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How to cite: COELHO, M.V., et al. Accelerated aging test in the determination of safflower seeds vigor. *Bioscience Journal*. 2022, **38**, e38003.
<https://doi.org/10.14393/BJ-v38n0a2022-54228>

Abstract

In assessing the quality of seed lots, the vigor tests are complementary to the germination test and they identify differences in the degree of deterioration of the lots. For safflower, there is little information regarding these tests. In this way, the intention of this study was to adapt the accelerated aging test methodology to assess the physiological potential of safflower seeds (*Carthamus tinctorius*). For this purpose, 12 seed lots were evaluated for thousand-seed weight, germination, first germination count, seedling emergence test (emergence percentage, emergence speed index, relative emergence frequency and the initial, final and mean times) and accelerated aging. For the accelerated aging test, the traditional and saline methods were used. For this, the samples were conditioned in periods of 0, 8, 16, 24, 32 and 48 hours at 42 °C. Afterwards, they were submitted to the germination test, with evaluation of normal seedlings on the 3rd day. The 12 lots were evaluated within each period, in independent experiments. The data were submitted to analysis of variance and the means were compared using the Scott-Knott clustering method at 5% probability. In the traditional accelerated aging test the periods of 16, 24, 32 and 48 hours were more efficient in differentiating the lots in vigor levels, as they stratified the lots in three classes and the time of 8 hour classified the lots in two levels of vigor. In the accelerated saline aging method the time 32 hours were more efficient since it ranked seed lots at three levels of vigor and the periods of 8, 16 and 24 hour stratified the lots in two levels. In results obtained by the principal component analysis it was verified. The variables traditional accelerated aging for 24 and 32 hours correlated with emergence in the field. Therefore, the traditional accelerated aging test at 42 °C for 24 hours are promising for evaluating the physiological quality of safflower seeds.

Keywords: *Carthamus tinctorius*. Physiological quality. Stress test. Vigor test.

1. Introduction

The safflower (*Carthamus tinctorius*) is an annual oleaginous plant to the Asteraceae Family (Yao et al. 2018). Due to the several forms of utilization, it has high economic value and is cultivated as a commercial product in several countries (Bidgoly et al. 2018). This culture presents several important features, such as: tolerance to saline soils, high temperatures, water deficit and low humidity (Kizil et al. 2008; Bagheri and

Sam-Dailiri 2011). The safflower plant has the capacity to withstand a wide temperature range (-7 to 40 °C), depending on its stage of development, and adapts to different soil types (Coronado 2010; Emongor 2010). Given this, it can be used as an alternative for crop rotation in different areas of Brazil (Anicesio et al. 2015).

In addition to being used as an ornamental plant, its grains have an oil content of 35 to 50% and is very widespread in the form of capsules in natura, seeking health benefits. It can also be used as edible and industrial; its flowers are used as a source of natural dyes for food and fabrics and its grains are used in the feeding of birds and bran in the feeding of ruminants. This plant can also be used as a medicinal plant (Galavi 2012; Singh and Nimbkar 2016; Soleymani 2019). Studies are carried out with various plants that have a significant oil content in the production of biodiesel, aiming at the profitability of this product (Gomes Filho et al. 2015).

Evaluating the physiological quality of seeds is fundamental for making decisions regarding their use, as propagating material and for the subsequent stages to which they will be submitted (Frandonoso et al. 2017). The quality of the seed is the set of genetic, physical, physiological and sanitary attributes that affect its ability to originate high productivity plants (Lopes et al. 2017). The physiological potential can be assessed through germination and vigor tests (Marcos Filho 2015). However, as the germination test is performed under ideal conditions, vigor tests are relevant to complement the evaluation of seed lot potential.

The physiological quality of a seed lot is not easily measurable, as only an individual evaluation is not sufficient to define the vigor of the seed lot (Marinho et al. 2019). Therefore, it is important to use more than one vigor test to complement the germination test when evaluating the potential of seed lots.

The accelerated aging test is one of the efficient methods for evaluation in several species and is included in quality control programs by seed producing companies, because in a few days, relatively safe information can be obtained about the potential for storage of lots and field seedlings emergence. This is because it simulates stress conditions, generating a high rate of respiration and consumption of reserves, accelerating metabolic processes that lead to deterioration (Marcos Filho 2016).

In this test, the seeds are subjected to high temperatures, in conditions of high relative humidity, for varying periods of time, and then subjected to the germination test. The accelerated aging is based on the fact that the rate of seed deterioration is increased considerably through exposure to very adverse levels of temperature and relative humidity (Machado et al. 2019). Under these conditions, seeds of lower quality deteriorate faster than the more vigorous ones, with reflexes on germination after the accelerated aging period (Marcos Filho 2015).

There are few studies that performed this test on safflower seeds: Girardi et al. (2013) evaluated three lots at 41 and 43 °C in times of 0, 24, 48, 72 and 96 hours; Khavari et al. (2009) performed the aging of five lots at 38 °C for 72 hours; Godakahriz et al. (2012) studied only one lot at 40 °C, for 0, 4 and 6 days; Demir (2014) artificially aged three lots at 41, 43 and 45 °C for 24, 48, 72 and 96 hours. Therefore, it is noted that all the studies in which the accelerated aging test was performed on safflower seeds, evaluated few lots, with a maximum of five. Kaya et al. (2019), however, performed the accelerated aging test in 34 lots of safflower seeds, but used very long conditioning periods, which were 48, 72, 96, 120 and 144 hours. Consequently, there is still no standardized methodology for evaluating the vigor of safflower seeds through this test.

Moreover, in Brazil, in the Rules for Seed Testing (Brasil 2009), there are no standardized vigor tests for any crop. In the International Rules (ISTA 2014) there is standardization for electrical conductivity testing for peas, beans and soybeans; accelerated aging testing for soybeans; controlled deterioration testing for *Brassica* spp. and emergence of primary corn roots. For safflower, there is no standardized test.

Thus, the aim was to adapt the accelerated aging test methodology to assess the physiological potential of safflower seeds (*Carthamus tinctorius*). For this purpose, the best exposure period for the classification into different vigor levels was verified.

2. Material and Methods

Twelve lots of safflower seeds from the S-351 cultivar were selected, which come from the 2017/2018 off-season crop produced at the School Farm of the Federal University of Goiás - Jataí Regional. These lots were sent to the Seed Analysis Laboratory of the Federal University of Goiás - Jataí Regional, where the experiments were conducted.

According to the requirements of the Rules for Seed Testing - RAS (Brasil 2009), the samples were initially homogenized, using the soil divider, passing them three times through the device. They were divided until four sub-samples were obtained, which corresponded to the statistical repetitions of the experiments performed.

Determination of the moisture content of the seeds

It was determined by the oven method according to the methodology indicated by RAS (Brasil 2009). The seeds were evenly distributed in the container and placed in the oven at 105 ± 3 °C for 24 hours, with the use of two sub-samples of 4.0 g for each lot.

Thousand-seed weight

Four replicates of 8 sub-samples of 1000 seeds per lot were used. The masses were determined in a precision scale of 0.0001g according to the instructions of the RAS (Brasil 2009).

Germination test

The eight replicates of 25 seeds were placed to germinate between two layers of paper (blotting paper) inside transparent plastic boxes (11.0 x 11.0 x 3.5 cm). The paper was moistened with a volume of water (mL) equivalent to 2.5 times the mass of the dry paper (g) (Brasil 2009), with final count the seeds germinated at eight days, according to Gama et al. (2019).

In the germination chambers, after the installation of the tests, the transparent plastic boxes remained conditioned in closed plastic bags of 45 x 35 cm, to avoid dehydration (Coimbra et al. 2007).

First germination count

It was performed along with the germination test, with a three-day count, accounting for the number of normal seedlings, according to Gama et al. (2019).

Emergence of field seedlings

The field seedling emergence test was conducted in March/April of 2019. Four subsamples of 50 seeds per lot were sown in furrows of one meter long with four centimeters of depth, without irrigation.

The maximum, average and minimum temperatures and rainfall prevailing during the period of conducting the field seedling emergence test are shown in Figure 1.

The evaluations were carried out with the normal seedling count, being accounted when the cotyledons were found above soil level, daily after sowing until stabilization in each lot, when the percentage of seedling emergence in the field was calculated (Nakagawa 1994).

It was also evaluated:

- First emergence count: accounted for when 50% + 1 of the total seedlings for most lots emerged.

- Emergence Speed Index (ESI): calculated from the daily seedling count data emerged from the field seedling emergence test and determined according to the formula proposed by Maguire (1962):

$$ESI = \frac{G_1}{N_1} + \frac{G_2}{N_2} + \dots + \frac{G_n}{N_n}$$

ESI = Emergence Speed Index;

G_1, G_2, G_n = number of normal seedlings computed in the first, second and last count, respectively;

N_1, N_2, N_n = number of days of sowing in the first, second and last count, respectively.

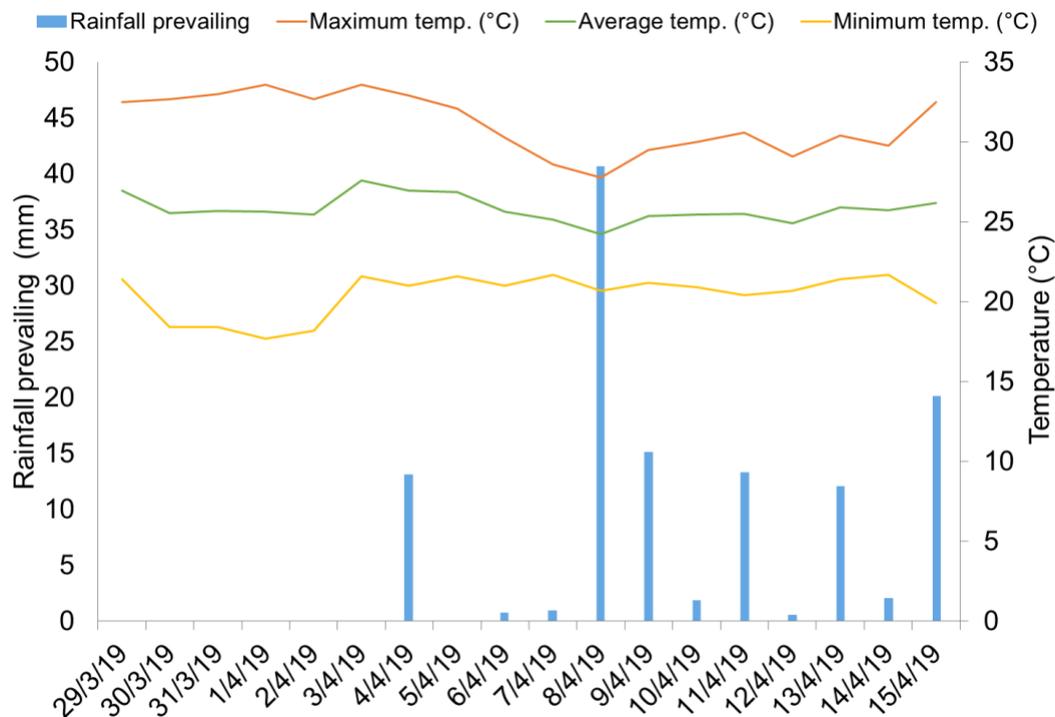


Figure 1. The maximum, average and minimum temperatures and rainfall prevailing during the period of conducting the field seedling emergence test.

- Initial, final, mean time and relative frequency of emergence of seedlings: from the daily emerged seedling count data of the field seedling emergence test, the initial, final, mean and relative frequency of emergence were determined. The initial time corresponds to the first emergence day after sowing and the final time to the last emergence day after sowing, for each lot. For the mean time and relative emergence frequency of emergence, the formulas described by Santana & Ranal (2004) were used:

$$t_m = \frac{\sum_{i=1}^k n_i t_i}{\sum_{i=1}^k n_i}$$

t_m = mean time;

t_i = time between the beginning of the experiment and the i -th observation (day or hour);

n_i = number of seeds emerging in the time t_i (not the cumulative number, but the number referred to the i th observation);

k = last seed emergence time.

$$fr = \frac{n_i}{\sum_{i=1}^k n_i}$$

fr = relative frequency of emergence;

n_i = number of seeds emerging on day i ;

k = last day of observation.

- Traditional accelerated aging: Six independent experiments were conducted, in which the conditioning periods were represented: 0, 8, 16, 24, 32 and 48 hours. Within each period, the 12 seed lots were evaluated in an entirely randomized design.

It was developed using 150 seeds for each lot that were distributed in a simple layer in a transparent plastic box (11.0 x 11.0 x 3.5 cm) adapted with an aluminum screen tray (McDonald Jr and Phaneendranath 1978). 40 mL of distilled water was added to the interior of the box. The containers were then placed in a germination chamber at 42°C and conditioned in the periods 0, 8, 16, 24, 32 and 48 hours 40 mL of distilled water was added to the inside of the box. The containers were then placed in a germination chamber set at 42°C and packed in periods of 0, 8, 16, 24, 32 and 48 hours. After these periods, 100 seeds were divided into 4 sub-samples of 25 seeds and the germination test was installed, as previously described, maintained at 25°C, with the counting of the number of normal seedlings performed after 3 days of permanence of the

seeds in the germinator. After the aging of the seeds, the degree of moisture was determined using 50 seeds that were subdivided into two sub-samples and placed in the oven at 105 ± 3 °C for 24 hours, according to the Rules for Seed Analysis (Brasil 2009).

- Accelerated aging with saturated salt solution (NaCl): It was performed similar to the traditional method. However, 40 mL of saturated NaCl solution was added inside each plastic box to replace the distilled water. This solution was prepared in the proportion of 40 g of NaCl for 100 mL of water, establishing an environment with 76% relative humidity (Jianhua and McDonald 1996).

The data obtained in the initial characterization and in the tests of accelerated aging and cold (in which the 12 lots were evaluated within each period, in independent experiments) were submitted to analysis of variance at 5% probability by the F test and for comparison of the means the Scott-Knott method was used at 5% probability. Data were tested for normality and homogeneity and when necessary were transformed to $(x + 0,5)^{0,5}$, the original data being shown in the table.

The principal component analysis was performed and processed in the R program (R Core Team 2019). The eigenvectors between the original variables and the main components were calculated, being considered relevant with values above $0.5/(\text{eigenvalue})^{0,5}$ (Ovalles and Collins 1988). We considered significant eigenvectors greater than 0.128; 0.32 and 0.35 for components 1, 2 and 3 respectively.

3. Results and Discussion

The seeds of the 12 safflower lots showed moisture content between 5.23 and 6.18%, the variation being less than one percentage point between the lots. This result is similar to the one found by Macedo (2018), who reports a variation in the moisture content of safflower seeds from 5.96 to 7.05%. This variation is considered acceptable and desirable. Because, according to Marcos Filho (2016), differences of 1 to 2% between samples do not compromise the test results, since the uniformity of the initial seed moisture content is a key factor for the standardization of evaluations to be performed later.

In the characterization of the initial quality of the lots, significance was observed only for the variable dead seeds (Table 1).

Table 1. Summary of the analysis of variance of a thousand-seed weight (TSW), germination (G), abnormal seedlings (AS), dead seeds (DS) and germination first count (GFC), in a completely randomized design, emergence (E), emergence first count (EFC) and emergence speed index of seedlings in the field (ESI), initial time (IT), mean time (MT) and final time (FT) of the field emergence test, in a randomized block design, of twelve lots of safflower seeds.

SV	DL	Middle square											
		Completely randomized design					Randomized block design						
		TSW	G	AS	DS	GFC	GL	E	EFC	ESI	IT	MT	FT
Lots	11	1.76ns	35.96ns	0.76ns	2.23*	97.79ns	3	284.30*	817.77**	1.14*	1.47**	1.96**	2.58ns
Residue	36	0.74	29.00	0.80	1.04	84.33	11	43.17ns	70.60ns	0.14ns	0.11ns	0.16ns	0.57ns
CV (%)	-	2.51	5.89	56.97	45.35	10.75	33	73.33	76.62	0.28	0.24	0.12	1.21

*, **, ^{ns} Significant at 5, 1% and not significant by the F test, respectively. SV: Source of variation. DL: Degree of liberty. CV: Coefficient of variation.

The 12 lots of safflower seeds were grouped for the variable dead seeds in lots 1, 3, 4, and 7, with lower percentages, between 1 and 2%; in the other lots, values were observed between 5 and 11%. The Rules for Seed Testing define dead seeds as seeds that at the end of the test did not germinate, were not hard or dormant, and were generally softened and attacked by microorganisms (Brasil 2009). Marcos Filho (2016) emphasized that the death of the seed is caused by the deterioration that is a process determined by a series of physiological, physical, biochemical changes, starting from the physiological maturity, in progressive rhythm, in which culminates in the decline of the performance potential of the seed until its death.

For the other variables evaluated in the germination and emergence tests of field seedlings, no statistical differences were observed. Therefore, it is shown, in Figure 2, the bar of means and standard deviation of them. Carvalho and Nakagawa (2012) pointed out that the mass of the seeds is related to the number of reserves, being that seeds of the same species with greater mass present a superior number of

tissues from reserves, thus conferring greater quality to these seeds. For this reason, usually lots with mass of a thousand similar seeds, present similar germination percentage, as found in this study.

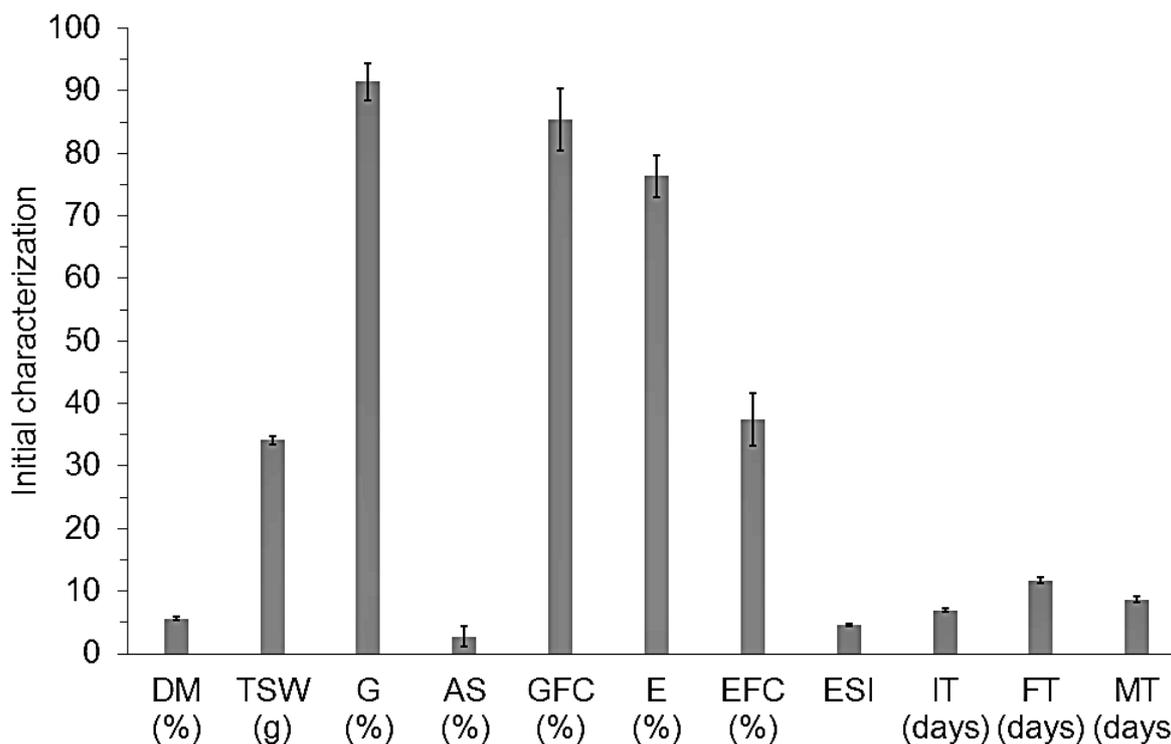


Figure 2. Initial characterization of the degree of moisture (DM), thousand-seed weight (TSW), germination (G), abnormal seedlings (AS) and germination first count (GFC), in a completely randomized design, emergence (E), emergence first count (EFC) and emergence speed index of seedlings in the field (ESI), initial time (IT), mean time (MT) and final time (FT) of the field emergence test, in a randomized block design, of twelve lots of safflower seeds.

It is important that the evaluated samples, in addition to similar germination, are compatible with the standards established for marketing, because one of the objectives of vigor tests is to identify significant differences in the physiological quality of marketable lots (Marcos Filho 2015). The germination percentage maintained above 60%, which is the minimum required for the production and marketing of seeds of species of large crops registered in the national register of cultivars not contemplated with a specific standard, as well as safflower (Brasil 2013).

Although the first count in this study of germination test and seedling emergence is considered an indication of vigor, it is known that during the process of seed deterioration, the reduction in germination speed is not among the first changes in the seed during deterioration, as related by Delouche and Baskin (1973). Therefore, it is a test that normally does not detect minor differences of vigor.

The field seedling emergence test allows the classification of lots according to their physiological potential, detecting differences not evidenced by the germination test. This test is considered an indicator parameter of the effectiveness of tests to assess the physiological potential of seed lots (Martins et al. 2014). However, there is not always a correlation between the results of vigor tests and those observed in the field, as found by Ávila et al. (2005) in canola seeds. Marcos Filho (2015) emphasized that the exclusive use of correlation analysis in evaluating the comparative efficiency of vigor tests may contribute to obtaining inconsistent information.

The mean emergence times, as well as the initial and final times, showed no difference, as found by Lenz et al. (2017) who assessed the germination of four different safflower genotypes at six sowing depths.

It was verified by the relative emergence frequency polygons (Figure 3) that the seedlings started to emerge between the 6th and 7th day after sowing, while the time for the last emergence ranged from 11 to 14 days.

The distribution showed polymodal behavior, with more than one emergence peak, with the exception of lot 8, demonstrating that there was no homogeneity in the emergence. This fact is explained because the germination process is not perfectly synchronized and is distributed over time.

Through the frequencies, it is possible to observe if over time the seeds germinate until they reach a maximum value and then decline (Santana and Ranal 2004). There was no displacement of the polygon in any of the cases because the mean times were similar. In general, the displacement of the polygonal line to the right or left of the mean time shows a delay in the germination process, as a result of the reduction in seed vigor (Berger 2014).

In Table 2 is a summary of the analysis of variance of the traditional and saline accelerated aging test in twelve lots of safflower seeds and six periods of traditional and saline aging, at a temperature of 42 °C. It is noted that in the traditional method, only the 0-hour period was not significant. As for the saline aging, the periods of 0 and 48 hours did not differ between the lots.

It can be observed that there was a significant increase in the moisture content of the seeds after the traditional accelerated aging test (Table 3), as observed by Araújo et al. (2017) in leucene seeds. Marcos Filho (2016) states that the moisture content corresponds to the equilibrium point, which increases with the elevation of the relative humidity of the air and vice-versa. The seeds tend to reach hygroscopic equilibrium at higher water contents, as the relative humidity of the air increases (Costa et al. 2008).

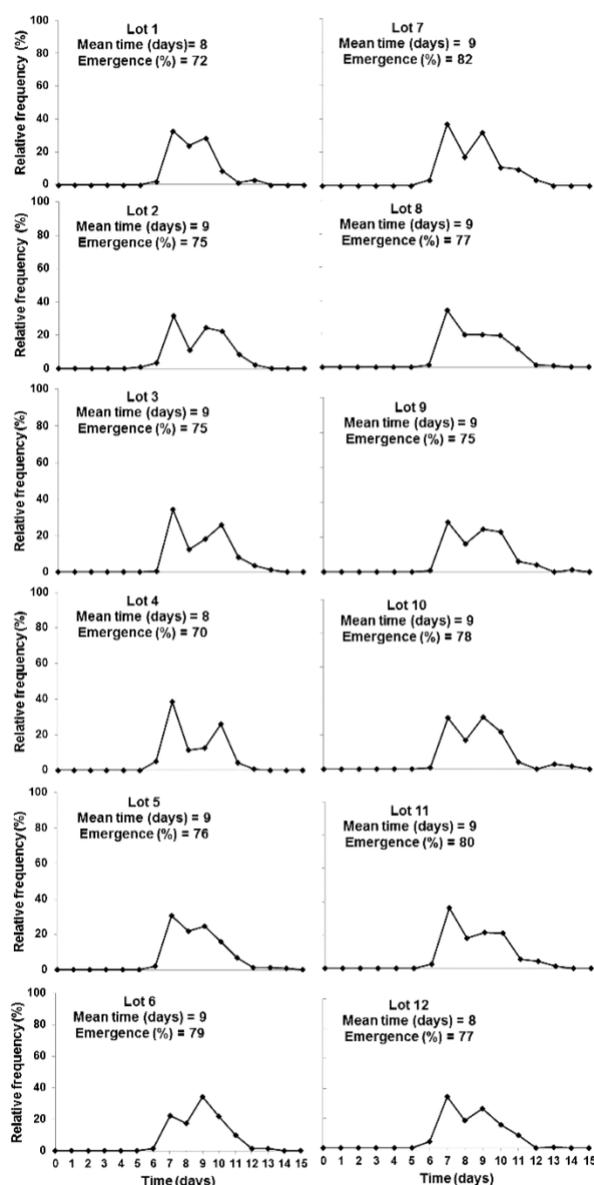


Figure 3. Distribution of the relative frequency of field seedling emergence in 12 lots of safflower seed.

Table 2. Summary of the variance analysis of the traditional and saline accelerated aging test in twelve lots of safflower seeds after being submitted to the traditional and saline accelerated aging test in six periods.

SV	DL	Middle square					
		Periods of traditional aging (hours)					
		0	8	16	24	32	48
Lots	11	97.79 ^{ns}	122.42**	269.75**	445.88**	253.96**	738.34**
Residue	36	84.33	30.92	76.90	24.97	26.73	34.31
CV (%)	-	10.75	6.55	10.92	6.14	6.42	8.02
SV	DL	Periods of saline aging (hours)					
		0	8	16	24	32	48
		Lots	11	97.79 ^{ns}	96.38*	88.34**	177.17**
Residue	36	84.33	39.13	18.23	16.19	26.35	41.56
CV (%)	-	10.75	7.74	5.01	4.95	6.27	8.05

**, ^{ns} Significant at 1% and not significant by the F test, respectively. SV: Source of variation. GL: Degree of liberty. CV: Coefficient of variation.

It was noted that seed moisture also increased by the accelerated aging method with saturated salt solution, but to a lesser extent than the traditional method (Table 3). These results are similar to those found by Frandoloso et al. (2017), Tunes et al. (2013) and Radke et al. (2016), who by performing the accelerated aging test on seeds of lettuce, parsley and coriander, respectively, also noted that the traditional method increases the moisture content higher than the saline method. Thus, it is possible to verify that the use of NaCl solution provided the reduction in water absorption by the seeds, as proposed by Jianhua and McDonald (1996). This is because the water is osmotically retained in the saline solution, so that the increased concentration of salts makes it less and less available (Ribeiro et al. 2001).

Table 3. Degree of moisture (%) of the safflower seeds submitted to the traditional and saline accelerated aging test at 42 °C for 0, 8, 16, 24, 32 and 48 hours.

Lots	Periods of traditional aging (hours)						Periods of saline aging (hours)					
	0	8	16	24	32	48	0	8	16	24	32	48
1	6.18	12.91	11.74	11.84	17.95	14.92	6.18	7.39	7.12	7.58	7.20	7.59
2	5.94	12.65	14.35	13.89	17.24	17.78	5.94	6.81	6.81	7.85	7.28	7.34
3	5.47	11.76	11.31	13.93	17.78	14.19	5.47	7.43	6.68	6.96	7.39	7.41
4	5.57	12.28	13.15	11.15	18.53	14.26	5.57	7.68	7.16	7.53	7.02	7.48
5	5.57	11.52	12.43	14.77	17.79	13.23	5.57	7.40	6.79	7.21	6.99	7.39
6	5.79	11.80	12.35	13.44	17.81	16.15	5.79	7.59	6.99	7.50	7.55	7.45
7	5.47	12.20	11.83	11.40	17.54	14.76	5.47	7.21	7.62	7.50	7.09	7.74
8	5.55	12.36	11.35	13.31	17.19	17.28	5.55	7.82	7.32	7.67	7.39	7.50
9	5.63	11.72	10.82	12.95	17.30	16.27	5.63	7.18	6.33	8.21	7.32	7.40
10	5.62	11.44	12.83	14.70	17.40	14.31	5.62	7.74	7.04	7.54	6.76	7.48
11	5.23	12.38	14.65	14.39	16.48	16.69	5.23	7.49	6.98	7.76	7.25	8.03
12	5.69	12.84	13.82	12.15	17.74	16.07	5.69	7.28	6.73	7.21	7.12	7.52

Marcos Filho (2016) recommends that the difference in the moisture content of the seeds after aging must be less than four percentage points. In this sense, it can be noted that the data of saline aging are more uniform, because the variation in water content was less than 4%. In traditional aging, in the period of 48 hours, the seeds presented a higher variation than recommended.

The comparison of means referring to the germination percentage of twelve lots of safflower seeds (Table 4), in traditional accelerated aging, the time of 8 hours, ranked the lots in two levels of vigor. However, the periods of 16, 24, 32 and 48 hours of traditional accelerated aging stratified the lots into three classes, thus being more efficient in differentiating the lots into levels of vigor. Menezes et al. (2008) pointed out that the efficiency of this test is assessed by the difference in sensitivity presented by the seeds to aging. These results corroborate with those found by Girardi et al (2013) and Godakahriz et al. (2012) who also identified differences in the physiological potentials in safflower seed lots in different periods. However, these authors used long periods of exposure, being: 0, 24, 48, 72 and 96 hours and 0, 4 and 6 days, respectively. Marcos Filho (2015) emphasizes that the vigor test must be simple, fast, low cost, objective and reproducible. Therefore, the faster the test runs, the more efficient it will be. Rocha et al. (2015), who also

differentiated lots of sunflower seeds at different levels of vigor through the accelerated aging test, corroborating with the results found in lettuce seeds (Barbosa et al. 2011) and parsley (Tunes et al. 2013).

With the increase of the temperature and longer time spent in aging conditions, the germination tends to be negatively affected (Flavio and Paula 2010). However, this information cannot be generalized, since in the present study, as found by Araújo et al. (2017) in leucene seeds, some lots increased the germination percentage with the expansion of the period of exposure to accelerated aging. This fact is explained due to the greater stress tolerance of these lots, thus giving them greater physiological potential.

In the accelerated saline aging method, the 8-, 16- and 24-hour times stratified the lots of safflower seeds in two levels of vigor. The 32-hour period, on the other hand since it ranked the safflower seed lots at three levels of vigor. Martins et al. (2018) also succeeded in stratifying amaranth seed lots at different vigor levels.

Table 4. Germination (%) of the seeds of twelve safflower lots, after six conditioning periods (0, 8, 16, 32, 24 e 48 horas) at a temperature of 42 °C for the traditional and saline accelerated aging test.

Lots	Periods of traditional aging (hours)						Periods of saline aging (hours)					
	0	8	16	24	32	48	0	8	16	24	32	48
1	94 ^a	76 ^b	72 ^b	79 ^a	76 ^b	68 ^b	94 ^a	72 ^b	87 ^a	75 ^b	79 ^b	79 ^a
2	77 ^a	84 ^a	84 ^a	71 ^b	68 ^c	88 ^a	77 ^a	79 ^b	78 ^b	88 ^a	81 ^b	75 ^a
3	91 ^a	87 ^a	88 ^a	86 ^a	83 ^b	81 ^a	91 ^a	85 ^a	93 ^a	90 ^a	80 ^b	87 ^a
4	80 ^a	87 ^a	88 ^a	83 ^a	80 ^b	56 ^c	80 ^a	82 ^a	87 ^a	80 ^b	88 ^a	81 ^a
5	87 ^a	91 ^a	87 ^a	88 ^a	83 ^b	51 ^c	87 ^a	85 ^a	81 ^b	88 ^a	71 ^c	79 ^a
6	87 ^a	91 ^a	60 ^c	86 ^a	83 ^b	50 ^c	87 ^a	77 ^b	80 ^b	81 ^b	75 ^c	76 ^a
7	88 ^a	88 ^a	81 ^a	86 ^a	81 ^b	85 ^a	88 ^a	88 ^a	83 ^b	79 ^b	85 ^a	79 ^a
8	82 ^a	80 ^b	83 ^a	88 ^a	92 ^a	84 ^a	82 ^a	81 ^a	90 ^a	84 ^a	86 ^a	73 ^a
9	84 ^a	91 ^a	81 ^a	90 ^a	83 ^b	79 ^a	84 ^a	86 ^a	89 ^a	89 ^a	84 ^a	85 ^a
10	82 ^a	77 ^b	73 ^b	86 ^a	87 ^a	77 ^a	82 ^a	74 ^b	88 ^a	76 ^b	88 ^a	84 ^a
11	83 ^a	79 ^b	81 ^a	52 ^c	64 ^c	80 ^a	83 ^a	83 ^a	85 ^a	69 ^b	85 ^a	85 ^a
12	90 ^a	89 ^a	85 ^a	82 ^a	88 ^a	77 ^a	90 ^a	79 ^b	80 ^b	76 ^b	80 ^b	78 ^a

Means followed by the same letter in the column do not differ by Scott-Knott test at 5% probability.

Based on the results obtained by the principal component analysis (Table 5), it was verified the need for three components, since these effectively summarize the total sample variance and can be used to study the data set, since according to Hongyu et al. (2016) the eigenvalues of these components were higher than 1. The three main components accounted for 64.41% of the accumulated variation, on the breakdown of lots in relation to their quality, where CP1 accounted for 27.13%, CP2 by 20.14% and CP3 by 17.14% of the data variation (Table 5).

Table 5. Matrix of eigenvectors and eigenvalues of principal components (PC) and evaluation of physiological quality of 12 safflower seeds lots.

Variables		PC 1	PC 2	PC 3
First germination count		0.18	0.43	0.22
Germination		0.12	0.42	0.25
Field seedling emergence		0.39	0.09	0.04
Aging Traditional	8 hours	0.41	-0.16	-0.28
	16 hours	0.08	-0.44	0.10
	24 hours	0.49	0.07	0.14
	32 hours	0.42	0.11	0.22
Aging Saline	8 hours	0.24	-0.43	0.02
	16 hours	0.02	-0.14	0.62
	24 hours	0.33	0.31	-0.13
	32 hours	-0.19	0.24	0.39
48 hours		-0.09	-0.19	0.43
Eigenvalues		3.26	2.42	2.06
Variance (%)		27.13	20.14	17.14

Representative variables of the component based on the ratio module $0,5/(\lambda)^{0,5}$, highlighted in bold (Ovalles and Collins 1988).

4. Conclusions

The traditional accelerated aging test at 42 °C for 24 hours are promising for evaluating the physiological quality of safflower seeds. This result is satisfactory since the period used is shorter than the other research already carried out. Therefore, the test becomes more efficient in identifying different physiological potentials in safflower seed lots.

Authors' Contributions: COELHO, M.V.: conception and design, acquisition of data, analysis and interpretation of data, drafting the article; LIMA E SILVA, I.M.H.: acquisition of data, analysis and interpretation of data; SILVA, A.A.S.: acquisition of data, analysis and interpretation of data; PAZ, R.B.O.: acquisition of data, analysis and interpretation of data; ROCHA, D.I.: conception and design, analysis and interpretation of data, drafting the article; MACHADO, C.G.: conception and design, analysis and interpretation of data, drafting the article; SILVA, G.Z.: conception and design, acquisition of data, analysis and interpretation of data, drafting the article, critical review of important intellectual content. All authors have read and approved the final version of the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

Ethics Approval: Not applicable.

Acknowledgments: The authors would like to thank the funding for the realization of this study provided by the Brazilian agency CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil), Finance Code 001.

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Received: 26 April 2020 | **Accepted:** 12 October 2020 | **Published:** 16 February 2022



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