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Seed Vigor Testing of Subtropical Corn Hybrids

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ABSTRACT

The cold test has been the standard vigor test for temperate corn (*Zea mays* L.) hybrids; however, it is not known if the cold test is as effective for evaluating seed vigor for subtropical corn hybrids. The objective of this study was to compare the performance of various seed vigor tests for evaluating seed vigor of subtropical corn cultivars. Seeds of five subtropical and two temperate hybrids were placed in storage at a constant 30ºC for 12 months. Every 3 months, samples of each hybrid were evaluated for seed viability and vigor. Laboratory tests of seed quality included standard germination; cold, cool, and accelerated aging tests; and modified versions of the cold, cool, and accelerated aging tests. Field emergence was measured after 0 and 12 months in storage. There was no decline in viability over the course of the study, but a significant drop in field emergence was observed after 12 months of storage. A significant decrease in seed quality was observed in the subtropical hybrids as measured by all six vigor tests. The accelerated aging and modified accelerated aging tests also indicated a decline in seed quality of the temperate hybrids. The accelerated aging and modified accelerated aging tests showed the highest correlations (0.86 and 0.87, respectively) with field emergence for the subtropical hybrids after 12 months in storage. Differences among hybrids for seed viability, vigor, and field emergence were detected after 12 months in storage. The two temperate hybrids differed only for the two accelerated aging tests. These two tests indicated low vigor for temperate hybrid 3293; however, this had no effect on field emergence of this hybrid. Significant differences among subtropical hybrids were detected by all six vigor tests. The decline in seed vigor was more pronounced for subtropical hybrids than for temperate hybrids. The best, single predictor of field emergence was the modified accelerated aging test.

INTRODUCTION

The standard germination test, which is considered the universal test for seed quality, evaluates the maximum potential of a particular seed lot under an ideal set of conditions (ISTA, 1987). Since the standard germination test is conducted under ideal conditions, it does not necessarily reflect the performance potential of that seed lot under field conditions. There are significant differences between standard germination and actual field emergence (Munn, 1926). High standard germination does not necessarily result in rapid and uniform emergence or vigorous stand under actual planting conditions (Delouche and Baskin, 1973). Seed vigor is defined by the International Seed Testing Association (1987) as the sum total of those properties of the seed that determine the level of activity and performance of the seed during germination and seedling emergence. Alternatively, AOSA (1983) defines seed vigor as properties that determine the potential for rapid, uniform emergence, and development of normal seedlings under a wide range of field conditions. Tests have been developed to evaluate the quality or vigor of a seed lot. Seed vigor assesses the ability to germinate under a wide range of environmental conditions (Woodstock, 1969). Seed vigor testing is considered an important tool in making decisions regarding which seed lots to market. The concept of seed vigor is of

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vital importance to the seed industry because two seed lots with same germination percentage, but differing vigor, could show significant variation in stand and yield when planted under various stress conditions.

Seed vigor tests rank seed lots according to their physiological quality. Vigor test results for a particular seed lot also help to determine the conditions under which it can be successfully planted. Steiner (1990) recommended the seedling rate of development index in conjunction with standard germination or other vigor tests for the evaluation of seedling vigor in different seed lots. Copeland and McDonald (1995) emphasized that vigor tests can have an important role in seed production and in making marketing decisions. High-vigor seed lots may be planted earlier under more stressful field conditions. The results of vigor tests can also be used to decide whether to keep a particular seed lot in storage for a longer period of time. Vigor tests also help isolate possible causes of poor performance of a particular seed lot in the field, which may be beneficial in defending against litigation (ISTA, 1987).

Perry (1981) suggested that a vigor test would provide a better indication of seed performance in the field than the standard germination test. Lower emergence and seedling development rates of corn (*Zea mays* L.) have been related to lower soil temperatures in no-till production systems (TeKrony et al., 1989). Field emergence ability is the major aspect of seed quality that concerns growers, and a high germination (greater than 90%) serves as a prerequisite for seeds to be sown (Pieta-Filho and Ellis, 1991).

Martin et al. (1988) reported that the cold test was a superior predictor of field emergence of corn. Woltz et al. (1998) found that both soil temperature and soil moisture content influenced the outcome of the cold test for corn seed. Gupta et al. (1988) indicated that the effect of cooler temperature, which can delay emergence of corn in no-tillage systems, could be compensated for by reducing the planting depth by approximately 25 mm from that of the average planting depth under conventional tillage systems. Helms et al. (1949) studied the influence of soil temperature (17/8, 21/12, 25/16 ºC, day/night) and varying soil water content on corn seedling emergence. Emergence was greater than 85% at all temperature levels regardless of soil moisture content. TeKrony and Hunter (1995) found a significant quadratic relationship between cold test results and black layer maturity of corn.

The accelerated aging test has been shown to correlate with seedling emergence (Hall and Wiesner, 1990). The accelerated aging and leachate conductivity tests detected low vigor resulting from immature seeds in sweet corn (Wilson and Trawatha, 1991). Wilson et al. (1992) suggested combining the accelerated aging, leachate conductivity, and other vigor tests to develop a multiple regression model for prediction of final stand in sweet corn. Zorrilla et al. (1994) reported that the accelerated aging and cold tests were good estimates of field emergence at low infection levels of *Phomopsis* in soybean [*Glycine max* (L.) Merr.] seed. The standard germination and cool tests combined were good predictors of field emergence in cotton (*Gossypium hirsutum* L.) (Kerby et al., 1989). Gill and Delouche (1973) reported that the cold test effectively evaluated deterioration in corn seed.

The cold test is widely used in the hybrid corn industry as a means of determining seed vigor. Companies producing subtropical corn hybrids also utilize the cold test to determine the vigor of seed lots; however, it is not known whether the cold test is as effective in segregating lots on the basis of seed quality for subtropical genotypes as it is for temperate genotypes. The objective of this study was to compare the performance of various seed vigor tests for subtropical corn genotypes.

Materials and Methods

Seven corn hybrids were utilized in this study. These included five subtropical hybrids (Pioneer Brand 3050, 3086, 3098, 3281, and 3428) produced in Weslaco, Texas, and two temperate hybrids (Pioneer Brand 3163 and 3293) produced in Tipton, Indiana, as controls. All seven hybrids exhibited initial germination of 97% or greater. Ten 1-kg samples of seed of each hybrid were placed into double 27x28-cm, moisture-proof sealable plastic bags. The 10 seed samples of each hybrid were then placed in storage at a constant 30ºC. Every 3 months, a subsample of each hybrid was removed from storage, and laboratory evaluations of seed quality were conducted.

Seven laboratory evaluations were conducted every 3 months on the stored seed samples. The standard germination test was conducted according to the methods specified by the Association of Official Seed Analysts (AOSA, 1983). The only deviation from these procedures was that four replications of 50 seeds were planted, instead of the 100 seeds per replication recommended by AOSA. The 50 seeds were planted on two sheets of moistened germination towels and covered with a third towel. The three towels were then rolled and placed in a germinator under alternating 20/30 ºC temperature. The germinator was set to provide light during the high-temperature cycle (8 hours) and to remain dark during the low-temperature cycle (16 hours). An initial count was made after 4 days and a final count after 7 days.

The cool test was conducted according to AOSA rules by randomly planting four replications of 50 seeds each on two sheets of moist towels covered with a third towel (AOSA, 1983). The three towels were then rolled and placed in a plastic box in a constant 18ºC-incubator. The boxes were positioned inside the incubator in a manner to permit the towels to stand upright. A final count was made 6 days after planting. Only those seedlings with a radicle of 5 mm or longer — or those without the radicle but at least one 5-mm seminal root — were counted. For the modified cool test, a temperature of 15ºC was used instead of 18ºC; otherwise, sample preparation and evaluation of seedlings were conducted as in the cool test.

Soil obtained from the top 5 cm of a cornfield at the Mississippi Agricultural and Forestry and Experiment Station Plant Science Research Center at Mississippi State University was used for the cold test. The soil was thoroughly mixed with an equal amount of sand, and 1,500 g of the soil-sand mixture were placed into 19x6x9.5-cm plastic boxes. Four replications of 50 seeds from each treatment were planted in each plastic box and covered with 1,000 g of sand-soil mixture. A calculated quantity of prechilled (10ºC) water was added to adjust the moisture content to 70% saturation. The boxes were then covered and incubated at 10ºC for 7 days, after which they were transferred to a 25ºC-chamber for a 4-day grow-out period and normal seedlings were counted. The modified cold test utilized an incubation temperature of 13ºC, after which the boxes were transferred to 25ºC for 3 days.

The AOSA Seed Vigor Testing Handbook was followed to conduct the accelerated aging test (AOSA, 1983). One hundred seeds from each of the subsamples were placed on a wire mesh tray in a plastic container containing 40 ml of distilled water. The seeds were aged by closing the containers and placing them in a water jacket in a 42ºC-chamber for 96 hours. Upon completion of the aging period, the seeds were removed from the containers and planted in a moistened paper towel (50 seeds per roll), and a standard germination test was conducted using two replications of 50 seeds each. The modified accelerated aging test involved changing the incubating temperature and length of time used for aging the seeds. The chamber temperature was raised to 45ºC, and the incubation time was reduced to 60 hours. Standard germination evaluation of the aged samples was conducted as described previously. All laboratory tests were conducted using a completely randomized design with four replications with 50 seeds per replication.

A cone planter was used to plant seed of the seven hybrids at the MAFES Plant Science Research Center in June 1994 and 1995. The experimental design was a completely randomized design with four replications. Plots consisted of a single row, 6.7 m long with 0.97 m between rows. One hundred seeds were planted in each row. Field emergence was measured 22 days after planting by counting the number of seedlings that had emerged from the ground.

Data were subjected to analysis of variance, and means were separated using Fisher's protected least significant difference (LSD). Correlation coefficients were calculated between laboratory test results and field emergence. Multiple regression analysis using a stepwise variable selection procedure was employed to determine the best model for prediction of field emergence.

RESULTS AND DISCUSSION

The standard germination test revealed no decline in germination over the course of the study; however, a significant drop in field emergence was observed after 12 months of storage (Table 1). The standard germination tests were conducted under an optimal set of temperature and moisture conditions, which allowed for optimum seed germination with minimal stress (International Seed Testing Association, 1987). Field emergence, however, was measured under much more stressful conditions, which was reflected in slower emergence and decreased crop stand (Delouche and Baskin 1973).

A significant decrease in seed quality was observed in the subtropical hybrids as measured by all six vigor tests. This finding indicates that vigor tests can serve as better predictors of field emergence, which is consistent with the recommendation of Perry (1981). Both the standard and modified cold and cool tests indicated no decrease in seed quality for the temperate hybrids; however, the accelerated

Table 1. Standard germination, seed vigor test, and field emergence means of subtropical and temperate corn hybrids after 0, 3, 6, 9, and 12 months in storage at 30°C.

Month	Standard germination		Field emergence		Cold test		Modified cold test		Cool test		Modified cool test		Accelerated aging (AA) test		Modified AA test	
	Sub.	Temp.	Sub.	Temp.	Sub.	Temp.	Sub.	Temp.	Sub.	Temp.	Sub.	Temp.	Sub.	Temp.	Sub.	Temp.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
0	98.4	97.8	97.4	97.5	92.8	95.8	91.0	90.5	96.7	97.5	94.8	98.3	94.5	91.4	93.2	91.8
3	98.5	97.5	—	—	86.1	89.8	92.3	95.0	98.9	98.3	96.4	96.5	95.8	90.8	92.6	87.8
6	98.7	99.0	—	—	74.9	88.0	88.7	92.3	95.9	97.5	86.0	96.6	91.9	90.6	86.8	81.2
9	98.2	97.6	—	—	80.3	84.0	84.1	89.3	90.2	96.8	90.8	98.4	87.8	76.0	84.2	77.2
12	97.4	98.4	84.9	90.4	86.8	91.5	84.8	93.0	95.3	98.4	88.4	96.8	85.3	77.0	82.1	81.6
LSD (0.05)	**ns**	**ns**	**3.0**	**1.5**	**5.5**	**ns**	**2.7**	**ns**	**1.1**	**ns**	**4.0**	**ns**	**2.3**	**3.1**	**4.1**	**5.0**

aging and modified accelerated aging tests indicated a decline in seed quality for temperate hybrids.

Significant correlations were found between various laboratory evaluations and field emergence after 12 months in storage (Table 2). The accelerated aging and modified accelerated aging tests detected differences among hybrids and showed the highest correlations (0.86 and 0.87, respectively) with field emergence for the subtropical hybrids. Similar results have been reported for sweet corn (Wilson and Trawatha, 1991). Among the vigor tests, the cold and modified cold tests also exhibited significant correlations (0.63 and 0.75, respectively) with field emergence for the subtropical hybrids. The standard germination test also showed a high correlation (0.75) with field emergence for the subtropical hybrids. The modified accelerated aging test appeared to be the single best seed vigor test for both subtropical and temperate hybrids in the current study.

Table 2. Correlation coefficients between field emergence and laboratory evaluations of seed quality for subtropical corn hybrids after 12 months in storage.[1]

Seed test	Correlation coefficient
Cold test	0.63*
Modified cold test	0.75*
Cool test	0.61
Modified cool test	0.50
Accelerated aging	0.86**
Modified accelerated aging	0.87**
Standard germination	0.75*

[1] * = significant at the 0.05 level of probability; ** = significant at the 0.01 level of probability.

Differences among hybrids for seed viability, vigor, and field emergence were detected after 12 months in storage (Table 3). The two temperate hybrids, 3293 and 3163, differed only for the accelerated aging and modified accelerated aging tests. These two tests indicated low vigor for hybrid 3293, but this had no effect on field emergence of this hybrid. Significant differences among subtropical hybrids were detected by all the vigor tests with hybrid 3086 showing the lowest values for all six vigor tests after 12 months in storage. The best model for prediction of field emergence in the subtropical hybrids obtained from stepwise multiple regression analysis was a single-variable model utilizing the modified accelerated aging test as the independent variable [field emergence = 55.9 + 0.35 (modified accelerated aging); r^2 = 0.75]. However, if the modified accelerated aging test was not included as an independent variable, stepwise regression yielded a two-variable model utilizing the accelerated aging and cool tests [field emergence = 142.4 + 0.66 (accelerated aging) - 1.19 (cool test); r^2 = 0.86]. This apparent discrepancy was the result of strong colinearity between the two accelerated aging tests (r = 0.98).

After 12 months under good storage conditions, declines in seed quality and field emergence were observed. This effect was more pronounced for subtropical hybrids than for temperate hybrids. The best, single predictor of field emergence in subtropical corn hybrids was the modified accelerated aging test; however, a combination of the standard AOSA cool test and accelerated aging test gave a better prediction. In either case, the cold test was not among the best predictors of field emergence for these subtropical corn hybrids.

Table 3. Standard germination, seed vigor test, and field emergence means of seven corn hybrids after 12 months in storage.

Seed test	Subtropical hybrids					Temperate hybrids		LSD (0.05)
	3050	3098	3086	3281	3428	3293	3163	
Field emergence	91.1	82.4	74.9	82.8	93.2	92.1	88.7	7.6
Cold test	93.5	69.5	76.0	95.0	100.0	89.5	93.5	11.2
Modified cold test	91.5	74.0	63.0	98.0	97.5	92.0	94.0	8.3
Cool test	96.8	97.5	87.0	98.0	97.3	99.3	97.5	2.7
Modified cool test	93.5	70.0	80.5	99.0	99.0	97.5	96.0	7.7
Accelerated aging (AA)	97.8	88.8	55.3	84.8	99.8	65.0	89.0	2.0
Modified AA	98.5	84.3	52.0	77.0	98.8	76.0	87.3	8.3
Warm germination	99.8	96.3	91.5	100.0	99.5	99.3	97.5	3.3

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