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PHYSIOLOGICAL CHANGES IN WHEAT SEEDS DURING THE ARTIFICIAL DRYING PROCESS

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ABSTRACT

The desiccation tolerance presented by orthodox species is a characteristic that allows the loss of water keeping the seed viable. However, the reduction of the moisture content by drying, has a critical limit, and a loss beyond this limit results in a reduction in the physiological quality of the seeds, TBIO Sossego cultivar. The objective of this study was to evaluate the physiological changes resulting from the reduction of moisture percentage in the artificial drying process of wheat seeds. The seeds used were of the cultivar TBIO Sossego with initial water content of 14.7%. The seeds were dried at 40 ± 2 °C until reaching 12, 10 and 8% moisture. The evaluated variables were germination, seedling length, electrical conductivity, field emergence, shoot length and root length. Drying of wheat seeds can be performed up to 8% moisture without affecting the physiological quality of the seeds.

Palavras-chave:
germinação
emergência
Triticum aestivum
vigor
teor de umidade

ALTERAÇÕES FISIOLÓGICAS EM SEMENTES DE TRIGO DURANTE O PROCESSO DE SECAGEM ARTIFICIAL

RESUMO

A tolerância à dessecação apresentada por espécies ortodoxas é uma característica que permite a perda de água mantendo a semente viável. Entretanto, a redução do teor de umidade pela secagem, possui um limite crítico, sendo que, uma perda além deste limite resulta em redução da qualidade fisiológica das sementes. O objetivo do trabalho foi avaliar as alterações fisiológicas com a perda no percentual de umidade no processo de secagem artificial de sementes de trigo, cultivar TBIO Sossego. As sementes utilizadas foram da cultivar TBIO Sossego com teor de água inicial de 14,7%. As sementes foram submetidas à secagem à 40 ± 2ºC até atingirem teores de umidade de 12, 10 e 8%. As variáveis avaliadas foram germinação, comprimento de plântulas, condutividade elétrica, emergência a campo, comprimento de parte aérea e raiz. A secagem de sementes de trigo pode ser realizada até 8% de umidade sem afetar a qualidade fisiológica das sementes.

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INTRODUCTION

The wheat (*Triticum aestivum* L.) crop is one of the main cereals grown worldwide and has great importance in human nutrition. The Brazilian production of this cereal in the 2018 harvest was 5.43 million tons, with this production located mainly in the southern region of Brazil (CONAB, 2019).

The use of seeds of high physiological quality is one of the main factors responsible for the establishment of the plant stand, which may directly or indirectly influence the production of a crop (MARCOS-FILHO, 2015).

One of the processes performed after the harvest is the drying of the seeds. If this process is done improperly, it can result in physical, chemical changes and loss of the physiological quality of wheat seeds (DELIBERALI *et al.* 2010). Drying is a strategy used to reduce seed moisture, which acts directly to decrease metabolism, further reducing damage caused by fungi and insects (OLIVEIRA *et al.* 2011) and increasing seed longevity during storage (CARLESSO *et al.* 2008).

Tolerance to desiccation is a characteristic of species that produce orthodox seeds, which provides great longevity to seeds when stored with low water content (BEWLEY *et al.* 2013). Drying seeds at low water levels was studied in carrot, peanut, lettuce, rapeseed and onion seeds, and below 7% of moisture the seeds did not change in their physiological quality (HONG *et al.* 2005). Similar results were obtained by José *et al.* (2009), in which sunflower seeds dried to a moisture content of 3.2%, did not show any difference in physiological quality.

Despite the importance of reducing the moisture content, different species have a critical moisture content, and a loss beyond this limit results in a reduction in seed longevity (ELLIS and HONG, 2006). However, the literature is contradictory about the effects of drying at low or close to critical levels, being necessary to evaluate the effects on germination and vigor in seeds with reduced moisture content, seeking to define critical levels (MIRA *et al.* 2015).

Thus, the work aimed to evaluate the physiological changes during the process of reducing the moisture percentage due to the artificial drying of wheat seeds, cultivar TBIO Sossego.

MATERIAL AND METHODS

Four repetitions of a batch of seeds of the cultivar TBIO Sossego, produced in the 2017 harvest, and stored by a seed processing unit located in Campos Novos - Santa Catarina, were used to evaluate the drying effect. The seeds were transferred to the Seed Analysis Laboratory of the Agroveterinary Sciences Center, University of Santa Catarina State, CAV/UDESC, Lages, SC, where the experiment was carried out.

Two repetitions of 5 g, packed in aluminum capsules and taken to the oven at 105ºC, for 24 hours were used to determine the initial moisture content (BRASIL, 2009). The seed lot initially had a moisture content of 14.7%.

The effect of drying on the final moisture content of seeds was evaluated by drying the seed to a moisture content of 12% (treatment 1), 10% (treatment 2) and 8% (treatment 3). The seeds were divided into three working samples of 300g each.

In order to perform the drying process, the seeds were placed in Kraft paper bags and the working samples were submitted to drying in an oven with forced air circulation at a temperature of 40 ± 2 °C until reaching 12, 10 and 8% moisture content, respectively. The control of water loss was carried out using the gravimetric method, weighing every hour using an analytical balance with an accuracy of 0.001 g, thus generating a drying curve. To monitor the temperature of the seed mass, a digital thermo-hygrometer was used, in which the electrode was placed inside the Kraft bags and between the seeds during drying.

To evaluate the effects of treatments, the variables such as germination (normal seedlings, abnormal seedlings and dead seeds), seedling length, electrical conductivity, field emergence, shoot length and root length were evaluated.

The germination test was conducted using eight repetitions of 50 seeds arranged on germitest® paper in the form of a roll, which was moistened using 2.5 times the dry paper mass. The rollers were arranged vertically inside the Mangelsdorf-type germinator set at a temperature of 20 ± 1ºC. The first count was performed on the fourth day, and the final count on the eighth day after the test was set up (BRASIL, 2009). For the evaluation of the first count, seedlings in which the coleoptile had been broken by the plumule were counted.

After the final count, the seedling length test was performed. For this purpose, eight replications were used, each one composed of ten seedlings from each germination roller. The seedlings length was determined using a ruler graduated in millimeters and the results were expressed in cm.plantula^{-1} (NAKAGAWA, 1999).

For conducting the electrical conductivity test, seeds with different water content were submitted to a moisture content correction to 12%. Thereafter, eight repetitions of 50 seeds previously weighed and placed in a plastic cup containing 50 mL of distilled water were used, which were kept in a germination chamber type BOD (Biological Oxygen Demand) at a constant temperature of 25ºC for 24 hours. After this period, electrical conductivity was evaluated using a Quimis® bench-top conductivity meter and the results were expressed in µS cm^{-1} g^{-1} of seed.

The seedling emergence test in the field was performed in sand, (20 cm layer on soil), in homogenized beds, roofless. Eight replications of 50 seeds per treatment were sown at a depth of 3 cm using a template. The evaluation of the number of normal seedlings emerged was performed on the fifteenth day after sowing and the results were expressed as a percentage. A ruler graduated in millimeters was used to evaluate the shoot and root length. The data on air temperature and precipitation conditions during the test were obtained through the INMET automatic meteorological station located in Lages, Santa Catarina (Figure 1).

The results were submitted to analysis of variance (F test) by the Sisvar software, 5.6 version. The comparison of means was performed using the Tukey test at 5% probability level.

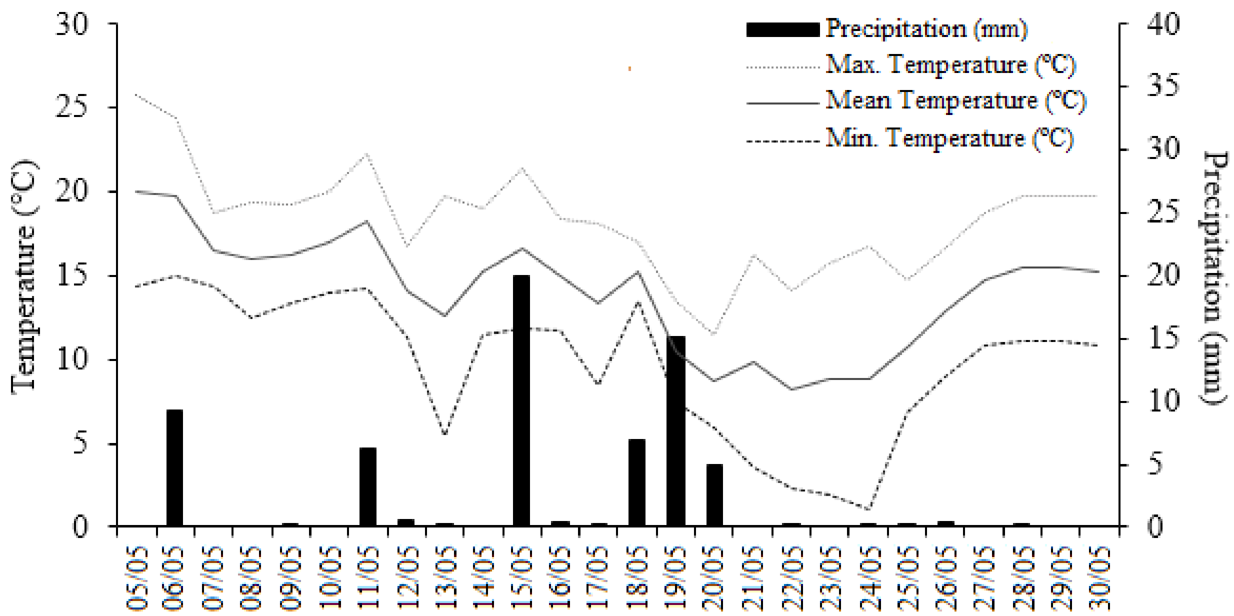

Figure 1. Precipitation, maximum, mean and minimum temperatures recorded during the month of May 2018. The vertical lines correspond to the period in which the emergency test was performed

RESULTS AND DISCUSSION

The drying curve and temperature of the wheat seed mass during the period of exposure to the temperature of 40 ± 2 °C in a forced air circulation oven can be seen in Figure 2. After the first hour of drying, a temperature of 37 °C was observed, reaching a peak of 43 °C after 24 hours. Thereafter, the mass temperature remained constant until the end of the process. The initial seed moisture of 14.7% reached 12.0% five hours after drying started. The moisture of 10.0% was reached after 13 hours of drying, and 8.0% moisture was obtained after 31 hours of the drying time.

The drying curve shows that the decrease in moisture is not linear. According to Oliveira *et al.* (2016) there is a higher speed and rate of water removal from the seeds due to the higher moisture gradient between them and the air. With the reduction of the water content, the evaporation rate decreases gradually until reaching its equilibrium water content. The reduction of the water content of the seeds involves the partial removal of water from the seed through the simultaneous transfer of heat from the air to the seed. However, depending on the method and conditions used for drying, changes in the physiological quality and on the physical properties of the batch can occur (PESKE *et al.*, 2019).

The statistical analysis revealed a significant effect for the first germination count between each final moisture content (Table 1). The seeds with a final moisture content of 8% presented the lowest percentage of first germination count, followed by seeds with 10 and 12%, respectively. According to Marcos-Filho (2015), seeds with a moisture content of less than 11% are most affected when subjected to the germination test, resulting in greater damage during imbibition. This damage occurs due to the effect on the reorganization of cell membranes, in which, the rapid absorption of water by the seeds results in a transition from the "gel" state of the membranes to the crystalline liquid state, resulting in the overflow of solutes and cellular damage (BEWLEY *et al.* , 2013). Thus, the greatest difference in water potential between seed and substrate resulted in rapid water absorption and damage to seeds with lower initial moisture content, which affected the speed of germination (i.e. first count).

However, despite wheat seeds with moisture content below 12% showing a delay in coleoptile

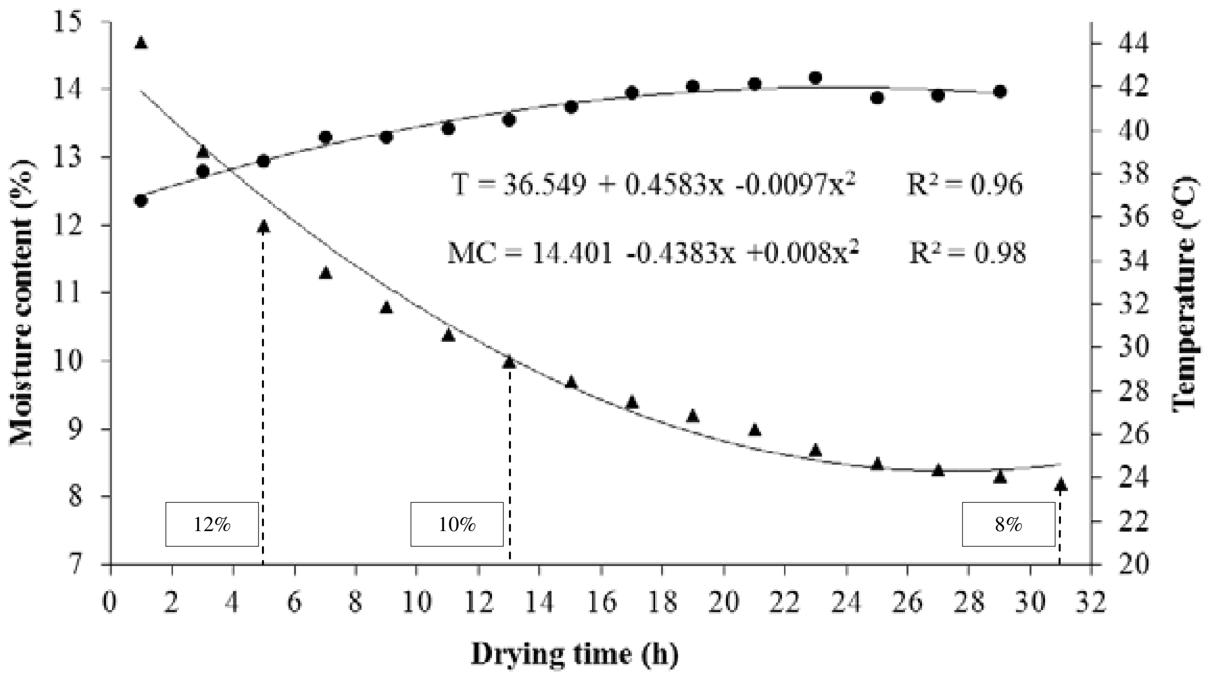

Figure 2. Drying curve and temperature of the wheat seed mass during the period of exposure to the temperature of 40 ± 2 °C in a forced air circulation oven

breaking (criteria determined for the evaluation of the first count), there was no statistical difference between normal, abnormal and dead seedlings in the final count of the germination test (Table 1), indicating that drying up to 8% did not compromise seed germination.

The vigor determined by the seedling length and electrical conductivity was not affected by the drying and reduction of the moisture content of the seeds (Table 2).

The seedlings length is a parameter used to segregate seed lots, and the lots with greater vigor present seedlings with greater length (NAKAGAWA, 1999). Nevertheless, even after drying, the reduction in moisture content did not significantly affect the length of the seedlings. This result may be related to the drying temperature used, since according to Hartmann-Filho *et al*. (2016) the temperature of 40 ºC can be used for drying seeds, as it does not affect seedling performance.

The seeds, when subjected to imbibition, undergo a process of reestablishing the integrity of the membranes resulting in the release of solutes into the medium. This loss of solutes can be assessed by electrical conductivity, wherein seeds with a higher degree of deterioration have higher values (BEWLEY *et al*., 2013). However, it is observed that the reduction of moisture by drying at 40 °C up to the values of 12, 10 and 8% did not significantly alter the electrical conductivity of the seeds. These results indicate that there was no severe damage to the seeds or their membrane structure.

The percentage of emergence in sand, as well as the shoot length and root length of the seedlings in sand did not show significant differences (Table 3), demonstrating coherence with the seedling length and electrical conductivity values.

Table 1. Percentage of normal, abnormal seedlings and dead wheat seeds with different water contents after artificial drying, at first count and final count

Moisture (%)	First count	Final Count		
	Normal (%)	Normal (%)	Abnormal (%)	Dead (%)
12	50 a*	95 a	2 a	3 a
10	31 b	94 a	3 a	4 a
8	6 c	94 a	3 a	3 a
CV (%)	32.0	2.6	87.0	68.6

* Means followed by the same letter in the column, do not differ statistically from each other by the Tukey test at 5% probability level.

Table 2. Seedling length and electrical conductivity of wheat seeds with different water contents after drying

Moisture (%)	Seedling length (cm)	Electrical conductivity ($\mu S.cm^{-1}.g^{-1}$)
12	32.3 a*	24.0 a
10	33.6 a	25.5 a
8	28.7 a	27.4 a
CV (%)	16.7	10.9

* Means followed by the same letter in the column, do not differ statistically from each other by the Tukey test at 5% probability level

Table 3. Percentage of emergence, shoot and root length of wheat seeds seedlings with different water contents after drying

Moisture (%)	Emergency (%)	Shoot length (cm)	Root length (cm)
12	92 a*	11.5 a	12.5 a
10	92 a	12.3 a	14.1 a
8	90 a	12.1 a	14.7 a
CV (%)	5.5	11.7	14.9

*Means followed by the same letter in the column, do not differ statistically from each other by the Tukey test at 5% probability level.

Although Eichelberger (2011) indicates that the temperature of the seed mass cannot exceed 40 °C in order to maintain its physiological quality, in this study, the physiological quality was maintained even though the seed mass reached 43 °C. According to Prado *et al*. (2000), the removal of water during the drying of biological products generates a reduction of the tension existing inside the cells, thus promoting their volumetric contraction. The use of high temperatures for drying causes a rapid mobilization of water from the seed surface, generating a greater moisture gradient with its interior, resulting in damage to the seeds.

Considering that seed moisture is a determining factor for storage, it is desirable to achieve a moisture reduction that does not alter the physiological quality of the seeds. Thus, it is possible to dry wheat seeds up to 8% moisture content using a temperature of 40 ± 2ºC, without affecting their physiological quality. Considering that the seeds may present moisture gains due to their hygroscopic behavior, this study is important in environments where humidity is controlled, such as the preservation of genetic resources in germplasm banks.

CONCLUSION

- The drying of wheat seeds can be performed up to 8% of moisture without affecting the physiological quality of the seeds.
- The oven drying with forced air circulation using a temperature of 40 ± 2ºC, can be used to reduce the moisture content of the seeds without affecting their physiological quality.

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