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Physiological Quality of Hybrids and Creole Maize Seeds

Qualidade Fisológica de Sementes de Milho Híbrido e Crioulo

Helis Maria Salomão[a]; Silvia Rahe Pereira*[b]; Andreia Suchoronczek[c]; Adriano Suchoronczek[d]; Larissa Leite Momoli[a]; Sayonara Salvatti Müller[a]; Aline Ferreira Coelho[b]; Adriana Paula D'Agostini Contreiras Rodrigues[a]

[a]Universidade Tecnológica Federal do Paraná, *Campus* Pato Branco. PR, Brasil.
[b]Universidade Anhanguera UNIDERP, Programa de Pós-Graduação *Stricto Sensu* em Produção e Gestão Agroindustrial. MS, Brasil.
[c]Universidade Estadual do Centro-Oeste, Programa de Pós-Graduação *Stricto Sensu* em Biologia. PR, Brasil.
[d]Universidade Tecnológica Federal do Paraná, *Campus* Pato Branco, Programa de Pós-Graduação *Stricto Sensu* em Agronomia. PR, Brasil.
*E-mail: silviarahe@gmail.com

Abstract

The aim of this study was to evaluate the physiological quality of hybrid maize seeds (within the validity period and expired seeds) and of a Creole variety within the validity period. The study was performed using the hybrids C1 BM3063 PRO 2 (valid until 12/2018) and C1 SYN8A98 (valid until 03/2017 - expired one year ago) and a Creole maize (freshly harvested, collected at Pato Branco city, Paraná State, Brazil). Seed germination, germination speed index, germination speed, cold test, length and fresh and dried matter of shoot and root system were evaluated in a laboratory experiment. In the field we evaluated emergency, emergency speed index, emergency speed, length and fresh and dried matter of aerial part. Creole cultivar had the worse performance in all the variables tested. Expired hybrid (SYN8A98) presented similar development to the hybrid within the validity period (BM3063) in practically all the evaluated parameters. SYN 8A98 hybrid can be sown without risks of reduced productivity, provided that cold periods during field establishment are avoided. Creole variety in question did not perform satisfactorily and could not be used as seed.

Keywords: Seeds Validity Period. Open Pollinated Variety. Viability. Production Costs. Seeds Reuse.

Resumo

O objetivo deste estudo foi avaliar a qualidade fisiológica de sementes de milho híbrido (dentro do período de validade e sementes expiradas) e de uma variedade crioula dentro do período de validade. O estudo foi realizado utilizando os híbridos C1 BM3063 PRO 2 (válido até 12/2018) e C1 SYN8A98 (válido até 03/2017 - expirou há um ano) e um milho crioulo (recém-colhido, coletado na cidade de Pato Branco, Paraná, Brasil). Foram avaliados, em experimento laboratorial, a germinação de sementes, o índice de velocidade de germinação, a velocidade de germinação, o teste de frio, o comprimento e matéria fresca e seca da parte aérea e sistema radicular. No campo foram avaliados emergência, índice de velocidade de emergência, velocidade de emergência, comprimento e matéria fresca e seca da parte aérea. A cultivar crioula teve o pior desempenho em todas as variáveis testadas. O híbrido expirado (SYN 8A98) apresentou desenvolvimento similar ao híbrido dentro do período de validade (BM3063) em praticamente todos os parâmetros avaliados. O híbrido SYN 8A98 pode ser semeado sem riscos de produtividade reduzida, desde que sejam evitados períodos frios durante o estabelecimento em campo. A variedade crioula em questão não teve desempenho satisfatório e não pôde ser usada como semente.

Palavras-chave*: Período de Validade das Sementes. Variedade de Polinização Aberta. Viabilidade. Custos de Produção. Reutilização de Sementes.*

1 Introduction

Maize (*Zea mays* L.) is one of the most cultivated cereals in the world, belongs to the family Poaceae, originating in Central America, more specifically from Mexico (GALVÃO; BORÉM; PIMENTEL, 2017). USA and China are the largest producers of the grain, accounting for 37 and 21% of the world total produced, respectively (CONAB, 2018). Brazil is the third largest producer in the world (with 82 million tons produced) and the second largest exporter of the grain (ANTUNES, 2019).

Brazilian maize production is mainly destined to agroindustrial system, where grain is processed. Due to its high nutritional quality, it is one of the main sources of human and animal feeding (such as cattle, pigs and poultry) and is used for the biofuels production in the technological industries (CRUZ, 2011; OLIVEIRA JÚNIOR *et al*., 2006; COUTO *et al*., 2017; ROSSETO *et al*., 2017; GOMES *et al*., 2018). In addition, maize is used in silage production, where the plant still in the reproductive stage is crushed, compacted and passes through anaerobic fermentation process (GALVÃO; BORÉM; PIMENTEL, 2017).

In the last 40 years, traditional maize varieties have been replaced by hybrid cultivars, with higher productive potential and greater requirements in fertilization, irrigation and pesticides to express their potential productive (EMYGDIO *et al*., 2008). Open pollinated varieties are essential for maize breeding programs. Many of these materials are kept in their origin center, germplasm banks or cultivated by small producers. Small producers usually have a lower level of technology and use a smaller amount of inputs, obtaining better economic return with native varieties (PAULUS; MACHADO NETO, 2001). However, in order to obtain high yields in maize crop, attention should be paid to factors such as the use of seeds with high physiological and sanitary quality, adapted to the edaphoclimatic conditions of the planting region (MARCOS FILHO, 2015; PIZÁ *et al*., 2018).

Seed quality is defined as the sum of four basic characteristics, being genetic, physiological, physical and sanitary potential (FRANÇA NETO, 2009). Among the characteristics most studied in germplasm banks and seed industry, we highlight physiological potential (KAPPES *et al*., 2012; CARDOSO *et al*., 2012). This congregate information about germination (viability) and seed vigor (MARCOS FILHO, 2015). Germination can be defined as the reactivation of embryo growth, which results in seed cover rupture and seedling emergence (COPELAND; MCDONALD, 1995). Already, vigor is defined as the properties set capable of determining rapid and uniform germination in the development of normal seedlings under different environmental conditions (AOSA, 1983; FRANÇA NETO *et al*., 2010).

It is important to emphasize that seeds vigor loss is related to degenerative changes of biochemical, physiological and physical origin, reducing germination and triggering a greater sensitivity to environmental conditions (DELOUCHE; BASKIN, 1973). In this way, seed physiological quality is one of the most important characteristics to be considered in crop implementation (GRABE, 1976; CARVALHO, 1986), since its evaluation is the main component of quality control. In this way, information about seed physiological quality helps to solve problems during the production process, besides estimating seed field performance (MARTINS *et al*., 2014).

Maintenance of seed physiological quality, which is essential for sowing must be ensured throughout storage (PACHECO *et al*., 1998). There are few studies that prove that, in fact, after validity period expiration of a maize seed, its vigor and germination do not allow the field sowing, questioning about the possible reuse of these materials as an alternative of costs reduction, due high seeds costs. Thus, the aim of the present study was to evaluate maize seeds physiological quality, evaluating the hybrid BM3063 and a creole variety within the validity period and the SYN8A98 hybrid, with validity period expired one year ago.

2 Material and Methods

The study was carried out in the Seeds Analysis Laboratory of the Federal Technological University of Paraná, Campus Pato Branco and in the field, in a property at Vitorino city in Paraná State (26°16’48.2”S and 52°47’27.9 “W), with a climate in transition between Cfa and Cfb (KÖPPEN; GEIGER, 1928) in March 2018.

Three maize materials (one lot for each material) were used: 1) BM3063 PRO 2 hybrid with validity up to 12/2018 industrially treated with Clotianidin (Poncho®, 400 mL / 100 kg) in 12/2017; 2) SYN8A98 hybrid with validity period expired one year ago (March 2017), industrially treated wtih Thiamethoxam (Cruiser 350 FS®, 600 mL/100 kg) in March 2016; 3) creole maize seed recently harvested (30 days post-harvested) in Pato Branco city, Paraná State, without seed treatment.

Seeds of the three materials (both hybrids and Creole seed) were stored under controlled humidity and temperature conditions in a cold chamber. They had a constant moisture content of 13%.

The analyzes were carried out in the laboratory to assess the physiological and seed development aspects characterization. They were carried out using germitest paper as substrate, moistened with the equivalence of 2.5 times its initial weight. The seeds were incubated in Mangelsdorf germinator with a temperature of 25 °C and controlled humidity. Including experiments conducted in the field, we carried out five experiments and the following tests were performed.

2.1 First experiment

Germination speed index (GSI): 50 seeds were uniformly deposited on two germitest paper sheets, previously moistened and covered with another leaf and rolled. We used 8 replicates. We carried out daily evaluations up to the seventh day after the test start, counting seeds with at least 2.0 mm of seminal root (JUNTILA, 1976). GSI was determined according to the formula $GSI = G1 / T1 + G2 / T2 + ... + G7 / T7$, where G1 to G7 is equal to the sum of the seeds germinated each day; and T1 to T7 represents the time in days (NAKAGAWA, 1999).

Germination speed (GS): evaluated through the same execution and evaluations procedures cited for the GSI. The used formula $GS = G1 * T1 + G2 * T2 + ... + G7 * T7 / SN$, where G1 to G7 represents seeds number germinated each day, T1 to T7 the time in days; and NS total seeds number sown (NAKAGAWA, 1999).

2.2 Second experiment

Germination (G): germination test were carried out through the same execution procedures mentioned for the first experiment. Evaluations were carried out at the fourth day by counting normal seedlings and at the seventh day by counting normal and anormal seedlings and dead seeds. Germination corresponds to the sum of normal seedling data at the fourth and seventh days, expressed as a percentage (BRAZIL, 2009).

2.3 Third experiment

Cold test (CT): this test were carried out through the same execution procedures previously mentioned, being the rollers deposited in transparent plastic bags and maintained for seven days in the refrigerator with temperature close to 4 °C. After that, they were placed into germinator and the evaluations were performed four days after the test start (DIAS; BARROS, 1995).

2.4 Fourth Experiment

Aerial and root part length, fresh and dry shoot and root mass: 25 seeds were deposited transversely on 2 germitest paper sheets previously moistened. The seeds were positioned to the roller upper portion and kept in the germinator for 7 days, when root and aerial length of each seedlings were measured with a ruler. Seedlings fresh mass were registered and they were placed in paper packages, for 72 hours at 60 °C. After this period seedlings dry mass was registered (VIEIRA; KRZYZANOWSKI, 1999).

2.5 Fifth experiment

In the field, four replicates of 25 seeds were sown at 3 cm depth and we evaluated: emergency speed index (ESI), emergency speed (ES), emergency (E), shoot length and shoot fresh and dried mass at 7 days. For these, we performed the same methodologies previously mentioned (VIEIRA; KRZYZANOWSKI, 1999).

The results were submitted to ANOVA using SAS Studio® 3.5 software and when significant the means were compared by the Tukey test at 5% of error probability.

3 Results and Discussion

BM 3063 and SYN 8A98 materials obtained better performance in relation to the creole cultivar when analyzed the results of G and GSI (Table 1). According to the results, it can be inferred that expired seed physiological quality (SYN 8A98) does not differ from a seed within the validity period (BM 3063), and therefore both meet the standards for seeds commercialization, which must be higher than 85%. Creole cultivar, however, did not reach the minimum required germination percentage, and cannot be used as seed (BRAZIL, 2013).

Creole cultivar, on the other hand, germinated in a shorter period of time (lower VG) compared to the out-dated cultivar (SYN 8A98), occupying BM 3063 cultivar an intermediate position (Table 1). Although we detected significant differences for VG among the evaluated materials, none took more than two days to germinate. This result can be considered as a good germination speed value, implying into a rapid emergence and establishment, allowing a shorter time exposure of seeds to soil pathogens that may negatively affect their viability, as well as reducing the competition wtih weeds (KIMATI *et al,* 2005; DIAS; MONDO; CICERO, 2010).

Table 1 - Germination (G), germination speed index (GSI), germination speed (GS) and cold test (CT) in maize seeds of a hybrid within the expiration date (BM 3063), an expired hybrid (SYN 8A89) and a creole cultivar recently harvested

Materials	G%	GSI	GD (days)	CT %
BM 3063	98.0 a	81.1 a	1.9 ab	90.0 a
SYN 8A98	94.0 a	77.0 a	2.0 b	65.5 b
Creole	79.0 b	60.50 b	1.9 a	41.5 c

Means followed by the same letter in each columns do not differ significantly ($p<0.05$; Tukey test).

Source: Research data

Regarding the cold test (Table 1), the material that stood out was BM 3063 hybrid, followed by the SYN 8A98 hybrid. Creole variety showed inferior development compared to others. This result allows us to assume a seedlings emergence delaying the field due to the occurrence of cold and humid days (COIMBRA *et al.*, 2009; MARCOS FILHO, 2015), a fact commonly found in early crops sown, mainly in colder places such as in the south of Brazil (GRZYBOWSKI; VIEIRA; PANOBIANCO, 2015).

These results were proved in the field test (Table 2), where we found the same pattern observed for E, ESI and ES to those obtained in the laboratory. However, in general, performance of all variables was lower, fact that can be explained because field conditions are not ideal as the in laboratory. There was little variation in the ES, being that BM 3063 hybrid did not differ from the expired hybrid (SYN 8A98).

Table 2 - Emergence (E), emergence speed index (ESI) and emergence speed (ES) and cold test (CT) in maize seeds of a hybrid within the expiration date (BM 3063), an expired hybrid (SYN 8A89) and a creole cultivar recently

Materials	E%	ESI	ES
BM 3063	94.0 a	81.1 a	2.5 b
SYN 8A98	96.0 a	77.0 a	2.5 b
Creole	69.0 b	60.5 b	1.9 a

Means followed by the same letter in each columns do not differ significantly ($p<0.05$; Tukey test).

Source: Research data

Shoot length obtained in the laboratory differed among the evaluated materials (Table 3). Better performance was obtained by the hybrid BM 3063, SYN 8A98 presented intermediate position and worst result was found for creole cultivar. In the field (Table 4), however, shoot length of expired hybrid (SYN 8A98) did not differ from the hybrid within the validity period (BM 3063). Again, the worst performance was obtained in creole cultivar.

Table 3 - Shoot and root lenght (cm), fresh mass (g) and dry massa (g) of maize seedlings, in laboratory tests of a hybrid within the expiration date (BM 3063), an expired hybrid (SYN 8A89) and a creole cultivar recently harvested

Materiais	Lenght (cm)		Fresh mass (g)		Dry mass (g)	
	Shoot	Root	Shoot	Root	Shoot	Root
BM 3063	9.39 a	14.22 a	10.08 a	6.36 a	0.99 a	0.77 a
SYN 8A98	8.79 ab	13.75 a	8.54 ab	5.60 a	0.69 b	0.65 a
Creole	7.07 b	13.23 a	7.70 b	5.66 a	0.68 b	0.62 a

Means followed by the same letter in each columns do not differ significantly ($p<0.05$; Tukey test).

Source: Research data

Table 4 - Shoot lenght (cm), fresh mass (g) and dry massa (g) of maize seedlings, in field test of a hybrid within the expiration date (BM 3063), an expired hybrid (SYN 8A89) and a creole cultivar recently harvested. Pato Branco, PR, Brazil 2018

Materiais	Lenght	Fresh mass	Dry mass
	cm	g	
BM 3063	7.11 a	9.25 a	0.92 a
SYN 8A98	7.37 a	9.78 a	0.97 a
Creole	5.16 b	5.92 b	0.57 b

Means followed by the same letter in each columns do not differ significantly ($p<0.05$; Tukey test).

Source: Research data

In fresh and dry mass of aerial part analysis obtained in the laboratory (Table 3) it was observed a better performance in BM 3063 hybrid. Creole cultivar obtained a worse performance, which did not differ from the overdue hybrid (SYN 8A98).

Root length, fresh and dry root mass obtained in the laboratory (Table 3) did not differ among evaluated materials, demonstrating similar root system development and, possibly, no prejudice of nutrient uptake by the plant.

The worst fresh and dry shoot mass results obtained in the field were found in Creole cultivar (Table 4), while expired hybrid (SYN 8A98) and hybrid within the validity period (BM 3063) presented the best performance.

Analyzing the results together, it is possible to verify that the hybrid SYN 8A98 could be sown even when expired. This cultivar showed a good performance in the most relevant parameters for a proper crop establishment and, consequently, a good productivity, not differing from the hybrid within the expiration date (BM 3063). However, special care must be taken regarding sowing season, being necessary to avoid cold periods that can delay seed emergence, since in cold test the expired hybrid had a great reduce in its germination (from 94.0% in normal conditions to 65.5% in the cold test). Under these conditions, a great failure will occur in plant stand establishment (BURRIS; NAVRATI, 1979; MUNDO, 2009) and consequently a productivity reduction.

High costs of acquiring hybrid seeds (that demands in their production a technological apparatus and complex isolation), make production costly (BOREM; MIRANDA, 2013). Seeds not used in an agricultural crop are discarded, not being used in the subsequent year because they are, theoretically, with insufficient germination and vigor to be used again as seeds (GALVÃO; BORÉM; PIMENTEL, 2017, JUNQUEIRA; MORABITO, 2008). Based on the results of this research, however, it is possible to change this view, and it is feasible to send expired maize samples to the laboratory to check their physiological parameters and, in case of a positive response, to reuse the material, reducing waste and production costs.

4 Conclusion

Based on our experiments, expired SYN 8A98 hybrid could be sown without risk of reduced productivity, unless cold periods during field establishment are avoided. Creole variety did not perform satisfactorily and could not be used as seed.

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