Investigating the elimination of dormancy and germination power of rice varieties under artificial storage in response to different temperatures

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ABSTRACT

When the seeds of the plants had harvested, they are not planted immediately and are kept in storage for some time. Storage has positive and negative effects on the elimination of the dormancy and germination of different plants. Therefore, a study has carried out with the aim of investigating the elimination of dormancy and the germination power of rice varieties under artificial storage in response to different temperatures. In the treatments of zero (control) to eight days artificial aging on the germination of rice varieties AHS, DAH and DBC In response to the temperatures of 15, 20, 25, 30 and 35°C, with the help of thermal time model, it was done in the agriculture laboratory of Gorgon University of Natural Resources and Agricultural Sciences in 2019. Accelerated aging test has used in artificial storage. So that the seeds of AHS, DAH and DBC rice cultivars were kept for zero (control), one, two, three, four, six and eight days of artificial deterioration at a temperature of 45°C and a relative humidity of 100%. After that, the germination test of artificially aging seeds of rice cultivars has studied at temperatures of 15, 20, 25, 30 and 35°C. The results of this research showed that the germination percentage of rice cultivars in all treatments of artificial storage at 15°C was low. With the increase in temperature during artificial storage, the germination percentage of these cultivars increased. Additionally, with the increase of artificial storage treatments, it has observed that the percentage of germination decreases among all rice cultivars, and this decrease was evident at lower temperatures, therefore germination stopped in all cultivars of AHS, DAH and DBC in eight days of artificial aging.

Keywords: Seed Dormancy, Seed Vigor, Seed Germination, Artificial Storage, Thermal Time Model.

Introduction

Rice is the main food of more than half of the population, while only 11% of the total land on this planet is cultivated with this crop. It is, expected that the global production of cereals will increase by 50% from 2010 to 2030 to meet the growing food needs. This is not an easy task, because it requires not only genetic improvement of the product and optimization of management but it is therefore influenced, by socio-economic and physical factors related to rice production (Khosh,2013; Afeniri et al., 2013; Pantani et al., 2016). The lack of labor in the agricultural sector has caused the increase in the price of labor and rice production. Meanwhile, the lack of water for rice cultivation is serious and widespread. It is, predicted that by 2025, about 18 million hectares of rice cultivation in the world will decrease. Therefore, rice cultivation technology should be developed to simultaneously reduce labor and water use while maintaining yield potential (Tuong et al., 2002; Yuan et al., 2017; Axio et al., 2019; Behandri et al., 2019-2020).

In general, farmers have to keep their own rice seeds from one growing season to the next growing season, in other word, short-term storage period are typically three to 18 months. It is also sometimes necessary to keep the seeds for several years (6 years). Therefore, during storage in the warehouse, it is important to try to control the factors that reduce quality and germination of seeds (Hong and Ellis, 1996., McDonald's and Nelson, 1999). Seeds are, divided into two categories based on their shelf life during the storage period, recalcitrant seeds and orthodox seeds (Roberts, 1997). Many researchers reported that keeping the seeds during the storage period eliminates their dormancy. Especially the seeds that have physiological and morphological coexistence (Cristado et al., 2019; Janaki et al. 2017). Siadat et al (2012) stated that the initial colonization of some rice cultivars is, eliminated with time during storage. Additionally, rice seeds has kept at a temperature of 48-50 ᵒ C for three to five days the artificial decay of their commune is lost. In Agricultural farming, seed aging is an undesirable process and the yield decreasing due to seed aging has been, reported at about 25% (Shalar et al., 2008). This irreversible process occurs on the farm, harvest time and storage period (natural and artificial) (Walters et al., 2010). Seed aging begins with a chain of biochemical events, often "damage to the membrane and biochemical reactions disorder. Thereafter many vital properties of the seed decrease, which begins with a decrease in germination rate, decrease in seedling establishment, and increase in abnormal seedlings, and eventually lead to seed death (Walters et al., 2010). Seed aging reduces the quality, viability and survival of the seeds due to environmental adverse effects (Kapoor et al., 2010). Seed aging and deterioration typically occur during physiological maturity of the seed (before hatching) and continue during seed harvesting, processing and storing with intensity that is affected by genetic, environmental and seed production conditions (Calber, 1995). Odoba et al (2016) reported that with the accelerated aging period, the germination components of the canopy decreased. The accelerated aging process also occurs more rapidly on plants that have oily seeds than seeds that have starch (Lee et al., 2008. Qaderi-far et al., 2009; Shu et al. 2016). During the research, Alvarado and Bradford (2002) stated that the plants in total have three thermal levels including low, optimum and high temperatures (maximum) for germination. The highest level of seed germination has performed at the desired temperature and the germination of the seeds has stopped at or below the base temperature and at most or more (Akram qader-far et al, 2008). The importance of temperature on seed aging processes is for two reasons. A determination of the amount of moisture stored in the air is due to the increased activity of the aging phenomenon that occurs during seed storage and accelerates at higher temperatures (McDonald's, 2004). Siadat et al. (2013) stated that the temperature was at least 8-10 °C, the maximum of 44 °C and the appropriate temperature with the maximum germination was 30-32 °C. However, in warm and temperate regions due to low temperatures, rice crop damage is higher (Crouch and 2000, Lee M H, 2001). Kabaki et al (1982) also reported that a decrease in temperature in the range of 12-18 °C reduces seedling growth. As rice, seeds have reduced temperature not only the germination rate but also the germination percentage. According to the Harrington Act, each percentage decreases in the moisture content of the seed during storage, and every five degrees Celsius reduces the seed life by two times. The Harrington law, should not be used in humidity above 14% and below 5% of seeds, because seeds stored at humidity above 14% begin to breathe and the heat generated can accelerate, including fungi, and reduce seed viability below 5% of seed moisture (Harrington, 1973).

Materials and methods

This research has conducted in the seed research laboratory of Gorgon University of Agricultural Sciences and Natural Resources in

2019. The experiment has applied on different varieties of rice with artificial storage at different temperatures of 15, 20, 25, 30 and 35ºC. In this experiment, first, seeds of AHS, DAH and DBC rice cultivars were stored with aging acceleration test for zero (control) one, two, three, four, six and eight days at a temperature of 45ºC and with increasing the storage period the seeds were deteriorated. Then the germination of degenerated seeds of rice cultivars has studied at different temperatures of 15, 20, 25, 30 and 35ºC. The germination test has done in Petri dishes with a diameter of 9 cm, on two layers of filter paper. After the seeds have placed in the Petridis and (5cc) distilled water were add to them and placed in the incubator at the desired temperature. The germinated seeds have counted three times every day (depending on temperature and germination rate). The Germination criteria were considered to be 2mm or more shoot (Bialy and Black, 1994). Counting of germinated seeds continued until no germination had observed for a week.

Data analysis

Data analysis has done with SAS statistical software. Since the germination percentage data is the result of counting and has a binomial distribution, the **Generalized Linear Model:** method with the **Proc Genmod Procedure** has used to compare the treatments. To quantify the effects of temperature and deteriorated treatments on the germination of rice seeds, the following thermal time model has used.

$$\text{Probit}(g) = \{\log[(T - T_b)\, t_g] - \log \theta_T\}/\sigma\theta_T$$

Probit (g) Probit function for cumulative germination percentage data θ_T, mean thermal time for germination $\sigma\theta_T$ is standard deviation in log θ_T, Tb minimum temperature and T temperature (Donato et al., 2017).

Results and discussion

The Investigation of the germination response of artificially aging seeds (Zero-eight days) in different rice cultivars in response to temperature showed. that the lowest percentage of germination in all (AHS, DAH and DBC) cultivars at different levels of artificial deterioration occurred at a temperature of 15ºC and with the increasing temperature in all treatments, the percentage of seed germination increased in different varieties (Figure 1). The treatments of one day and two days of artificial aging not only did not decrease the germination percentage, but also increased the germination percentage in some cultivars including AHS and DAH compared to the controlled one. Increasing the length of the artificial aging period to more than two days (or three days) decreased the germination percentage of the investigated cultivars at different temperatures (Figure 1). There for that the lowest percentage of germination in all varieties and temperatures has observed in the treatment of eight days of artificial aging. Soltani et al (2008) reported that the degenerate seeds of wheat (*Tritium aestivum* L.) compared to the control seeds. The germination speed is lower and for every day of increase in the deterioration, the germination speed decreases by 0.9 percent.

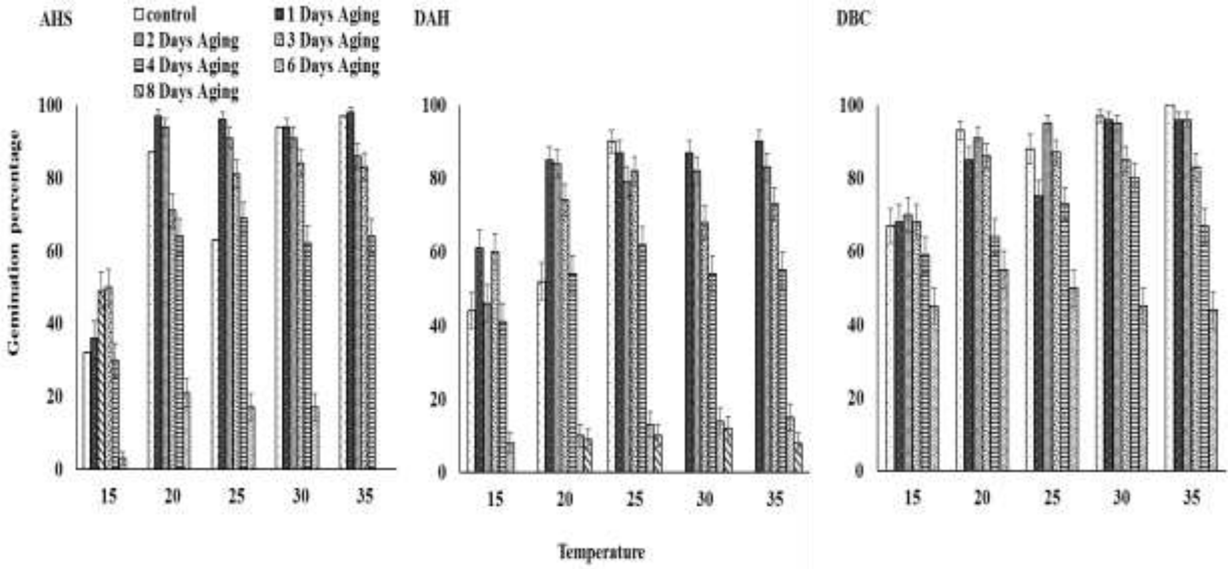

Figure1. Germination percentage of different rice cultivars in response to temperature in treatments of one to eight days of artificial storage

Furthermore, the cumulative germination percentage changes in the thermal time model also showed that the lowest germination percentage occurred in all seed consignments at a temperature of 15°C and with increasing temperature, the germination percentage increased in all seed consignments (Figure2). Additionally, with the increase in the duration of the artificial aging period in all seed shipments to more than two days, the percentage of germination decreased in different temperatures and cultivars (Figure 2). The highest percentage of germination was observed in control treatments, one, two and three days of artificial aging and the lowest percentage of germination was observed in treatments of four, six and eight days of artificial aging. Therefore that the germination percentage of all the seeds of rice cultivars was stopped in the treatment of eight days of artificial aging (Figure 2).

The parameters of thermal time model for different rice cultivars at different levels of artificial aging with binomial distribution are show in the (table 1). The lowest basal temperature has observed in all cultivars (AHS, DAH and DBC) in the treatment of three days of artificial aging. Additionally, the highest base temperature has additionally observed in the DAH variety in the control treatment, in the DBC variety, in the two-day artificial deterioration treatment, and in the AHS variety in the six-day artificial deterioration treatment (Table 1). Changes in the numerical value of θ_t at different levels of aging showed that the germination speed increased in DAH and DBC cultivars up to one day of artificial aging and in AHS cultivar up to two days of artificial aging and decreased with increasing the length of the aging period in all cultivars (Table 1). Furthermore, germination uniformity increased in DBC cultivar up to two days of artificial aging and in DAH and AHS cultivars up to one day of artificial aging and decreased as the duration of the aging period increased (Table 1).

As mentioned, in artificial deterioration, the thermal time parameter has more affected compared to the other two coefficients (base temperature and sigma). Therefore, the noteworthy point in this section is that up to two days of deterioration, the thermal time parameter first decreased and then increased again. In other words, when the rice seeds have subjected to artificial aging, the germination rate first increased and then decreased again. The cause of this increase might attributed to the elimination of the dormancy through the increase of the germination rate (Bialy et al., 2013). In other words, by placing the rice seeds at a temperature of 45°C for a short time in the accelerated aging test, the germination of rice seeds increased by increasing the germination rate, and after that, by increasing the test period to eight days, both the germination rate and percentage decreased in all cultivars. In addition, in Haste, the day of decrease reached zero. Therefore, it is be said that exposure of rice seeds to high temperature and high humidity (accelerated aging test) first resolves the germination of the seeds, and if the duration of exposure to these conditions is increased, the mechanisms involved in the deterioration of the seeds are increased and thus lead to. The aging of the seed causes a decrease in the speed and percentage of germination. In the study of Xia et al (2004) on oat seeds at three humidity levels of 4, 10, and 16%, high temperature and its storage time at six levels of zero, 16, 24, 32, and 40 days at a temperature of 45°C degrees Celsius. They stated the seeds that were in 4% humidity, the germination of the seeds of this vegetable species decreased from 88% to 80% within forty days. So that seeds with moisture content of 10% after 40 days, their germination went from 88% to zero. Additionally, the moisture content of the seeds was 16%, after 8 days of germination, this amount reached zero.

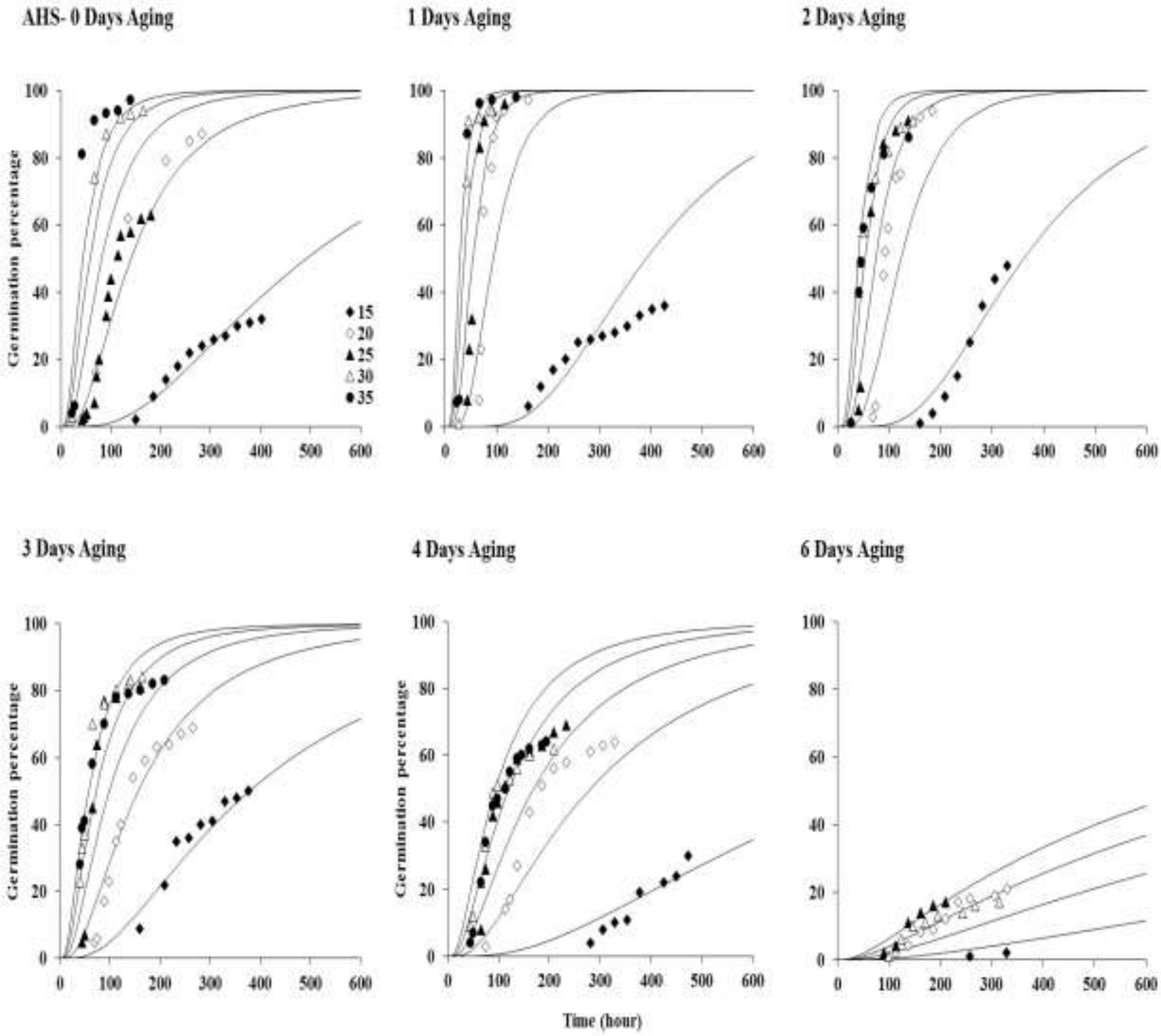

Figure 2. Fitting the thermal time model to the cumulative germination percentage data of AHS variety in response to different temperatures in treatments of zero to eight days of artificial storage

Table 1. Thermal time model parameters for different rice cultivars at different levels of artificial storage with binomial distribution

R^2	$\sigma\theta_t$ (°C)	θ_t (°Ch)	T_b (°C)	artificial of storage	Verity
0/68	0/9547 ±0/07203	897/82 ±49/3466	13/4678 ±0/2037	0	AHS
0/86	0/4436 ±0/04321	691/21 ±20/7615	13/4879 ±0/09244	1	
0/93	0/5637 ±0/04253	878/33 ±39/0577	12/5156 ±0/2386	2	
0/92	0/8531 ±0/07042	1256/18 ±73/5897	11/6643 ±0/3809	3	
0/89	0/9666 ±0/08426	2035/77 ±108/580	12/6728 ±0/3853	4	
0/44	2/04221 ±1/0851	1151/55 ±319/440	15/0000 ±0/11	6	
-	-	-	-	8	
0/87	0/8087 ±0/05674	1286/77 ±57/3335	13/4335 ±0/1570	0	DAH
0/92	0/5786 ±0/04031	1038/25 ±49/0782	12/0453 ±0/2252	1	
0/87	0/8713 ±0/07589	1001/35 ±58/6878	13/2547 ±0/2214	2	
0/93	0/9138 ±0/07112	2211/33 ±178/200	7/9055 ±1/0179	3	
0/88	1/1735 ±0/1366	2665/88 ±198/480	11/4335 ±0/6601	4	
0/67	1/4678 ±0/2089	29503/22 ±7937/40	10/2657 ±1/1436	6	
-	-	-	-	8	
0/76	0/7087 ±0/05689	796/44 ±45/8688	11/4674 ±0/3765	0	DBC
0/95	0/5011 ±0/03358	698/33 ±29/3815	12/0870 ±0/1879	1	
0/95	0/4884 ±0/03322	624/18 ±26/5856	12/6463 ±0/1553	2	
0/87	0/8849 ±0/06236	1445/55 ±124/612	7/7148 ±1/0586	3	
0/86	0/7715 ±0/05368	1912/46 ±105/150	10/3631 ±0/4789	4	
0/80	0/7742 ±0/08420	4074/37 ±373/590	7/9888 ±1/0244	6	
-	-	-	-	8	

Conclusion

The results of this research indicated that the artificial storage reduces the viability of seeds. Figure 1 to 2. The fitting of the thermal time model to the germination percentage data of AHS, DAH and DBC cultivars in response to different degrees of 15, 20, 25, 30, and 35°C in the treatments of one to eight days of artificial aging and control is show. Germination percentage in all cultivars in different treatments at 15 °C temperature was lower than other temperatures. There for, with the increase in temperature, the percentage of germination increased in all cultivars and artificial storage treatments. Additionally, the percentage of germination at different temperatures decreased with the increase of one day of artificial storage in all cultivars. Additionally, the highest germination percentage has observed in the control treatments (without artificial storage), one, two and three days, and the lowest germination percentage has observed in the four, six and eight day artificial storage treatments. Also, the results of this research in Table 1. Above parameters of the thermal time model for different rice, cultivars at different levels of artificial storage are show with binomial distribution. In this table, Tb (°C) shows the low temperature (degrees Celsius), θ_t (°Ch) the coefficient of thermal time (degrees Celsius hours), and $\sigma\theta_t$ (°C) shows the uniformity of germination (degrees Celsius). Since these parameters have a biological meaning, θ_t (°Ch) indicates the germination speed and $\sigma\theta_t$ (°C) indicates the uniformity of germination. Low temperature was different between all the stored treatments in AHS, DAH and DBC cultivars. This difference has observed with the increase of each day of artificial storage in different temperatures. So, the low temperature difference has observed in AHS variety in the treatment of six days of storage at 11/664°C and three days of storage at 150000°C, with the highest and lowest temperature levels. Additionally, low temperature in other rice cultivars, DAH cultivar in the treatment of control 7.9°C and three days of storage 13/433°C, and DBH cultivar in treatment two 7.71°C and three days of artificial storage 12/64°C, with the highest and lowest temperature levels observed. The percentage of germination with the increase of storage treatments of AHS variety in one-day storage treatment was 691/21°C and four days artificial storage was 2035/77°C hours. Additionally, the percentage of germination in other cultivars with the increase of storage treatments in DAH variety in the treatment of two days of desolation 1001/35°C and six days of storage 29503/33°C and DBC cultivar in the treatment of two days of storage 624/28°C and eight days of artificial storage 4074/37°C Time difference has observed. Uniformity of germination in different temperatures was different with increasing storage treatments in all cultivars. This difference in AHS variety in the treatment of one day of storage was 0/44°C and six days of artificial storage was 2/04°C. Additionally, with the increase of artificial storage treatments in other cultivars, in the DAH variety, in the treatment of one day of storage, 0/57°C and six days of artificial storage, 1/46°C, and in DBC cultivar, the treatment of two days of storage, 0/48°C and eight days of artificial storage. A difference of 0/88°C has observed, there for that, these differences show the resistance of the seeds against the storage period and different temperatures.

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