

Physiological Traits and Their Relationships in Black Oat Populations

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ABSTRACT. The objective of this work was to verify physiological quality of black oat populations, in order to know and point out the relationships among physiological characters for selection of progenies. The experiment was carried out at the Laboratory of Plant Breeding and Production, Federal University of Santa Maria, Campus of Frederico Westphalen - RS. Seed samples were collected from 14 black oat populations from small producers in the region, and cultivars BRS Madrugada and BRS Centauro (populations 15

and 16, respectively). A randomized block design with four replications was used. It was evaluated seed length, seed width, thousand seed weight, percentage of germination, non-germinated seeds, abnormal seedlings, hypocotyl length, root length, dry matter of seedlings. Populations revealed a difference in the physiological quality of seeds, and populations 1, 8, 9, 11, 12, 13, with germination within the required standard, have a greater potential to compose progenies. Seed width, thousand seed weight, dry matter of seedlings and hypocotyl length revealed association with germination. It is worth highlighting that seed width and thousand seed weight are characters of easy and immediate measurement that can guarantee greater efficiency of selection.

Keywords: *Avena strigosa* S; Germination; Correlation.

INTRODUCTION

Black oat (S., *Avena strigosa*), winter cereal, known worldwide for its ability to produce grains and fodder. When cultivated with fodder, it reveals production gains in dairy cows (Salgado et al., 2013). When used in soil cover, black oat contributes to improving the physical and biological quality of the soil, as well as helping to control diseases and weeds in the area (Oliveira et al., 2014; Souza et al., 2009).

The use of seeds with high vigor guarantees stand establishment of plants with uniform germination, a fundamental factor to ensure success of the production (Oliveira et al., 2009). In the case of low-vigor seeds, it may be possible to produce a uniform stand of plants and, depending on the situation, it may be necessary to carry out new sowing, resulting in increased production costs (Pinto et al., 2007).

Breeding has led to development of more and more productive cultivars. These gains account for more than 50% of the increase in grain yield. Seeds of new cultivars, within the required quality standards, are made available to producers and will provide a uniform plant stand, consequently increasing productive performance. However, when the producer uses his own seed, called “seed saved”, produced outside the required quality standards, in addition to having badly established crops, may stop using new technologies already available (Torres et al., 2015, Tozzo and Peske, 2007).

The use of quality seeds is crucial to give potential crops high yield. Quality seeds provide plants with higher productive potential, i.e., higher initial growth rate and metabolic efficiency, which leads to greater accumulation of dry matter and yield (Kolchinski et al., 2006). The quality of the seeds is conferred by genetic, physical, physiological and sanitary factors. These factors have a direct influence on crop performance and production costs.

The economy in the purchase of quality seeds can result in increased of crop costs, due to the greater amount of seeds used to guarantee an adequate plant stand (Kryzanowski and Neto, 2003). In addition, it is important to emphasize the sanitary quality of the seeds saved. According to Silva et al. (2016), analyzing salted beans seeds revealed that seeds are unsuitable for sowing and/or commercialization, because they presented agents potentially disseminating pest insects and diseases, which generates an increase in production costs.

In order to quantify the physiological quality of seeds, germination and vigor tests are used. The procedure for performing the tests is described by the Regras para Análise de Sementes (BRASIL, 2009), specifying variations for each species. The vigor tests are essential for the characterization of physical, biological and physiological attributes, and especially for differentiation of vigor levels among lots and genotypes (Carvalho and Nakagawa, 2000). According to Toledo et al. (2009), the decrease in the percentage of germination,

indicates reduction of the physiological quality, and consequently the increase of abnormal seedlings and of low vigor. For the purpose to guarantee progenies selection with high productive potential in oat breeding programs, it is worth considering physiological quality of the crop. The more characteristics are known, the greater the efficiency in selection strategies.

Thus, hypotheses were formulated: (i) seeds with larger size present higher germinative potential; (ii) visual selection of seeds, according to their size, can be performed efficiently in breeding programs. In this way, hypotheses motivated aim of the work: to verify physiological quality of black oat populations, to know and to point out relationships among physiological traits for progenies selection.

MATERIAL AND METHODS

The present work was carried out in the Genetic Breeding and Plant Production Laboratory (GBPPL), Federal University of Santa Maria, Campus of Frederico Westphalen - RS. In order to carry out experiment, seed samples were collected from black oat populations, about 3 kg, from small farmers in Rio Grande do Sul, in the harvest of 2013. Totaling 14 populations, as well as two commercial cultivars, BRS Madrugada and BRS Centauro, referred to as populations 15 and 16, respectively.

The experimental design was randomized blocks, with four replications. Initially, evaluations were performed on seed samples, such as the description of traits: seed length (SL) and seed width (SW). For this, four replicates of ten seeds of each population were analyzed, using a digital caliper, in millimeters (mm). It was also determined thousand seeds weight (TSW), by counting eight replicates of 100 seeds of each population of black oats, weighed in a precision balance, given in grams (g).

In order to conduct the germination test, four replicates of 100 seeds of each population were used (BRASIL, 2009). The seeds were placed in germitest type paper and placed in germination camera type B.O.D, at a constant temperature of 20°C and photoperiod of 12 hours. After the test installed, were evaluated traits: germination (G), evaluated at 10 days, percentage of normal seedlings was counted; non-germinated seeds (NG), evaluated percentage of seeds not germinated at 10 days and abnormal seedlings (AS), obtained by the percentage of abnormal seedlings. At the end of the germination test (10 days), hypocotyl length (HL) and radicle length (RL) were obtained by measuring ten randomly selected seedlings per repetition with the aid of a digital caliper, expressed results in centimeter (cm). After mediation, the same ten seedlings were used to determine dry matter of seedlings (DMS), where the seedlings were conditioned in an oven with forced air circulation at 60°C until reaching constant weight, and weighed in a precision balance, results expressed in grams (g).

Data analysis was performed with genes statistical software (CRUZ, 2013). The data were submitted to variance analysis by the F test, after the homogeneity assumptions of the variances and normality of the residues were met. For traits that showed a significant difference at 5% probability of error, the means clustering test was performed by Scott Knott ($p < 0.05$).

Pearson correlation analysis was performed for nine traits obtained, and represented graphically, using Microsoft Office Excel®. The magnitudes of the estimates were classified according to Carvalho et al. (2004).

RESULTS

The variance analysis revealed a significant difference for traits SL, SW, TSW, G, NG, DMS and HL (Table 1), evidencing a difference in physiological quality among the studied black oat populations. As for seed size, it can be observed that for SL, population 2 showed a longer length, and for SW populations 9, 8, 13, 7, 12, 15 and 16 showed higher values (Table 2).

Table 1. Summary of variance analysis (mean square) for seeds length (SL), seeds width (SW), thousand seeds weight (TSW), germination (G), non-germination seeds (NG), abnormal seedlings (AS), dry matter of seedlings (DMS), hypocotyl length (HL), root length (RL) for 16 black oat populations.

FV ^(d)	DF	SL	SW	TSW	G	NG	AS	DMS	HL	RL
Blocks	3	0.20	0.01	0.30	0.01	0.003	0.001	0.000	0.21	7.37
Population	15	1.60*	0.08*	35.49*	0.20*	0.19*	0.003ns	0.001*	11.09*	21.47ns
Residue	45	0.14	0.01	0.17	0.003	0.002	0.001	0.0001	1.57	6.44
Total	55									
Means		10.04	1.72	17.27	76.04	18.65	5.29	0.07	9.44	8.57
CV (%)		3.77	4.15	2.39	6.62	22.56	60.69	15.56	13.26	29.59

For TSW, populations 9 and 16, and population 10, with higher and lower weight values, respectively (Table 2). Population 9, with higher TSW, showed higher percentages of G, and population 10 had the lowest percentages, consequently higher percentage of NG, evidencing that greater accumulation of reserves in the seed collaborates to increase the potential of vigor and germination.

DMS revealed equality of averages for populations, except for population 10, which revealed a lower matter than the others. HL showed values between 4.99 cm (Population 10) to 11.32 cm (Population 8), again evidencing that seed reserve is responsible for the growth and maintenance of the seedling, until it is able to perform photosynthesis.

Table 2. Means for seeds length (SL), seeds width (SW), thousand seeds weight (TSW), germination (G), non-germination seeds (NG), dry matter of seedlings (DMS), hypocotyl length (HL) for 16 black oat populations.

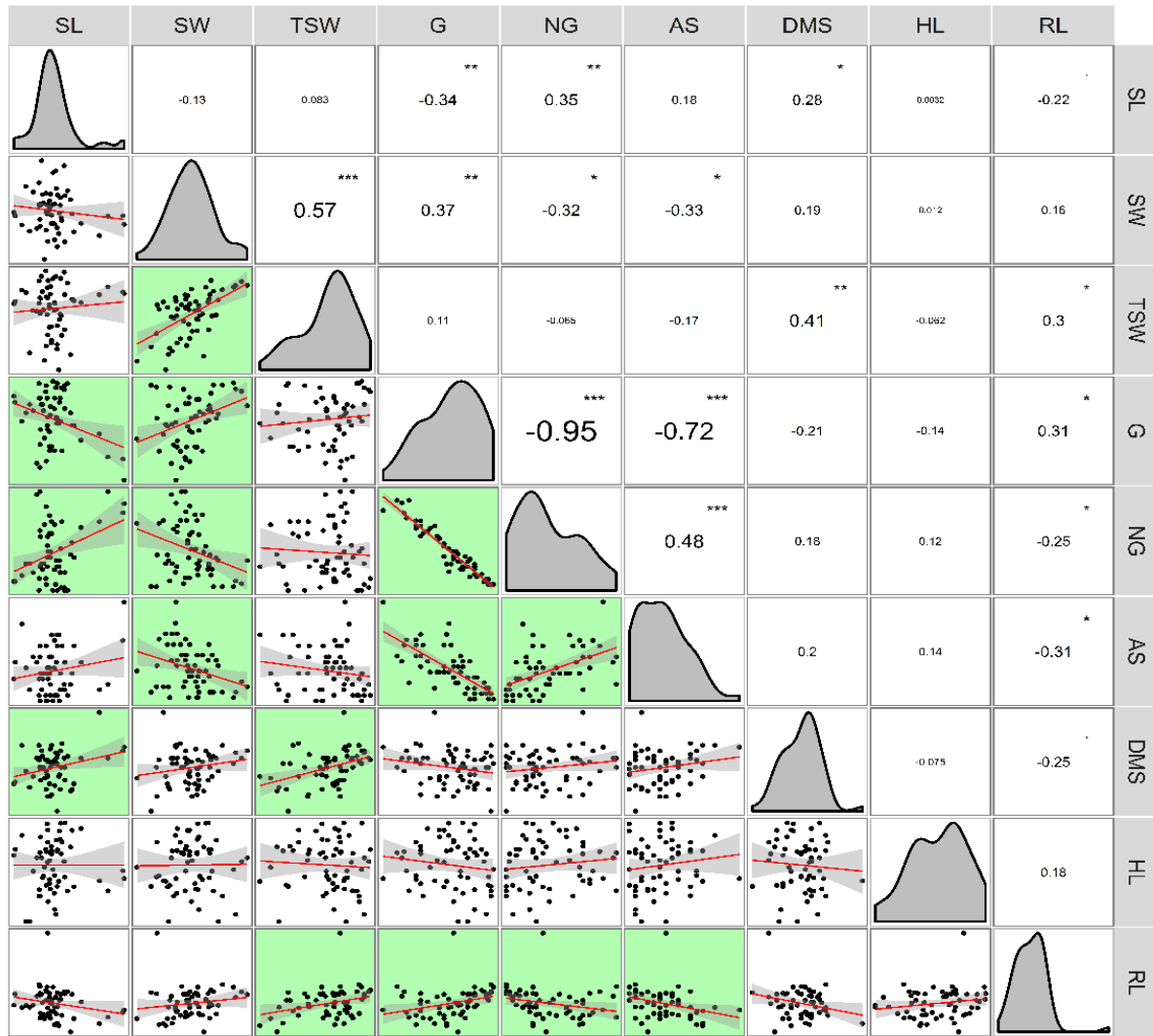
Population	SL (mm)	SW (mm)	TSW (g)	G (%)	NG (%)	DMS (g seedling ⁻¹)	HL (cm)
1	8.935 c	1.73 c	18.52 c	88.00 b	4.75 e	0.069 a	10.16 a
2	12.09 a	1.68 c	19.09 b	62.75 e	28.75 b	0.083 a	8.90 b
3	10.03 b	1.70 c	18.73 c	76.75 c	17.25 c	0.065 a	10.99 a
4	10.04 b	1.67 c	18.05 d	69.75 d	20.50 c	0.070 a	8.67 b
5	10.15 b	1.65 c	14.28 g	78.50 c	13.50 d	0.063 a	9.93 a
6	9.99 b	1.71 c	15.73 f	69.50 d	21.75 c	0.074 a	11.00 a
7	10.04 b	1.78 b	16.71 e	78.25 c	16.00 c	0.062 a	10.64 a
8	10.26 b	1.82 b	18.68 c	83.25 b	11.75 d	0.065 a	11.32 a
9	9.99 b	1.92 a	20.33 a	89.25 b	8.00 d	0.076 a	10.68 a
10	10.27 b	1.32 d	7.98 h	3.00 f	94.00 a	0.029 b	4.99 c
11	9.87 b	1.61 c	15.38 f	95.00 a	3.75 e	0.057 a	8.22 b
12	9.76 b	1.78 b	17.89 d	86.75 b	8.25 d	0.066 a	8.495 b
13	9.60 b	1.81 b	19.23 b	84.25 b	11.50 d	0.073 a	7.95 b
14	9.64 b	1.72 c	18.31 c	61.75 e	30.50 b	0.067 a	9.94 a
15	9.96 b	1.76 b	17.45 d	92.25 a	6.75 e	0.065 a	10.99 a
16	10.02 b	1.92 a	19.95 a	97.75 a	1.50 e	0.076 a	8.21 b
CV (%)	3.77	4.15	2.39	6.62	22.5	15.56	13.26

According to ABRASEM (2013), only populations 1, 8, 9, 11, 12, 13, 15 and 16 that presented G above 80%, meet the minimum requirements and could be marketed as seeds, with the other populations have low G values.

Evaluating the linear associations among studied traits, one can observe strong and positive correlation among traits SL, TSW, G, DMS and HL (Figure 1). The SW showed a positive and strong association with TSW, G, DMS and moderate with HL and RL. TSW revealed positive and strong correlation with G, DMS and moderate for HL and RL. It should be noted that seed size and weight showed a relation with vigor, germination potential and, consequently, potential for seedling development.

In addition, SW, TSW, DMS and HL revealed strong and negative association with NG. Noting that seeds with greater width and accumulation of reserves have a greater chance of germinating and generating healthy seedlings.

DMS has an association with traits SW, TSW, G and HL, and the reduction of these traits implies the reduction of DMS, reducing the seedling establishment potential. It can be emphasized that the increase in the percentage of AN results in a decrease in RL



SL: Seed Length; SW: Seed Width; TSW: Thousand Seeds Weight; G: Germination; NG: Non-Germinated Seeds; AS: Abnormal Seedlings, DMS: Dry Matter of Seedlings; HL: Hypocotyl Length, RL: Root Length.

Figure 1. Pearson correlation among physiological traits of black oat populations, correlations highlighted in green are significant at 5% by the t test (N = 60).

DISCUSSION

Genotypes that showed higher SL and TSW were the ones revealed higher G. Studies report that seed size has a positive influence on plant development and grain yield, which is provided by large seeds (Pádua et al., 2010; Pagliarini et al., 2014). Studies with assisted soybean selection have shown that hundred seed weight is a trait has high importance for progeny selection, and can be applied in the selection for other crops (Shu et al., 2013).

Alves et al. (2011), evaluating physiological quality of primary, secondary and tertiary spikelet seed of white oat, reports that, regardless of genotype, the primary seeds, with higher weight, have superior germination and vigor. For this reason, the classification of seeds by weight is valid, being a strategy that guarantees emergency uniformity of seedlings of similar size and vigor (Carvalho and Nakagawa, 2012).

In addition, high-vigor seeds have potential for faster and more uniform germination, a characteristic that confers the ability to withstand environmental adversities through the escape, allowing greater yield potential (Lopes et al., 2002; Melo et al., 2016).

The low germination observed for populations, mainly population 10, can be explained by their origin, called seeds saved. In this way, the importance of the purchase of certified seeds, which present adequate germination potential to guarantee better growth and development of plants, is emphasized. The certified seeds undergo a more rigid process, in which technology is required from choice of the cultivar until commercialization. This technology includes area selection, recommended cultivars, sowing within the agricultural zoning, monitoring throughout the cycle, use of cultural and chemical practices, determination of the ideal point for harvesting, in addition to the ideal conditions of harvest, transportation, processing and storage of seeds (Marcondes et al., 2005; Sinício et al., 2009).

As regards relationships among physiological traits, the results found show a positive relationship among SW, TSW, G, DMS and HL, corroborate with the research carried out. Carvalho et al. (2015), studying phenotypic associations among physiological traits of soybean, emphasizes that seedling size implies on field emergence, that is, the larger the potential the greater the potential for emergence.

Carvalho and Nakagawa (2012) reported a positive association between seed weight and germination potential, and the greater the nutrient reserve contained in the seed, the greater vigor of the seedling, as well as the potential for seedling survival. This is observed because heavier seeds have been developed under optimum conditions of nutrition, temperature, water availability, and luminosity, therefore, contain more reserves. In conditions of environmental variability, seed size and protein content are predictors of seedling vigor and germination (Snider et al., 2016).

Ching (1973) studying ryegrass, clover and canola seedlings, observed a positive association between seed weight, seedling length, dry and fresh matter of seedling with adenosine triphosphate (ATP) content per seed, and seedlings vigor. As is known, before plant is photosynthetically active, reserves present in the seed are responsible for seedling establishment (Turley and Chapman, 2010). Therefore, the accumulation of seed reserves is important in the germination process, because with the breakdown of the organic compounds, energy is generated necessary for the growth and maintenance of the seedling in the initial period of development (Taiz et al., 2017).

CONCLUSION

We can conclude that populations showed a difference in physiological quality of seeds, and populations 1, 8, 9, 11, 12, 13, with germination within required standard, have a greater potential to make progenies. The traits of seed width, thousand seeds weight, dry matter of seedlings and hypocotyl length showed association with germination. It is worth mentioning that seed width and thousand seeds weight are traits of easy and immediate measurement that can guarantee greater efficiency of seed selection.

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