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RICE CULTIVAR VARIABILITY IN TOLERANCE FOR ACCELERATED AGING OF SEED

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ABSTRACT

Seed of 64 rice cultivars produced in the dry season and of 121 cultivars in the wet season (WS) of 1985 in Los Baños, Philippines, was subjected to accelerated aging treatment (43 °C, 100% relative humidity) for 2, 4, and 6 d. Treated seed and seed from a nontreated control were tested for germination at 25-30 °C.

A portion of the seed of each of 30 selected cultivars from the WS cropping was treated with dry heat at 50 °C for 5 d to break dormancy, the remaining portion serving as an untreated (dormant) control. Both the treated seed and the untreated seed were subjected to accelerated aging treatments for 2, 4, and 6 d and their germinations compared.

Cultivars with superior tolerance for the aging conditions were found in each of the ecogeographic races of *Oryza sativa* L. (indica, japonica, and javanica) and among photoperiod-sensitive and -insensitive strains, upland and lowland types, and salt-tolerant and tungro virus-resistant cultivars. In general, the higher the dormancy level of the seed, the greater was the tolerance for accelerated aging.

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Humid tropical climates (with high temperatures and high relative humidity [RH]) are conducive to rapid seed deterioration. This problem is encountered by farmers throughout monsoonal Asia. Differences have been shown to exist among cultivars in several crop species in their resistance to seed deterioration. A rapid screening test (accelerated aging at 43 °C and 100% RH) has been developed that can evaluate rice (*Oryza sativa* L.) seed tolerance for adverse environmental conditions. The degree of tolerance for accelerated aging treatments has been related to the survivability of the seed in storage (Delouche and Baskin 1973). Accelerated aging treatments could help breeders determine differences in a cultivar's potential to resist seed deterioration during storage. In this study, accelerated aging treatments were used to identify rice cultivars with higher tolerance for aging conditions and to examine the association of that trait with ecogeographic origin and seed dormancy.

MATERIALS AND METHODS

Seed of 64 rice cultivars (44 indicas, 16 japonicas, and 4 javanicas) was grown in the 1985 dry season (DS), and 121 cultivars (72 indicas, 23 japonicas, and 26 javanicas) in the 1985 wet season (WS) at the International Rice Research Institute experimental farm in Los Baños, Philippines. At maturity, plots were harvested at 18-22% moisture content, and the panicles were threshed manually to avoid any injury to the seed. The threshed seed was then dried in a batch dryer at 43 °C to bring the moisture content to 11-12%, as determined by a Satake moisture tester. Seed harvested from each season was subjected to accelerated aging treatments at 43 °C and 100% RH in an accelerated aging chamber. Cultivars and treatments were included in a partially balanced lattice design with two replications.

Aging technique

Wire mesh nets (14 × 18 mesh size) were used to make trays of 30 × 5 × 1.25 cm to support 1,000 seeds. A 22-gauge iron sheet was used to fabricate 70- × 35- × 7.5-cm boxes with 2 inner ridges raised lengthwise 2.5 cm in height to hold the wire mesh trays with the seed above the water level. The bottom 15 mm of each box was filled with 4 liters of distilled water. A 10-mm gap was maintained between the water surface and the seed trays. The boxes were covered with airtight lids and kept in an oven at the desired temperature and RH. The inner side of the lid of each box was lined with styrofoam to absorb any condensed water resulting from temperature fluctuations.

Seed lots were aged for 0 d (control), 2 d, 4 d, and 6 d. Each aging box contained seed of one of the blocks of the partially balanced lattice design and made up of one of the aging treatments. Aging boxes containing seed to be treated for 2 d, 4 d, and 6 d were put into the oven at the same time. After aging, seed was taken out of the aging chamber and dried to 11.5 ± 0.5% moisture content.

Relationship between dormancy and tolerance for aging

Seed of 30 selected cultivars grown in 1985 WS (harvested on the same day) was heat-treated at 50 °C for 5 d to break dormancy (Jennings and de Jesus 1964). The heat-treated seed along with untreated (dormant) seed was subjected to accelerated aging for 4 and 6 d. A split-plot design with two replications was used. The aging duration served as the main plots and the dormancy-breaking treatments (heat-treated and untreated control) as subplots.

Germination test

Aged seed and nonaged controls (fresh seed) were tested for germination in 9-cm petri dishes with 3 replications. The petri dishes were lined with Whatman #1 filter paper moistened with 5 ml distilled water. Fifty seeds were tested for each treatment of each cultivar in each replication. The "expert line" germinator was set at 25-30 °C with 8 h daily photoperiod and 95% RH. Germination counts were made on the 5th and 10th days after seed soaking.

RESULTS AND DISCUSSION

Varietal differences in tolerance for accelerated aging

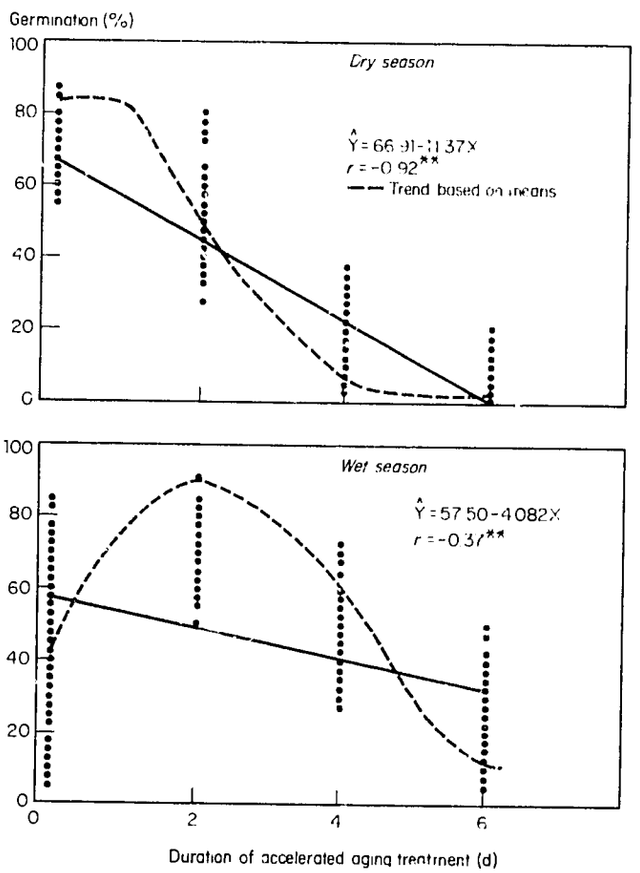
The germination percentages for seed of the various cultivars grown in DS ranged from 63 to 100% in the control, 21 to 98% after 2 d of aging, 0 to 65% after 4 d of aging, and 0 to 13% after 6 d of aging. The mean germination percentages for the three ecogeographic races are given in Table 1.

For seed grown during WS, the mean germination percentage after 2 d of aging was higher than the nonaged control, suggesting a breakage in dormancy. The regression line and trend of seed deterioration for DS and WS and also for the three races are presented in Figures 1 and 2.

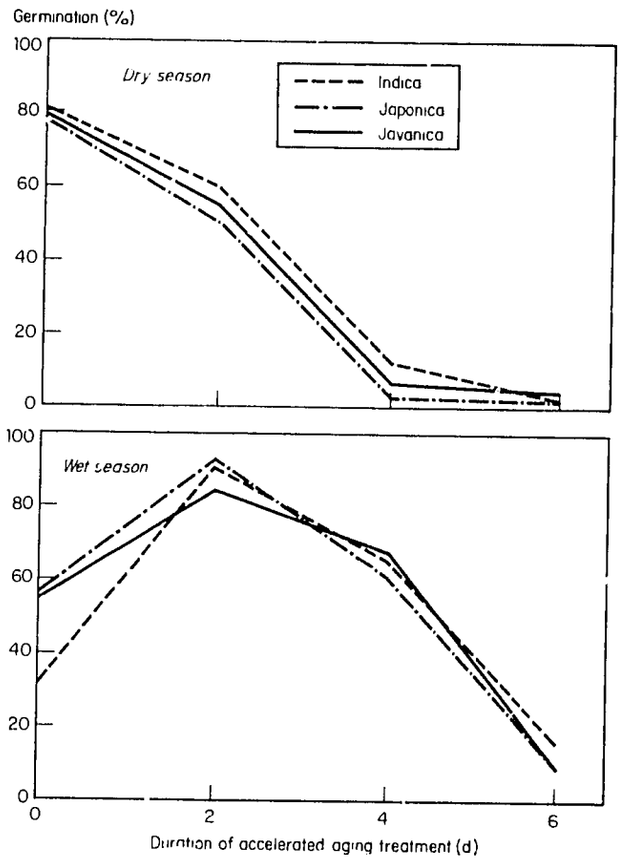
Cultivar differences were evident in tolerance for accelerated aging, as shown by seed germinability, in tests

Table 1. Mean seed germination percentage of cultivars from the three ecogeographic races of *Oryza sativa* L. after accelerated aging treatments.

Ecogeographic race	Mean germination (%) after accelerated aging treatment for			
	0 d (control)	2 d	4 d	6 d
	Dry season			
Indica	83	58	10	1
Japonica	79	51	3	0
Javanica	81	54	6	1
Mean	81	54	6	1
	Wet season			
Indica	30	91	64	15
Japonica	58	92	60	9
Javanica	54	86	67	10
Mean	47	90	64	11



1. Regression of germination percentage on the duration of accelerated seed aging in rice. ** = significant at the 1% level.



2. Effect of accelerated aging on germination in the three races of rice.

performed on the seed harvested from WS and DS crops. Tables 2 and 3 list the cultivars most tolerant of accelerated aging, as shown by higher germination percentages after 4 and 6 d of aging. The most promising entries included cultivars belonging to all three races (e.g., Djaub, japonica; Boak, javanica; and several indicas). Superior entries also included photoperiod-sensitive (ARC11554) and -insensitive (Dharial) cultivars as well as upland (OS4, N22), lowland (several), salt-tolerant (Pokkali and Nona Bokra), and tungro virus-resistant (ARC11554 and Utri Rajapan) cultivars.

Genetic diversity exists among rice cultivars in seed longevity, even when seeds are grown under similar environmental conditions. This can lead to differences among cultivars in subsequent germination (Biswas 1973, Chang 1978, Haque and Haroon 1983). Researchers working with other species have found significant variation among cultivars in tolerance for seed aging as reflected by maintenance of viability in storage. These include Shands et al (1967) on Oderbrucker barley; Toole and Toole (1937) on black valentine bean; James et al (1967) on bean, cucumber, peas, sweet maize, and watermelon; and Neal and Davis (1956) on inbred lines of maize. Several researchers have suggested that variability in tolerance for aging between and within cultivars of the same species may be due to genetic factors. Weiss and Wentz (1937) demonstrated that short longevity and low vigor in maize were associated with *luteus 2* and *luteus 4* genes found on chromosome 10. Similar variations in tolerance for natural aging were reported by Justice and Bass (1978) in hybrid maize.

Table 2. The 10 entries with the best tolerance for accelerated aging at 4 and 6 d (1985 DS).

Cultivar	Germination (%)[a]	DMRT[b]	Cultivar	Germination (%)[c]	DMRT[b]
	Aged 4 d			*Aged 6 d*	
ARC11554	65		Habiganj Boro IV	13	
IR56	37		Dharial	10	
Habiganj Boro IV	35		ARC11554	6	
IR28	29		Suweon 287	5	
Suweon 287	25		SR26-B	4	
Dharial	23		Imminon	3	
IR8455-K2	18		ARC6000	3	
IR19743-46-2-3	16		Taal 2	2	
Taal 2	15		IR19743-46-2-3	1	
Utri Rajapan	15		Hu Lu Tuo	1	

[a]$\bar{X}$ (10 best entries) = 27.8, $\bar{X}$ (all 64 entries) = 8.05. [b]Based on angular values. [c]$\bar{X}$ (10 best entries) = 4.8, $\bar{X}$ (all 64 entries) = 0.88.

Table 3. The 25 entries with the best tolerance for accelerated aging at 4 and 6 d (1985 WS).

Cultivar	Germination (%)[a]	DMRT[b]	Cultivar	Germination (%)[c]	DMRT[b]
	Aged 4 d			*Aged 6 d*	
IR19743-46-2-3	92		Djaub	57	
Habiganj Boro IV	92		Muthumanikam	55	
Dharial	91		Boak	55	
Karan Serang 55	91		Mahsuri (Acc44452)	55	
Mahsuri (Acc44452)	89		ARC6000	55	
Ti 1	89		Djoweh	54	
Mahsuri (Acc10929)	89		Dharial	53	
Major	89		Suweon 303	45	
Djaub	87		Taal 2	45	
Taal 2	87		Pokkali	44	
Benong 130	86		Habiganj Boro IV	41	
ARC6000	86		Mahsuri (acc10929)	38	
Kalubala Vee	84		Utri merah	37	
Solo 110	84		Kalubala Vee	37	
IR8455-K2	82		OS4	36	
Djalen 37	82		Perurutong NBB	34	
UPR103-80-1-2	81		Nakhi	34	
Imminon	81		Nona Bokra	32	
Ziri Palman 434	81		Mahsuri	32	
K Kawoeng	80		N22	28	
Habiganj Boro II	79		Imminon	25	
Suweon 303	79		ARC11554	25	
Lan Saw	78		Utri Rajapan	23	
Ta Mao Tao	78		H4	23	
Binirhen	77		Suweon 287	22	

[a]$\bar{X}$ = 84.56, $\bar{X}$ (all 121 entries) = 63.82. [b]Based on angular values. [c]$\bar{X}$ = 39.44, $\bar{X}$ (all 121 entries) = 12.58.

Seasonal variations in tolerance for accelerated aging

Fifty-one cultivars were common to the test material grown in the two seasons. Differences in germination percentage among those cultivars after accelerated aging between DS and WS were highly significant. The 6 cultivars with best tolerance for 6-d aging from both season harvests are listed in Table 4. The differences in germination percentage of the untreated control between DS and WS reflected differences in dormancy level. The lower germination after aging of DS-harvested seed than that from WS may therefore have been due to lower initial dormancy.

In the seed from WS, the mean germination percentage after 2-d aging showed an increase over the control, while that from DS showed a decrease. The mean value for WS seed increased from 40% for the control to 91% for the 2-d aging treatment. Thus, in dormant seed, the 2-d aging treatment acted to break dormancy. On the other hand, with DS seed, even 2 d of accelerated aging can be deleterious if the initial dormancy level is low. In this test, 2 d of accelerated aging reduced mean germination to 56%, compared with 82% for the control.

Degree of dormancy at wet season harvest and effects of accelerated aging

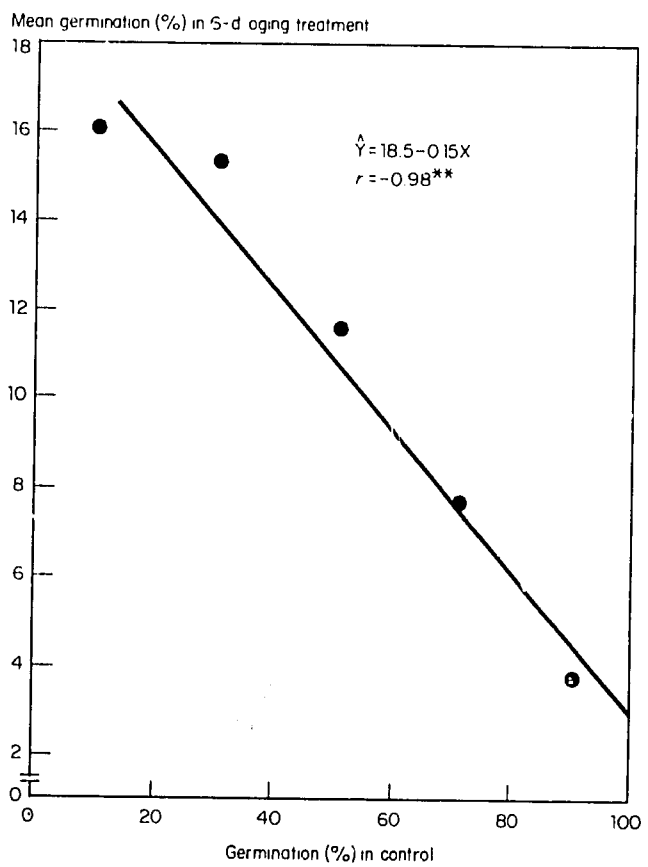
Seed of 121 cultivars grown in WS with different degrees of dormancy was compared for tolerance for aging as indicated by germination percentage after 6 d of aging.

Table 4. The 6 cultivars with the best tolerance for 6-d accelerated aging (1985 DS and WS).

Cultivar	Germination (%) after accelerated aging treatment for							
	0 d (control)		2 d		4 d		6 d	
	DS	WS	DS	WS	DS	WS	DS	WS
ARC6000	81	8	63	97	15	86	3	56
ARC11554	98	2	93	75	65	29	6	25
Dharial	96	37	90	98	23	91	10	53
Habiganj Boro IV	90	9	80	97	35	92	13	41
Suweon 287	69	25	53	96	26	74	6	22
Taal 2	88	37	56	97	15	87	2	45
Mean (6 cultivars)	90	20	73	93	30	77	7	40
Mean (all 51 cultivars)	82	40	56	91	9	61	1	12

Table 5. Frequency distribution of germination percentages after 0-, 2-, and 6-d accelerated aging of rice seed grown in 1986 WS.

Germination class (control)	Frequency of cultivars	Mean germination (%) after aging for		
		0 d (control)	2 d	6 d
0-20	38	8	89	16
21-40	27	30	89	15
41-60	22	50	90	12
61-80	19	71	90	8
81-100	15	90	92	4



3. Regression of germination percentage of 6-d aged rice seed on germination percentage of untreated control, 1985 WS. (Values for germination percentage of 6-d aged seed represent corresponding means over the cultivars that fall in a specific germination class of the control.)

For this purpose, the 121 cultivars were grouped into 5 germination classes (0-20%, 21-40%, 41-60%, 61-80%, 81-100%) based on their germination in the control treatment (Table 5). A highly significant inverse relationship ($r = -0.98^{**}$) was observed between germination in the control and that in the 6-d aging treatment (Fig. 3), thus establishing the positive influence of dormancy on aging tolerance. The mean germination percentage after 2 d of aging was 90% for the 5 germination classes in the control, the range being 89-92%. This indicated that dormancy was broken successfully in all five groups and the seed was equally affected by further accelerated aging.

The present studies did not include observations upon extended periods of natural aging, and the observed association of dormancy with tolerance for aging was under artificial aging treatment. This, however, conforms with the findings of Ikehashi (1973) and Chang and Tolentino (1983) under natural aging, although it is contrary to the findings of Roberts (1963) and Sivasubramanian et al (1967).

Accelerated aging effects on dry heat-treated seed

The analysis of variance indicated that the differences among the main plot treatments (aging duration) as well as among the subplot treatments (heat treatment) were highly significant (Table 6). The interaction between aging duration and heat treatment was not significant. Thus, the heat treatment (50 °C for 5 d) used to reduce the

Table 6. Aging tolerance for nonheat-treated seed compared with heat-treated (50 °C, 5 d) seed.

Treatment	Mean loss in germination (%)[a]
Aging duration	
6 d	95 (81.88) a
4 d	36 (36.19) b
LSD (0.05)	3.58
Heat treatment	
Heat-treated	63 (62.81) a
No heat treatment	61 (55.18) b
LSD (0.05)	2.64

[a]Figures in parentheses are angular means.

dormancy of the 30 selected cultivars significantly increased the loss in germination percentage after accelerated aging as compared with nonheat-treated seed. Apparently, the residual dormancy in the nonheat-treated seed helped maintain seed viability through the accelerated aging process.

CONCLUSIONS

The results indicate that rice cultivars differ significantly in their ability to maintain seed viability through artificial aging. Further studies are needed to determine the heritability of seed tolerance for aging stresses in rice. If studies indicate a high level of heritability, resistant cultivars such as Dharial, Habiganj Boro IV, Djaub, Djoweh, Boak, Muthumanikam, ARC6000, and ARC11554 may be exploited in breeding programs as sources of genes for aging tolerance in seed, to help in developing improved cultivars with the potential for maintaining longer and stronger seed viability in storage.

Grain dormancy appears to have positive effects on the tolerance of seed for aging.

REFERENCES CITED

Biswas S (1973) Varietal differences in the seed viability period of rice seeds during storage. Indian Agric. 17(1):143-146.

Chang T T (1978) Differential seed longevity of rice cultivars held in cold storage. Page 109 *in* Agronomy Abstracts. American Society of Agronomy, Madison, Wisconsin.

Chang T T, Tolentino V T (1983) Seed longevity of three rice cultivars in three packing materials under six storage conditions. Page 118 *in* Agronomy Abstracts. American Society of Agronomy, Madison, Wisconsin.

Delouche J C, Baskin C C (1973) Accelerated ageing techniques for predicting the relative storability of seed lots. Seed Sci. Technol. 1:427-452.

Haque M Z, Haroon M (1983) Rice seed viability under two storage conditions. Int. Rice Res. Newsl. 8(5):3-4

Ikehashi H (1973) Studies on the environmental and varietal differences of germination in rice seeds with special reference to plant breeding. J. Cent. Agric. Exp. Stn., Jpn. 19:1-60.

James E, Bass L N, Clark D C (1967) Varietal differences in longevity of vegetable seeds and their response to various storage conditions. Am. Soc. Hortic. Sci. Proc. 91:521-528.

Jennings P R, de Jesus J Jr (1964) Effect of heat on breaking seed dormancy in rice. Crop Sci. 4:530-533.

Justice O L, Bass L N (1978) Seed factors that affect storage life. *In* Principles and practices of seed storage. USDA Agric. Handb. 506. Washington, D.C. 289 p.

Neal N P, Davis J R (1956) Seed viability of corn inbred lines as influenced by age and conditions of storage. Agron. J. 48:383-384.

Roberts E H (1963) An investigation of intervarietal differences in dormancy and viability of rice seed. Ann. Bot. London 27(106): 365-369.

Sivasubramanian S, Kalyanikutty T, Purushothaman G (1967) The study of seed dormancy and viability in rice. Madras Agric. J. 54(6):297-301.

Shands H L, Janisch D C, Dickson A D (1967) Germination response of barley following different harvesting conditions and storage treatments. Crop Sci. 7:444-446.

Toole E H, Toole V K (1937) Relation of storage conditions to germination and to abnormal seedlings of bean. Int. Seed Testing Assoc. Proc. 18:123-129.

Weiss M G, Wentz J B (1937) Effect of *luteus* genes on longevity of seed in maize. Am. Soc. Agron. J. 29:63-75.

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