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Effects of Accelerated Aging Treatments on Six Cotton Cultivars[1]

F. M. Bourland and Adly A. L. Ibrahim[2]

ABSTRACT

The objectives of this study were to determine if cotton (*Gossypium hirsutum* L.) cultivars having different genetic backgrounds would respond to accelerated aging as predicted by Bird and Reyes' seed quality curve and to determine the resistance to seed deterioration of the cultivars. The seed quality curve predicts seed germination to increase with low exposure to aging, reach a peak then decrease rapidly with addition exposure. Mold growth on seed is expected to increase linearly with exposure to aging.

Acid-delinted seed of each cultivar having minimum preharvest deterioration were exposed to accelerated aging for varying periods of time then evaluated in laboratory tests at 13.3 and 18.3 C and in field tests. Germination percentages in all tests tended to respond to accelerated aging as predicted with variation accentuated in the 13.3 C test. When removed from the aging chamber, molds growing on the seed in proportion to the length of the aging period were observed. When the 13.3 C test was initiated the same day seed were removed from the chamber, mold growth increased linearly with length of aging period but when initiation was delayed, mold growth on seed did not respond to aging as expected. A strain (TX-ORMAR-S-2) selected for resistance to seed deterioration consistently was the least sensitive to the effects of accelerated aging; 'Deltapine 61,' 'CAMD-E,' and 'Stoneville 213' were intermediate; and 'Delcot 277J' and 'DES 56' were the most sensitive.

Variation for resistance to seed deterioration exists among cotton cultivars. Absence of mold growth on seed can be an indicator of high seed quality. However, precautions should be taken to validate relationships involving mold growth before it is used as a selection criterion in a breeding program.

Additional index words: Gossypium hirsutum L., Mold growth, Germination, Seed quality, Seed deterioration.

PROBLEMS associated with establishing stands of vigorously growing cotton (*Gossypium hirsutum* L.) seedlings are often related to poor planting seed quality. High quality cottonseed have the capacity to produce vigorous seedlings over a wide range of environments. Seed deterioration can render seed worthless for planting purposes although its germination percentage remains relatively high (10).

Delouche (11) indicated seed deterioration is a progressive process from the time of physiological maturity until the seed is completely dead. Presley (13) suggested that cottonseed must be conditioned before they reach optimum germination capacity. This suggestion was developed into the seed quality curve by Bird and Reyes (6). They found that the germination of unconditioned cottonseed to increase until seed reached the conditioned stage. With additional exposure to moisture and heat the seed enters the deteriorated stage and germination capacity is rapidly lost. The amount of mold growth on seed coats in a cool germination test was used to determine whether a seed lot was entering or passing the conditioned stage of quality. Mold growth on the seed coat is directly related to the presence of seed leachates. Schnathorst and Presley (16) found the increased cell permeability of deteriorated cottonseed allowed large quantities of cellular components to diffuse out when seed were placed in water. Non-deteriorated seed allowed less diffusion of leachates.

The relationship between mold growth on cottonseed and resistance to seed deterioration formed the basis of the Texas A&M Multi-Adversity Resistance (TAM-MAR) cotton improvement program (1, 8). The procedures used to identify and develop lines which resisted seed deterioration were later found to simultaneously improve resistance to several diseases and insects, enhance earliness, and increase yield potential (2, 3, 4, 7). Improvements and additions to the basic program have permitted 60 to 100% of the variability in disease resistance, earliness and yield to be explained (4). Although these concepts have been tested in many Texas environments they have received only limited attention in other states and with other germplasms.

The objectives of this study were to determine if the concepts of Bird and Reyes' (6) seed quality curve are applicable to cotton germplasms developed in the Mississippi delta and to estimate the resistance to seed deterioration of six cotton cultivars.

MATERIALS AND METHODS

Five cultivars and one strain of Upland cotton were grown on the Plant Science Research Center at Mississippi State in 1978 using standard production procedures. 'Tamcot CAMD-E' (5) and the breeding strain TX-ORMAR-S-2-72 (7) are from the TAM-MAR program; 'DES 56' (9), 'Delcot 277J' (15), 'Stoneville 213', and 'Deltapine 61' represent different breeding programs in the Mississippi delta. Seedcotton was harvested daily from first boll opening through peak boll opening. Daily harvests (excluding seedcotton exposed to rain) were bulked on an individual cultivar basis and samples were saw-ginned and acid-delinted. No chemical seed treatment was added to the seed.

Five 40 g subsamples of seed were exposed to accelerated aging (ca. 100% relative humidity, 45 C) for 0, 24, 48, 72, and 96

[1]Contribution from the Dep. of Agronomy, Mississippi Agric. and For. Exp. Stn., Mississippi State, MS 39762. Received 27 July 1981.

[2]Assistant agronomist and former graduate student, respectively.

hours. The seed were allowed to dry at room temperature for several days before being used in the first series of germination tests and the 1979 field tests. For the second series of germination tests, subsamples of seed were aged for 0, 48, 96, and 144 hours and placed into the tests the same day they were removed from the aging chamber.

Germination tests were conducted at 13.3 and 18.3 C. For the 13.3 C test, 25 seeds of each entry replicated four times were placed on 1.5% water agar in petri plates. After 10 days at 13.3 C the percentage of seed coats having visible mold growth was determined. The plates were then left at room temperature (ca. 23 C) for four additional days and the number of seed having visible radicle extension were expressed as a percentage of the seed plated.

Standard low temperature germination test procedures (12) with four replications were used for the 18.3 C test. Plots consisted of 50 seed on wetted germination paper, rolled and placed into crispers. After seven days at 18.3 C the percentage of seed having visible radicle extension (germination) and the percentage of seedlings having a radicle length of at least 4.5 cm (standard germination) were determined. The latter measurement coincides with the criterion prescribed in the standard test procedures.

Four replications of the 30 (six cultivars × five aging periods) entries were planted at two locations on the Plant Science Research Center at Mississippi State in 1979. Location 1 soil was a Leeper silty clay loam (fine, montmorillonitic, non-acid, thermic Vertic Haplaquepts) and was planted on 8 May while location 2 soil was a Marietta sandy loam (fine-loamy, siliceous, thermic Fluvaquentic Eutrochlepts) and was planted on 15 May. A duplicate test was planted 6 May 1980, at the first site. Seed for the 1980 test were obtained from the 1979 tests, then processed and aged as previously described. Plots for each test were single rows 6 m in length with 1 m between rows. Eighty acid-delinted, untreated seed were planted in each plot. The number of seedlings that emerged and survived were counted five weeks after planting and expressed as a percentage of the number of seed planted.

Differences among plot means were determined by analysis of variance. Separate analyses for germination and mold growth in the germination tests and stand in the field tests were performed. Similarities in variation of the traits were detected by simple correlation coefficients.

RESULTS AND DISCUSSION

The accelerated aging treatments had significant effects on all germination and stand measurements (Table 1). Generally, germination was highest for seed aged for 24 or 48 hours, intermediate for seed aged for 0 or 72 hours, and lowest for seed aged for 96 hours. Following the terminology of Bird and Reyes (6) in their seed quality curve, seed with the 0 hour treatment were in the unconditioned stage, seed with the 24 and 48 hour treatment represented the conditioned stage, and seed with the 72 and 96 hour treatment were in the deteriorated stage. Similar results were found in the second series of germination tests (Table 2). When accelerated aging was increased to 144 hours, all seed were killed. Among the measurements, germination percentages were highest and had the least variation over aging treatments for germination in the 18.3 C test. Therefore, as Presley (14) found, germination of deteriorated seed increased as the test environment became more favorable.

Significant cultivar by aging period interactions were present for each measure of germination. Differential cultivar responses were most evident at high levels of aging indicating varying degrees of resistance to seed deterioration among the cultivars. Variation in germination percentages was relatively low for TX-ORMAR-S-2, CAMD-E, Stoneville 213, and Deltapine 61 (Table 1). Germination of DES 56 and Delcot 277J was significantly reduced at the 96 hour treatment. Relative germination percentages at the 96-hour treatment indicated resistance to deterioration was highest for TX-ORMAR-S-2, intermediate for CAMD-E, Deltapine 61, and Stoneville 213, and lowest for DES 56 and Delcot 277J. Germination percentages in the second series of tests were lower than in the first, but a similar trend of differences among the cultivars was found (Table 2).

Accelerated aging was expected to cause increased percentages of moldy seed but the opposite trend was found in the first 13.3 C test (Table 1). When the seed were removed from the accelerated aging chamber, visible mold growth was present in proportion to the time the seed were in the chamber. The seed were permitted to dry several days before they were placed into the germination tests. During this time the superficial molds may have assimilated the nutrients leached during accelerated aging. The deteriorated seed would then actually have less leachates than non-deteriorated seed and would sustain less mold growth. The seed for the second series of germination tests were placed into the tests on the same day they were removed from the accelerated aging chamber. Except for a decrease from 0 to 48 hour treatments, moldy seed increased as the aging period increased (Table 2). The initial decrease may be a split-plot effect because the seed having the 0 hour treatment were never placed in the accelerated aging chamber. In the second series of tests, correlation coefficients of moldy seed with germination at 13.3 C, germination at 18.3 C, and standard germination at 18.3 C were −0.83, −0.79, and −0.74, respectively. Omission of the 0 hour treatment would furhter increase these negative associations. The magnitude of these coefficients sharply contrasts identical comparisons in the first series of tests (Table 3).

The methodology difference between the two series of tests had little effect on germination percentages (Tables 1 and 2). Germination percentages exhibited the same trend of increasing with short periods of accelerated aging, reaching a peak, then rapidly declining with increased aging. Except for the initial decrease in moldy seed the relationship of moldy seed and germination percentages in the second series of tests was consistent with the seed quality curve of Bird and Reyes (6). The amount of mold growth on the seed appears to be indicative of which side from conditioned qualty a seed lot is when reduced germination percentages are obtained.

The highest resistance to mold growth was exhibited by TX-ORMAR-S-2 (Table 2). Intermediate levels were found for CAMD-E, Stoneville 213, and Deltapine 61, while DES 46 and Delcot 277J were most sensitive to mold growth. These relationships among the cultivars were similar to those found for the germination measurements. The drastic differences in mold growth between the tests indicate this characteristic is very sensitive to processing

Table 1. Germination, moldy seed, and stand percentages for cultivars over five accelerated aging treatments in the first series of germination tests and in the field tests.

Cultivar	Aging treatment	13.3 C test		18.3 C test		Field tests — Stand		
						1979		1980
		Germination†	Moldy seed	Germination†	Standard germ.‡	Loc. 1	Loc. 2	Loc. 1
	hours	%						
TX-ORMAR-S-2	0	81	25	90	74	87	61	85
	24	90	14	92	74	85	67	85
	48	89	13	95	73	90	72	68
	72	78	24	93	83	80	57	58
	96	63	9	95	81	77	56	48
CAMD-E	0	57	44	80	32	87	66	66
	24	75	21	80	46	79	68	68
	48	77	16	85	60	87	63	51
	72	78	15	87	63	76	55	28
	96	46	7	80	46	68	40	21
DES 56	0	83	44	93	73	75	71	50
	24	90	28	97	79	84	69	46
	48	91	9	92	73	84	70	34
	72	78	25	92	70	80	64	7
	96	7	7	62	19	55	35	2
Delcot 277J	0	60	60	83	51	65	56	51
	24	68	40	87	50	72	73	41
	48	74	26	89	61	79	63	27
	72	28	37	73	47	59	35	25
	96	10	11	52	27	44	27	8
Deltapine 61	0	74	35	86	46	81	74	74
	24	70	30	89	43	80	63	67
	48	79	19	90	67	85	75	66
	72	79	27	94	73	73	55	36
	96	52	15	88	71	64	56	6
Stoneville 213	0	85	41	95	70	75	77	68
	24	84	28	97	67	85	67	70
	48	85	18	89	89	84	73	23
	72	77	23	89	82	70	63	34
	96	35	8	91	58	62	51	9
C.V.		18	63	10	24	8	14	24
L.S.D. (0.05)		8	10	5	4	4	5	15

† Includes seed having visible radicle extension.
‡ Includes seedlings having radicles at least 4.5 cm in length.

procedures and is more difficult to measure than germination. Precautions should be taken to validate relationships involving mold growth on seed before it is used as a criterion to select for resistance to seed deterioration.

Average stand was highest for the 1979 location 1 test, followed by the 1979 location 2 and 1980 field tests (Table 1). The relatively low values for the 0 hour treatment in the 1980 test and the decline over increasing aging periods suggest these seed were in the conditioned stage before they were subjected to accelerated aging. Assuming the 0 hour treatment in 1980 was equivalent to the 24 or 48 hour treatments in 1979, the trends over the high aging periods were similar for each stand estimate. The effect of accelerated aging in the two 1979 tests closely resembled that found for germination in the laboratory tests. The cultivar by aging period interaction was significant for each stand measurement. These interactions were mainly associated with differential cultivar responses at 72 and 96-hour treatments.

Comparing the three measurements of germination, the highest correlations with the stand measurements were for germination at 13.3 C, germination at 18.3 C, and standard germination at 18.3 C, respectively (Table 3). The relatively low correlations of stand with standard germination suggest the radicle length restriction should not be imposed upon measurements of germination in cool temperature tests.

Relatively consistent responses to accelerated aging were found for each measurement over all tests. Therefore, the basic concepts of the seed quality curve appear valid. The relative resistance to seed deterioration of TX-ORMAR-S-2 and CAMD-E indicated progress has been accomplished by the TAM-MAR selection procedures.

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Table 2. Germination and moldy seed percentages for cultivars over four accelerated aging treatments in the second series of germination tests.

Cultivar	Aging treatment	13.3 C test		18.3 C test	
		Germination†	Moldy seed	Germination†	Standard germ.‡
	hours	%			
CAMD-E	0	89	63	77	42
	48	93	40	82	45
	96	61	79	67	37
	144	0	88	0	0
TX-ORMAR-S-2	0	92	56	84	63
	48	96	19	89	62
	96	53	73	73	51
	144	0	84	0	0
DES 56	0	63	80	87	78
	48	89	48	85	75
	97	0	93	19	7
	144	0	92	0	0
Delcot 277J	0	57	76	59	49
	48	52	64	75	48
	96	0	91	12	4
	144	0	100	0	0
Deltapine 61	0	88	59	83	53
	48	91	35	87	57
	96	23	69	58	41
	144	0	85	0	0
Stoneville 213	0	76	63	88	69
	48	96	43	83	75
	96	9	72	42	19
	144	0	85	0	0
C.V.		8	7	5	9
L.S.D. (0.05)		3	4	2	2

† Includes seed having visible radicle extension.
‡ Includes seedlings having radicles at least 4.5 cm in length.

Table 3. Correlation coefficients between measurements of moldy seed (Mds), germination (Gm), and stand percentages in the first series of germination tests and the field tests.

	Gm† at 13.3 C	Gm† at 18.3 C	Stand. gm‡ 18.3 C	1979 Stand		1980 Stand
				Loc. 1	Loc. 2	
Mds at 13.3 C	0.20	0.13	−0.08	0.08	0.32	0.36
Gm at 13.3 C		0.84**	0.75**	0.86**	0.86**	0.60**
Total gm, 18.3 C			0.82**	0.72**	0.74**	0.43**
Standard gm, 18.3 C				0.52**	0.52**	0.19
1979 Stand Loc. 1					0.81**	0.59**
1979 Stand Loc. 2						0.54**

** Significantly different from zero at the 0.01 probability level.
† Includes seed having visible radicle extension.
‡ Includes seedlings having radicles at least 4.5 cm in length.

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