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Relationship between physical and physiological quality variables in analyzes of black oat seeds

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The success of species implantation depends on the quality of seeds used initially. It is therefore important to ascertain that the seed is in an excellent physical, physiological, sanitary and nutritional condition as this will determine the genetic cultivars' potential. Thus, this research work studied the relationships between physical and physiological variables in the seed. Samples were analysed and grouped according to their similarities. A total of 2,586 black oat seed samples were studied, 2,229 were samples of the seed production process and 357 were samples of their own use, and analyzed in the laboratory of the Agronomy Course of Unijuí, Ijuí, RS. Pearson's linear correlation coefficients, multicollinearity analysis, track and cluster analysis was determined by the agglomerative method of the most distant neighbor. The normal seedlings showed the highest correlation of negative signs, and direct effect with dead seeds. The multicollinearity analysis indicated a severe condition number, influenced by the percentage of pure seeds and number of other seeds per number. Three groups of samples were identified in the seeds produced according to the national seed system and four groups in seeds for their own use. The most representative groups presented the highest physical and physiological qualities. The variable, dead seeds, was the one that influenced the germination of normal seedlings most.

Key words: *Avena strigosa* (Schreb.), multicollinearity, path analysis, grouping.

INTRODUCTION

Black oats (*Avena strigosa* Schreb.) show good adaptability and develop well in temperate and subtropical regions. It is a species used as pasture, as a soil cover plant in no-tillage systems, has an inhibitory effect on the germination of adventitious plants, and conserved as hay or whole plant silage. In Brazil, it is cultivated in the south, southeast and partly in the central-west region, mainly to feed dairy and beef cattle

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(Fontaneli et al., 2016).

To ensure proper planting, there is a need to produce seeds with high genetic, physical, physiological and sanitary qualities. In recent years, seed production in Brazil has undergone profound changes with the implementation of the national system of seeds and seedlings, keeping the possibility of own use seeds and thus not framed as pirate seeds, or saved grains (Marcos-Filho, 2015). The new system, however, allowed the breeder to become the main system actor by modifying the relationships between breeders and seed producers, impacting prices (Andrade and Pereira, 2013; Peske et al., 2006).

Seed analysis plays an important role in the certification and quality control of seed produced, providing information on physical attributes such as: percentage of pure seeds, percentage of other seeds, percentage of inert material, number of other seeds per number, number of seeds from other species cultivated, number of seeds from wild species, number of seeds from noxious species tolerated and number of seeds from prohibited noxious species. It also reports on the physiological attributes of the percentage of normal seedlings, percentage of abnormal seedlings, percentage of dead seeds and other indicators such as origin and representativity of the seed lot.

Thus, it is necessary to identify the variables that most interfere with the physical and physiological quality of the seeds produced, in order to ensure that farmers acquire high quality seeds for use. Therefore, different types of statistical analysis are applied to explain the variables that most interfere with the quality of black oat seeds.

The correlations between characters are measures of association used in different areas of knowledge, especially in genetic improvement, since they allow predicting the transmission of the selected character to the following generations or associate one character with another. As Vencovsky (1987) points out, these measures are important because they are concerned with a set of characters and not with single characters.

Pearson's linear correlation coefficient is a measure of the degree of linear relationship between two variables. The closer it is to 1 or -1, the stronger the linear association between the two characters being studied (Ferreira, 2009). In studies on ryegrass, Müller et al. (2012) found positive correlations between grain yield with leaf dry matter yield, protein content, ear length and weight of one thousand seeds in ryegrass.

The strong linear relationships among characters, however, can be an important obstacle to be visualized to obtain accurate estimates in data analysis. By means of the multicollinearity diagnosis, it is possible to verify if there are highly correlated characters among them (Cruz and Carneiro, 2006). Among the methodologies used, the condition number described by Montgomery and Peck (1982) established the following criteria: multicollinearity considered weak when the condition number is less than 100, moderate to strong, when the condition number is between 100 and 1,000 or severe when the condition number exceeds 1,000.

In the presence of high multicollinearity, the most usual way to reduce its degree is the elimination of highly correlated variables. In cases where multicollinearity ranges from moderate to strong or severe, it is recommended to discard characters that cause it. A study by Toebe and Cargnelutti Filho (2013) on evaluation of multivariate non-normality and multicollinearity in trail analysis in maize crop, showed that the adverse effects of the high degree of multicollinearity are greater than the violation of the multivariate normality assumption. The elimination of variables to circumvent the violation of the multicollinearity assumption was also performed in corn by Collado et al. (2011) and sunflower by Martin et al. (2012).

Track analysis, in turn, can be defined as a standardized regression coefficient, being an expansion of multiple regression analysis when complex interrelationships are involved (Cruz and Carneiro, 2006). Track analysis provides values, called track coefficients that measure the direct influence of one variable on the other, regardless of the others, in the context of cause and effect. This type of analysis also allows deploying simple correlation coefficients in their direct and indirect effects, whose estimates are obtained by means of regression equations (Cruz et al., 2004).

Track analysis is based on the evaluation of the effect of an independent variable (X) on a dependent variable (Y), after removing the influence of all other independent variables (Xi) included in the analysis (Hartwig et al., 2007). This analysis is useful in the verification of direct and indirect relationships, indicating the type and degree of relationship among variables. It can be applied as a method to identify less explanatory variables of the behavior of the main dependent variable and, therefore, to eliminate it from the study (Lúcio, 1999). Through track analysis, Lorentz et al. (2006) concluded that the percentage of dead seeds and stored seed moisture were the variables that most influenced the percentage of normal seedlings in exotic forest species.

The cluster analysis, in turn, has the purpose of gathering, by some classification criteria, the sample unit in several groups in such a way that there is homogeneity within the group and heterogeneity among groups. Alternatively, clustering techniques also aim to divide original group of observations into several groups, according to some criteria of similarity or dissimilarity.

In grouping analysis, several issues arise. Thus, the final number of desired groups, the adequacy of the partition obtained and the type of similarity measure to be used are questioned. Regarding the number of groups desired, what is most commonly done is using several numbers of groups and, by some optimization criteria, select the most convenient. In order to evaluate the adequacy of the partition, it is common to use the discriminant analysis and, in relation to similarity measures, most of them are cited, however, the ones used most are the Euclidian and Mahalanobis distances (Herbert and Vincourt, 1985; Miranda et al., 1988, Cruz and Regazzi, 1997).

There are a large number of clustering methods available, of which the researcher has to decide which is the most suitable for his or her work, since the various techniques can lead to different clustering patterns. Hierarchical models are divided into agglomerative and divisive methods. Among the agglomerative methods, the nearest neighbor, the most distant neighbor, the weighted or not weighted average binding of the centroid are mentioned.

The most distant or complete-linkage neighbor method uses the general algorithm of hierarchical clustering using the maximum distance between member objects of the two groups (Ferreira, 2011). This method has the advantage of eliminating the problem of chaining generated by the single bond method, considering the most extreme observations of a cluster, and was efficient in separating the groups from all the species tested, since the origin had little influence on the formation of the groups in the studies on forest species seeds (Fortes et al., 2008).

The present work aimed to identify the main variables that correlate with the percentage of pure seeds and the emergence of seedlings, to identify the presence of multicollinearity and the variables that most influence this occurrence. It was also proposed to identify the most important variables in relation to the main dependent variable, percentage of normal seedlings, and to group samples by their degrees of resemblance.

MATERIALS AND METHODS

The work was carried out based on the database from the Laboratory of Seed Analysis of the Agronomy Course, Regional University of the Northwest, the State of Rio Grande do Sul, Ijuí, RS. The analysis results of black oats (*Avena strigosa* Schreb.) analyzed between 2006 and 2014 were evaluated. A total of 2,586 samples were used, of which 2,229 were samples of the seed production process, belonging to the first and second generation categories S1 and S2, respectively, and 357 were seeds for their own use.

Physical and physiological quality analyzes were performed following the methodology recommended by the Seed Analysis Rules (Brazil, 1992, 2009). Samples in the seed production process were analyzed for purity and germination, while seed samples for own use were analyzed using only the germination test.

The variables used were: percentage of pure seeds (%), percentage of inert material (%), percentage of other seeds (%), number of other seeds per number, number of seeds from other cultivated species, number of seeds from wild species, number of seeds from noxious species tolerated, percentage of germination from normal seedlings (%), percentage of germination from abnormal seedlings (%), percentage of dead seeds (%) and batch representativeness, in seed samples produced in the seed production process. In the seeds for own use, the percentage of germination of normal seedlings (%), germination percentage of abnormal seedlings (%) and dead seeds (%) were used.

The study on degree of relationship among variables was performed through Pearson's linear correlation analysis. The multicollinearity analysis was performed to identify the existence of a strong correlation between two or more variables and the results were interpreted according to the condition number (CN), as proposed by Montgomery and Peck (1982), whereas the direct and indirect effects of the other variables studied on the percentage of germination were determined by track analysis. The cluster analysis was also carried out by the agglomerative hierarchical method of the most distant neighbor, or full binding through the Euclidean distance. This method was chosen because it formed more in the homogeneous groups, favoring the discussion and interpretation of the results. The defined criterion for the formation of the groups was 70% of resemblance and, after the group's formation, the arithmetic mean of each variable was estimated to characterize them. Statistical analyzes were performed using the GENES programs (Cruz, 2013), adopting 1% probability of error.

RESULTS AND DISCUSSION

The results of the purity analysis indicated negative and significant correlations between pure seeds with the following variables: percentage of inert material, percentage of other seeds, number of other seeds per number, number of seeds from other cultivated species, number of seeds from wild species, percentage of abnormal seedlings and percentage of dead seeds. There was, however, a positive and significant correlation between the percentage of pure seeds with percentage of normal seedlings and batch representativeness (Table 1).

The positive and significant correlation between the percentage of pure seeds and normal seedlings indicates that the purer the seeds, the higher the values of normal seedlings. These data indicate that crops intended for seed production, with less presence of other species, or harvested with efficient removal of inert material, generate seed batches with higher physiological quality (Peske and Barros, 2006). From the agronomic point of view, these data point to the need to observe the species that occur in the fields of seed production in order to take preventive and management measures to reduce their presence, which reinforces the recommendation to identify the history of the area in terms of crop rotation and the species present, that is, to identify the cultural background and their respective technical itineraries (Sebillotte, 2006).

The percentage of other seeds correlated positively and significantly with number of other seeds by number, number of seeds from other cultivated species, number of seeds from wild species and number of seeds from noxious tolerated species and percentage of dead seeds and, in a negative and significant way, percentage of normal seedlings. In this variable, the negative effect of the presence of other seeds with the percentage of germination is also observed, reinforcing the need for decontamination of the seed production fields (Peske and Barros, 2006).

The percentage of normal seedlings correlated negatively and significantly with percentage of abnormal seedlings, percentage of dead seeds and batch

Table 1. Pearson linear correlations between the percentage of pure seeds (PUR), percentage of inert material (MAT), percentage of other seeds (OSE), number of other seeds per number (NOS), number of seeds from cultivated species (OES), number of seeds from wild species (SIL), number of seeds from noxious tolerated species (NOC), percentage of germination from normal seedlings (GER), percentage of germination from abnormal seedlings (ANO), percentage of dead seeds (MOR) and the batch representativeness, in kg, (REP) in black oat seeds analyzed between 2006 and 2014, in LAS/UNIJUI. Santa Maria, RS, 2016.

Variable	MAT	OSE	NOS	OES	SIL	NOC	GER	ANO	MOR	REP
PUR	-0.91*	-0.59*	-0.42*	-0.43*	-0.19*	0.04	0.13*	-0.07*	-0.12*	0.06*
MAT		0.21*	0.19*	0.22*	0.02	-0.09*	-0.13*	0.11*	0.08*	-0.02
OSE			0.61*	0.60*	0.42*	0.07*	-0.06*	-0.04	0.11*	-0.12*
NOS				0.99*	0.28*	0.32*	-0.06*	-0.02	0.09*	0.04*
OES					0.21*	0.22*	-0.05	-0.03	0.09*	0.01
SIL						0.01	-0.06*	-0.04	0.12*	-0.16*
NOC							-0.07*	0.17*	0.01	0.43*
GER								-0.69*	-0.80*	-0.07*
ANO									0.14*	0.14*
MOR										-0.02

*Significant at 1% probability by the t test.

representativeness. The high levels of negative correlation between percentage of germination, with dead seeds and abnormal seedlings stand out. The negative and significant correlation between percentage of germination and batch representativeness, although of smaller magnitude, indicates that the increase of the batches representativeness would negatively influence the physiological seeds quality. This was one of the parameters changed by the legislation, being adopted to maximum batches of up to 30.000 kg, with the ingress into force, the Normative Instruction No. 33/2010 (Ministério da Agricultura, Pecuária e Abastecimento, 2010).

The results of the relationships between the variables in seeds for own use also indicated negative and significant correlations between percentage of germination from normal seedlings with percentage of germination from abnormal seedlings (-0.57) and percentage of dead seeds (-0.94). The correlation between the percentage of germination of abnormal seedlings and percentage of dead seeds was significant and positive (0.27). Negative correlations between percentage of germination with abnormal seedlings and dead seeds were expected somehow, since in the germination analysis, the results are presented as a percentage for these variables, while the positive correlations between abnormal seedlings and dead seeds indicate aggravation of the seeds physiological conditions.

It was observed that, in seeds produced according to the national seed system as well as for their own use, the germination percentage of normal seedlings presented a higher negative correlation with percentage of dead seeds. These results are similar to those obtained by Lorentz et al. (2006) in studies of forest species seeds.

The high number of significant correlations to a certain extent, is explained by the high number of samples studied, 2229 seed samples were produced according to the national seed and seedlings system and 357 were produced for own use. The multicollinearity analysis indicated a condition number of 4,433,241.83 classified as severe. Thus, the percentage of pure seeds and number of other seeds per number were removed from the statistical analyzes. With this withdrawal, the condition number had 5.87 weak multicollinearity.

The variable percentage of dead seeds had the greatest direct effects on germination percentage from normal seedlings (Table 2). As the sign of the estimated effect was negative, the samples with higher rates of dead seeds exhibited lower germination percentages of normal seedlings. This variable also had the highest correlation of negative effect on the germination percentage. Therefore, the results obtained in Pearson's linear correlation coefficient decomposition in direct and indirect effects, as well as the correlation coefficient were the same or similar in magnitude and sign, indicating that this direct correlation explains the true association among these variables (Vencovsky and Barriga, 1992).

These results reinforce the importance of cultivating crops in conditions that potentiate the seeds vigor and viability (Peske et al., 2006), as well as reinforce the previous study on identifying situations that need agronomic advice in the crops management and cultivation of the crops for seeds (Wünsch, 2015).

The clustering analysis revealed the existence of three similar groups for the analysis of seeds produced according to the national seed system (Table 3). The first group collected only two samples, the second group collected 2.199 and the third group collected 28 samples.

In the first group, the two samples presented low germination and high levels of dead seeds, which is characterized as a group with low physiological quality.

Table 2. Direct and indirect effects of percentage of inert material (MAT), percentage of other seeds (OSE), number of seeds from cultivated species (OES), number of seeds from wild species (SIL), number of seeds from noxious species (NOC), percentage of abnormal seedlings (ANO), percentage of dead seeds (MOR) and batch representativeness in kg (REP) on the percentage of germination of normal seedlings in black oat seeds analyzed between 2006 and 2014, in LAS/UNIJUI. Santa Maria, RS, 2016.

Effects	MAT	OSE	OES	SIL	NOC	ANO	MOR	REP
Direct	-0.13	-0.06	-0.05	-0.06	0.07	-0.69	-0.81	-0.07
Indirect by MAT	---	0.01	-0.01	-0.00	-0.00	-0.06	-0.06	0.00
Indirect by OSE	-0.01	---	-0.00	- 0,01	0.00	0.03	-0.08	0.00
Indirect by OES	-0.00	0.01	---	-0.01	0.00	0.02	-0.07	-0.01
Indirect by SIL	-0.00	0.00	-0.00	---	0.00	0.03	-0.08	0.00
Indirect by NOC	0.00	0.00	-0.00	-0.00	---	-0.07	-0.01	-0.01
Indirect by ANO	-0.00	-0.00	0.00	0.00	0.00	---	-0.10	-0.00
Indirect by MOR	-0.00	000	-0.00	-0.00	0.00	-0.08	---	0.00
Indirect by REP	0.00	-0.00	-0.00	0.00	0.00	-0.08	0.01	---

Determination coefficient: 0.989; effect of the residual variable: 0.102.

Table 3. Mean per group, number of observations per group (N), percentage of pure seeds (PUR), percentage of inert material (MAT), percentage of other seeds (OSE), number of other seeds per number (NOS), number of seeds from cultivated species (CUL), number of seeds from wild species (SIL), number of seeds from noxious tolerated species (NOT), percentage of germination from normal seedlings (GER), percentage of germination from abnormal seedlings (ANO) , percentage of dead seeds (MOR) and batch representativeness, in t, (REP) in certified seeds and for own use of black oat seeds analyzed between 2006 and 2014, in LAS / UNIJUI. Santa Maria, RS, 2016.

Group	N	PUR	MAT	OSE	NOS	CUL	SIL	NOC	GER	ANO	MOR	REP
	Physical and physiological variables (certified seeds)											
I	2	99.4	0.5	0.1	3	3	0	0	4.0	2.5	93.5	17.5
II	2199	99.4	0.5	0.1	8.0	6.5	0.6	0.9	90.9	5.3	3.8	19.1
III	28	97.9	1.1	1.0	177.5	170.0	1.2	6.3	89.4	4.6	6.0	20.2
		N			**GER**			**ANO**			**MOR**	
	Physiological variables (own use seeds)											
I		4			9			11.3			79.8	
II		8			58.5			26			15.5	
III		298			88.6			5.9			5.5	
IV		47			60.7			8.4			31.3	

The third group, in turn, was distinguished by the high number of other seeds, especially of seeds from other cultivated species, showing low physical quality. Whereas, the second group, which is more representative, presented a high degree of physical and physiological quality (Table 3).

The grouping of the self-use analyzes formed four groups (Table 3). Four samples were obtained in the first group, eight in the second group, 298 in the third and 47 in the fourth group. The analysis of the first group indicates a low index of seed germination and high index of dead seeds. The second group presented low germination and high index of abnormal seedlings. The third group, more representative, presented high germination, demonstrating a high degree of physiological quality, while the fourth group had intermediate values of normal seedlings and significant values of dead seeds (Table 3).

The higher variability observed in seeds for own use, with the formation of four similar groups, support the results obtained by Tozzo and Penske (2008), which showed a great discrepancy in the results and subjectivity in the criteria adopted by the farmers in the selection of their seeds. As for crop productivity, Marcos-Filho (2015) emphasized the importance of the use of quality seeds for establishment of the field stand and highlighted other factors directly associated with productivity, such as cultivar choice, climatic conditions, soil fertility, sanity, timing and procedures adopted at harvest to reduce losses.

Conclusions

The percentage of germination of normal seedlings presented high negative correlation, and significant and direct effect on percentage of dead seeds. Clustering analysis formed three seedling groups in seeds produced according to the national seed system and four groups in seeds for their own use, which indicates a great diversity in the seeds for their own use.

The groups with the highest sample representativeness were the ones that presented the highest physical and physiological qualities, both in seeds produced according to the national seed system and those for their own use.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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