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Seed Deterioration Response of Different Genes of Sweet Corn during Long-term Storage

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ABSTRACT : Sweet corn seeds deteriorate faster due to low starch content than field corn seeds when stored for a long term. This study had been conducted to observe the seed deterioration of four different sweet corns in a long term storage conditions in room temperature. Four kinds of sweet corn genes (*sh2, bt, su,* and *se*) were harvested from 15 days to 50 days after silking with 5-day intervals. These seeds were stored in the room temperature and tested for germination percentages from 3 months to 18 months period with 3-month interval. *su* seeds germinated better than other types of gene. Hybrid Mecca which is *sh2* gene germinated better when stored for 3 months to 18 months. For all genes, mean regression equations in relation to storage periods showed linear responses. For regression equation, the slope of *sh2* gene was lower than that of *su* gene. The highest slope value was observed in *bt* gene showing faster deterioration rate. The rate at which seed deteriorates seems to be affected by the date at which it was harvested. The seeds that were harvested at the optimum time deteriorated more slowly than those which were not.

Keywords : sweet corn, *sh2, bt, su, se,* seed deterioration, storage condition.

Sweet corn has higher sugar and less starch content than other types of corns. The sweet corn kernels are smaller, lighter, more easily damaged than other corn kernels; moreover sweet corns are also more susceptible to fungal rots during germination (Anderegg & Guthrie, 1981; Halfon-Meiri, 1990). The evaluation of corn seed deterioration would be useful to corn breeders and seed producers, especially because seeds often have to be stored for a long time. The rate at which seeds deteriorate depends on following factors; storage temperature, seed moisture, and cultivars. Seed deterioration can be defined as an increased number of dead seed as deterioration proceeds. Seed-survival response according to the storage periods showed reverse sigmoid curve resembling a negative cumulative normal distribution (Roberts, 1973; Ellis, 1988; Ellis *et al.*, 1990). It has been reported that seed survival was normally distributed in hybrid corn in constant storage environment (Tang *et al.*, 1999a). The curves for low-vigor seed lots followed normal or near-normal distribution more than those of medium and high-vigor seed lots.

It has been reported that crop seeds within a given species deteriorated at the same rate when stored in the same environmental condition (Kraak & Vos, 1987; Parkes *et al.*, 1990). In contrast, seed lots did not always deteriorate at the same rate in the identical storage environment in corn (Bruggink, 1989; Tang *et al.*, 1999b). Similar results were reported in soybean (Fabrizius *et al.*, 1999), lettuce (Tarquis & Bradford, 1992), and tomato (Argerich *et al.*, 1989). The deterioration rates were significantly different among seed lots and corn genotypes. Initial seed quality affected the rate of deterioration with low-vigor seed lots generally deteriorating at a faster rate than high-vigor seed lots (Tang *et al.*, 1999b). This result suggests that genotypic background and initial seed quality may influence the deterioration rate and seed longevity. This also implies that low-vigor seed lots have less resistance to stress environment. Thus, corn seed longevity seems to related to the rate at which seeds deteriorate and initial seed quality. It has been reported that mean germination percentages of four different types of sweet corn (*shrunken2, brittle, sugary, and sugary enhancer*) showed the highest germination percentages at 45 days to silking, suggesting the production of high-vigor seed lots at this stage of maturity (Lee, 2000). Mathematical analyses of seed deterioration have been reported by several researchers (Moore & Roos, 1982; Moore & Jolliffe, 1987). The purpose of analysis was to predict the seed germination in breeder's germplasm or during commercial seed storage.

The objective of this study was to determine the response of seed deterioration of four different types of sweet corn (*shrunken2, brittle, sugary, and sugary enhancer*) in relation to storage periods.

MATERIALS AND METHODS

Four kinds of commercial hybrids of sweet corn seed were obtained from the US seed companies. Four genes are *shrunken2(sh2), brittle(bt), sugary(su),* and *sugary enhancer (se).* Sources of eight hybrids tested in this study were

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reported in the previous paper (Lee, 2000). These hybrid seeds were planted at the Waimanalo Research Station of the University of Hawaii in 1966. All seeds were produced by open pollination within each hybrid. The plot size of each hybrid was 10 m long with 10 planting rows. Harvesting was made from 15 days to 50 days to silking with 5-day interval. Contaminated seeds were removed during seed shelling because the contaminated seeds were normal in phenotype due to the different loci of each gene on the chromosome.

Germination test was conducted from 3 months after the harvest to 18 months periods of storage with 3-month interval. All seed lot was stored in room temperature. The ranges of storage temperature were approximately 25-30°C in summer and 15-20°C in winter. Seed lot was not treated with any fungicide or insecticide during the storage.

Paper towel method was used to determine germination percentage using 50 seeds with 2 replications. Germination counts was made with 2-day interval for 10 days after treatment. Some fungal rot was observed in some treatment, especially for the seed lot that were less matured at the final stage of germination test. Germination criteria was 2 mm or more in radicle length and the germinated seed was removed at each germination counts.

RESULTS AND DISCUSSION

Germination percentages of four kinds of sweet corn during the storage are shown in Table 1. Higher germination percentages were observed in hybrid HMX4396REC and Sun Dance which have *su* gene. This was expected because of the higher starch contents in kernel compared with other sweet corn genes. The mean germination percentage of two *su* hybrids after 18 months of the storage was also higher than those of other gene hybrids, suggesting that *su* hybrids are more suitable for long term storage.

There were differences between two hybrids with the same kind of gene for *sh2*, *bt*, and *se*, respectively. These differences within the same type of genes suggest that the germination difference might be related to the characteristics of specific hybrids within the same type of gene. It was reported that crop seeds deteriorated at the same rate under the same environmental conditions (Kraak & Vos, 1987; Parkes *et al.*, 1990). However, according to Bruggink, 1989 and Tang *et al.*, 1990, corn seed did not always deteriorate at the same rate in the same storage condition. Results from this study showed that sweet corn seeds do not deteriorate at the same rate. Hybrid Mecca, which is *sh2* gene, showed 83% and 63% of germination at 3 months and 18 months of the storage, respectively. This shows that the problem of poor germination for super sweet corn might be solved if suitable germplasm is used as the breeding material. It would be expected that *bt* gene might be better than *sh2* gene for germination due to its higher starch contents in kernel. However, hybrid HMX2353BB, which is *bt* gene, was much poorer than *sh2* hybrids. This result shows that *bt* gene is not necessarily better than *sh2* for germination.

Regression equations between storage period and germi-

Table 2. Regression equations and correlation coefficients of different genes of sweet corn, calculated using storage period (X) and germination percentages (Y).

Hybrid	Gene	Regression equation	Correlation coefficient
Forever	*sh2*	Y=77.360 – 1.787X	-0.914*
Mecca	*sh2*	Y=84.333 – 1.114X	-0.930**
HMX2353BB	*bt*	Y=67.113 – 2.674X	-0.992**
HS10	*bt*	Y=91.793 – 1.643X	-0.989**
HMX4396REC	*su*	Y=94.633 – 1.848X	-0.983**
Sun Dance	*su*	Y=91.973 – 2.113X	-0.923**
Dancer	*se*	Y=63.847 – 2.089X	-0.924**
Silver Choice	*se*	Y=94.200 – 2.048X	-0.980**
Mean		Y=83.140 – 1.913X	-0.993**

Table 1. Germination percentages in relation to storage periods of different genes of sweet corn.

Hybrid	Gene	Storage period (months)						Mean
		3	6	9	12	15	18	
Forever	*sh2*	72.0	60.6	65.8	60.6	51.8	40.8	58.6
Mecca	*sh2*	83.0	74.7	75.6	68.4	70.6	63.5	72.6
HMX2353BB	*bt*	58.9	51.0	44.8	34.6	23.8	21.1	39.0
HS10	*bt*	87.5	80.4	76.6	74.4	67.6	61.3	74.6
HMX4396REC	*su*	89.9	83.2	76.9	71.0	70.5	59.9	75.2
Sun Dance	*su*	89.6	81.2	63.5	65.5	63.4	55.5	69.8
Dancer	*se*	62.0	49.5	39.6	36.8	38.0	25.6	41.9
Silver Choice	*se*	85.3	83.6	77.9	68.8	65.8	54.8	72.7
Mean		78.5	70.5	65.1	60.0	56.4	47.8	

nation percentage are shown in Table 2. All the regression equations for eight hybrids tested showed significant linear relationships. Hybrid HMX2353BB which showed the lowest germination at 3 months storage showed the highest slope, implying much faster seed deterioration during the storage. Hybrid Mecca, which is *sh2* gene, showed the lowest slope in the regression equation and the highest germination percentage after the 18 months of storage. It can be estimated from the regression equation that the germination reduction range from 1.1% to 2.7% for sweet corn seeds. The mean seed-deterioration rate for all these hybrids would be about 2% per month during the storage in warehouse. Tang *et al.* (1999a) reported that seed deterioration curve was normally distributed; however the response of seed deterioration in this trial showed linear response in all hybrids.

It would be expected that the deterioration rate for *su* gene is low and *sh2* gene is high due to their differences of starch content. However, *sh2* gene showed the lowest slope implying a lower deterioration rate (Table 3). The highest slope for regression equation was observed in *bt* gene implying that *bt* would be more susceptible to seed deterioration during the storage. Optimum harvesting date is about 35 and 45 days after silking (DAS), but harvesting at 45 DAS would be more desirable for the long term storage (Table 4). Harvesting at 25 days after silking showed 81% for germination at early storage period, but a much lower germination after long storage. This result suggests that harvesting at 25 DAS would be suitable for the fall planting in case of rapid generation advancement during the sweet corn breeding program. Harvesting at 30 DAS would be more practical because more than 50% of seeds germinated after 18 months of storage.

Table 3. Mean regression equations and correlation coefficients of different genes, calculated using storage periods (X) and germination percentages (Y).

Gene	Regression equation	Correlation coefficient
sh2	Y=80.853 – 1.450X	-0.943**
bt	Y=79.453 – 2.154X	-0.997**
su	Y=93.333 – 1.981X	-0.964**
se	Y=79.093 – 2.072X	-0.983**

Table 4. Mean germination percentages of four genes, arranged according to storage periods and harvesting dates.

Harvesting date	Storage periods (month)						Mean
	3	6	9	12	15	18	
15	38.8	24.9	16.6	9.9	5.8	3.6	16.6
20	65.3	52.0	40.9	29.4	25.0	16.3	38.1
25	81.8	75.5	62.3	58.1	48.9	37.8	60.7
30	84.9	78.8	75.2	68.9	65.1	53.8	71.1
35	91.1	83.4	79.4	77.4	77.9	66.4	79.3
40	92.1	85.9	81.8	80.4	79.4	69.1	81.4
45	89.3	84.6	84.3	83.1	78.9	73.5	82.3
50	85.0	79.1	80.1	72.9	70.5	62.0	74.9
Mean	78.5	70.5	65.1	60.0	56.4	47.8	

Table 5. Mean regression equations and correlation coefficients of four genes calculated using storage periods (X) and germination percentages (Y).

Harvesting Date	Regression equation	Correlation coefficient
15	Y=40.600 – 2.286X	-0.960**
20	Y=71.900 – 3.214X	-0.989**
25	Y=91.133 – 2.895X	-0.944**
30	Y=91.407 – 1.932X	-0.985**
35	Y=93.467 – 1.352X	-0.937**
40	Y=95.040 – 1.294X	-0.952**
45	Y=92.013 – 0.927X	-0.956**
50	Y=89.733 – 1.410X	-0.964**
Mean	Y=83.140 – 1.913X	-0.993**

Regression equation between storage and germination for different harvesting date are shown in Table 5. Germination decreased linearly to storage period for all harvesting dates. The slope of the linear equation for early harvesting between 15 and 25 DAS were relatively higher than those of other late harvesting date. This result suggests that less mature seeds would be deteriorated more rapidly than mature seeds that were harvested at later stage. This observation is consistent with the other report (Tang *et al.*, 1999b). Slope of regression equation of the optimal harvesting date was lower than those of other early and late harvesting date, implying that sweet corn seed harvested at an optimal stage would be an important factor for the long term storage.

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