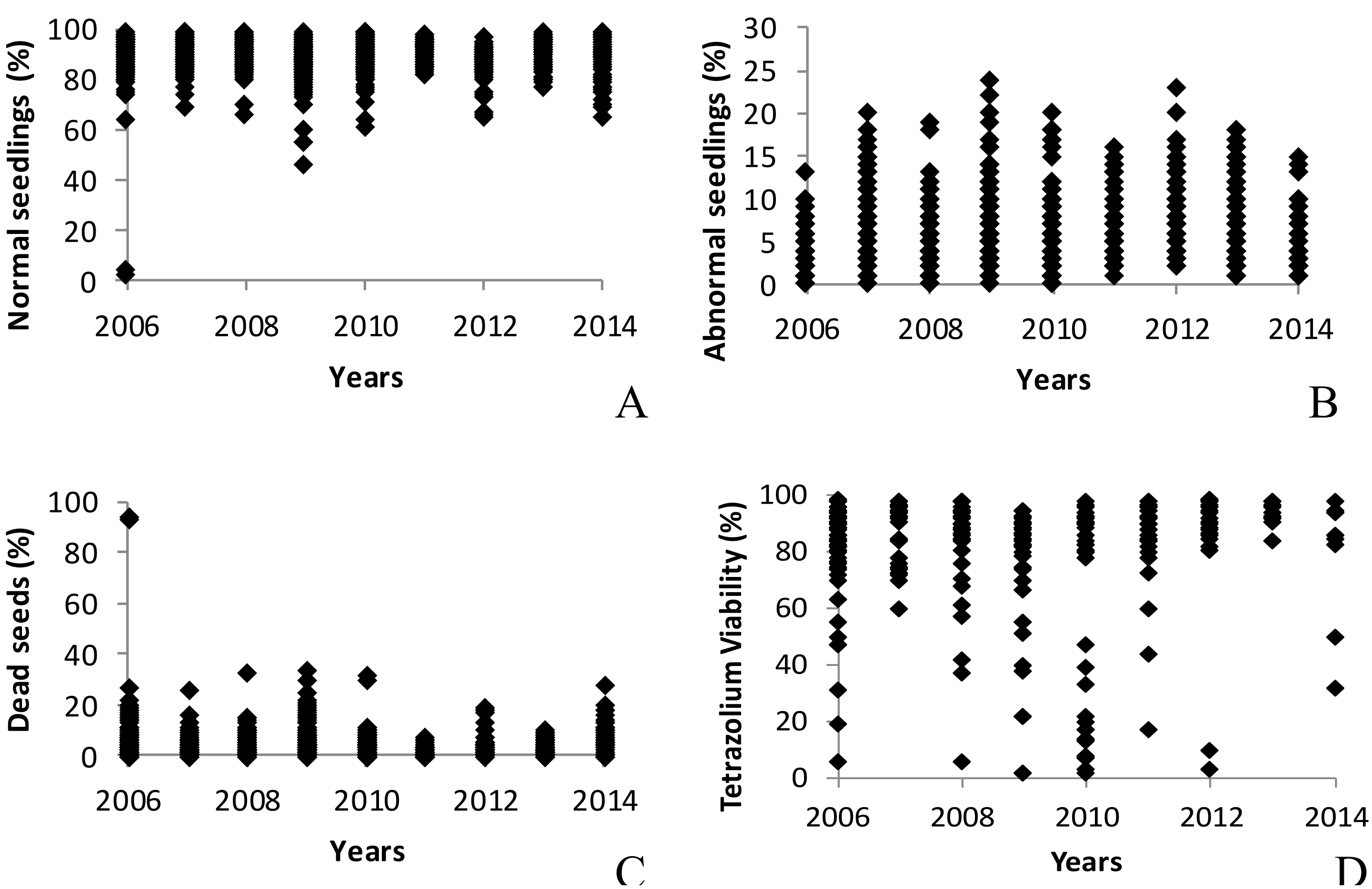

Figure 3. Normal seedlings for scatter plots (%), abnormal seedlings (%) and dead seeds (%) in samples of own use seeds and viability (%) of seeds evaluated by the tetrazolium test in black oat seeds analyzed between 2006-2014, LAS / UNIJUI. Santa Maria, RS, 2016. A, Normal seedlings; B, abnormal seedlings; C, dead seeds; D, tetrazolium viability.

Table 5. Descriptive statistics (ED), number of samples (N), mean ($\bar{x}$), standard deviation (SD), maximum (Mmax), Minimum (Mmin) to viable seeds through tetrazolium test in black oat seeds analyzed between 2006 and 2014, LAS / UNIJUI. Santa Maria, RS, 2016.

Variable	ED	Years/viability seeds through tetrazolium test									
		2006	2007	2008	2009	2010	2011	2012	2013	2014	$\bar{x}$
Viability (%)	N	84	42	42	46	38	31	20	11	10	36.0
	$\bar{x}$	83.1	89.9	84.3	75.9	60.7	85.3	83.3	93.4	81.4	81.9
	DP	16.5	9.5	18.9	23.9	36.4	17.1	26.7	4.0	22.3	19.5
	Mmáx	99.0	98.0	98.0	95.0	98.0	98.0	99.0	98.0	98.0	97.9
	Mmin	6.0	60.0	6.0	2.0	2.0	17.0	3.0	84.0	32.0	23.5

Table 6. Percentage of samples classified as below the minimum standard required by the legislation in oats seeds analyzed between 2006 and 2014, LAS / UNIJUI. Santa Maria, RS, 2016.

Variable	Seeds S1;S2		Own use		Tetrazolium	
	2006\10	2011\14	2006\10	2011/14	2006\10	2011/14
Physical putity (%)	0.0	0.0	-	-	-	-
Other seeds (%)	1.8	0.0	-	-	-	-
Others cultured species	3.1	14.0	-	-	-	-
Wild species	0.0	0.0	-	-	-	-
Harmful tolerated	0.0	14.5	-	-	-	-
Harmful Prohibited	*	0.0	-	-	-	-
Germination (%)	0.7	3.8	18.1	31.7	19.4	12.5
Total evaluated samples	1738	491	215	142	252	72

-, Test not performed; *Only one non-standard sample.

seedlings, abnormal seedlings and dead seeds in samples of own use seeds and viability (%) of seeds evaluated by the tetrazolium test.

As for the own use seeds, there is less dispersion of results for the variable normal seedlings in the years 2008, 2011 and 2013, being considered the best years in terms of physiological quality. However, a greater dispersion of data occurred for this indicator in 2006, 2009, 2012 and 2014.

In terms of abnormal seedlings, data point to the years 2009 and 2012 with higher dispersions, meaning loss of physiological quality. In terms of dead seeds, the data dispersions were higher in the years 2006, 2010, 2012 and 2014.

The results of the samples analyzed by the tetrazolium test are shown in Table 5. The average viability was 81.9%. In 2010, the average viability was only 60.7% for a 80% minimum standard, according to Normative Instruction No. 33/2010 (Ministry, 2010). In this year, there were significant number of samples with low levels of viability, probably due to the introduction of a practice of pre-harvest desiccation that interfered with the seeds germination (Figure 3D). The highest average was 93.4%, obtained in 2013, considered the best year for this category of seeds.

The standard deviation was the highest in terms of physiological quality, with 19.5. This means that there was great variability in the samples analyzed, which can be seen by observing the dispersion shown in Figure 3 D, in which the years 2006, 2008, 2009 and 2010 stood out. It should be noted that the tetrazolium test is widely accepted and used for previous analysis of seed samples produced according to the national seed system, as well as for own use seed evaluation, to be an effective test for the rapid assessment of the viability of oats seeds (Souza et al., 2009).

The results of the percentage of samples classified as below the minimum standard required by the legislation in black oat seeds, both for seeds obtained in the seed production process, identified as seeds, as well as proper use of seeds and seeds analyzed through the tetrazolium test are shown in Table 6.

In Table 6, it can be observed that no sample was below the standard for physical purity of the seeds, that is, all samples were within the standards required by law, with a minimum of 95% by 2010 and 97% based on Instruction No. 33/2010 (Ministry, 2010).

From 2006 to 2010, 1.8% of the samples were below the standard for variable percentage of other seeds, that is, 98.2% of the samples were within the required standards (Table 6). In 2011 to 2014, no sample was approved in this parameter which indicates also that the seeds showed a high degree of physical purity.

From 2006 to 2010, 3.1% of the samples were rejected for the presence of other seeds from cultivated species, while from 2011 to 2014, 14% of the samples was rejected (Table 6). The elevation of disapproval percentage in the last period is due in part to the inclusion of this analysis in the determination of other seeds by number, in the sample of 500 grams (before it was performed the purity sample in 100 g), and reduction 50 to 16 seeds as limit from other seeds of cultivated species present, as stated in Instruction No. 33/2010 for oat (Ministry, 2010).

No sample was outside the standards for the presence of seeds of wild species over the nine years of study.

From 2006 to 2010, no sample was approved for the presence of seeds of harmful tolerated species; however, from 2011 to 2014, 14.5% of the samples were exposed. There was increased failure percentage in the last period, due, in part, to a reduction from 40 to six seeds as a limit on the sample of 500 g and the inclusion of wild species in harmful tolerated ratio, *A. barbata* L., based on Instruction No. 33/2010 for oat (Ministry, 2010).

The physical purity parameters indicate high degrees of purity of the samples analyzed, except for the number of cultivated species of seed and the number of seeds of harmful tolerated species reached levels of 14 and 14.4%, respectively, from 2011 to 2014. The increase in disapproval level of samples occurred largely because of the changes in the patterns introduced by the Normative Instruction No. 33/2010 (Ministry ..., 2010).

In Table 6, it is observed that only 0.7% of the samples did not meet the standard for germination from 2006 to 2010, and 3.8% were below the minimum from 2011 to 2014. These data point to high levels of physiological quality of the seeds analyzed, and the increase of seeds that have not reached the standard, was due, in part, to raising the minimum germination from 75% to 80%, as determined by the Normative Instruction No. 33/2010 (MINISTRY, 2010).

The data obtained for the analysis of seeds obtained in the seed production process indicate high physical and physiological quality conditions of the desired plant population per area (Krzyzanowski, 2013; Marcos-Filho, 2013).

The index of samples that did not reach the minimum germination standard in own use seeds was 18.1% from 2006 to 2010 and increased to 31.7% from 2011 to 2014 (Table 6). That is, close to one third of the samples analyzed for the purpose of own use did not provide the standard of viability to be used for sowing.

For the samples analyzed by the tetrazolium test, 19.4% were below the standard in the years from 2006 to 2010, decreasing to 12.5% from 2011 to 2014. In this test, prior analyses are carried out in the seed production process and/ or own use. This probably explains the high data samples below standard, although there was a reduction in the last period, unlike what happened with the own used seeds.

The changes introduced by legislation with regard to increasing the minimum percentage of germination and the decrease in the number of seeds of other cultivated species and the number of seeds of harmful tolerated species increased considerably the number of samples approved.

The years 2009, 2012 and 2014 suffered negative effect from meteorological factors of maximum temperatures and rainfall being that intense rainfalls which occurred during the vegetative growth favor leaching and nutrient losses and heavy rains during the physiological maturity and harvest interfere negatively on physiological seed quality. This is because harsh environmental conditions may change the preferential metabolic drain, wherein the vegetative plant parts and roots become preferred drains to the detriment of reproductive organs or seeds, affecting the yield and quality of seeds (Pedó et al., 2013). In addition to environmental conditions, the composition of the seeds can affect the quality thereof, as identified in soybean seeds by Castro et al. (2016), who find that seeds that had higher lignin content in the seed coat had lower percentages of damage from moisture and better physiological qualities.

The physiological attributes were enhanced when it comes to performance in 2008, 2010 and 2011, due to the levels of rainfall and appropriate temperatures for their vegetative development, physiological maturity and harvest (Figure 4).

Conclusion

The black oat seeds produced between 2006 and 2010, according to the National Seed System, had high levels of physical and physiological quality. However, 14.0 and 14.5% of the samples exhibited seeds levels from other cultivated species and harmful prohibited species above the standards, respectively, from 2011 to 2014. Own used seeds showed wide variability in results, with 18.1 and 31.7% of samples below standard for germination from 2006 to 2010 and 2011 to 2014, respectively, while the samples analyzed through the tetrazolium test showed disapproval levels of 19.4 and 12.5%, respectively.

The major physiological qualities were obtained in 2008, 2010 and 2011 and the lowest in 2009, 2012 and 2014. It is noteworthy that the seed quality is related to the years with levels of rainfall and temperatures appropriate for the vegetative development, physiological maturity and harvest.

CONFLICTS OF INTERESTS

The authors have not declared any conflict of interests.

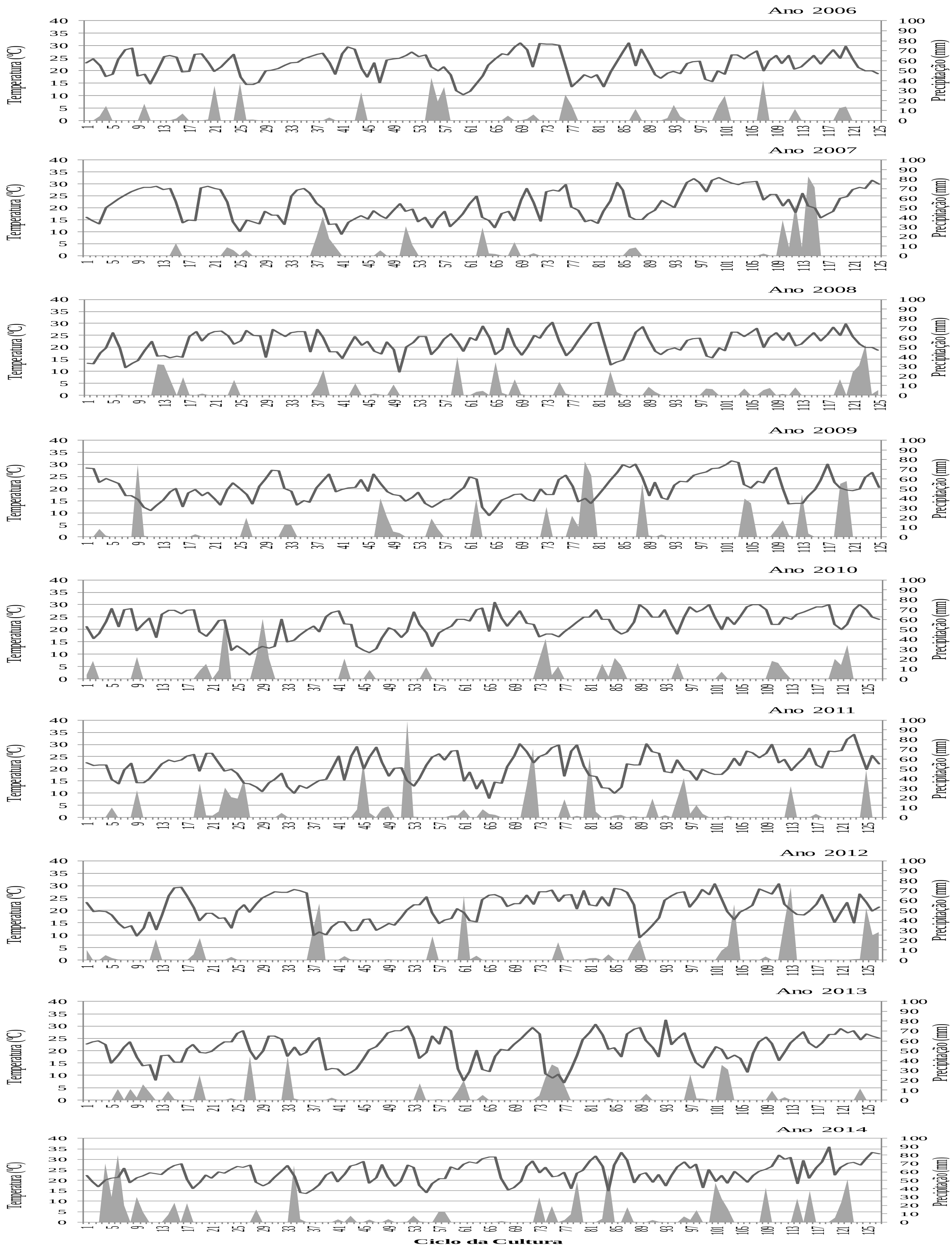

Figure 4. Maximum temperature (°C) and daily precipitation (mm) occurred during the crop cycle of black oat (Avena strigosa Schreb.), From June to September in the years from 2006 to 2014, Weather Station, Regional Institute of Rural Development Department of Agrarian Studies, UNIJUÍ, Augusto Pestana, RS, Santa Maria, in 2016.

REFERENCES

ABRASEM (2014). Anuário 2014: Estatística da produção e comercialização de sementes no Brasil. ABRASEM, Brasília.

Bortolini CG, Silva PRF da, Argenta G (200). Efeito de resíduos de plantas jovens de aveia preta em cobertura de solo no crescimento inicial do milho. Pesquisa Agropecuária Gaúcha 6(1):83-88.

Brazil (1997). Lei nº 9.456: Institui a Lei de Proteção de Cultivares e dá outras providências. Brasília: Presidência da República, 25/4/1997.

Brazil (2003). Lei n^{o} 10.711: Dispõe sobre o Sistema Nacional de Sementes e Mudas e dá outras providências. Brasília: Presidência da República, 5/8/2003.

Brazil (1992). Ministério da Agricultura, Pecuária e Abastecimento. Regras para análise de Sementes. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Brasília, DF: Mapa.

Brazil (2009). Ministério da Agricultura, Pecuária e Abastecimento. Regras para análise de sementes. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Brasília, DF: Mapa; ACS, 2009.

Carvalho NM, Nakagawa J (2012). Sementes: ciência, tecnologia e produção. 5. ed. Jaboticabal: Funep.

Carvalho PC de F, Santos DT de, Gonçalves EN, Moraes A de, Nabinger C (2010). Forrageiras de Clima Temperado. In: Fonseca DM. de, Martuscello JA. Plantas forrageiras. Viçosa: UFV pp. 494-537.

Castro E de M, Oliveira JA, Lima AE de, Santos HO dos, Barbosa JIL (2016). Physiological quality of soybean seeds produced under artificial rain in the pre-harvesting period. Journal of Seed Science, Viçosa, ABRATES 38(1):14-21.

Cruz CD (2013). GENES - a software package for analysis in experimental statistics and quantitative genetics. Acta Sci. 35(3):271-276.

Debiasi H, Martins JD, Missio EL (2007). Produtividade de grãos e componentes do rendimento da aveia preta (*Avena strigosa* Schreb.) afetados pela densidade e velocidade de semeadura. Ciência Rural, Santa Maria 37(3):649-655.

Del Duca L de JA, Fontaneli RS, Dalla Lana B, Nascimento Junior A do, Cunha GR da, Rodrigues O, Guarienti EM, Miranda MZ de, Costamilan LM, Chaves MS, Lima MIPM (2004). Experimentação de trigo e outros cereais de inverno para duplo propósito no Rio Grande do Sul, em 2003. Documentos Online 41. Passo Fundo: Embrapa Trigo 21p.

html. (Embrapa Trigo. Documentos Online; 41). Disponível em: http://www.cnpt.embrapa.br/biblio/do/p_do41.htm.

Flaresso JA, Gross CD, Almeida DX (2001). de Época e Densidade de Semeadura de Aveia Preta (Avena strigosa Schreb.) e Azevém (Lolium multiflorum Lam.) no Alto Vale do Itajaí, Santa Catarina. Rev. Bras. de Zootecnia 30(6S):1969-1974.

Fonseca MG da, Maia M de S, Lucca-Filho OA (1999). Avaliação da qualidade de sementes de azevém-anual (*Lolium multiflorum* Lam.) produzidas no Rio Grande do Sul. Revista Brasileira de Sementes, Campinas 21(1):101-106.

Grzybowski CR de S, Farinácio R, Panobianco M (2015). Reduction in the period for evaluation of the physiological quality of newly harvested black oat seeds. J. Seed Sci. Viçosa, ABRATES 37(4):244-248.

Krzyzanowski FC (2013). Controle de qualidade e a produção de sementes de alta qualidade. Informativo ABRATES 23(2):17.

Maia MS (2013). A pesquisa em sementes de espécies forrageiras de clima temperado e subtropical no Brasil. Informativo ABRATES 23(2):38.

Marcos-Filho J (2013). Importância do potencial fisiológico da semente de soja. Informativo ABRATES 23(1):21-24.

Medeiros RB de (1987). Introdução. Efeitos das pastagens nas rotações agrícolas. In: Dhein, R. A.; Carbonera, R.; Medeiros, R. B. de. Resultados de experimentação e pesquisa*:* Centro de Treinamento Cotrijuí – CTC – 1976-1986. Ijuí: Cotrijuí.

Medeiros RB de (1976). Formação e manejo de pastagens para a Região do Planalto Médio e Missões*.* Porto Alegre: Secretaria da Agricultura do RS.

Mello J (2013). Vantagens competitivas e comparativas da produção de leite no RS. Cruz Alta: CCGL.

Ministério Da Agricultura (1998). Pecuária E Abastecimento. Mapa. Portaria nº 381, de 05/08/1998.

Ministério Da Agriculturan (2010). Pecuária E Abastecimento. Mapa. Instrução Normativa nº 33, de 4/11/2010.

Nakagawa J, Cavariani C, Castro MM (2004). Armazenamento de sementes de aveia preta produzidas em solos de diferentes fertilidades. Rev. Bras. de Sementes, Londrina 26(2):07-14.

Ohlson O de C, Souza CR de, Panobianco M (2008). Levantamento da qualidade de sementes de azevém comercializadas no Estado do Paraná. Informativo Abrates, Londrina 18(1,2,3):18-22.

Ohlson O de C, Souza CR de, Panobianco M (2010). Qualidade física e fisiológica de sementes de capim-colonião e milheto, comercializadas no Estado do Paraná. Informativo Abrates*,* Londrina 20(1,2):30-36.

Ohlson OC, Grzybowski CRS, Da Silva BA, Nogueira JL, Panobianco M (2011a). Análise exploratória de dados: qualidade de sementes de azevém comercializadas no Estado do Paraná. Informativo Abrates, Londrina 21(3)47-51.

Ohlson OC, Grzybowski CRS, Da Silva BA, Nogueira JL, Panobianco M (2011b). Informações sobre a qualidade de sementes de *Brachiaria brizantha* comercializadas no Estado do Paraná. Informativo Abrates, Londrina 21(3):52-56.

Oliveira AL, Moreira AA, Sampaio GV, Oliveira EAS, Santos ES, Dourado VV (2013). Produção de sementes em comunidades tradicionais da agricultura familiar. In: Schuch LOB, Vieira JF, Rufino C de A, Júnior J de SA. Sementes: produção, qualidade e inovações tecnológicas. Pelotas: Editora e Gráfica Universitária pp. 483-495.

Parmejiani RS, Silva RB da, Mello R de A (2014). Qualidade física e fisiológica de sementes de forrageiras comercializadas no estado de Rondônia: safra 2012/2013. Informativo Abrates*,* Londrina 24(3):112-117.

Pereira S (2013). Sistema de produção de sementes de espécies forrageiras tropicais na visão da Sulpasto: pesquisa, comercialização e fiscalização. In: Informativo Abrates 23(2):40.

Peske ST, Lucca Filho OL, Barros ACS (2006). Sementes: fundamentos científicos e tecnológicos. 2. ed. Pelotas: Ed. Universitária UFPel.

Pedó T, Martinazzo EG, Aumonde TZ, Villela FA (2013). Princípios fisiológicos na produção de sementes. In: Schuch L. OB, Vieira JF, Rufino C de A, Júnior J de SA. Sementes: produção, qualidade e inovações tecnológicas. Pelotas: Editora Gráfica Universitária.

Rio Grande Do Sul (2014). Comissão de Sementes e Mudas. Catálogo de produtores de sementes e mudas do Rio Grande do Sul 2013/2014. Passo Fundo: Comissão de Sementes e Mudas do RS.

Souza CR de, Ohlson O de C, Panobianco M (2009). Avaliação da viabilidade de sementes de aveia preta pelo teste de tetrazólio. Revista Brasileira de Sementes*,* Londrina. 31(3):057-062.

Souza JM, Medeiros RB, Zambra JEG, Gieseler P, Guth O (1992). Introdução e avaliação preliminar de gramíneas tropicais e subtropicais no Noroeste do Rio Grande do Sul. In: Carbonera R, Pereira TFP, Severo, JLP, Viau LVM. Pesquisa no Centro de Treinamento Cotrijuí. Ijuí: Cotrijuí pp. 143-156.

Trennepohl D (2011). Avaliação de potencialidades econômicas para o desenvolvimento regional. Ijuí: Ed. Unijuí.