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Appropriate Temperature and Time for an Accelerated Aging Vigor Test in Sesame (*Sesamum indicum* L.) Seed

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ABSTRACT

Sesame is a small-seeded oil crop for which a proper method of testing seed vigor has not been successfully developed. This study was conducted to identify the appropriate combination of temperature and time for accelerated aging vigor testing of sesame. Five seed lots of sesame were used: KU 18 (2006), CPlus 2 (2006), KU 18 (2007), and CPlus 2 (2007), grown at the National Corn and Sorghum Research Center and KU 18 (Contract Farmer 2007), grown by a contract farmer. A completely randomized factorial design with four replications was used. The accelerated aging test was carried out at five different temperatures: 40, 41, 42, 43 and 44°C with six duration periods of 24, 48, 72, 96, 120 and 144 hr and a relative humidity of 100%. The results showed that accelerated aging under conditions of 42-43°C at 100 % RH for 120 hr were appropriate for an accelerated aging test for seed vigor in sesame.

Key words: *Sesamum indicum* L., accelerated aging, seed vigor, aging temperatures, aging periods

INTRODUCTION

Accelerated aging is one of the vigor tests widely used to determine the quality of seed lots. It was initially developed as a test to predict the life span of a number of different species under a range of storage conditions. Accelerated aging is very effective in testing the relative storage potential of seed lots. A seed lot consists of a population of seeds, which may be genetically and physically similar, but vary in degree of deterioration from relatively non-deteriorated to completely dead (100-0%). Deterioration within a lot is on an individual seed basis (Delouche and Baskin, 1973).

An accelerated aging technique is simple to perform; in addition, it can be used with a wide variety and species of seed. An accelerated aging stress test exposes seeds for short periods (1 to 8 days) to high temperature (40 to 45°C) and high relative humidity (greater than 90%). During the test, the seeds absorb moisture from the humid environment along with the high temperature, causing rapid seed aging. High vigor seed lots withstand these stress conditions and deteriorate more slowly than low vigor seed lots. After accelerated aging, high vigor seed lots remained high in germination, while the germination of low vigor seed lots was reduced (ISTA, 2004). The changes in germination of high and low quality

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seed lots after accelerated aging followed a similar trend to the germination of the same seed lots after time in warehouse storage (Delouche and Baskin, 1973).

Seeds of oil crops are vulnerable to deterioration. They cannot be stored for a long time and are described as poor storers (Delouche, 1973). The seed quality of peanut and soybean is difficult to maintain (Duangpatra and Kuphotipan, 1986). Sesame seed was found to be a 'poor storer' compared with soybean and peanut seed. Germination percentages after artificial aging of two sesame cultivars began to decrease in the first month of storage at a temperature of 20 to 30°C and 75% relative humidity (Aponte, 1973). However, sesame seed could be stored for up to two years with little loss of viability provided it was dried below 8% moisture content (Weiss, 2000).

Hampton and TeKrony (1995) recommended that a temperature of 41°C for 72 hr should be used for the accelerated aging (AA) vigor test for soybean [*Glycine max* L. (Merrill)] and canola (*Brassica napus* L.). For peanut (*Arachis hypogaea* L.), Duangpatra and Homdork (1986) proposed an AA test with a temperature of 42°C and 100% relative humidity (RH) for 192 hr, while 42°C and 100% RH for 264 hours was suggested by Promchote and Duangpatra (2002) and Phyo *et al*. (2004). However, Siri *et al*. (2002) reported that a temperature of 42°C and 100% RH for 264 hours should be used for the AA vigor test for peanut. Differences in aging periods for peanut seed from the previous studies may have been attributable to genotypic differences (Duangpatra and Kittitanasuan, 1990; Phyo *et al*., 2004). However, the methods of vigor testing for sesame seed have not been clearly documented. The purpose of this study was, therefore, to determine an appropriate combination of temperature and time of accelerated aging (AA) for vigor testing sesame seed from various sources.

MATERIALS AND METHODS

This study was carried out at the Seed Technology Laboratory, Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok, Thailand from October 2007 to April 2008. Five different sesame seed lots: No.1, KU 18 (2006), No.2, CPlus 2 (2006), No.3, KU 18 (2007), No.4, KU 18 (Contract Farmer, 2007) and No.5, CPlus 2 (2007) were used in this study. Seed lots No.1 and No. 2 were old sesame seed lots grown and cultivated in 2006 and seed lots No.3, 4 and 5 were new sesame seed lots grown and cultivated in 2007. KU 18 (2006), KU 18 (2007), CPlus 2 (2006) and CPlus 2 (2007) were obtained from the seed multiplication plot of the National Corn and Sorghum Research Center, in their respective years. KU 18 (Contract Farmer, 2007) was obtained from the contract farmer seed multiplication program during the 2007 rain-fed planting season. KU 18 was black seed coat sesame, while CPlus 2 was white seed coat sesame. After harvesting, all seed lots were sundried, cleaned, processed and stored at 15°C and 65% RH. Initial seed moisture contents and germination ranged from 6.38 to 7.49% and 60 to 81%, respectively. The experiments were arranged in a factorial completely randomized design with four replications. AA was conducted at five different temperatures of 40, 41, 42, 43 and 44°C at 100% RH for six periods of 24, 48, 72, 96, 120 and 144 hr. An aging bottle containing 50 ml of deionized water was used to maintain 100% RH.

The AA bottles and wire mesh were sterilized with 90% alcohol. Four replications of a two-gram sample of each seed lot were put in the sterilized wire mesh. The wire mesh was placed in the sterilized aging bottles, which each contained 50 ml of deionized water. The wire mesh in the bottle was held above the water level. The aging bottles were seal-locked and kept in the AA chamber at five different temperatures for six periods, as previously mentioned.

The germination test was carried out after AA using the top paper method. Four replications of twenty-five seeds of each lot were placed on the filter paper in each petri dish and kept at 25°C throughout the testing period. Seedling evaluation followed the method of ISTA (2004). First and final counts were made at three and six days after germination, respectively. Normal seedling numbers were expressed as a percentage. The IRRI statistics package was used for analysis of variance (ANOVA) and Fisher's LSD for the comparison among treatment means.

RESULTS AND DISCUSSION

The germination percentage after AA at the five temperature levels of five sesame seed lots are shown in Table 1. The results revealed that

Table 1 Germination (%) of the five sesame seed lots after accelerated aging at different temperatures and 100 % relative humidity for different aging periods.

Temperature (°C)	Seed lot (No)	Aging period (hours) 24	48	72	96	120	144	Mean	Grand mean
40°C	1	76.00 cd	91.00 ab	88.00 bc	87.00 bc	94.00 ab	97.00 ab	**88.83 c**	
	2	45.00 f	57.00 ef	49.00 f	61.00 de	28.00 g	16.00 h	**42.67 j**	
	3	92.00 ab	97.00 ab	97.00 ab	95.00 ab	87.00 bc	82.00 bc	**91.67 bc**	
	4	53.25 ef	87.00 bc	95.00 ab	87.00 ab	86.00 bc	92.00 ab	**85.04 d**	
	5	76.00 cd	68.00de	83.00 bc	83.00 bc	88.00 bc	61.00 de	**76.50 ef**	
	Mean	68.5 E	80 CD	82.4 BC	84.6 BC	76.6 D	69.6 E		76.94 A
41°C	1	89.00 bc	93.00 ab	87.00 bc	89.00 bc	6.00 i	85.00 bc	**74.83 ef**	
	2	52.00 ef	62.00 de	59.00 e	58.00 ef	15.00 hi	8.00 hi	**42.33 j**	
	3	87.00 b	91.00 ab	95.00 ab	93.00 ab	97.00 ab	97.00 ab	**93.33 ab**	
	4	64.00 de	95.00 ab	95.00 ab	95.00 ab	74.00 cd	99.00 ab	**87.00 cd**	
	5	79.00 cd	62.00 de	45.00 f	84.00 bc	13.00 hi	23.00 gh	**51.00 h**	
	Mean	74.2 DE	80.6 CD	76.2 D	83.8 BC	41.0 G	62.4 F		69.70 C
42°C	1	89.00 bc	75.00 cd	97.00 ab	87.00 bc	89.00 bc	51.00 ef	**81.33 d**	
	2	62.00 de	55.00 ef	51.00 f	61.00 de	27.00 g	32.00 g	**48.00 i**	
	3	97.00 ab	83.00 bc	93.00 ab	97.00 ab	93.00 ab	80.00 c	**90.50 bc**	
	4	91.00 ab	90.00 b	91.00 ab	96.00 ab	89.00 bc	99.00 ab	**92.67 b**	
	5	84.00 bc	82.00 b	69.00 d	63.00 de	55.00 ef	73.00 cd	**71.00 f**	
	Mean	84.6 BC	77.0 D	80.2 CD	80.8 CD	70.6 E	67.0 E		76.70 A
43°C	1	91.00 ab	76.00 cd	92.00 ab	92.00 ab	71.00 cd	67.00 de	**81.50 d**	
	2	70.00 d	51.00 ef	59.00 e	31.00 g	2.00 i	1.00 i	**35.67 k**	
	3	92.00 ab	94.00 ab	95.00 ab	93.00 ab	79.00 cd	97.00 ab	**91.67 bc**	
	4	96.00 ab	99.00 ab	100.0 a	94.00 ab	93.00 ab	100.00 a	**97.00 a**	
	5	80.00 c	87.00 bc	77.00 cd	85.00 bc	91.00 ab	79.00 cd	**83.17 d**	
	Mean	85.8 B	81.4 C	84.6 BC	79 .0 CD	67.2 E	68.8 E		77.80 A
44°C	1	84.00 bc	88.00 bc	88.00 bc	91.00 ab	85.00 bc	0.00 i	**72.67 f**	
	2	55.00 ef	55.00 ef	65.00 de	70.00 d	69.00 d	0.00 i	**52.30 h**	
	3	90.00 b	90.00 b	72.00 c	96.00 ab	95.00 ab	85.00 bc	**88.00 cd**	
	4	64.00 d	93.00 ab	98.00 ab	100.0 a	99.00 ab	97.00 ab	**91.80 bc**	
	5	81.00 bc	86.00 bc	81.00 bc	91.00 ab	24.00 g	0.00 i	**60.50 g**	
	Mean	74.8 D	82.4 BC	80.8 CD	89.6 AB	74.4 DE	36.4 H		73.07 B
	Grand mean	**77.6 C**	**80.3 B**	**80.9 B**	**83.6 A**	**65.9 D**	**60.8 E**		

Within each column for each aging temperature, means followed by the same lower case letter are not significantly different at P < 0.01 as determined by Fisher's LSD.

Within each column, temperature means followed by the same upper case letter are not significantly different at P < 0.01 as determined by Fisher's LSD.

Within each row, means followed by the same upper case letter are not significantly different at P < 0.01 as determined by Fisher's LSD.

AA at 42 and 43°C resulted in the highest average germination percentages (76.70 and 77.80%, respectively) but they were not significantly different from the average germination percentage at 40°C (76.94%). However, at 40°C, differences in the mean germination percentages among seed lots were slightly less pronounced than at 42 and 43°C. In terms of aging period, statistically significant differences were found among different aging periods for 24 hr up to 144 hr, except for the aging periods of 48 (80.3%) and 72 hr (80.9%), which were not statistically significant different. An AA time of 96 hr gave the highest mean germination percentage (83.60%) and 144 hr (60.80%) gave the lowest.

The average germination from all seed lots after AA for 96 hr (83.6%) identified the transition point for sesame seed quality, after which germination decreased sharply. In addition, the average germination of all seed lots was highest after AA at 40°C (76.94%), 42°C (76.70%) and 43°C (77.80%). Therefore, temperatures of 41 and 44°C were not considered appropriate for the AA test in sesame.

Regression analysis of the AA test results at 40, 42 and 43°C for new seed and old seed lots are shown in Figure 1. The germination percentages after aging at 40, 42 or 43°C and 100% RH indicated quadratic responses with the aging period (Figures 1a, 1b and 1c). The germination percentages increased after aging for 24 hr up to 96 hr and then decreased with longer aging (Table 1, Figures 1a, 1b and 1c). From regression analysis (in which the germination after AA was tested against aging periods), the regression coefficient value (R^2) for the period from 0 to 144 hr at 42°C (R^2 = 0.709) was greater than the value at 40°C (R^2 = 0.685) and not different from the value at 43°C (R^2 = 0.705) (Figures 1a, 1b and 1c). Although the aging at 42 and 43°C provided the transition point for sesame seed quality, the vigor of sesame seeds was changed distinctly after aging for 120 hr. Therefore, the appropriate accelerated condition for sesame seed could be aging at 42-43°C and 100% RH for 120 hr.

The results in Figures 1(b) and 1(c) also showed that the germination percentages of new seed lots (No. 3, 4 and 5) after AA at 42 and 43°C,with 100% RH were higher than old seed lots (No. 1 and 2) in all tested aging periods. In addition, the regression coefficients indicated that the vigor of old seed lots after aging at 42°C (R^2= 0.825) and 43°C (R^2= 0.825) decreased faster than the vigor of new seed lots (R^2 = 0.198) at 42°C and (R^2 = 0.636) at 43°C. Justice and Bass (1979) found that vigorous seed or new seed lots possessed a greater storage potential than low vigor or older lots and one of the first indications of deterioration was reduced vigor, which was shown by the reduced rate of germination and production of weak or watery seedlings and seedlings with stunted radicles. Delouche and Baskin (1973) found that temperature and relative humidity had to be maintained at desired levels and all seeds must be equally exposed to the enforced environmental conditions. Results from the current study are consistent with the suggestion from Hampton and TeKrony (1995) that for canola, small oil seed rape (*Brassica napus* L), a temperature of 41°C and an aging period of 72 hr should be used for the accelerated aging vigor test. Therefore, an aging temperature of 44°C was too high for small seed types like sesame. Under high relative humidity conditions (100% RH), the results indicated that an aging temperature of 44°C was improper for sesame seed.

In this study, the initial seed moisture content and initial germination percentage ranged from 6.38 to 7.49% and 60 to 81%, respectively. The average germination percentage after AA at 42°C for 24 to 96 hr of each seed lot in Table 2 was higher than the average initial percentage. This may be due to the accelerated aging conditions reducing the effects of internal factors that inhibit the germination process under normal condition.

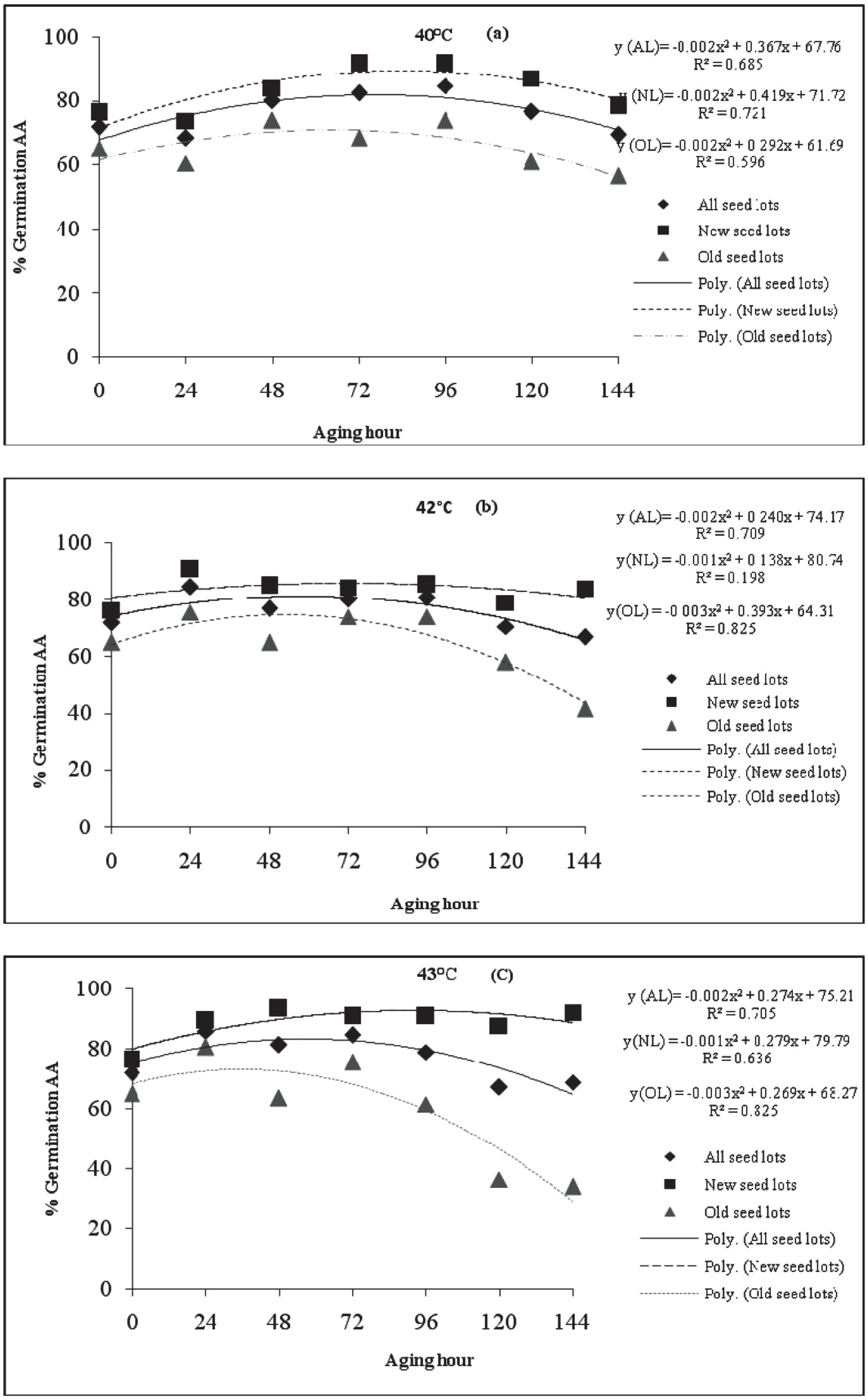

Figure 1 Graphs and regression coefficient of germination percentages after accelerated aging at (a) 40°C (b) 42°C and (c) 43°C at 100 % RH for 0 to 144 hours.

Table 2 Germination percentage (%) of five sesame seed lots after different periods of accelerated aging at 42°C and 100% RH.

Seed lot (No)	Variety	Aging period (hours)				
		24	48	72	96	120
1	KU 18 (2006)	89.00 bc	75.00 cd	97.00 ab	87.00 bc	89.00 bc
2	CPlus 2 (2006)	62.00 de	55.00 ef	51.00 f	61.00 de	27.00 g
3	KU 18 (2007)	97.00 ab	83.00 bc	93.00 ab	97.00 ab	93.00 ab
4	KU 18 (CF, 2007)	91.00 ab	90.00 b	91.00 ab	96.00 ab	89.00 bc
5	CPlus 2 (2007)	84.00 bc	82.00 b	69.00 d	63.00 de	55.00 ef
	Mean	**84.6 BC**	**77.0 D**	**80.2 CD**	**80.8 CD**	**67.0 E**

Within each column, means followed by the same lower case letter are not significantly different at P < 0.01 as determined by Fisher's LSD.
Within each row, means followed by the same upper case letter are not significantly different at P < 0.01 as determined by Fisher's LSD.

Ramamoorthy *et al*. (1990) found that germination percentages of sesame seeds after AA hydration-dehydration treatment were higher than for the untreated (control) seeds. This may have been due to the effective repair of lesions of vital bio-organelles during the hydration phase. It was also noted that, importantly, at an aging period of 120 hr, the average germination percentage was significantly lower than for aging periods of 24 to 96 hr. Therefore, AA for 120 hr was the appropriate aging time for sesame.

It was also found that after AA at 42°C for 72 hr and 96 hr, the germination percentages for lots No.2 (CPlus 2, 2006) and No.5 (CPlus 2, 2007), which were white sesame seed samples, were lower than for the black sesame seed lots No.1 (KU 18, 2006), No.3 (KU 18, 2007) and No.4 (KU 18, Contract Farmer, 2007) (Table 1 and Figure 2). These results agreed with the report from Chanprasert and Tungsakul (2001) that the black-seed cultivar, Nakhon Sawan, had higher quality and storability than the white-seed cultivars Roi Et 1 and Maha Sarakham 60. Therefore, it is necessary to develop standards separately for white and black sesame, because white sesame has different storability parameters from other sesame cultivars (Chanprasert and Tungsakul, 2001; Srirattana and Juntakool, 2005). Moreover, further investigations are needed to develop standard procedures for all sesame cultivars.

CONCLUSION

Among the AA tests, an aging temperature of 42-43°C and 100% RH for 120 hr could be used in AA tests of sesame. It is necessary, either to develop standard procedures separately for white sesame or further investigations are needed to develop a procedure appropriate for all sesame seed types.

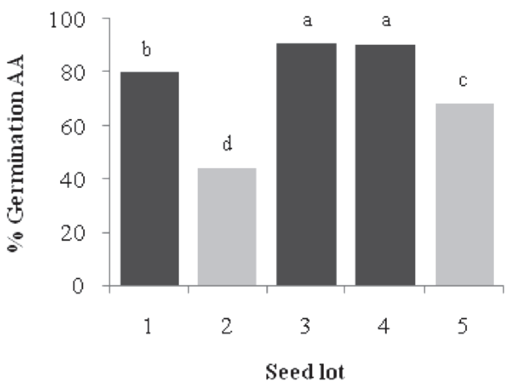

Figure 2 Differences in germination (%) after AA between black and white sesame seed lots in all tested periods. [1= KU 18 (2006), 2= CPlus 2 (2006), 3= KU 18 (2007), 4= KU 18 (Contract Farmer, 2007) and 5= CPlus 2 (2007)].

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