Santipracha, W., Santipracha, Q and Wongvarodom, V. (1997). *Seed Sci. & Technol.*, 25, 203–208

Hybrid corn seed quality and accelerated aging

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(Accepted October 1996)

Summary

The three crosses of hybrid corn seed used were single cross variety Tevada 77, double cross variety Pacific 11, and three-way cross variety Pacific 47. The seed were subjected to accelerated aging in nearly 100% relative humidity at 42, 43 and 44°C for 48, 72 and 96 hours at each temperature. Seed quality tests consisted of standard germination, speed of germination, conductivity, seedling dry weight, and seedling shoot and root length of the seed before and after accelerated aging. The aim was to investigate the quality and accelerated aging of hybrid corn seed. All hybrid seed had a high germination of 90–99%. Single cross seed had the lowest vigor followed by double and three-way crosses. Single cross seed showed a gradual and sequential reduction in germination and vigor as accelerated aging temperature and duration increased whereas the seed from double and three-way crosses showed a sharp reduction in germination only at 43 and 44°C for 96 hours. Speed of germination had the most response to accelerated aging. Accelerated aging increased conductivity of seed leachates, but conductivity was statistically different only in single cross seed. Data suggested that appropriate accelerated aging condition for the evaluation of hybrid corn seed quality in the humid tropics should be at nearly 100% relative humidity at 44°C for 96 hours.

Introduction

Corn or maize (*Zea mays* L.) is one of the world's most important cereals with production of more than 500 million metric tons annually after wheat and rice (FAO, 1993). There is an increase in demand due to world population increase but with a limited production area. Hybrid seed is required to give higher yield per unit area. Hybrid seed also has a better seed quality due to hybrid vigor.

Accelerated aging is a good vigor test for various crop seed (Association of Official Seed Analysts, 1983) and has been used for predicting seed storability (Delouche and Baskin, 1973). It has also shown a good correlation with stand establishment of bean (Roos and Manalo, 1971), cotton (Bishnoi and Delouche, 1975), pea (Caldwell, 1960), peanut (Baskin, 1971), and soybean (TeKrony and Egli, 1977). It was also the best test for determining the relative field emergence of corn (Medina and Filho, 1991) and large-seeded peanut (Romkaew, 1996) and the test results were related to seedling emergence and final stand at crop maturity of chickpea (Ram, Kumari, Singh and Sardana, 1989). High temperatures and humidity in the humid tropics increased the seed deterioration rate (Abdullah, Powell and Matthews, 1992). Therefore, evaluating of corn seed storability in the humid tropics, accelerated aging at 44°C was related to seed deterioration changes (Santipracha, Santipracha and Suwansin, 1993) instead of at

42°C as determined by Association of Official Seed Analysts (1983). Basavarajappa, Shetty and Prakash (1991) found that accelerated aged double top cross corn seed had higher germination with lower membrane deterioration and biochemical changes than the single cross seed.

This study aimed to investigate seed quality of three different crosses of hybrid corn; single, double and three-way crosses and their responses to accelerated aging.

Materials and methods

The three crosses of commercial hybrid corn seed used were the single cross variety Tevada 77, double cross variety Pacific 11, and three-way cross variety Pacific 47. The seed were packed in plastic bags and had been harvested for six months. Seed quality was tested according to the rules of the International Seed Testing Association (1993) and the Association of Official Seed Analysts (1981 and 1983). Each test was done with four replications.

Moisture content. Ten seeds per replication were weighed and dried at 105°C for 24 hours. Dry seed were weighed, and moisture content was calculated on a percentage of wet weight basis.

Standard germination. One hundred seeds per replication were germinated in between paper (BP) in a 20–30°C germinator. First and final counts were made at four and seven days, respectively, and normal seedlings were averaged as the germination percentage.

Speed of germination. The seeds were germinated as standard germination test. Normal seedlings were counted daily from the first through the final counts. Speed germination index (SGI) was calculated as described in the Association of Official Seed Analysts (1983) handbook on vigor as the following formula.

$$SGI = \frac{\text{number of normal seedlings}}{\text{days of first count}} + \cdots\cdots + \frac{\text{number of normal seedlings}}{\text{days of final count}}$$

Conductivity. Twenty five seeds per replication were weighed and soaked in 25 ml of deionized water at 20°C for 24 hours. Conductivity of seed leachates was measured in μmho per cm per mg of seed.

Seedling growth rate. Twenty seeds per replication were lined up in two rows, six and 13 cm from the top of the paper and rolled as in the between paper germination test. They were placed upright in a germinator at 25°C for seven days. Normal seedlings were counted, and their shoot and root lengths were measured. Seedling shoot and root length were calculated in cm per seedling. The remaining seed parts were cut from the seedling axis and the axes form each replication were separately dried at 80°C for 24 hours. Dry seedlings were weighed and calculated in mg per seedling.

Accelerated aging was done by exposing the seed in nearly 100% relative humidity

chamber at three different temperatures of 42, 43 and 44°C. After 48, 72 and 96 hours of accelerated aging, the seed quality were tested as the unaged seed.

Analysis of variances of the quality between the hybrid crosses and between before and after accelerated aging was in completely randomized design. The statistical significance of means was tested by Duncan's multiple range test (DMRT).

Results

All three crosses of hybrid corn seed had high germination of 90.00–99.00% (Table 1). Three-way cross seed showed the highest vigor in speed of germination, conductivity, seedling dry weight, and seedling shoot and root length, while single cross seed showed the lowest vigor. Moisture content of the seeds after accelerated aging increased from 6.17–7.00 to 17.68–22.62% and varied depending on aging duration and a lesser extent on aging temperature (Table 2, 3 and 4). Germination of single cross seed was reduced at accelerated aging temperatures of 42°C for 96 hours and 43°C for 72 hours. In contrast the double and three-way crosses seed showed a sharp reduction in germination only at the higher temperatures of 43 and 44°C for the longest duration of accelerated aging (96 hours). Single cross seed had a significant reduction in speed of germination at every accelerated aging temperature and duration, while double and three-way crosses seed showed the most reduction at accelerated aging temperature of 43°C and followed by 44°C.

All hybrid seed showed an increase in conductivity, but only the single cross seed was statistically different from the unaged seed, after accelerated aging at 43 and 44°C for 48 hours and 44°C for 96 hours. Accelerated aging reduced seedling dry weight of single cross seed except at 42°C for 48 hours. Double and three-way crosses seed showed decrease in seedling dry weight when aged at 43 and 44°C with greater reductions as aging temperature increased. Seedling shoot and root length showed a smaller

Table 1. Germination, speed of germination, conductivity, seedling dry weight and seedling shoot and root length of hybrid corn seed.

Cross/variety	Germination	Speed of germination	Conductivity	Seedling dry weight	Shoot length	Root length
	%	index	µmho/cm/gm	mg/seedling	cm/seedling	cm/seedling
Single/Tevada 77	97.50	25.96b	20.17a	32.90d	8.22b	12.26d
Double/Pacific 11	90.00	25.68b	14.98b	47.13a	9.36ab	16.68a
Three-way/Pacific 47	99.00	27.37a	9.85c	51.15a	10.05a	16.42a
F test	ns	**	**	**	**	**
C.V. (%)	1.22	1.67	6.66	6.32	4.66	6.93

ns and ** = non significant and significant at $P < 0.01$, respectively.
Means not sharing the same letter are statistically different by DMRT.

Table 2. Moisture content, germination, speed of germination, conductivity, seedling dry weight and seedling shoot and root length of single cross variety Tevada 77 corn seed accelerated aging (AA) at different temperatures and durations.

AA temp/duration	Moisture content	Germination	Speed of germination	Conductivity	Seedling dry weight	Shoot length	Root length
C/hrs	%	%	index	µmho cm gm	mg seedling	cm seedling	cm seedling
0/0	6.17d	97.50a	25.96a	20.17e	32.90a	8.22a	12.26a
42/48	12.70e	94.25ab	21.76b	26.21abc	28.17ab	8.35a	11.56ab
42/72	15.78bc	90.75abc	18.74c	23.51bc	23.82bc	7.56ab	9.87bcd
42/96	16.70bc	87.00bcde	18.25cd	25.75abc	25.51bc	8.47a	10.14abc
43/48	14.91bc	89.75abcd	19.70c	28.77ab	24.42bc	7.85ab	11.14ab
43/72	14.65bc	82.00de	16.69de	23.34bc	20.31cd	7.18ab	8.61cbc
43/96	15.78bc	57.75f	10.19f	27.31abc	19.53cd	5.93b	7.65dc
44/48	14.96bc	85.00cde	19.76c	30.53ab	22.51bcd	6.84ab	9.59bcde
44/72	18.90ab	81.00e	16.29e	28.14abc	17.46d	5.95b	8.37cde
44/96	22.62a	56.7f	10.71f	32.77a	19.55cd	5.87b	7.24e
F test	**	**	**	**	**	**	**
C.V. (%)	13.53	4.89	4.81	14.14	12.13	13.38	11.70

** = significant at P < 0.01.
Means not sharing the same letter are statistically different by DMRT.

Table 3. Moisture content, germination, speed of germination, conductivity, seedling dry weight and seedling shoot and root length of double cross variety Pacific 11 corn seed accelerated aging (AA) at different temperatures and durations.

AA temp/duration	Moisture content	Germination	Speed of germination	Conductivity	Seedling dry weight	Shoot length	Root length
C/hrs	%	%	index	µmho/ cm/gm	mg/ seedling	cm/ seedling	cm seedling
0/0	6.77d	99.00a	25.68a	14.98	47.15a	9.36abc	16.68a
42/48	14.92c	98.50a	24.51ab	19.21	42.50a	10.95a	17.31a
42/72	14.91c	97.00a	25.19a	20.32	44.50a	9.73ab	16.44a
42/96	17.95abc	96.25a	22.94b	18.17	45.49a	10.74a	17.27a
43/48	16.07bc	95.50a	20.81c	19.26	31.99b	8.36abc	13.49bc
43/72	20.35a	92.50a	18.99c	17.36	30.90b	7.30bcd	11.87cd
43/96	16.65bc	26.50c	4.24e	19.34	17.50c	3.68e	3.23e
44/48	17.08bc	97.75a	24.84ab	20.52	35.88b	9.72ab	14.73ab
44/72	19.06ab	94.75a	19.50c	18.60	21.11c	5.73de	9.58d
44/96	18.91ab	67.50b	12.93d	19.46	18.27c	7.05cd	5.03e
F test	**	**	**	ns	**	**	**
C.V. (%)	9.13	4.66	5.13	14.48	9.33	14.63	10.03

ns and ** = non significant and significant at P < 0.01, respectivelv.
Means not sharing the same letter are statistically different by DMRT.

Table 4. Moisture content, germination, speed of germination, conductivity, seedling dry weight and seedling shoot and root length of three-way cross variety Pacific 47 corn seed accelerated aging (AA) at different temperatures and durations.

AA temp/duration	Moisture content	Germination	Speed of germination	Conductivity	Seedling dry weight	Shoot length	Root length
C/hrs	%	%	index	µmho/cm/gm	mg/seedling	cm/seedling	cm seedling
0/0	7.00d	99.00a	27.37a	9.85	51.15a	10.05bc	16.42a
42/48	14.92c	98.25a	25.33bc	12.89	44.63bc	11.05ab	16.84a
42/72	17.19b	98.00a	26.59ab	14.19	49.05ab	11.54a	17.16a
42/96	17.36b	98.00a	24.58cd	13.29	50.62a	11.67a	16.48a
43/48	14.95c	100.00a	24.94bc	12.39	45.88abc	11.54a	16.96a
43/72	15.34c	93.00a	23.63cd	13.35	37.47d	9.52c	13.62b
43/96	18.00ab	41.75c	7.47f	13.84	18.88e	4.63d	4.62d
44/48	18.33ab	97.00a	25.25bc	13.60	40.97cd	11.40a	15.76a
44/72	17.68ab	94.75a	22.91d	13.40	35.22d	9.64c	13.72b
44/96	18.79a	81.25b	16.16e	13.44	21.88e	5.67d	7.04c
F test	**	**	**	ns	**	**	**
C.V. (%)	3.96	3.78	3.99	16.28	7.24	6.33	5.15

ns and ** = non significant and significant at $P < 0.01$, respectively.
Means not sharing the same letter are statistically different by DMRT.

response to accelerated aging as compared to seedling dry weight. Root length showed a clearer statistical reduction than shoot length.

Discussion

These three crosses of commercial hybrid corn seed packed in plastic bags had moisture content of 6–7% with germination of 97.50, 90.00 and 99.00% for single, double and three-way crosses, respectively. Among three crosses, single cross seed had the lowest vigor followed by double and three-way crosses which were similar to that double top cross seed after accelerated aging germinated higher than single cross seed (Basavarajappa *et al.*, 1991). Single cross seed showed a greater response to accelerated aging with a sequential and gradual reduction in germination and vigor as accelerated aging temperature and duration increased. In contrast the seed from double and three-way crosses had a marked reduction in germination only at 43 and 44°C for 96 hours of accelerated aging.

Speed of germination showed the clearest response to accelerated aging. Conductivity increased after the seed were subjected to accelerated aging, the same results were found in soybean seed (Ratanaphun, 1995), but the increases were statistically significant only in single cross seed. The conductivity increased due to membrane deterioration and metabolical changes in seed after accelerated aging (Basavarajappa *et al.*, 1991). Accelerated aging at 42°C for 96 hours, as determined for corn seed by the Association of Official Seed Analysts (1983), showed some reduction in germination and

vigor of single cross seed, but affected only speed of germination of double cross seed. For more appropriate evaluation of seed vigor and storability in the humid tropics, accelerated aging of hybrid corn seed should be at 44°C for 96 hours, the same as used for open pollinated and composite cultivars (Santipracha *et al.*, 1993) because of high temperature and relative humidity affected a rapid loss of seed viability (Abdul-Baki and Anderson, 1970; Bradnock and Matthews, 1970) and germination (Abdullah *et al.*, 1992).

It was concluded that these hybrid corn seed had shown the differences in seed vigor, three-way cross was the highest followed by double and single crosses. Accelerated aging to evaluate hybrid corn seed quality in the humid tropics should be at nearly 100% relative humidity at 44°C for 96 hours.

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