ISSN 2175-6813

Revista Engenharia na Agricultura

Viçosa, MG, DEA/UFV - DOI: 10.13083/reveng.v28i.972 V.28, p.185-191, 2020

QUALITY OF CORN SEEDS STORED IN DIFFERENT TYPES OF PACKAGING AND STRESS CONDITIONS

André Fernandes Capilheira[1], Joseano Graciliano da Silva[2], Jerffeson Araujo Cavalcante[3], Nander Ferraz Hornk[4] & Gizele Ingrid Gadotti[5]

1 - Agronomist. Doctorate student in Seed Technology and Science, UFPel, capilheira@hotmail.com

2 - Agronomist Master Science student in Seed Technology and Science at UFPel.

3 - Agronomist. Doctorate student in Seed Technology and Science at UFPel.

4 - Agriculture engineer. Master Science student in Seed Technology and Science at UFPel.

5 - Agriculture engineer. Professor PhD in Seed Technology and Science at UFPel.

KEYWORD:
deterioration
hermeticity
moisture content
Zea mays

ABSTRACT

Corn (*Zea mays*) is one of the most cultivated poaceae in the world with high agricultural potential. It is propagated through seeds, which sometimes remain stored until the sowing period. Among the various forms of storage, some aspects related to the environment and the type of material that constitutes the packaging may compromise the viability and vigor of these seeds. Therefore, the objective of this study was to evaluate the physiological quality of corn seeds stored in different types of packaging and subjected to conditions of high temperature and relative humidity throughout storage. For this purpose, moisture content, germination and vigor were evaluated through the cold test. A completely randomized design in a 4 x 4 factorial scheme (packaging x evaluation times) with four replications was used. Data were subjected to analysis of variance and regression, and the means were compared by Tukey test at 5% probability, using the Sisvar 5.3 statistical software. It was concluded that, in 45 days of storage, the moisture content in corn seeds reached values of up to 13.62%, which resulted in a reduction in the vigor due to high respiration caused by the storage temperature.

PALAVRAS-CHAVE:
deterioração
hermeticidade
teor de água
Zea mays

QUALIDADE DE SEMENTES DE MILHO ARMAZENADAS EM DIFERENTES EMBALAGENS E CONDIÇÃO DE ESTRESSE

RESUMO

O milho (*Zea mays*) é uma das poáceas mais cultivadas no mundo e de elevado potencial agrícola, com diversas finalidades. Sua propagação se dá por meio de sementes que, por vezes, permanecem armazenadas até o período de semeadura. Dentre as diversas formas de armazenamento, aspectos relativos ao ambiente e ao tipo de material que constitui as embalagens podem comprometer a viabilidade e o vigor dessas sementes. Diante disso, objetivou-se avaliar a qualidade fisiológica de sementes de milho armazenadas em diferentes embalagens e submetidas a condições de elevada temperatura e umidade relativa ao longo da armazenagem. Para tanto, foram realizadas avaliações do teor de água, germinação e vigor por meio do teste de frio. Utilizou-se o delineamento inteiramente casualizado, em esquema fatorial 4 x 4 (embalagens x épocas de avaliação) com quatro repetições. Os dados foram submetidos a análise de variância e regressão, com médias comparadas pelo teste de Tukey a 5% de probabilidade, com auxílio do programa estatístico Sisvar 5.3. Conclui-se que, em 45 dias de armazenamento, o teor de água nas sementes de milho atingiu valores de até 13,62%, o que resultou na redução do vigor devido a elevada respiração ocasionada pela temperatura de armazenamento.

Recebido para publicação em 26/10/2018 • Aprovado em 12/12/2019 • Publicado em 25/06/2020

INTRODUCTION

In the 2017/18 harvest, Brazil produced approximately 89 million tons of corn (*Zea mays*), with a cropped area of 16,639.8 thousand hectares, reaching a productivity of 4939 kg ha^{-1}; however, this represented a reduction by 11.2% in relation to the previous year. The southern region of the country, more specifically the state of Rio Grande do Sul, showed, in the same period, reductions of 11.6% and 20% in productivity and in corn production, respectively, compared to the previous year (CONAB, 2018). In relation to sowing, until 2015, the rate of use of seeds for this crop was 90%, according to data from the Brazilian Association of Seeds and Seedlings, which is also due to the large number of hybrids available in the market.

To achieve results of this magnitude, depending on climatic conditions, it is necessary to use seeds of higher quality, with a germination percentage above 85%, according to Normative Instruction No. 45 of September 17, 2013 (Brasil, 2013). Hence, they will be able to show greater tolerance to adverse conditions and to form a uniform crop with high agricultural productivity. In addition to the field production, other post-harvest activities are relevant, such as the off-season storage, in order to maintain the quality of the seed until it reaches the producer.

Storage emerges as an important tool in the conservation of viability and vigor in corn seeds, especially if it is used packaging that mitigates the influence of the external environment, which will influence respiration and the consequent deterioration of the seeds. Packaging made of cotton fabric (TONIN *et al*., 2014), polyethylene bags (PARAGINSKY *et al*., 2015), PET bottle (hermetic) (ANTONELLO *et al*., 2009; RODRIGUES *et al*., 2018) have been used in several works in order to preserve the physiological quality of the seed. In turn, this is determined by the interaction between genetic, sanitary physical and physiological attributes.

Previero *et al*. (2015) and Rodrigues *et al*. (2018) emphasize the importance of using hermetic packaging to preserve the physiological quality of corn seeds. It is worth noting that not only does the type of packaging influences the quality of the stored seeds, as well as their moisture content, since, when associated with high temperature (above 35 ºC), there is an increase in the respiratory rate and a consequent deterioration in the reserves and reduced vigor (SMANIOTTO *et al*., 2014; PARAGINSKI *et al*., 2015).

This effect is even more evident in seeds stored in permeable packaging, as they allow a greater interaction between them and the environment, as they are living beings and, when viable, they breathe constantly. Given the above, the objective of this study was to evaluate the physiological quality of corn seeds stored in different packaging and storage conditions.

MATERIAL AND METHODS

The experiment was conducted at the Didactic Laboratory of Seed Analysis of the Faculty of Agronomy Eliseu Maciel owned by the Federal University of Pelotas. Hybrid corn seeds 30F53VYHR, with 11% moisture, produced in the 2016 harvest were used.

The experiment used a completely randomized experimental design with four replications in a 4 x 4 factorial scheme (packaging x evaluation period). The packaging used were the following: hermetic (0.156-mm polyethylene), foil (aluminum paper), paper and raffia, all with a capacity of 1 kg of seed. The storage of corn seeds, in the condition of high temperature and humidity, was simulated in a BOD-type chamber, regulated at 30ºC and 75% relative humidity. To increase the humidity in the BOD, distilled water was placed in the lower compartment of the equipment.

Evaluations of moisture content, germination and vigor started at the storage. They were carried out using a cold test every 15 days, totaling four evaluations.

The determination of the moisture content in the seeds was carried out through the heater method with forced air circulation at 105±3°C for 24 hours (BRASIL, 2009), using four 4.5 + 0.5-gram repetitions weighed on a 0.0001-accuracy analytical scale. The results were expressed as a percentage.

The germination test used four replications of 50 seeds per treatment, sown in a germitest® paper roll moistened with distilled water in an amount equivalent to 2.5 times the mass of the non-hydrated substrate and stored in a germinator, regulated at 25°C. The counts were performed seven days after installation of the test, according to the Rules for Seed Analysis (BRASIL, 2009).

For the characterization of vigor through the cold test, four repetitions of 50 seeds per treatment were used. The seeds were sown in a roll of germitest® paper moistened with distilled water in an amount equivalent to 2.5 times the mass of the dry substrate. The rolls were placed in plastic bags and taken to a cold chamber at 10°C, where they remained for seven days (BARROS *et al*., 1999); after this period, they were removed from the bags and placed in a germinator at 25°C in the dark for five days, when the percentage of normal seedlings was computed.

The data obtained were subjected to analysis of variance and, when significant, the data of the qualitative factor (packaging) were compared using the test of Tukey at 5% probability and the quantitative factor subjected to regression analysis with the aid of the statistical software Sisvar 5.3 (FERREIRA, 2011).

RESULTS AND DISCUSSION

The variables shown in Table 1, referring to the attributes of physiological quality in corn seeds, had a significant statistical effect ($p < 0.01$) for the interaction between packaging type and storage periods. The influence of these factors on seed quality may be related to the permeability of the packaging in which they were stored, since, according to Smaniotto *et al*. (2014), certain types of packaging allow gas exchange with the environment, maintaining the balance with relative humidity and air temperature.

Regarding the moisture content of corn seeds (Table 2), a significant difference was observed between the types of packaging at 15, 30 and 45 days of storage, among which, the seeds stored in raffia and paper packaging had the highest moisture content, due to the greater permeability of the material.

For the germination variable (Table 2), it was observed that the seeds stored in the hermetic packaging had higher germination than those stored in the other packaging, even under stress conditions. The reduction in the viability of the seeds stored in the permeable packaging may the response of the variation in the moisture content of the seeds, as well as the high temperature imposed during storage.

The loss on the quality of corn seeds observed in this work may be related to the degenerative

Table 1. Summary of the analysis of variance for the variables moisture content (WC), germination (GERM) and cold test (COLDT) in corn seeds under stress conditions. UFPel, Pelotas – RS, 2018.

	-------------------- Mean square ---------------------			DF
	Moisture content	Germination	Cold test	
Packaging (P)	4.602**	2467.224**	1159.687**	3
Storage (S)	10.224**	11331.140**	14389.062**	3
P x S	2.568**	911.502**	400.132**	8
Error	0.058	18.745	33.489	48
Mean	11.64	72.20	45.22	
CV (%)	2.07	6.00	12.80	

** = significant at 1% probability by the test of Tukey. CV = coefficient of variation. DF = Degree of freedom.

Table 2. Analysis of the packaging factor for the variables moisture content (WC), germination (GERM) and cold test (COLDT) in corn seeds under stress conditions. UFPel, Pelotas – RS, 2018.

Evaluation Period	Packaging	Variable		
		WC	*GERM*	*COLDT*
0	Hermetic	11.22	96.00	76.00
	Foil	11.22	94.00	76.00
	Paper	11.22	95.00	75.00
	Raffia	11.22	96.00	76.00
15	Hermetic	11.02 a	94.00	71.00 a
	Foil	10.87 a	89.00	56.00 b
	Paper	10.30 b	95.00	67.00 a
	Raffia	10.67 ab	93.00	62.00 ab
30	Hermetic	11.17 b	88.00 a	55.00 a
	Foil	11.42 b	64.00 b	37.50 b
	Paper	13.55 a	54.00 c	25.00 c
	Raffia	13.10 a	40.00 d	5.50 d
45	Hermetic	11.17 c	74.00 a	26.00 a
	Foil	11.30 c	49.00 b	7.50 b
	Paper	13.12 b	32.00 c	6.50 b
	Raffia	13.62 a	3.50 d	2.00b

Means with equal letters in the column for each evaluation period do not differ statistically from each other by the test of Tukey at 5% probability.

changes that occur in the internal structures of the seeds, which promote the degradation of essential metabolisms, such as the loss of reserves, when they are subjected to unfavorable conditions of temperature and humidity. (RAVIKUMAR *et al*., 2002). The initial seed aging process, according to Goel *et al*. (2003), is caused by the increase in the oxidative activity, leading to the peroxidation of free radicals. Thus, through this free radical, a non-enzymatic peroxidation is induced, which disrupts the membrane systems at the cellular level, becoming the major cause of the deterioration of stored seeds (CARVALHO, 1994).

It is worth mentioning that, up to 30 days of storage, only the seeds stored in the hermetic packaging had germination higher than the minimum required (Table 2), in accordance with Law No. 10.711 of August 5, 2003, through Normative Instruction No. 45, of September 17, 2013, for commercialization which is 85% (BRASIL, 2013).

Regarding the vigor of the corn seeds (Table 2), it was found that at 15 days of storage there was a significant difference between the packaging, and those seeds stored in the foil packaging showed less vigor. However, at 30 days, the seeds stored in the hermetic packaging were more vigorous than the seeds stored in the other packaging. Also, this behavior was maintained until 45 days, even if showing low values. The reduction in the physiological quality of corn seeds was also observed by Tonin *et al*. (2014) when storing corn seeds in cotton fabric bags in room conditions up to 270 days, in the municipality of Pelotas – RS.

According to the regression analysis, whose data are shown in Figure 1A, only two types of packaging allowed variations in the moisture content of corn seeds stored under high temperature and air humidity, namely: paper and raffia packaging with values that adjusted to a linear equation of increasing effect, so that, the seeds gained 0.56 and 0.60% of water at every day of storage, due to the attempt to maintain the hygroscopic balance. On the other hand, hermetic and foil packaging did not statistically influence the values related to the moisture content of these seeds.

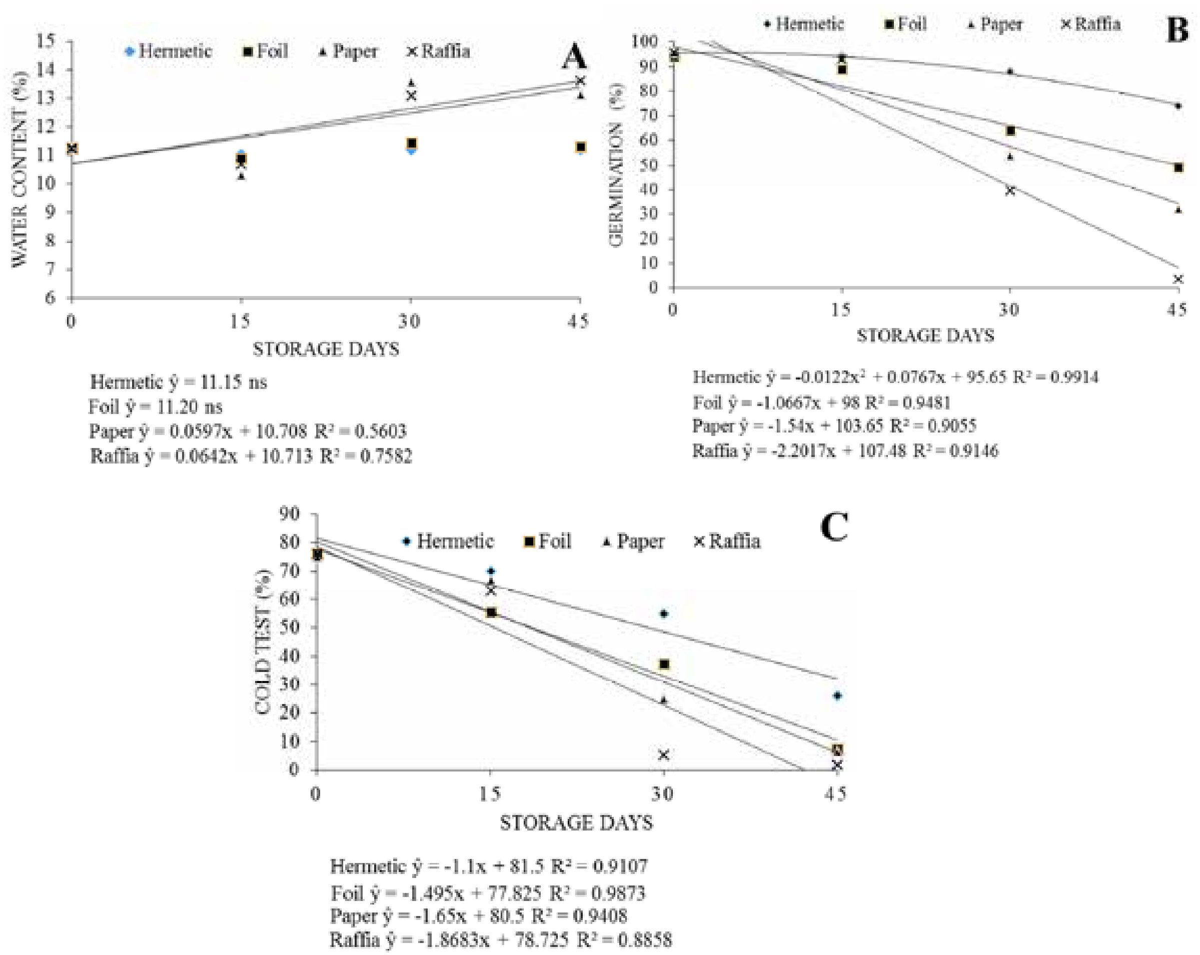

Figure 1. Moisture content (A), germination (B) and cold test (C) in hybrid corn seeds under stress conditions. UFPel, Pelotas – RS, 2018.

These results corroborate those of Smaniotto *et al*. (2014) and Paginski *et al*. (2015), where the authors suggest that the moisture content of the seeds is influenced by the temperature and the type of packaging in which the seed is stored. Thus, both the hermetic and the foil packages were efficient in maintaining the physiological quality of the seeds, avoiding excessive gains in the moisture content and consequent deterioration of the reserves due to the storage temperature.

According to Figure 1B, the storage of corn seeds in hermetic packaging provided germination values of up to 96.00% on the third day of storage, with a subsequent reduction to 74% at 45 days. However, the lower germination value estimated by the equation suggests that up to 32 days of storage under stress conditions imposed on seeds, it is still possible to obtain germination higher than the minimum required by the Brazilian seed legislation (BRASIL, 2013).

The reduction observed in the germination of corn seeds (Figure 1B) packed in foil and paper packaging was 1.09 and 1.48 percentage points per day, respectively. This reduction was even more accentuated when the seeds remained stored in raffia type packaging, in which it is possible to observe a decrease of 2.05 percentage points every day that the seeds remained stored under stress conditions.

These results suggest that the reduction in the percentage of germination in seeds results from several physiological changes that occur in the membrane structure of these seeds. In addition, when the temperature and humidity are high (greater than those tested in this work), the changes are more significant, resulting in loss of the physiological quality of the product and, therefore, of the viability of these seeds (PAGINSKI *et al*., 2015).

The results obtained by Paginski *et al*. (2015) corroborate with the previous statement, in which values for germination in corn equal to zero at 90 days were obtained when using semi-hermetic packaging at storage temperatures of 35ºC.

With regard to vigor, represented by the cold test (Figure 1C), it was observed that, regardless of the type of packaging in which the seeds remained stored, the values observed for this variable adjusted to a linear equation of decreasing effect, with daily reductions of 1.35; 1.92; 2.05; and 2.37 percentage points for hermetic, foil, paper and raffia packaging, respectively. Thus, up to 45 days of storage under stress conditions, estimated minimum values of up to 2% germination were obtained for seeds stored in raffia-type packaging. This justifies the mean value observed in Table 1 regarding the germination of the seeds submitted to the cold test.

It is likely that the reduction observed in the germination of corn seeds submitted to the cold test was caused by the difficulty of reorganizing the cell membranes during imbibition (GRZYBOWSKI *et al.*, 2015). This feature is compounded by the fact that corn is a summer crop, therefore, when sown at low temperatures, germination and the establishment of the seedling stand can be compromised due to temperatures below 10 ºC.

It should be mentioned that temperature and humidity, such as those tested in this study, occur in several places in Brazil and an understanding of the behavior that occurred is necessary. Considering the above, it is essential for the seed producer, dealer and farmer to understand the metabolisms that occurred during the storage period until sowing so that there is a guarantee of high quality in the lots they manage. Seed storage is an extremely important stage in the chain to guarantee a higher quality.

CONCLUSIONS

- The storage of corn seeds at 30ºC and 75% of relative humidity in foil and hermetic packaging were efficient in conserving the viability of the seeds until 15 and 30 days, respectively. Paper and raffia packaging allowed variations in moisture content and reductions in the seed vigor.

ACKNOWLEDGEMENTS

This experiment was supported by the Coordination for the Qualification of Higher Level Staff – Brasil (CAPES) – Funding Code 001.

REFERENCES

ANTONELLO, L.M.; MUNIZ, M.F.B.; BRAND, S.C.; RODRIGUES, J.; MENEZES, N.L.; KULCZYNSKI, S.M.. Influência do tipo de embalagem na qualidade fisiológica de sementes de milho crioulo. **Revista Brasileira de Sementes,** Londrina – PR, v.31, n.4, p.75-86, 2009.

BARROS, A.S.R.; DIAS, M.C.L.L.; CICERO, S.M.; KRZYZANOWSKI, F.C.. Testes de Frio. In: KRZYZANOWSKI, F.C.; VIEIRA, R.D.; NETO, J.B.F. (eds). **Vigor de Sementes: Conceitos e Testes.** 1ed. Londrina - PR: ABRATES, 1999. Cap.8. p.5.1-5.15.

BRASIL. Legislação Brasileira Sobre Sementes E Mudas; Lei n° 10.711, de 05 de agosto de 2003, **Instrução Normativa nº 45, de 17 de setembro de 2013**. Disponível em: <http://www.agricultura.pr.gov.br/arquivos/File/PDF/padroes_milho.pdf>. Acesso em: 19 ago. 2018.

CARVALHO, N.M.. O conceito de vigor em sementes. In: VIEIRA, R.D.; CARVALHO, N.M. (eds.). **Teste de vigor em sementes**. Jaboticabal: FUNEP, 1994. p.1-30.

CONAB – Companhia Nacional de Abastecimento. **Acompanhamento da Safra Brasileira.** Disponível em: <https://www.conab.gov.br/info-agro/safras>. Acesso em: 22 ago. 2018.

FERREIRA, D.F.. **Sisvar – software: versão 5.3**. Lavras: UFLA/DEX, 2011. Software.

GRZYBOWSKI, C.R.; VIEIRA, R.D.; PANOBIANCO, M.. Testes de estresse na avaliação do vigor de sementes de milho. **Revista Ciência Agronômica,** Fortaleza – CE, v.46, n.3, p.590-596, 2015.

GOEL, A.; GOEL, A. K.; SHEORAN, I. S. Changes in oxidative stress enzymes during artificial ageing in cotton (*Gossypium hirsutum* L.) seeds. **Journal of Plant Physiology**, Campos dos Goytacazes – RJ, v.160, p.1093-1100, 2003.

PARAGINSKI, R.T.; ROCKENBACH, B.A.; SANTOS, R.F.; ELIAS, M.C.; OLIVEIRA, M.. Qualidade de grãos de milho armazenados em diferentes temperaturas. **Revista Brasileira de Engenharia Agrícola e Ambiental,** Campina Grande – PB, v.19, n.4, p.358-363, 2015.

PREVIERO, C.A.; MORAES, E.D.S.; SANTOS, D.L.. **Avaliação da qualidade fisiológica de sementes de milho variedade (*Zea mays*) armazenadas em garrafas PET.** In: Congresso Latinoamericano de Agroecologia, 5., 2015. La Plata – ARG. 2015. 5p.

RAVIKUMAR, R.; ANANTHAKRISHNAN, G.; GIRIJA, S.; GANAPATHI, A.. Seed viability and biochemical changes associated with accelerated ageing in *Dendrocalamus strictus* seeds. **Biologia Plantarum**, v.45, n.1, p.153-156, 2002.

RODRIGUES, M.H.B.S.; SOUSA, V.F.O.; SANTOS, G.L.; NOBREGA, E.P.; ANDRADE, F.E.. Armazenamento de grãos em pequenas propriedades de São Francisco, Paraíba, Brasil. **Colloquium Agrariae,** Presidente Prudente – SP, v.14, n.2, p.35-47, 2018.

SMANIOTTO, T.A.S.; RESENDE, O.; MARÇAL, K.A.F.; OLIVEIRA, D.E.C.; SIMON, G.A. Qualidade fisiológica das sementes de soja armazenadas em diferentes condições. **Revista Brasileira de Engenharia Agrícola e Ambiental,** Campina Grande – PB, v.18, n.4, p.446-453, 2014.

TONIN, R.F.B.; LUCCA FILHO, O.A.; BAUDET, L.M.; ROSSETTO, M.. Potencial fisiológico de sementes de milho híbrido tratadas com inseticidas e armazenadas em duas condições de ambiente. **Scientia Agropecuaria,** Trujillo – PE, v.5, n.1, p.07-16, 2014.