Genetic variability for tolerance of drying injury in seed corn (Zea mays L.)

Paul Mari Bdliya
Iowa State University

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GENETIC VARIABILITY FOR TOLERANCE OF DRYING INJURY IN SEED CORN (ZEA MAYS L.)

Iowa State University
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Genetic variability for tolerance of drying injury in seed corn (*Zea mays* L.)

by

Paul Mari Bdliya

A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of the Requirements for the Degree of DOCTOR OF PHILOSOPHY

Department: Agronomy Major: Crop Production and Physiology

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Signature was redacted for privacy.

Members of the Committee:

Iowa State University
Ames, Iowa

1987
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DEDICATION

In the memory of my father, Mari Yabira Edliya
and
To my son, Danjuma Paul Mari
INTRODUCTION

Early harvest and artificial drying of seed corn by seed producers are necessary so as to avoid frost injury and damage due to insects and field weathering. It is, however, known that the artificial drying of high moisture seed corn can reduce seed quality, especially when dried at high temperatures.

Genetic variability exists with regards to susceptibility to high drying temperature among inbreds used as maternal (seed) parents. Reiss (1944) found the inbred R₄ to be more tolerant of drying temperatures than Wf9. Burris and Navratil (1980) reported that high moisture seeds produced on the maternal inbred A632 were more tolerant of high drying temperature (50°C) than seeds produced on the maternal inbred Mo17. More recently, a survey of fifteen public inbred lines used as seed parents in seed corn production further confirmed the existence of genetic variability among these inbreds for tolerance to high drying temperature (Meier, 1983). The single-cross hybrid H99 x H95 was used as the pollinator in both the later experiments.

The role of the male (pollinator) parent in the behavior of the seed of the maternal parents with respect to drying injury has not been studied. Also, no information has been documented on the type of gene actions that are involved in the tolerance of high drying temperature. Such information is useful to the breeder in selecting materials and in deciding the appropriate method to be used in a breeding program.

The objectives of this work are:
1. To study the influence of the male parent on drying injury in some selected corn inbreds.

2. To study the inheritance of tolerance of high drying temperature injury on these inbreds.

3. To determine the genetic component(s) which contribute(s) most to the tolerance of high drying temperature in these inbreds.
LITERATURE REVIEW

Physiological Aspects of Drying Injury

The adverse effect of drying seed corn at high temperature has been known for a long time. In 1925, Duncan and Marston (1925) observed that a 60% reduction in germination resulted when seeds were harvested while in the milk stage and dried at 44.6°C but that 90% of the seeds dried at 35°C germinated. However, the germination of corn seed harvested in the hard or soft dough stages was not affected by drying temperatures of 44.4°C. These results indicate that maturity, harvest moisture and drying temperature all interact to cause the drying injury in seed corn.

The lethal effect of high drying temperature was also reported by Harrison and Wright (1929). They found that seeds harvested at 39.6% moisture had reduced germination values when dried at 50°C, and that drying such seeds at 60 or 70°C completely inhibited germination. The same study showed that seeds harvested at up to 62.8% and dried at 40°C did not show a significant reduction in germination. That the reductions in germination were caused by the drying temperature, rather than by rapid or excessive drying, were shown by their overdrying experiment. They found that no damage occurred even when seeds were overdried to four percent moisture at nonharmful temperatures.

Kisselbach (1939), showed that seed of Krug variety with 19, 27 and 30% moisture could withstand drying temperatures as high as 44.4°C but seeds with moisture contents of 50 and 57% could not. The seeds of Minn.13
harvested at moistures as low as 26% resulted in reduced germination when
dried at 54.4 C as compared to germination values of similar seeds when
dried at 48.9 C. Seedlings from seeds dried at the higher temperatures
emerged more slowly than those receiving the less harsh treatments, an
indication that their vigor was reduced by the high temperature treatments.
In another study, McRostie (1949), utilizing several hybrids to represent
different moisture groups, found that little damage was done to germination
of corn harvested at 33 to 40% by drying temperatures of up to 54.4 C.
However, increasing either the initial moisture or drying temperatures
above these levels decreased the germination of the seeds.

Washko (1941) and Wileman and Ullstrup (1945) proposed that the
harvest moisture of corn is the main factor which should be considered when
determining a safe drying temperature. According to Wileman and Ullstrup
(1945), seed corn should not be dried at temperatures higher than 43.3 C if
it is above 25% moisture and at no higher than 48.9 C if it is 25% or less.
Because corn of different moistures is often in the same dryer, Washko
(1941) recommended that seed corn be dried at 43.3 C or less.

Genotype variability exists with regards to susceptibility to drying
injury. Reiss (1944) reported on genotype variability. He showed that
seeds from the inbred Wf9 suffered more injury than seeds from the inbred
R4 at increasing drying temperatures and harvest moistures. This was
exhibited in results of the warm and cold germination and seedling vigor
tests. Dimmock (1947) reported that single cross hybrids were more
severely injured by high drying temperatures than double cross hybrids.
Similar conclusions were reached by Washko (1941) who reported that inbreds
were least tolerant of high drying temperatures; double crosses were most
tolerant and single crosses showed intermediate tolerance. He proposed
that the drying tolerance of single crosses was not simply genetically
controlled by the component inbreds. McRostie (1949) also reported that
differences existed among inbreds used as females with regards to drying
temperature injury.

More recently, Navratil (1981) found seeds produced on the inbred A632
more tolerant of high drying temperatures of 50 C than seeds produced on
Mo17 and B73 when harvested at moistures greater than 40%. He recommended
that seeds from the inbred Mo17 should not be dried at temperatures of 45 C
or above unless the harvest moisture content is 25% or less. Seeds
harvested from B73, however, could withstand drying at 45 C when harvested
at moistures up to 40%.

Factors responsible for the variability among genotypes with regards
to drying injury are not known. Navratil (1981), suggested that tolerant
genotypes may loose moisture faster, thus keeping the seeds cool until
moisture is low enough for the seed to tolerate higher temperatures.

Some environmental factors believed to contribute to the variance in
field drying rates could also affect artificial drying rates. Air
temperature was observed to be significantly related to drying rate when
kernels were above 35% moisture and relative humidity was significantly
related to drying rate of kernels below 30% moisture (Schmidt and Hallauer,
1966). Several workers, Dungan (1958), Gilmore et al. (1958) and Schmidt
and Hallauer (1966) reported that heat units accumulated are the most
important environmental factors influencing field drying rates of corn.
Hallauer and Russell (1961), however, feel that heat units were not reliable estimates of moisture loss.

Purdy and Crane (1967) found that physical characteristics of the ear affect drying rates. Using three 'fast' and three 'slow' drying corn inbreds in hybrid combinations, these workers obtained correlations which indicated that selection for faster drying rate would most likely result in smaller ears, later silking date and lower moisture content at 60 days after silking.

Several studies have established the pericarp as a major factor controlling moisture loss by the corn kernel. Purdy and Crane (1967) found that faster drying rates generally were associated with thinner pericarp and greater permeability. Removing the pericarp from kernels of 'fast' and 'slow' drying corn hybrids resulted in almost identical rates of moisture uptake or loss whereas intact kernels of the same hybrids demonstrated differing rates of moisture uptake or loss. Killing the kernels with potassium cyanide did not alter their rate of water uptake or loss. From these results they concluded that differential rates of water uptake and loss are due mainly to the physical structure of the pericarp and not due to metabolic processes within the kernels.

The type of compounds that make up the endosperm have also been implicated in the drying rate of corn kernels. Nass and Crane (1970), studied the effect of endosperm on kernel drying rate in nine endosperm mutants. They proposed that the drying rate is regulated at least in part, by colloids in the endosperm. Colloids would include proteins and carbohydrates which exhibit hydrophylic properties in the endosperm. The
amount and type of hydrophobic compounds present would then determine the amount of water held and its rate of release from the endosperm. Water holding colloids are prevalent in immature corn kernels and their presence could have an effect on kernel drying.

The actual site(s) of injury in the seed caused by high drying temperatures is still unclear. Several suggestions and observations associated with drying injury, however, exist. One theory is that drying tolerance may be partially dependent on the form of water present in the seed. When ears are harvested early, much of the water is free water. When the ears are allowed to mature on the plant, more of the water is in the bound form (Washko, 1941). As a support to this theory, the author observed that in artificially dried seeds, harvested between 36.7 and 46.4%, injury to the seeds was not observed until the moisture reached 18 to 23%. Most seeds harvested at those moistures could withstand high temperatures. Perhaps the forceful removal of water in the bound form results in seed injury.

Another approach relates to membrane structural changes which occur when the moisture content becomes low followed by rapid organization upon rehydration (Simon, 1974). It is possible that the membranes of the seeds which have suffered drying injury do not reorganize as quickly as uninjured membranes and therefore allow valuable nutrients to escape.

Livingston (1952) showed that hybrid seeds of Wf9 x M14 which were dried at 40.5 C were more susceptible to soil borne pathogens especially under cold environments. He attributed the observed reduction in seedling vigor of artificially dried seeds to be due to physiological differences.
between the two treatments which affected their susceptibility to pathogens. He found that the increased susceptibility was not entirely due to pericarp injury as has been previously noted on artificially dried seeds. His results, however, could also be interpreted as follows: that more pericarp injury occurred in artificially dried seeds and that this served as points of entry for pathogens which kill or damage the seed. Another explanation could be that more solutes leached out of seeds that were artificially dried and these leachate served as substrates on which the pathogens grow and finally attack the seed. Struve (1958) proposed that dryer damage could be due to lack of certain protoplasmic adjustments that occur when seeds are dried at lower temperatures.

Seyedin et al. (1984) observed that significantly more sugars were leached into water from seeds dried at 50 C than at 35 C for both maternal inbreds Mo17 (intolerant of high drying temperatures) and A632 (tolerant). Electrical conductivity of the leachate from maternal inbreds Mo17 and A632 was greater for seeds dried at 50 C than at 35 C. This may be indicative of membrane damage. Seed respiration was reported to be unaffected during the drying process although drying at high temperatures does reduce respiration during germination (Seyedin et al. 1983). A greater reduction in respiration was observed in the susceptible genotype (Mo17) than in A632, the tolerant genotype.
Genetic Aspects of Seed Quality

There has been much work on the physiology of seeds but relatively little on the genetics of various characteristics influencing seed quality. There are many facets of seed vigor for which the physiology and nature of these characteristics has been identified with cultivar differences. However, very few of those characters have been studied genetically and those that have been studied were found to be polygenic in inheritance (Dickson, 1980).

Perhaps one of the most widely studied genetic aspect of seed quality is the ability to germinate under cold stress conditions. Tatum (1942) observed reciprocal differences for germination and seedling vigor between single-cross hybrids and he concluded that seedling vigor may be influenced by maternal factors. He also observed that even in the absence of pericarp breaks, strains may still show large variations in ability to withstand unfavorable conditions during germination. These differences could be due either to differences in maternal seed characters which favor or hinder penetration of pathogens or to differences in resistance of the embryo itself. In view of the results with pericarp injury, it might be expected that maternal characters, particularly of the pericarp would be most important. Germination in cold-tests of inbreds and of crosses involving the inbreds as the seed parent, is determined to a large extent by seed-borne infection and seed-coat conditions both of which are related to the maternal parent. In tests of seeds produced on inbred plants, maternal influences were so important that genetic differences in resistance of the
zygote to the pathogens involved could not be detected with certainty.
Pinnell (1949), also showed that the maternal parent was of great importance in determining seedling stands in both single and double-crosses under both field and laboratory cold conditions. He proposed that the nature of the endosperm may be responsible for that portion of inheritance directly related to the maternal parent. Helgason (1953) and Tatum (1942) have both further shown that the emergence of seed of single-crosses under low temperature conditions is closely correlated to the cold tolerance of their maternal parents. A more recent study involving a two-year average emergence after cold treatment rating of 56 reciprocal single-crosses and their parental inbred lines indicates that the degree of tolerance to low temperature is strongly dependent on the emergence ability of the maternal parent (Pesev, 1970). The author postulated that this may be associated with the double contribution from the female parent at fertilization or with the importance of the quantity and quality of kernel endosperm.

Additive gene effects have been reported by Grogan (1970) as being important for germination and rate of seedling growth under cold environments. He further observed that epistatic and cytoplasmic effects influenced germination but not growth rate. He concluded that the inheritance of ability to germinate under cold conditions involved multiple factors and that a recurrent selection scheme would be the best approach to take advantage of the additive, dominant and epistatic gene contributions.

Evidence from S1 and full-sib families, comparison of S1 and within family variance as an estimate of dominance indicated that dominance variances were considerably larger than estimates of additive variances for
the time to emerge and emergence percentage (Eagles and Hardacre, 1979). This suggests that germination percentage and seed weight were either predominantly maternally inherited characters or were controlled by nonadditive genes. McConnell and Gardner (1979) used generation means to study inheritance of germination at 7.2 C in the laboratory, emergence, juvenile growth and yield in the field. Six inbreds, their 15 F1 and F2 hybrids and 30 backcross populations were used in the analysis. The result of their experiments indicate that cold tolerance traits (cold germination, emergence and growth after emergence) of the set of inbreds studied were inherited in a quantitative manner and that most of the genetic variability was non additive.

Eagles (1982), studied inheritance of emergence time in F1, F2, and backcross generations of a diallel cross of two rapidly emerging lines from CIMMYT pool 5, 5-113 and 5-154 and two corn belt dent lines, A619 and A632 in growth chambers at low temperatures. He observed reciprocal differences only in F1 generations involving A619, and then, only marked effects could be attributed to the male parents. The reciprocal differences however tended to disappear in the F2. This suggested that the genotype of the embryo and endosperm were of much greater importance than the genotype of the maternal parent in determining difference in time to emerge and seedling growth. Inheritance of traits believed to indicate cold tolerance were studied in the parents and selected populations of a Nebraska derivative of the Iowa stiff stalk synthetic (Keim and Gardner, 1984). Nonadditive genetic effects were operative in the parent population. Both additive and dominance genetic effects were operative in the selected
population with dominance more apparent for seedling vigor. Changes in additive genetic effects might reflect accumulation of favorable cold-tolerance alleles through selection. These workers gave similar explanations as other workers; that maternal influence could be caused by pericarp characteristics in addition to maternal contribution to the embryo. Different females mated to the same male could produce full-sib families which possess physical differences (e.g., pericarp differences) affecting response to low temperatures.

Genetic Aspects of Drying Injury

Very little information exists in the literature on the genetic aspects of drying injury of seed corn. In order to determine whether there are important heritable differences in the response of corn to artificial drying, Kisselbach (1939) dried seeds of 26 single-cross hybrids ranging in moisture from 16-38%, at 44.4 C for a period of five days. He selected this relatively high temperature because it might be expected to be more selective of heat susceptible hybrids than a lower temperature. The results indicated that there were no significant differences between hybrids for the germination values. It would seem possible that among hybrids differing greatly in moisture content at the time of drying, those with excessive moisture would be injured. This would not necessarily suggest a heritable difference in heat susceptibility and might be associated solely with moisture content. Another reason could be that the harvest moisture was so low that no damage could be detected at this drying
temperature.

Variance in maturity intervals was reported to be due more to dominance deviations than additive variance (Hillson and Penny, 1965). They also noted that hybrids lost moisture at different rates and the effect was influenced by the lines making up the hybrid. Most workers agree that differences exist between corn strains in their rate of drying. Crane, Miles and Newman (1959) found that some hybrids which silk at the same time and maintain the same water to dry matter ratio until they reach 45% moisture may differ in drying rate after that point.

Purdy and Crane (1967) observed in 1965 that significant differences in field drying rates occurred due to both general combining ability (GCA) and specific combining ability (SCA) effects. The genetic variance components were GCA=1.441; SCA=0.189. This indicates that for the particular diallel (Oh7, C190A, B14, Oh45, P8 and C103), set of inbreds, the GCA component was of much more importance than the SCA component. The small magnitude of SCA indicates that there was very little deviation between crosses involving these parents which could mean that they transmitted their drying rate ability uniformly to all their offspring.

From the above information, it appears that many seed quality traits are under maternal control or are mostly under the influence of additive gene effects. Although maternal effects of all kinds are considered to be rather uncommon in plants, it is not surprising to find maternal effects for traits like germination and early seedling growth since they are close to the mother plant developmentally. Coleoptile length in wheat has also been reported to be under maternal control (Parodi et al. 1970). Burris
(1977) reported that location of production and female parentage had a highly significant effect on germination, shoot and root dry weights. He further observed that in some cases where the reciprocal cross was significant, its mean square value was a factor of ten less than the mean square for maternal effects. The GCA had at least three times larger mean square than did SCA for any of the traits observed. Other workers, Singh and Hadley (1968, 1972) found oil and protein content of soybeans to be primarily under maternal control, although small but significant paternal effects were detected in comparing F1 seed to selfed seed at the same node. Generally, in the presence of a large amount of variability due to maternal factors, any differences due to genetic effects of the embryo are masked to such an extent they can not be detected.

Apparent direct effects of the pollen parent on many seed quality traits have not been documented. However, Dessureaux et al. (1948), presented evidence that certain inbred lines when used as pollen parents may exert significant effects on the rate and duration of increase in dry matter content of the crossed kernels. Pollen of the inbred R4 was found to contribute a tendency toward shortening the period during which translocation of dry matter to the kernels occurred with other inbreds as seed parents. The depressing effect on kernel weight was observed in all crosses in which R4 was the pollen parent. The magnitude of the effect produced by pollen from R4 suggests that this inbred and possibly others may carry dominant or partially dominant genes that cause decreased kernel size which can not be explained by heterosis alone. Such genes might possibly affect kernel size by modifying certain specific processes or
phases in kernel development rather than by exerting broad general effects on kernel size. Leng (1949) also reported that corn inbred lines differ significantly in their effects on the weights of crossed kernels when used as pollen parents. In some cases the differences were as large as 25% of the total kernel weight. There was no close relationship between the kernel size and this fact making it unlikely that these effects are the result of size inheritance with additive gene action.
MATERIALS AND METHODS

Source of Materials

Six public inbred lines, A632, A641, B14A, B73, Mo17 and W64A were selected for this study. Each inbred was obtained from three different sources and seed were mixed in equal proportions prior to planting. The three sources of these lines are Clyde Black and Sons, Inc., Ames, Iowa, Mike Brayton Seeds, Inc., Ames, Iowa, and Holdens Foundation Seeds Inc., Williamsburg, Iowa. The selection of these inbreds was based on the results of a two-year genotype survey by Meier, 1983. In that study, A632 was classified as tolerant and Mo17 as intolerant of high temperature drying injury. The other four inbreds were of intermediate performance based on percentage germination and seedling vigor tests.

Field Plan

Inbreds were hand-planted in paired rows for two summers (1984 and 1985) on the Burner farm near Ames, Iowa. To ensure adequate pollen availability, each inbred was planted in two row plots of 4 meters each, 30 seeds per row. Delayed planting was employed based on number of days to maturity so as to ensure proper nicking at time of pollination. The field plan was a randomized complete block design (RCBD). Each cross was replicated three times, the blocks forming the replicates. Different randomization was used for each of the two growing seasons.
At pollination, crosses were made by hand among all the inbreds to form a complete diallel, including reciprocals. Since all lines used in this experiment were inbreds, homozygosity was assumed and hence, pollination between rows was random. Sometimes pollen was bulked from the male rows and used to pollinate the appropriate female. At flowering, tassels were covered with tassel bags in the evening prior to pollination the following day. Females were prepared by covering the shoot using shoot bags to avoid contamination. The silks were cut back the day before pollination so as to obtain a uniform "brush" of silks the following morning. Pollination was done between 10 a.m. and 3 p.m. each day. The tassel bag was removed after shaking the pollen into it and the bag contents emptied over the already prepared "brush" of silks. The pollen bag was used to cover the pollinated females as a further measure to prevent contamination.

Moisture Sampling and Harvesting

About 30-35 days after pollination, ears were sampled for moisture determinations. Two to four ears per cross within a pollination date were harvested and brought into the laboratory. These were unhusked, and 10-20 kernels removed from the center portion of the cob. These were weighed (fresh weight) and placed in coin envelopes and left in the oven at 105 C. After three days, the dry seeds were weighed (dry weight). The percentage moisture was calculated using the following formula:

\[ \text{Percentage Moisture} = \frac{\text{Fresh Weight} - \text{Dry Weight}}{\text{Fresh Weight}} \times 100 \]
The information obtained from the above sampling procedure was used in selecting samples to be harvested for the experiment. Six to eight ears were harvested per cross from each replication (block) at two different times. First harvest was ca. 48-52% kernel moisture (high harvest moisture, HHM) and second harvest, ca. 38-40% kernel moisture (low harvest moisture, LHM) (Table 3). Ears were brought to the laboratory, unhusked, and half of the ears from each sample were dried at 50 C and the other half were dried at 35 C.

Drying Procedure

All ears were dried to about 12% moisture in thin-layer dryers as described by Burrus and Navratil (1982). During the drying period, kernel moisture was determined periodically using a Delmhorst model G-6 moisture meter. The dried kernels were shelled, discarding the tip and base kernels, put in small paper bags, labelled and placed in cold storage at 10 C and 50% R.H. for about two weeks for moisture equilibration. One hundred kernel weight was determined (dry weight) and seed were treated with a fungicide - captan. Each treatment consisted of cross, harvest moisture and drying temperature combinations.
Germination Procedure

Germination tests were done in growth chambers using the rolled paper towel method (Loeffler et al. 1985). For the standard (warm germination) fifty seeds of each treatment were arranged in two rows of 25 seeds on the paper towel premoistened with approximately 35ml tap water. Each seed was planted with the embryo facing upward and radical pointing downward. The first row of 25 seeds was about 6cm from the upper edge of the towel while the second row was also about 6cm from the first row. A moistened paper towel was placed over the seeds and then loosely rolled. The rolled towels were randomly placed upright in plastic buckets as described by Burris and Fehr (1971). The buckets were placed in growth chambers at 25 C in the dark. After 7 days, germination values were recorded according to the Rules for Testing of the Association of Official Seed Analysts (1981).

Shoot and roots were removed from normally germinated seeds and oven-dried at 85 C for 24 hours and their dry weights recorded.

For the cold germination (stress test) similar planting procedures are used as described for the standard (warm) germination except that the planting was done on cold paper towels. Samples were placed in 10 C cold room for seven days (stress treatment) before being transferred to 25 C for seven more days. Germination counts were subsequently made without taking shoot and root weights.
The linear model used to compute the desired genetic information from the diallel for the combined analysis is:

$$Y_{ijkl} = \mu + g_i + g_j + s_{ij} + m_i + m_j + r_{ij} + e_k + (r/e)_{kl} + (ge)_{il} + (ge)_{jl} + (se)_{ijl} + (me)_{il} + \varepsilon_{ijkl}$$

where:

- $Y_{ijkl}$ is the $k$th replicate of the cross between the $i$th female and the $j$th male in the $l$th environment (year), $s_{ij} = s_{ji}$,
- $\mu$ is the mean of the diallel set,
- $g_i = \text{the average effect (GCA) of the } i^{th} \text{ parent on its crosses, } i = 1, \ldots, 6$,
- $g_j = \text{the average effect (GCA) of the } j^{th} \text{ parent on its crosses, } j = 1, \ldots, 6$,
- $s_{ij} = \text{specific combining ability (SCA) or the deviation of the } ij^{th} \text{ cross from the expected performance based on the parent's average effect,}$
- $m_i (m_j) = \text{maternal effect or general reciprocal effect (GRE) due to } i^{th} \text{ parent when used as a female (} j^{th} \text{ male),}$
- $r_{ij} = \text{reciprocal effect or specific reciprocal effect (SRE) due to the cross between the } i^{th} \text{ female and the } j^{th} \text{ male,}$
- $e_l = \text{effect of the } l^{th} \text{ environment (year), } l = 1, 2$
- $(r/e)_{kl} = \text{effect of the } k^{th} \text{ replication within the } l^{th} \text{ environment,}$
- $(ge)_{il}, (ge)_{jl}, (se)_{ijl}, (me)_{il} \text{ and } (re)_{ijl} = \text{previously defined effects' interaction with the environment,}$
- $\varepsilon_{ijkl} = \text{pooled error associated with the } ijkl^{th} \text{ observation.}$
The combined analysis of variance over the two years (environments) and expectation of the mean squares is shown in Table 1.

Variations among the crosses was subdivided into GCA, SCA, maternal and reciprocal sources of variation (Table 2) according to Cockerham (1963). The analysis was done according to Griffing (1956) method 3 (crosses and reciprocals), model 1 (fixed). Environments (years), however, were considered random effects. F-tests were carried out to test the null hypothesis for absence of variation among crosses caused by these different sources.

The GCA and SCA effects were estimated using these equations (Griffing, 1956):

$$
\hat{g}_i = \frac{1}{2n(n-2)} n(x_{i.} + x_{i.}) - 2\bar{x}.
$$

$$
\hat{s}_{ij} = \frac{1}{2} (x_{ij} + x_{ji}) - \frac{1}{2n(n-2)} (x_{i.} + x_{i.} + x_{j.} + x_{j.}) + \frac{1}{(n-1)(n-2)} \bar{x}.
$$

The standard errors on these effects were calculated as:

$$
\text{S.E.}(\hat{g}_i) = \sqrt{\frac{\sigma^2(C_{ii})}{z_{ij}}} \quad \text{and} \quad \text{S.E.}(\hat{s}_{ij}) = \sqrt{\frac{\sigma^2(C_{ij})}{z_{ij}}}
$$

where:

$$
\sigma^2 = \text{pooled error mean square},
$$

$$
C_{ii} = \frac{n-1}{2n(n-2)} \quad \text{and} \quad C_{ij} = \frac{n-3}{2(n-1)}
$$

The interaction of the effects of these genetic components with the environment (year) were calculated by subtracting the mean square of the effects obtained in the combined analysis from the sum of the individual year mean squares.
Table 1. Combined analysis of variance and expectation of the mean squares

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<tr>
<th>Source of variation</th>
<th>df</th>
<th>MS</th>
<th>E(MS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year(Y)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replication/Y</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment (T)</td>
<td>119</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HHM vs LHM (CHM)</td>
<td>1</td>
<td>(M_{16})</td>
<td>(\sigma^2 + \nu^2_{YCHM} + \nu_k^2CHM)</td>
</tr>
<tr>
<td>50 C vs 35 C/HHM</td>
<td>1</td>
<td>(M_{15})</td>
<td>(\sigma^2 + \nu^2_{YHHM} + \nu_k^2HHM)</td>
</tr>
<tr>
<td>50 C vs 35 C/LHM</td>
<td>1</td>
<td>(M_{14})</td>
<td>(\sigma^2 + \nu^2_{YLM} + \nu_k^2LHM)</td>
</tr>
<tr>
<td>Among Crosses (HHM and 50 C)</td>
<td>29</td>
<td>(M_{13})</td>
<td>(\sigma^2 + \nu^2_{YC1} + \nu_k^2C1)</td>
</tr>
<tr>
<td>Among Crosses (HHM and 35 C)</td>
<td>29</td>
<td>(M_{12})</td>
<td>(\sigma^2 + \nu^2_{YC2} + \nu_k^2C2)</td>
</tr>
<tr>
<td>Among Crosses (LHM and 50 C)</td>
<td>29</td>
<td>(M_{11})</td>
<td>(\sigma^2 + \nu^2_{YC3} + \nu_k^2C3)</td>
</tr>
<tr>
<td>Among Crosses (LHM and 35 C)</td>
<td>29</td>
<td>(M_{10})</td>
<td>(\sigma^2 + \nu^2_{YC4} + \nu_k^2C4)</td>
</tr>
<tr>
<td>Treatment*Year</td>
<td>119</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HHM vs LHM * Y</td>
<td>1</td>
<td>(M_9)</td>
<td>(\sigma^2 + \nu^2_{YT})</td>
</tr>
<tr>
<td>50 C vs 35 C/HHM * Y</td>
<td>1</td>
<td>(M_7)</td>
<td>(\sigma^2 + \nu^2_{YCHM})</td>
</tr>
<tr>
<td>50 C vs 35 C/LHM * Y</td>
<td>1</td>
<td>(M_6)</td>
<td>(\sigma^2 + \nu^2_{YLM})</td>
</tr>
<tr>
<td>Crosses (HHM and 50 C) * Y</td>
<td>29</td>
<td>(M_5)</td>
<td>(\sigma^2 + \nu^2_{YC1})</td>
</tr>
<tr>
<td>Crosses (HHM and 35 C) * Y</td>
<td>29</td>
<td>(M_4)</td>
<td>(\sigma^2 + \nu^2_{YC2})</td>
</tr>
<tr>
<td>Crosses (LHM and 50 C) * Y</td>
<td>29</td>
<td>(M_3)</td>
<td>(\sigma^2 + \nu^2_{YC3})</td>
</tr>
<tr>
<td>Crosses (LHM and 35 C) * Y</td>
<td>29</td>
<td>(M_2)</td>
<td>(\sigma^2 + \nu^2_{YC4})</td>
</tr>
<tr>
<td>Error (Rep/Y) (T-1)</td>
<td>476</td>
<td>(M_1)</td>
<td>(\sigma^2)</td>
</tr>
</tbody>
</table>

HHM = High harvest moisture.
LHM = Low harvest moisture.
C1 = Among crosses (high harvest moisture, HHM and high drying temperature, 50 C).
C2 = Among crosses (high harvest moisture, HHM and low drying temperature, 35 C).
C3 = Among crosses (low harvest moisture, LHM and high drying temperature, 50 C).
C4 = Among crosses (low harvest moisture, LHM and low drying temperature, 35 C).
r = replications.
K = estimated effects rather than variances.
Table 2. Analysis of variance and the expectation of the mean squares for the two environments

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year (Y)</td>
<td>y-1</td>
<td>1</td>
</tr>
<tr>
<td>Replication/Y</td>
<td>y(r-1)</td>
<td>4</td>
</tr>
<tr>
<td><strong>Crosses</strong></td>
<td>n(n-1)-1</td>
<td>29</td>
</tr>
<tr>
<td>GCA (G)</td>
<td>n-1</td>
<td>5</td>
</tr>
<tr>
<td>SCA (S)</td>
<td>n(n-3)/2</td>
<td>9</td>
</tr>
<tr>
<td>Maternal (I)</td>
<td>n-1</td>
<td>5</td>
</tr>
<tr>
<td>Reciprocal (R)</td>
<td>(n-1)(n-2)/2</td>
<td>10</td>
</tr>
<tr>
<td><strong>Crosses * Y</strong></td>
<td>y-1[n(n-1)-1]</td>
<td>29</td>
</tr>
<tr>
<td>GCA * Y</td>
<td>y-1(n-1)</td>
<td>5</td>
</tr>
<tr>
<td>SCA * Y</td>
<td>y-1[n(n-3)/2]</td>
<td>9</td>
</tr>
<tr>
<td>Maternal * Y</td>
<td>y-1(n-1)</td>
<td>5</td>
</tr>
<tr>
<td>Reciprocal * Y</td>
<td>y-1[(n-1)(n-2)/2]</td>
<td>10</td>
</tr>
<tr>
<td><strong>Pooled error</strong></td>
<td>y(r-1){[n(n-1)-1]}</td>
<td>116</td>
</tr>
</tbody>
</table>

Note: df and MS values are placeholders for the actual calculations.
E(\text{MS}) Expectation of the mean squares

\sigma^2 + r\sigma^2_{IC} + yr\kappa^2
\sigma^2 + r\sigma^2_{IG} + 2r(n-2)\kappa^2_G
\sigma^2 + r\sigma^2_{YS} + 2r\kappa^2_S
\sigma^2 + r\sigma^2_{YM} + \frac{r(n-2)}{2}[\kappa^2_{mi} + \kappa^2_{nj}]
\sigma^2 + r\sigma^2_{IR} + r\kappa^2_R
\sigma^2 + r\sigma^2_{YC}
\sigma^2 + r\sigma^2_{YG}
\sigma^2 + r\sigma^2_{YS}
\sigma^2 + r\sigma^2_{YM}
\sigma^2 + r\sigma^2_{YR}
\sigma^2
RESULTS

Average harvest moisture percentages of the six inbreds used as seed parents for the two harvests in each year are given in Table 3. Samples harvested in 1985 were of higher moistures, on the average, for the high harvest moisture than in 1984. This was intended to expose more of the variability which exists among the inbreds with respect to tolerance of drying injury. Data on the combined analyses will be presented mainly, with some reference to results within the individual years. Discussions will cover analyses of variance, inbred and hybrid (cross) means, general combining ability (GCA), specific combining ability (SCA) and maternal effect estimates for warm and cold germinations, kernel weight, seedling dry weight and shoot/root ratio. Effects of the four treatment combinations on these traits will be discussed separately.

Tables 4 and 5 show the analyses of variance for the 1984 and 1985 growing years individually. Replication was significant (P<0.05) for both germinations and kernel weight only in 1984 (Table 4). Orthogonal partitioning of treatment sums of square revealed highly significant effect of harvest moisture (HHM vs LHM) for all measured traits. Highly significant differences due to drying temperature was also observed within each harvest moisture (i.e., 50 C vs 35 C/HHM and 50 C vs 35 C/LHM) except for kernel weight and shoot/root ratio in 1985 (Table 5). In both years, the greatest variability was obtained when high moisture seeds were dried at 50 C as compared to those dried at 35 C (50 C vs 35 C/HHM). Variation among crosses treated alike were also highly significant for all traits.
Table 3. Harvest moisture of the seed parents across all male parents for 1984 and 1985

<table>
<thead>
<tr>
<th>Seed parent</th>
<th>High 1984</th>
<th>High 1985</th>
<th>Low 1984</th>
<th>Low 1985</th>
</tr>
</thead>
<tbody>
<tr>
<td>A632</td>
<td>48</td>
<td>50</td>
<td>38</td>
<td>37</td>
</tr>
<tr>
<td>A641</td>
<td>49</td>
<td>52</td>
<td>39</td>
<td>35</td>
</tr>
<tr>
<td>B14A</td>
<td>50</td>
<td>52</td>
<td>39</td>
<td>43</td>
</tr>
<tr>
<td>Mo17</td>
<td>51</td>
<td>52</td>
<td>42</td>
<td>38</td>
</tr>
<tr>
<td>W64A</td>
<td>46</td>
<td>51</td>
<td>37</td>
<td>41</td>
</tr>
</tbody>
</table>
Table 4. Orthogonal partitioning of treatment mean squares for seed quality traits measured in 1984

Mean Squares

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination warm</th>
<th>Germination cold</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication (Rep)</td>
<td>2</td>
<td>246.5*</td>
<td>670.5*</td>
<td>15.5*</td>
<td>30.2^{**}</td>
<td>0.12^{ns}</td>
</tr>
<tr>
<td>Treatment (Trt)</td>
<td>119</td>
<td>1763.1^{**}</td>
<td>3208.1^{**}</td>
<td>46.0^{**}</td>
<td>196.8^{**}</td>
<td>4.3^{**}</td>
</tr>
<tr>
<td>HHMvsLHM</td>
<td>1</td>
<td>22714.0^{**}</td>
<td>23919.3^{**}</td>
<td>1112.5^{**}</td>
<td>2230.3^{**}</td>
<td>108.6^{**}</td>
</tr>
<tr>
<td>50 C vs 35 C/HHM</td>
<td>1</td>
<td>77390.3^{**}</td>
<td>204014.0^{**}</td>
<td>12.8^{ns}</td>
<td>7641.6^{**}</td>
<td>122.6^{**}</td>
</tr>
<tr>
<td>50 C vs 35 C/LHM</td>
<td>1</td>
<td>8309.4^{**}</td>
<td>69590.0^{**}</td>
<td>5.6^{ns}</td>
<td>1304.7^{**}</td>
<td>16.8^{**}</td>
</tr>
<tr>
<td>Among Crosses (HHM, 50 C)</td>
<td>29</td>
<td>2692.2^{**}</td>
<td>1142.6^{*}</td>
<td>26.1^{**}</td>
<td>3.1^{**}</td>
<td>7.2^{ns}</td>
</tr>
<tr>
<td>Among Crosses (HHM, 35 C)</td>
<td>29</td>
<td>147.5^{ns}</td>
<td>178.6^{ns}</td>
<td>72.3^{*}</td>
<td>1.3^{ns}</td>
<td>0.66^{**}</td>
</tr>
<tr>
<td>Among Crosses (LHM, 50 C)</td>
<td>29</td>
<td>554.8^{**}</td>
<td>1561.7^{**}</td>
<td>49.6^{**}</td>
<td>2.8^{**}</td>
<td>0.79^{**}</td>
</tr>
<tr>
<td>Among Crosses (LHM, 35 C)</td>
<td>29</td>
<td>90.5^{**}</td>
<td>21.3^{*}</td>
<td>47.0^{**}</td>
<td>3.3^{**}</td>
<td>0.48^{**}</td>
</tr>
<tr>
<td>Error (Rep-1)(trt-1)</td>
<td>238</td>
<td>242.3</td>
<td>374.8</td>
<td>6.1</td>
<td>30.8</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Total 359

C.V. (%) 19.03 28.0 11.7 16.72 39.9

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.
^{ns} Nonsignificant at the 0.05 level.
HHM-High harvest moisture; LHM-Low harvest moisture.
50 C - drying at 50 C; 35 C drying at 35 C.
50 C vs 35 C/HHM - comparison between high moisture seeds dried at 50 C and high moisture seeds dried at 35 C.
50 C vs 35 C/LHM - comparison between low moisture seeds dried at 50 C and low moisture seeds dried at 35 C.
Table 5. Orthogonal partitioning of treatment mean squares for seed quality traits measured in 1985

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replication (Rep)</td>
<td>2</td>
<td>144.1 ns</td>
<td>94.0 ns</td>
<td>3.5 ns</td>
<td>0.8 ns</td>
</tr>
<tr>
<td>Treatment (Trt)</td>
<td>119</td>
<td>3316.7**</td>
<td>5432.6**</td>
<td>50.5**</td>
<td>7.4**</td>
</tr>
<tr>
<td>HHM vs LHM</td>
<td>1</td>
<td>13420.0**</td>
<td>4776.9**</td>
<td>3155.5**</td>
<td>82.1**</td>
</tr>
<tr>
<td>50 C vs 35 C/HHM</td>
<td>1</td>
<td>207264.8**</td>
<td>334369.8**</td>
<td>0.3 ns</td>
<td>243.1**</td>
</tr>
<tr>
<td>50 C vs 35 C/LHM</td>
<td>1</td>
<td>99405.0**</td>
<td>264806.8**</td>
<td>0.1 ns</td>
<td>292.0**</td>
</tr>
<tr>
<td>Among Crosses</td>
<td>29</td>
<td>1074.0**</td>
<td>56.4 ns</td>
<td>21.6**</td>
<td>2.4**</td>
</tr>
<tr>
<td>(HHK, 50 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Among Crosses</td>
<td>29</td>
<td>28.1**</td>
<td>54.5**</td>
<td>19.4**</td>
<td>1.4**</td>
</tr>
<tr>
<td>(HHM, 35 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Among Crosses</td>
<td>29</td>
<td>1456.7**</td>
<td>1342.6**</td>
<td>30.4**</td>
<td>4.1**</td>
</tr>
<tr>
<td>(LHM, 50 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Among Crosses</td>
<td>29</td>
<td>13.7 ns</td>
<td>13.6 ns</td>
<td>26.9**</td>
<td>1.4**</td>
</tr>
<tr>
<td>(LHM, 35 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error (Rep-1)(Trt-1)</td>
<td>238</td>
<td>148.9</td>
<td>110.6</td>
<td>2.6 ns</td>
<td>0.5 ns</td>
</tr>
<tr>
<td>Total</td>
<td>359</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C.V. (%) | 17.7 | 18.9 | 7.4 | 14.6 | 51.6

*, ** Significant at 0.05 and 0.01 levels of probability, respectively. ns, nonsignificant at the 0.05 level.

HHM—high harvest moisture, LHM—low harvest moisture.

50 C - drying at 50 C; 35 C - drying at 35 C.

50 C vs 35 C/HHM - comparison between high moisture seeds dried at 50 C and high moisture seeds dried at 35 C.

50 C vs 35 C/LHM - comparison between low moisture seeds dried at 50 C and low moisture seeds dried at 35 C.
except shoot/root ratio in 1984 for the high harvest moisture and 35 C
drying temperature treatment (Table 4). In 1985, variability among hybrid
seeds harvested at high moisture and dried at 50 C was nonsignificant in
the cold germination. The low harvest moisture and 35 C drying treatment
did not reveal any significant differences among crosses for both warm and
cold germinations in 1985 (Table 5).

Combined analysis of variance over both 1984 and 1985 revealed highly
significant year (environment) effect for all the traits except seedling
weight and shoot/root ratios (Table 6). Harvest moisture was highly
significant for all traits. Drying temperatures within each harvest
moisture did not produce a significant effect on kernel weight although
such effects were large and highly significant for the other four traits.
Differences among crosses treated alike were highly significant for all
traits in all four treatment combinations except for warm and cold
germinations in the HHM/35 C treatment. However, drying seeds at 50 C
produced large and highly significant variation among hybrids that received
such treatment (HHM/50 C and LHM/50 C) regardless of the harvest moisture.
Harvest moisture effect was stable across years for warm germination and
seedling weight in that HHM vs LHM * Year was nonsignificant for these
traits. Differences among crosses treated alike also showed highly
significant interaction with the environment (year) except, for warm and
cold germinations and shoot/root ratio in the hybrid seeds harvested at
high moisture and dried at 35 C.

Table 7 shows the combined ANOVA for GCA, SCA, maternal and reciprocal
mean squares for the high harvest moisture and 50 C drying temperature
Table 6. Orthogonal partitioning of treatment mean squares for seed quality traits combined over 1984 and 1985 environments

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm cold</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year (Y)</td>
<td>1</td>
<td>30165.0**</td>
<td>32395.6**</td>
<td>88.8**</td>
<td>0.7 ns</td>
</tr>
<tr>
<td>Replication/Y</td>
<td>4</td>
<td>195.3 ns</td>
<td>382.2 ns</td>
<td>9.5 ns</td>
<td>0.9 ns</td>
</tr>
<tr>
<td>Treatment (Trt)</td>
<td>119</td>
<td>4109.2**</td>
<td>7657.1 ns</td>
<td>81.8**</td>
<td>10.6 ns</td>
</tr>
<tr>
<td>HHM vs LHM</td>
<td>1</td>
<td>35052.2**</td>
<td>2450.0**</td>
<td>4034.4**</td>
<td>196.3 ns</td>
</tr>
<tr>
<td>50 C vs 35 C HHM</td>
<td>1</td>
<td>270199.0**</td>
<td>531615.4**</td>
<td>4.7 ns</td>
<td>436.6**</td>
</tr>
<tr>
<td>50 C vs 35 C LHM</td>
<td>1</td>
<td>83515.8**</td>
<td>304851.4**</td>
<td>4.0 ns</td>
<td>341.2 ns</td>
</tr>
<tr>
<td>Among Crosses</td>
<td>29</td>
<td>2615.4**</td>
<td>693.3*</td>
<td>39.6**</td>
<td>3.0 ns</td>
</tr>
<tr>
<td>(HHM; 50 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Among Crosses</td>
<td>29</td>
<td>82.2 ns</td>
<td>99.3 ns</td>
<td>36.1**</td>
<td>1.7**</td>
</tr>
<tr>
<td>(HHM; 35 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.2**</td>
</tr>
<tr>
<td>Among Crosses</td>
<td>29</td>
<td>263.5**</td>
<td>1337.7**</td>
<td>63.1**</td>
<td>2.7**</td>
</tr>
<tr>
<td>(LHM; 50 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.7 ns</td>
</tr>
<tr>
<td>Among Crosses</td>
<td>29</td>
<td>57.4**</td>
<td>19.3*</td>
<td>57.3**</td>
<td>3.5**</td>
</tr>
<tr>
<td>(LHM; 35 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.8**</td>
</tr>
<tr>
<td>Treatment * Y</td>
<td>119</td>
<td>970.6**</td>
<td>983.6**</td>
<td>14.9**</td>
<td>192.8**</td>
</tr>
<tr>
<td>HHM vs LHM * Y</td>
<td>1</td>
<td>736.9 ns</td>
<td>4052.3**</td>
<td>238.5**</td>
<td>2.2 ns</td>
</tr>
<tr>
<td>50 C vs 35 C HHM * Y</td>
<td>1</td>
<td>14685.8**</td>
<td>7054.3**</td>
<td>8.8 ns</td>
<td>0.9 ns</td>
</tr>
<tr>
<td>50 C vs 35 C LHM * Y</td>
<td>1</td>
<td>24072.9**</td>
<td>29120.3**</td>
<td>2.0**</td>
<td>30.7**</td>
</tr>
<tr>
<td>Crosses * Y</td>
<td>29</td>
<td>1150.8**</td>
<td>505.9 ns</td>
<td>8.1**</td>
<td>2.7**</td>
</tr>
<tr>
<td>(HHM; 50 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.2 ns</td>
</tr>
<tr>
<td>Crosses * Y</td>
<td>29</td>
<td>93.4 ns</td>
<td>133.8 ns</td>
<td>10.7**</td>
<td>1.0**</td>
</tr>
<tr>
<td>(HHM; 35 C)</td>
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<td></td>
<td>0.4 ns</td>
</tr>
<tr>
<td>Crosses * Y</td>
<td>29</td>
<td>1047.9**</td>
<td>1566.6**</td>
<td>17.6**</td>
<td>4.2**</td>
</tr>
<tr>
<td>(LHM; 50 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.4 ns</td>
</tr>
<tr>
<td>Crosses * Y</td>
<td>29</td>
<td>46.7**</td>
<td>15.4</td>
<td>16.4**</td>
<td>1.2**</td>
</tr>
<tr>
<td>(LHM; 35 C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4**</td>
</tr>
<tr>
<td>Error (Rep/Y)(trt-1)</td>
<td>476</td>
<td>344.1</td>
<td>384.1</td>
<td>2.6</td>
<td>0.97</td>
</tr>
<tr>
<td>Total</td>
<td>719</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.V. (%)</td>
<td>25</td>
<td>31.7</td>
<td>11.8</td>
<td>21.9</td>
<td>51.9</td>
</tr>
</tbody>
</table>

*, **Significant at 0.05 and 0.01 levels of probability, respectively. ns Nonsignificant at the 0.05 level of probability. HHM-high harvest moisture; LHM-low harvest moisture.
Table 7. Combined analysis of variance for general combining ability (GCA), specific combining ability (SCA) maternal and reciprocal effects for seed quality traits at high harvest moisture and 50°C drying temperature treatment

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Kermit weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td>(g)</td>
</tr>
<tr>
<td>Crosses</td>
<td>29</td>
<td>2615.4**</td>
<td>698.0*</td>
<td>39.6**</td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>4069.8**</td>
<td>1752.4**</td>
<td>118.0**</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>1955.2**</td>
<td>2241.1ns</td>
<td>7.9**</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>6429.5**</td>
<td>1054.7*</td>
<td>73.5**</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>575.3ns</td>
<td>404.5ns</td>
<td>12.0**</td>
</tr>
<tr>
<td>Crosses*Year</td>
<td>29</td>
<td>1150.8*</td>
<td>505.9ns</td>
<td>8.1**</td>
</tr>
<tr>
<td>GCA*Year</td>
<td>5</td>
<td>1471.5**</td>
<td>816.4*</td>
<td>9.7**</td>
</tr>
<tr>
<td>SCA*Year</td>
<td>9</td>
<td>1662.0*</td>
<td>283.9ns</td>
<td>4.5**</td>
</tr>
<tr>
<td>Maternal*Year</td>
<td>5</td>
<td>389.5*ns</td>
<td>594.6*ns</td>
<td>14.6**</td>
</tr>
<tr>
<td>Reciprocal*Year</td>
<td>10</td>
<td>969.3*</td>
<td>506.3*ns</td>
<td>9.2**</td>
</tr>
<tr>
<td>Error y(r-1)(c-1)</td>
<td>116</td>
<td>344.1</td>
<td>384.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.V. (%)</td>
<td></td>
<td>45.8</td>
<td>111.5</td>
<td>8.5</td>
</tr>
</tbody>
</table>

* Significant at 0.05 and 0.01 levels of probability, respectively.  
** Nonsignificant at the 0.05 level of probability.
treatment. All the sources were highly significant in warm germination except for the reciprocal component. However, mean squares due to the maternal effect was the largest; about 1.6 times that of GCA and 3.3 times that of SCA. In both 1984 and 1985, the maternal and GCA components showed highly significant effects in warm germination (Tables A1 and B1). Except for the maternal effects, all the genetic sources of variation had highly significant year effect in the combined analyses.

For cold germination, only the GCA and maternal components showed significant effects. Both had mean squares which were at least twice as large as that of the SCA or reciprocal components. In both 1984 and 1985, all the sources showed nonsignificant effects except for the GCA component which was highly significant in 1985 (Tables A1 and B1). This resulted in the significant \((P<0.05)\) GCA * year interaction for cold germination in the combined analyses.

For kernel weight, all the four genetic components displayed highly significant effects. However, GCA and maternal mean squares were still larger than those for SCA and reciprocal components. In 1984, maternal effect had the largest mean square followed by that of GCA. The effects of these components were not stable across years. In 1985, the GCA mean square was the largest and the reciprocal effects were nonsignificant (Table B1). These resulted in highly significant year effect in the combined analyses for these genetic components except for SCA (Table 7).

Seedling weight exhibited a highly significant response to maternal and GCA sources of variation. Both these showed highly significant year effect. GCA mean square was also large for shoot/root ratio although all
four components had highly significant effects. Like the seedling weight, highly significant interaction with year was also observed for all the sources of variation for the shoot/root ratio (Table 7).

Table 8 shows the means of germination, kernel weight, seedling weight and shoot/root ratio for the high harvest moisture and 50 C drying temperature treatment. Significant differences (P<0.05) were observed among the inbreds when used as seed parents for all the seed quality traits measured. Warm (standard) germination values ranged from 69% for A632 (tolerant) to 18% for B73 (intolerant). Mo17 was of intermediate performance. W64A proved to be tolerant in that for the two years, it had high warm germination percentages. Smaller differences were observed among these inbreds when used as male parents averaged across all females. A632 performed the poorest as a male (31%), though this was only significantly different from B14A and B73 (46%), the two best performing males in warm germination.

A similar trend was observed within the individual years with few changes in the ranking of inbred performance in germination. In 1984, W64A appeared to be the most tolerant seed parent with the highest warm germination value followed by A632. The reverse was true for the 1985 environment. As a female, B73 had the lowest warm germination value in 1984 but in 1985, Mo17 was the poorest female. More significant variability was observed between warm germination means in 1985 for the inbreds used as males (Tables A2 and B2).

Cold germination values were over 20% lower than warm germination values based on their overall means. This shows that the high harvest
Table 8. Germination, kernel weight, seedling dry weight and shoot/root ratio combined for 1984 and 1985 as affected by the inbred used either as the female or male parent. Means are for high harvest moisture and 50 C drying temperature treatment.

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>Female</td>
<td>------------</td>
<td>---------------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>A632</td>
<td>69.0a</td>
<td>12.0c</td>
<td>18.6c</td>
<td>26.2bc</td>
</tr>
<tr>
<td>A641</td>
<td>33.0c</td>
<td>15.0bc</td>
<td>18.1cd</td>
<td>29.8bc</td>
</tr>
<tr>
<td>E14A</td>
<td>21.0cd</td>
<td>9.0c</td>
<td>20.7b</td>
<td>30.8b</td>
</tr>
<tr>
<td>E73</td>
<td>16.0d</td>
<td>11.0c</td>
<td>17.0de</td>
<td>23.7c</td>
</tr>
<tr>
<td>Mo17</td>
<td>37.0b</td>
<td>26.0ab</td>
<td>22.6a</td>
<td>42.2a</td>
</tr>
<tr>
<td>W64A</td>
<td>62.0a</td>
<td>32.0a</td>
<td>16.7e</td>
<td>27.8bc</td>
</tr>
<tr>
<td>Means</td>
<td>40.5</td>
<td>17.6</td>
<td>19.0</td>
<td>30.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Male</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A632</td>
<td>31.0b</td>
<td>17.0a</td>
<td>18.9b</td>
<td>28.3a</td>
</tr>
<tr>
<td>A641</td>
<td>36.0ab</td>
<td>18.0a</td>
<td>17.3c</td>
<td>30.2a</td>
</tr>
<tr>
<td>E14A</td>
<td>48.0a</td>
<td>18.0a</td>
<td>18.8b</td>
<td>30.7a</td>
</tr>
<tr>
<td>E73</td>
<td>48.0a</td>
<td>17.0a</td>
<td>20.6a</td>
<td>31.4a</td>
</tr>
<tr>
<td>Mo17</td>
<td>41.0ab</td>
<td>19.0a</td>
<td>19.3ab</td>
<td>27.7a</td>
</tr>
<tr>
<td>W64A</td>
<td>40.0ab</td>
<td>17.0a</td>
<td>18.9b</td>
<td>33.5a</td>
</tr>
<tr>
<td>Means</td>
<td>40.5</td>
<td>17.6</td>
<td>19.0</td>
<td>30.3</td>
</tr>
</tbody>
</table>

1 Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
moisture seeds were more responsive to high drying temperature damage in the cold test (Table 8). However, wider range (9-32%) and significant variability was also observed among the seed parents compared to their performance as males (17-19%). W64A proved to be the best female in that it had the highest mean cold germination for both years. Mo17 was more tolerant than A632 as a seed parent in cold germination for both years. Variability among the inbreds used as male parents was nonsignificant.

Kernel weights displayed smaller but significant differences among inbreds when used either as female or males. B73 and Mo17 as male parents had the highest weights (Table 8). Values of seedling weight are reported as mg/normal seedling from the warm germination test. Like the other traits, large and significant differences existed among seed parents. Mo17 as the seed parent had the heaviest seedling weight. These differences were smaller and nonsignificant among inbred lines used as males. B73, Mo17, and W64A performed poorly compared to the other inbreds when used as male parents. W64A and B73 performed comparatively poorly as male parents. Shoot/root ratios were comparatively high compared to their values in the LHK/35C treatment (Table 17).

Hybrid means of seed quality traits from the high harvest moisture and 50 C drying temperature treatment are presented in Table 9. The performance of lines was very inconsistent though the inconsistency appears to be more pronounced in their performance as males. W64A however, showed some consistency in its performance as a male. Except for A641 x W64A, all hybrids in which W64A was involved as the pollen parent resulted in the highest warm germination within each seed parent. Crosses in which A632
Table 9. Effect of parentage on seed quality traits combined for 1984 and 1985 for seeds harvested at high moisture and dried at 50°C

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>female</td>
<td>male</td>
<td>warm cold</td>
<td></td>
</tr>
<tr>
<td>A632 x A641</td>
<td>59.0</td>
<td>23.0</td>
<td>15.7</td>
<td>26.1</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>57.0</td>
<td>8.0</td>
<td>16.5</td>
<td>17.1</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>81.0</td>
<td>4.0</td>
<td>20.9</td>
<td>24.4</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>72.0</td>
<td>10.0</td>
<td>20.4</td>
<td>29.1</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>77.0</td>
<td>14.0</td>
<td>19.4</td>
<td>34.4</td>
</tr>
<tr>
<td>A641 x A632</td>
<td>29.0</td>
<td>11.0</td>
<td>17.9</td>
<td>27.5</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>35.0</td>
<td>14.0</td>
<td>17.6</td>
<td>30.0</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>43.0</td>
<td>28.0</td>
<td>18.1</td>
<td>35.7</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>40.0</td>
<td>20.0</td>
<td>19.5</td>
<td>28.4</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>19.0</td>
<td>4.0</td>
<td>17.5</td>
<td>27.6</td>
</tr>
<tr>
<td>B14A x A632</td>
<td>28.0</td>
<td>13.0</td>
<td>21.6</td>
<td>27.6</td>
</tr>
<tr>
<td>B14A x A641</td>
<td>18.0</td>
<td>3.0</td>
<td>18.5</td>
<td>28.0</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>15.0</td>
<td>5.0</td>
<td>21.6</td>
<td>31.5</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>12.0</td>
<td>11.0</td>
<td>20.7</td>
<td>33.2</td>
</tr>
<tr>
<td>E14A x W64A</td>
<td>32.0</td>
<td>12.0</td>
<td>21.0</td>
<td>34.8</td>
</tr>
<tr>
<td>B73 x A632</td>
<td>9.0</td>
<td>4.0</td>
<td>16.7</td>
<td>18.1</td>
</tr>
<tr>
<td>B73 x A641</td>
<td>15.0</td>
<td>7.0</td>
<td>16.4</td>
<td>23.0</td>
</tr>
<tr>
<td>B73 x B14A</td>
<td>24.0</td>
<td>1.0</td>
<td>17.5</td>
<td>23.6</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>19.0</td>
<td>20.0</td>
<td>19.5</td>
<td>21.2</td>
</tr>
<tr>
<td>B73 x W64A</td>
<td>25.0</td>
<td>22.0</td>
<td>15.1</td>
<td>29.5</td>
</tr>
<tr>
<td>Mo17 x A632</td>
<td>30.0</td>
<td>18.0</td>
<td>21.8</td>
<td>32.3</td>
</tr>
<tr>
<td>Mo17 x A641</td>
<td>34.0</td>
<td>30.0</td>
<td>20.0</td>
<td>43.6</td>
</tr>
<tr>
<td>Mo17 x B14A</td>
<td>52.0</td>
<td>31.0</td>
<td>25.4</td>
<td>55.2</td>
</tr>
<tr>
<td>Mo17 x B73</td>
<td>28.0</td>
<td>18.0</td>
<td>24.3</td>
<td>39.1</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>43.0</td>
<td>32.0</td>
<td>21.4</td>
<td>40.2</td>
</tr>
<tr>
<td>W64A x A632</td>
<td>56.0</td>
<td>38.0</td>
<td>16.5</td>
<td>31.3</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>54.0</td>
<td>27.0</td>
<td>15.9</td>
<td>23.9</td>
</tr>
<tr>
<td>W64A x B14A</td>
<td>69.0</td>
<td>32.0</td>
<td>16.9</td>
<td>28.3</td>
</tr>
<tr>
<td>W64A x B73</td>
<td>70.0</td>
<td>32.0</td>
<td>17.6</td>
<td>27.7</td>
</tr>
<tr>
<td>W64A x Mo17</td>
<td>61.0</td>
<td>33.0</td>
<td>16.5</td>
<td>21.3</td>
</tr>
<tr>
<td>Means</td>
<td>40.5</td>
<td>17.6</td>
<td>19.0</td>
<td>38.3</td>
</tr>
<tr>
<td>L.S.D. (0.05)</td>
<td>21.2</td>
<td>22.4</td>
<td>1.9</td>
<td>1.1</td>
</tr>
</tbody>
</table>
(tolerant) was the male parent did not always result in seeds tolerant of high drying temperatures; Mo17 x A632 gave F₁ seeds which were intolerant even though seeds from the reciprocal cross (A632 x Mo17) were tolerant.

Crosses in which B73 and Mo17 were the pollen parents consistently resulted in high kernel weights. This was most evident especially when the small seeded lines, A632, A641, and W64A were the seed parents of the hybrids. This was also reflected in the seedling weights in that such hybrids were consistently the most vigorous within a given seed parent. Hybrids with A632, E14A, B73 and Mo17 as the seed parents and W64A as the pollen parent resulted in high seedling weights even though the kernel weight in some cases was not high. The shoot/root ratios were, however, lower for crosses in which W64A was the seed parent regardless of the pollen parent compared to the other crosses.

None of the genetic sources of variation showed significant effects in both warm and cold germinations for the high harvest moisture and 35 C drying treatments (Table 10). However, mean square values for GCA and maternal components were still about two times larger than SCA and reciprocal components. Only the maternal component showed instability across years in that the maternal * year interaction effect was highly significant in cold germination. In the 1985 (Table E4), GCA, maternal and reciprocal effects were also highly significant for warm germination and the later two were highly significant for cold germination. However, these effects were nonsignificant in 1984 (Table A4) even though they had large mean squares. For kernel weight, only SCA was nonsignificant even though both GCA and the maternal components were the largest. Both the GCA and
Table 10. Combined analysis of variance for general combining ability (GCA), specific combining ability (SCA) maternal and reciprocal effects for seed quality traits at high harvest moisture and 35°C drying temperature treatment

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crosses</td>
<td>29</td>
<td>82.2^ns</td>
<td>99.3^ns</td>
<td>36.1**</td>
<td>1.7**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.7**</td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>134.1^ns</td>
<td>176.6^ns</td>
<td>92.7**</td>
<td>3.1**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.2**</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>66.1^ns</td>
<td>38.4^ns</td>
<td>3.3^ns</td>
<td>1.4**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.9**</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>101.8^ns</td>
<td>195.7^ns</td>
<td>91.2**</td>
<td>2.7**</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.0**</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>61.0^ns</td>
<td>67.2^ns</td>
<td>9.5</td>
<td>0.8^ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.2^ns</td>
</tr>
<tr>
<td>Crosses * Year</td>
<td>29</td>
<td>93.4^ns</td>
<td>133.8^ns</td>
<td>10.7**</td>
<td>1.0**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.4^ns</td>
</tr>
<tr>
<td>GCA * Y</td>
<td>5</td>
<td>143.6^ns</td>
<td>172.8^ns</td>
<td>14.2**</td>
<td>1.9**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.2**</td>
</tr>
<tr>
<td>SCA * Y</td>
<td>9</td>
<td>35.6^ns</td>
<td>54.9**</td>
<td>6.2^ns</td>
<td>0.6^ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.3*</td>
</tr>
<tr>
<td>Maternal * Y</td>
<td>5</td>
<td>234.2^ns</td>
<td>336.7**</td>
<td>27.7**</td>
<td>2.2**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>Reciprocal * Y</td>
<td>10</td>
<td>40.2^ns</td>
<td>84.2^ns</td>
<td>4.2^ns</td>
<td>0.3^ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.7^ns</td>
</tr>
<tr>
<td>Error y(r-1)(c-1)</td>
<td>116</td>
<td>86.5</td>
<td>98.5</td>
<td>3.7</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.3</td>
</tr>
</tbody>
</table>

| Total               | 174                |             |                   |                      |                 |

C.V. (%) |

9.7 | 10.4 | 10 | 13.4 | 22

*, **Significant at 0.05 and 0.01 levels of probability, respectively.

^ns Nonsignificant at the 0.05 level of probability.
maternal components displayed highly significant interaction with the year. Both GCA and maternal sources of variation were also highly significant for seedling weight, but like kernel weight, it had a highly significant year interaction. Shoot/root ratio exhibited a similar behavior across the two years (Table 10).

Drying high moisture seeds at 35 C did not produce significant differences among the inbreds when used as seed parents in warm germination (Table 11). Significant differences were, however, observed among them in cold test. All six lines had germinations of 90% and above in both warm and cold tests when used as females or males. Significant differences was also observed among seed parents for kernel weight, seedling weight and shoot/root ratio. Differences among inbreds used as male parents were not significant for both warm and cold germinations though these differences were significant for the other traits. Even though both germination and seedling weight values were high, there seemed to have been some reduction in root development resulting in the higher shoot/root ratios compared to the LHM/35C treatment.

All hybrids except B73 x W64A and Mo17 x W64A had above 90% germination for both warm and cold germination values (Table 12). Even though kernel weights were lower in this treatment because of the early harvest, seedling weights were higher than when low moisture corn seeds were dried at 50 C (Table 14). This demonstrates how high drying temperature is harmful to seeds even at low harvest moistures.

Drying low moisture seeds at 50 C revealed that the highly significant variation observed among lines was due mainly to maternal and reciprocal
Table 11. Germination, kernel weight, seedling dry weight and shoot/root ratio combined for 1984 and 1985 as affected by the inbred used either as female or male parent. Means are for high harvest moisture and 35 C drying temperature treatment^1

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Warm (%)</td>
<td>Cold (%)</td>
<td>(g)</td>
</tr>
<tr>
<td>A632</td>
<td>99.0a</td>
<td>98.0a</td>
<td>18.8b</td>
<td>55.2ab</td>
</tr>
<tr>
<td>A641</td>
<td>94.0a</td>
<td>91.0bc</td>
<td>18.2b</td>
<td>53.8abc</td>
</tr>
<tr>
<td>B14A</td>
<td>96.0a</td>
<td>94.0ab</td>
<td>21.7a</td>
<td>50.9bc</td>
</tr>
<tr>
<td>E73</td>
<td>96.0a</td>
<td>98.0a</td>
<td>17.5bc</td>
<td>50.3c</td>
</tr>
<tr>
<td>Mx17</td>
<td>94.0a</td>
<td>90.0c</td>
<td>22.4a</td>
<td>57.7a</td>
</tr>
<tr>
<td>W64A</td>
<td>96.0a</td>
<td>97.0ab</td>
<td>16.6d</td>
<td>50.9bc</td>
</tr>
</tbody>
</table>

|        | Male        | Warm (%)      | Cold (%)       | (g)             | (mg)            | |
| A632   | 97.0a       | 95.0a         | 19.5a          | 50.8bc          | 2.4ab           |
| A641   | 94.0a       | 94.0a         | 17.9b          | 51.0bc          | 2.4ab           |
| B14A   | 97.0a       | 95.0a         | 18.7ab         | 49.0c           | 2.5a            |
| E73    | 95.0a       | 96.0a         | 20.2a          | 56.7a           | 2.1c            |
| Mx17   | 95.0a       | 93.0a         | 19.2ab         | 55.0ab          | 2.1c            |
| W64A   | 92.0a       | 94.0a         | 18.6a          | 56.2a           | 2.2bc           |

Means 95.6 95.0 19.2 53.1 2.3

^1Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table 12. Effect of parentage on seed quality traits combined for 1984 and 1985 for seeds harvested at high moisture and dried at 35°C

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>female</td>
<td>male</td>
<td>warm</td>
<td>cold</td>
</tr>
<tr>
<td>A632 x A641</td>
<td>98.0</td>
<td>97.0</td>
<td>16.4</td>
<td>51.9</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>99.0</td>
<td>98.0</td>
<td>18.7</td>
<td>46.2</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>99.0</td>
<td>99.0</td>
<td>19.1</td>
<td>54.3</td>
</tr>
<tr>
<td>A632 x No17</td>
<td>98.0</td>
<td>99.0</td>
<td>19.9</td>
<td>57.9</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>100.0</td>
<td>99.0</td>
<td>19.8</td>
<td>64.3</td>
</tr>
<tr>
<td>E73 x A632</td>
<td>98.0</td>
<td>98.0</td>
<td>17.3</td>
<td>51.3</td>
</tr>
<tr>
<td>E73 x A641</td>
<td>98.0</td>
<td>98.0</td>
<td>16.4</td>
<td>50.6</td>
</tr>
<tr>
<td>E73 x B14A</td>
<td>97.0</td>
<td>95.0</td>
<td>19.3</td>
<td>55.7</td>
</tr>
<tr>
<td>E73 x B73</td>
<td>97.0</td>
<td>96.0</td>
<td>21.2</td>
<td>54.8</td>
</tr>
<tr>
<td>E73 x W64A</td>
<td>97.0</td>
<td>94.0</td>
<td>17.2</td>
<td>55.9</td>
</tr>
<tr>
<td>No17 x A632</td>
<td>99.0</td>
<td>99.0</td>
<td>20.4</td>
<td>58.2</td>
</tr>
<tr>
<td>No17 x A641</td>
<td>95.0</td>
<td>91.0</td>
<td>19.7</td>
<td>55.2</td>
</tr>
<tr>
<td>No17 x B14A</td>
<td>96.0</td>
<td>86.0</td>
<td>22.9</td>
<td>55.1</td>
</tr>
<tr>
<td>No17 x B73</td>
<td>91.0</td>
<td>93.0</td>
<td>22.9</td>
<td>61.1</td>
</tr>
<tr>
<td>No17 x W64A</td>
<td>83.0</td>
<td>83.0</td>
<td>23.2</td>
<td>58.0</td>
</tr>
<tr>
<td>W64A x A632</td>
<td>100.0</td>
<td>92.0</td>
<td>15.8</td>
<td>50.8</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>93.0</td>
<td>98.0</td>
<td>16.9</td>
<td>51.3</td>
</tr>
<tr>
<td>W64A x B14A</td>
<td>96.0</td>
<td>97.0</td>
<td>16.9</td>
<td>47.2</td>
</tr>
<tr>
<td>W64A x B73</td>
<td>95.0</td>
<td>98.0</td>
<td>17.3</td>
<td>57.2</td>
</tr>
<tr>
<td>W64A x No17</td>
<td>97.0</td>
<td>98.0</td>
<td>16.1</td>
<td>46.2</td>
</tr>
<tr>
<td>Means</td>
<td>95.2</td>
<td>94.5</td>
<td>19.2</td>
<td>55.0</td>
</tr>
<tr>
<td>L.S.D (0.05)</td>
<td>10.6</td>
<td>11.5</td>
<td>2.2</td>
<td>0.82</td>
</tr>
</tbody>
</table>
effects in the warm germination test (Table 13). For cold germination and kernel weight, the maternal and GCA components showed highly significant effects. Only GCA * year and SCA * year effects were highly significant for cold germination. For kernel weight, SCA mean square was larger than that of the maternal component and had a highly significant effect. Both GCA and maternal components had highly significant interactions with the year. For this treatment, shoot/root ratio mean squares did not differ significantly for any of the genetic components.

The differences among the means of these lines when used as seed parents were smaller, though significant (Table 14), than in the high harvest moisture and 50 C treatment (Table 8). The values for germination, kernel weight and seedling dry weights were higher than in the high harvest moisture and 50 C treatment. Values of the cold germination test were, however, still lower than warm germination; an indication of the greater responsiveness of the cold test of seeds to drying injury. Differences among inbreds used as male parents were also significant except for cold germination and shoot/root ratios. The performance and ranking of these inbreds was completely different from that observed when seeds were harvested at high moisture and dried at 50 C. B14A, A641 and B73 were ranked as the best seed parents in warm and cold test performance (Table 14). Even though ranking the inbreds according to their performance in germination changed each year, B14A exhibited consistency in being in the top three each year (Tables A8 and B8). As males, W64A and K017 performed better in both warm and cold germinations for the two years. K017 performed better as a male parent than as female.
Table 13. Combined analysis of variance for general combining ability (GCA), specific combining ability (SCA) maternal and reciprocal effects for seed quality traits at low harvest moisture and 50 C drying temperature treatment.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean Squares</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crosses</td>
<td>29</td>
<td>936.5**</td>
<td>1337.7**</td>
<td>63.1**</td>
<td>2.7**</td>
<td>3.7ns</td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>363.7ns</td>
<td>1817.4*</td>
<td>177.1*</td>
<td>7.8**</td>
<td>5.5ns</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>493.3**</td>
<td>874.2</td>
<td>13.5</td>
<td>2.5**</td>
<td>2.7ns</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>2662.0**</td>
<td>3125.6**</td>
<td>142.7**</td>
<td>2.2*</td>
<td>2.3ns</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>837.4**</td>
<td>621.1ns</td>
<td>11.0</td>
<td>0.6ns</td>
<td>3.4ns</td>
</tr>
<tr>
<td>Crosses * Y</td>
<td>29</td>
<td>1048.0**</td>
<td>1566.6**</td>
<td>17.0</td>
<td>4.2**</td>
<td>3.4ns</td>
</tr>
<tr>
<td>GCA * Y</td>
<td>5</td>
<td>1430.0**</td>
<td>4289.0**</td>
<td>16.9</td>
<td>7.2**</td>
<td>3.1ns</td>
</tr>
<tr>
<td>SCA * Y</td>
<td>9</td>
<td>865.4**</td>
<td>1200.3**</td>
<td>58.8**</td>
<td>1.1ns</td>
<td>4.7ns</td>
</tr>
<tr>
<td>Maternal * Y</td>
<td>5</td>
<td>1543.2**</td>
<td>88.3ns</td>
<td>47.4</td>
<td>12.1**</td>
<td>2.8ns</td>
</tr>
<tr>
<td>Reciprocal * Y</td>
<td>10</td>
<td>773.6**</td>
<td>499.1hs</td>
<td>13.1*</td>
<td>1.5ns</td>
<td>3.8ns</td>
</tr>
<tr>
<td>Error y(r-1)(c-1)</td>
<td>116</td>
<td>301.7</td>
<td>436.3</td>
<td>5.3</td>
<td>0.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.V. (%)</td>
<td></td>
<td>26</td>
<td>53.9</td>
<td>9.7</td>
<td>20.7</td>
<td>62.9</td>
</tr>
</tbody>
</table>

*, **Significant at 0.05 and 0.01 levels of probability, respectively.
nsSignificant at the 0.05 level of probability.
Table 14. Germination, kernel weight, seedling weight and shoot/root ratio combined for 1984 and 1985 as affected by the inbred used either as female or male parent. Means are for low harvest moisture and 50 C drying temperature treatment.

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>68.0ab</td>
<td>20.0c</td>
<td>21.8de</td>
<td>39.5bc</td>
</tr>
<tr>
<td>A641</td>
<td>75.0a</td>
<td>59.0a</td>
<td>22.2cd</td>
<td>43.3a</td>
</tr>
<tr>
<td>B14A</td>
<td>76.0a</td>
<td>43.0b</td>
<td>25.7b</td>
<td>39.1c</td>
</tr>
<tr>
<td>B73</td>
<td>70.0ab</td>
<td>43.0b</td>
<td>23.8c</td>
<td>39.8bc</td>
</tr>
<tr>
<td>Mo17</td>
<td>51.0c</td>
<td>35.0b</td>
<td>28.6a</td>
<td>44.5ab</td>
</tr>
<tr>
<td>W64A</td>
<td>62.0b</td>
<td>33.0bc</td>
<td>20.3e</td>
<td>48.0a</td>
</tr>
<tr>
<td></td>
<td>Means</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>66.8</td>
<td>38.8</td>
<td>23.8</td>
<td>43.2</td>
</tr>
</tbody>
</table>

Male

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>64.0bc</td>
<td>42.0a</td>
<td>23.6abc</td>
<td>42.3ab</td>
</tr>
<tr>
<td>A641</td>
<td>67.0abc</td>
<td>36.0a</td>
<td>22.2c</td>
<td>42.3ab</td>
</tr>
<tr>
<td>B14A</td>
<td>60.0c</td>
<td>37.0a</td>
<td>23.7abc</td>
<td>37.3c</td>
</tr>
<tr>
<td>B73</td>
<td>64.0bc</td>
<td>37.0a</td>
<td>25.3a</td>
<td>45.9a</td>
</tr>
<tr>
<td>Mo17</td>
<td>76.0a</td>
<td>41.0a</td>
<td>23.2bc</td>
<td>45.8a</td>
</tr>
<tr>
<td>W64A</td>
<td>71.0ab</td>
<td>42.0a</td>
<td>24.6ab</td>
<td>45.8a</td>
</tr>
<tr>
<td></td>
<td>Means</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>66.8</td>
<td>38.8</td>
<td>23.8</td>
<td>43.2</td>
</tr>
</tbody>
</table>

1 Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table 15 shows the hybrid means of the LHK/50 C treatment. A632 x Mo17 and W64A x Mo17 (tolerant x intolerant), resulted in good warm germination but the reciprocals gave comparatively poor values. Except for A632 x W64A, hybrids in which A632 was the female parent resulted in lower cold germination values compared to the overall hybrid mean. This was similar to that observed in the high harvest moisture and 50 C drying treatment. Again, hybrids with B73 and Mo17 as the pollen parents exhibited high values of kernel weight regardless of the seed parent. Hybrids with W64A as the pollen parent displayed high values of seedling weight regardless of the seed parent.

For the low harvest moisture and 35 C drying temperature treatment, the mean squares for all the four genetic sources of variation were comparatively lower than in the other treatments (Table 16). Both maternal and SCA were highly significant for warm germination. GCA was significant only at the 5% level. Only SCA * year interaction was highly significant. In 1984, the SCA component was by far the largest and was highly significant (Table A10). In 1985 however, no significant differences were observed among the mean squares of the genetic components for warm germination (Table B10). For cold germination, only GCA was highly significant in the combined analysis. Variability among these lines for kernel weight seemed to be determined, mostly by the maternal and GCA components. These two were highly significant and did not show significant year effect. A similar situation was observed for seedling weight. Even though the mean squares for three of these components were highly significant, for shoot/root ratios, GCA displayed the largest mean square
Table 15. Effect of parentage on seed quality traits combined for 1984 and 1985 for seeds harvested at low moisture and dried at 50 \( ^\circ \)C.

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>female</td>
<td>male</td>
<td>warm</td>
<td>cold</td>
</tr>
<tr>
<td>A632 x A641</td>
<td>70.0</td>
<td>21.0</td>
<td>19.1</td>
<td>37.9</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>57.0</td>
<td>13.0</td>
<td>21.3</td>
<td>28.4</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>57.0</td>
<td>7.0</td>
<td>24.0</td>
<td>42.2</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>69.0</td>
<td>24.0</td>
<td>23.3</td>
<td>43.8</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>86.0</td>
<td>36.0</td>
<td>20.8</td>
<td>45.0</td>
</tr>
<tr>
<td>A641 x A632</td>
<td>71.0</td>
<td>57.0</td>
<td>19.2</td>
<td>43.1</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>79.0</td>
<td>61.0</td>
<td>22.7</td>
<td>41.4</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>77.0</td>
<td>63.0</td>
<td>24.2</td>
<td>49.0</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>73.0</td>
<td>63.0</td>
<td>23.3</td>
<td>58.8</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>67.0</td>
<td>48.0</td>
<td>21.3</td>
<td>49.4</td>
</tr>
<tr>
<td>B14A x A632</td>
<td>76.0</td>
<td>40.0</td>
<td>27.0</td>
<td>30.8</td>
</tr>
<tr>
<td>B14A x A641</td>
<td>73.0</td>
<td>50.0</td>
<td>23.1</td>
<td>37.0</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>77.0</td>
<td>46.0</td>
<td>26.8</td>
<td>38.4</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>71.0</td>
<td>40.0</td>
<td>24.8</td>
<td>41.4</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>83.0</td>
<td>42.0</td>
<td>27.1</td>
<td>48.1</td>
</tr>
<tr>
<td>B73 x A632</td>
<td>60.0</td>
<td>43.0</td>
<td>25.1</td>
<td>40.7</td>
</tr>
<tr>
<td>B73 x A641</td>
<td>67.0</td>
<td>44.0</td>
<td>22.6</td>
<td>37.8</td>
</tr>
<tr>
<td>B73 x B14A</td>
<td>64.0</td>
<td>45.0</td>
<td>23.4</td>
<td>38.7</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>77.0</td>
<td>27.0</td>
<td>24.9</td>
<td>34.9</td>
</tr>
<tr>
<td>B73 x W64A</td>
<td>81.0</td>
<td>55.0</td>
<td>22.8</td>
<td>46.8</td>
</tr>
<tr>
<td>Mo17 x A632</td>
<td>59.0</td>
<td>40.0</td>
<td>28.4</td>
<td>46.5</td>
</tr>
<tr>
<td>Mo17 x A641</td>
<td>68.0</td>
<td>50.0</td>
<td>25.0</td>
<td>52.3</td>
</tr>
<tr>
<td>Mo17 x B14A</td>
<td>36.0</td>
<td>22.0</td>
<td>29.9</td>
<td>35.9</td>
</tr>
<tr>
<td>Mo17 x B73</td>
<td>55.0</td>
<td>34.0</td>
<td>30.2</td>
<td>46.8</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>40.0</td>
<td>31.0</td>
<td>29.8</td>
<td>41.0</td>
</tr>
<tr>
<td>W64A x A632</td>
<td>52.0</td>
<td>29.0</td>
<td>18.1</td>
<td>50.3</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>56.0</td>
<td>13.0</td>
<td>20.9</td>
<td>45.8</td>
</tr>
<tr>
<td>W64A x B14A</td>
<td>64.0</td>
<td>35.0</td>
<td>21.1</td>
<td>42.0</td>
</tr>
<tr>
<td>W64A x B73</td>
<td>55.0</td>
<td>35.0</td>
<td>21.5</td>
<td>51.9</td>
</tr>
<tr>
<td>W64A x Mo17</td>
<td>86.0</td>
<td>52.0</td>
<td>19.7</td>
<td>50.0</td>
</tr>
<tr>
<td>Means</td>
<td>65.7</td>
<td>38.5</td>
<td>23.5</td>
<td>42.7</td>
</tr>
<tr>
<td>L.S.D. (0.05)</td>
<td>19.9</td>
<td>24.1</td>
<td>2.7</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Table 16. Combined analysis of variance for general combining ability (GCA), specific combining ability (SCA) maternal and reciprocal effects for seed quality traits at low harvest moisture and 35 C drying temperature treatment

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crosses</td>
<td>29</td>
<td>57.4**</td>
<td>19.3*</td>
<td>57.3**</td>
<td>3.5**</td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>56.6*</td>
<td>44.4</td>
<td>129.5*</td>
<td>13.4*</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>74.1**</td>
<td>18.3ns</td>
<td>12.9*</td>
<td>0.97*</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>87.0**</td>
<td>16.1ns</td>
<td>167.4**</td>
<td>3.6**</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>27.2ns</td>
<td>9.2ns</td>
<td>5.1ns</td>
<td>0.74*</td>
</tr>
<tr>
<td>Crosses * Year</td>
<td>29</td>
<td>46.7**</td>
<td>15.4ns</td>
<td>16.4**</td>
<td>1.2**</td>
</tr>
<tr>
<td>GCA * Y</td>
<td>5</td>
<td>26.4ns</td>
<td>15.4ns</td>
<td>46.6**</td>
<td>1.3**</td>
</tr>
<tr>
<td>SCA * Y</td>
<td>9</td>
<td>94.9**</td>
<td>20.4ns</td>
<td>5.2**</td>
<td>0.5**</td>
</tr>
<tr>
<td>Maternal * Y</td>
<td>5</td>
<td>28.3ns</td>
<td>11.5ns</td>
<td>19.4</td>
<td>3.9</td>
</tr>
<tr>
<td>Reciprocal * Y</td>
<td>10</td>
<td>23.1ns</td>
<td>13.0ns</td>
<td>10.1ns</td>
<td>0.5ns</td>
</tr>
<tr>
<td>Error y(r-1)(c-1)</td>
<td>116</td>
<td>21.0</td>
<td>11.7</td>
<td>5.8</td>
<td>0.3</td>
</tr>
</tbody>
</table>

C.V. (%)  

4.7  3.4  10  9.2  17.5

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.  
ns Nonsignificant at the 0.05 level of probability.
followed by the maternal component. Except for the reciprocal effect, all components showed a highly significant year effect.

Warm and cold germination values were high for inbreds used as females or males at the low harvest moisture and dried at 35 C (Table 17). Only A641, as female parent performed significantly lower than the other lines. For kernel weight, seedling weight and shoot/root ratio the differences observed among inbreds were significant when used either as females or males.

Both warm and cold germination values were above 90% for all hybrid seeds (Table 18). Values for kernel weight and seedling weight were also high for each hybrid compared to the high harvest moisture and 50 C drying treatment.

GCA estimates for the six lines for four of the five measured traits at the high harvest moisture and 50C are reported in Table 19. Both A632 and W64A (tolerant lines) displayed high positive GCA effects in warm germination in the combined analysis. B73 had the largest negative value. A highly significant year effect was displayed by these values. In 1984, Mo17 had a positive GCA effect but in 1985 this effect was negative. Mo17 and W64A consistently had the highest positive GCA values in the cold test. A632 had a low negative value in each year. There was also lack of consistency in line performance with regards to kernel and seedling weight. However, over the period of 2 years, Mo17 had the highest positive GCA effect for kernel weight and seedling weight followed by B14A.

When high moisture seeds were dried at 35C, (Table 20), A632 showed
Table 17. Germination, kernel weight, seedling dry weight and shoot/root ratio combined for 1984 and 1985 as affected by the inbred either used as a female or male parent. Means are for low harvest moisture and 35 C drying temperature treatment.

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>99.0a</td>
<td>98.0a</td>
<td>21.9cd</td>
<td>56.7c</td>
</tr>
<tr>
<td>A641</td>
<td>94.0b</td>
<td>95.0b</td>
<td>22.5c</td>
<td>60.9b</td>
</tr>
<tr>
<td>B14A</td>
<td>96.0ab</td>
<td>98.0a</td>
<td>25.3b</td>
<td>60.5bc</td>
</tr>
<tr>
<td>E73</td>
<td>99.0a</td>
<td>99.0a</td>
<td>24.7b</td>
<td>63.5b</td>
</tr>
<tr>
<td>Mo17</td>
<td>99.0a</td>
<td>97.0a</td>
<td>28.9a</td>
<td>73.2a</td>
</tr>
<tr>
<td>W64A</td>
<td>99.0a</td>
<td>99.0a</td>
<td>20.4d</td>
<td>62.5b</td>
</tr>
<tr>
<td>Means</td>
<td>97.7</td>
<td>97.7</td>
<td>24.0</td>
<td>63.0</td>
</tr>
</tbody>
</table>

| Male   |       |       |     |      |                |
| A632   | 96.0a | 97.0a | 24.2ab| 58.0c | 1.9a            |
| A641   | 98.0a | 97.0a | 23.2b | 61.9cd| 1.9a            |
| B14A   | 98.0a | 97.0a | 23.1b | 58.7c | 1.9a            |
| E73    | 96.0a | 99.0a | 25.2a | 65.2b | 1.7b            |
| Mo17   | 99.0a | 98.0a | 23.1b | 64.2b | 1.4bc           |
| W64A   | 99.0a | 98.0a | 25.2a | 70.3a | 1.4c            |
| Means  | 97.7  | 97.7  | 24.0  | 63.0  | 1.7             |

Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table 18. Effect of parentage on seed quality traits combined for 1984 and 1985 for seeds harvested at low moisture and dried at 35°C

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>female</td>
<td>male</td>
<td>warm</td>
<td>cold</td>
</tr>
<tr>
<td>A532 x A641</td>
<td>99.0</td>
<td>94.0</td>
<td>19.4</td>
<td>56.4</td>
</tr>
<tr>
<td>A532 x B14A</td>
<td>99.0</td>
<td>98.0</td>
<td>20.8</td>
<td>48.5</td>
</tr>
<tr>
<td>A532 x B73</td>
<td>98.0</td>
<td>99.0</td>
<td>24.0</td>
<td>56.4</td>
</tr>
<tr>
<td>A532 x Mo17</td>
<td>100.0</td>
<td>98.0</td>
<td>22.2</td>
<td>59.0</td>
</tr>
<tr>
<td>A532 x W64A</td>
<td>100.0</td>
<td>98.0</td>
<td>22.8</td>
<td>62.8</td>
</tr>
<tr>
<td>A641 x A632</td>
<td>87.0</td>
<td>94.0</td>
<td>21.4</td>
<td>55.6</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>97.0</td>
<td>95.0</td>
<td>22.4</td>
<td>55.9</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>97.0</td>
<td>98.0</td>
<td>24.9</td>
<td>68.0</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>96.0</td>
<td>97.0</td>
<td>22.6</td>
<td>65.3</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>94.0</td>
<td>92.0</td>
<td>21.0</td>
<td>61.0</td>
</tr>
<tr>
<td>B14A x A632</td>
<td>98.0</td>
<td>98.0</td>
<td>24.7</td>
<td>48.9</td>
</tr>
<tr>
<td>B14A x A641</td>
<td>98.0</td>
<td>99.0</td>
<td>24.8</td>
<td>55.2</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>86.0</td>
<td>100.0</td>
<td>26.1</td>
<td>59.4</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>98.0</td>
<td>97.0</td>
<td>23.8</td>
<td>62.8</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>100.0</td>
<td>99.0</td>
<td>27.6</td>
<td>76.0</td>
</tr>
<tr>
<td>B73 x A632</td>
<td>99.0</td>
<td>98.0</td>
<td>26.8</td>
<td>54.4</td>
</tr>
<tr>
<td>B73 x A641</td>
<td>100.0</td>
<td>100.0</td>
<td>22.5</td>
<td>61.4</td>
</tr>
<tr>
<td>B73 x B14A</td>
<td>96.0</td>
<td>96.0</td>
<td>23.9</td>
<td>60.0</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>100.0</td>
<td>99.0</td>
<td>26.6</td>
<td>70.5</td>
</tr>
<tr>
<td>B73 x W64A</td>
<td>99.0</td>
<td>100.0</td>
<td>23.5</td>
<td>71.2</td>
</tr>
<tr>
<td>Mo17 x A632</td>
<td>98.0</td>
<td>97.0</td>
<td>28.7</td>
<td>72.5</td>
</tr>
<tr>
<td>Mo17 x A641</td>
<td>98.0</td>
<td>96.0</td>
<td>28.2</td>
<td>71.0</td>
</tr>
<tr>
<td>Mo17 x B14A</td>
<td>100.0</td>
<td>98.0</td>
<td>27.8</td>
<td>69.1</td>
</tr>
<tr>
<td>Mo17 x B73</td>
<td>98.0</td>
<td>97.0</td>
<td>29.9</td>
<td>75.7</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>100.0</td>
<td>100.0</td>
<td>29.7</td>
<td>77.7</td>
</tr>
<tr>
<td>W64A x A632</td>
<td>99.0</td>
<td>98.0</td>
<td>19.4</td>
<td>58.4</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>98.0</td>
<td>97.0</td>
<td>20.4</td>
<td>64.8</td>
</tr>
<tr>
<td>W64A x B14A</td>
<td>98.0</td>
<td>98.0</td>
<td>20.4</td>
<td>59.9</td>
</tr>
<tr>
<td>W64A x B73</td>
<td>100.0</td>
<td>100.0</td>
<td>21.3</td>
<td>65.9</td>
</tr>
<tr>
<td>W64A x Mo17</td>
<td>99.0</td>
<td>100.0</td>
<td>20.3</td>
<td>63.2</td>
</tr>
</tbody>
</table>

Means 97.5 96.7 23.7 62.0 1.7

L.S.D. (0.05) 5.3 3.9 2.8 0.66 0.3
Table 19. Estimates of GCA effects for seed quality traits for high harvest moisture and 50°C drying temperature treatment

<table>
<thead>
<tr>
<th>Inbred</th>
<th>1984</th>
<th>1985</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Germination Warm</td>
<td>Cold</td>
<td>Kernel Warm</td>
</tr>
<tr>
<td></td>
<td>weight (g)</td>
<td></td>
<td>weight (mg)</td>
</tr>
<tr>
<td>A632</td>
<td>7.25</td>
<td>-8.38</td>
<td>-0.99</td>
</tr>
<tr>
<td>A641</td>
<td>-2.46</td>
<td>-1.50</td>
<td>-0.74</td>
</tr>
<tr>
<td>B14A</td>
<td>-13.8</td>
<td>-10.13</td>
<td>0.70</td>
</tr>
<tr>
<td>B73</td>
<td>-17.7</td>
<td>-6.75</td>
<td>-0.44</td>
</tr>
<tr>
<td>Ho17</td>
<td>3.92</td>
<td>11.13</td>
<td>2.46</td>
</tr>
<tr>
<td>W64A</td>
<td>22.79</td>
<td>15.63</td>
<td>-1.00</td>
</tr>
</tbody>
</table>

S.E.(+/-) 4.00 4.99 0.20 0.33 2.84 1.54 0.27 0.16 1.73 1.83 0.15 0.09
Table 20. Estimates of GCA effects for seed quality traits for high harvest moisture and 35 C drying temperature treatment

<table>
<thead>
<tr>
<th>Inbred</th>
<th>Germination (g)</th>
<th>Kernel weight (mg)</th>
<th>Sdling weight (mg)</th>
<th>Germination (g)</th>
<th>Kernel weight (mg)</th>
<th>Sdling weight (mg)</th>
<th>Germination (g)</th>
<th>Kernel weight (mg)</th>
<th>Sdling weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td></td>
<td></td>
<td></td>
<td>1985</td>
<td></td>
<td></td>
<td>Combined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>4.29</td>
<td>3.79</td>
<td>-0.86</td>
<td>1.13</td>
<td>-0.08</td>
<td>0.75</td>
<td>2.50</td>
<td>2.96</td>
<td>-0.03</td>
</tr>
<tr>
<td>A641</td>
<td>-0.33</td>
<td>-1.71</td>
<td>-0.69</td>
<td>-17.7</td>
<td>-2.00</td>
<td>-2.19</td>
<td>5.53</td>
<td>-0.92</td>
<td>-1.83</td>
</tr>
<tr>
<td>B14A</td>
<td>2.92</td>
<td>0.42</td>
<td>0.84</td>
<td>61.6</td>
<td>-0.75</td>
<td>-1.96</td>
<td>1.34</td>
<td>-6.83</td>
<td>0.96</td>
</tr>
<tr>
<td>B73</td>
<td>-0.58</td>
<td>2.42</td>
<td>-0.65</td>
<td>33.9</td>
<td>0.38</td>
<td>2.29</td>
<td>-0.10</td>
<td>5.27</td>
<td>0.04</td>
</tr>
<tr>
<td>Mo17</td>
<td>-2.96</td>
<td>-4.83</td>
<td>2.07</td>
<td>-1.8</td>
<td>1.88</td>
<td>1.79</td>
<td>1.99</td>
<td>1.97</td>
<td>-0.79</td>
</tr>
<tr>
<td>W64A</td>
<td>-3.33</td>
<td>-0.08</td>
<td>-0.87</td>
<td>-16.3</td>
<td>-0.63</td>
<td>0.29</td>
<td>-1.79</td>
<td>2.10</td>
<td>-2.17</td>
</tr>
</tbody>
</table>

S.E. (+/-) 2.42 2.52 0.42 0.18 0.24 0.78 0.29 0.17 0.87 0.92 0.18 0.07
the largest GCA effect followed by B14A in warm germination. Both B73 and Mol7 had positive GCA effects in 1985 but these effects were negative in 1984. A632 maintained a high positive GCA for cold germination. 873 had the largest GCA value under this treatment for cold germination. For kernel weight, both Mol7 and B14A had the largest GCA effects. However, this did not seem to affect seedling weight very much in that Mol7 showed the largest positive values followed by B73 and W64A.

The effect of 50C drying temperature on low moisture seeds produced a very dramatic results. All the inbred lines showed positive GCA effects except for A632 and Mol7 in warm germination (Table 21). This is an opposite behavior from that observed in the high harvest moisture and 50C drying treatment. Similar results were obtained for cold germination where both W64A and A632 had negative values. The lines that had positive GCA effects in 1984 for both warm and cold germinations had negative values in 1985 and vice versa. For kernel weight, E14A, B73 and Mol7 had positive GCA effects while A632, A641 and W64A, had negative values. Only A641, Mol7 and W64A gave positive values of GCA effects for seedling weight.

Under the low harvest moisture and 35C drying (Table 22) the combined analyses revealed that both Mol7 and W64A had the largest positive GCA effects for warm germination. In cold germination, only A632 and A641 had negative GCA values. B14A, B73 and Mol7 had positive values and the remaining three had negative GCA effects. Mol7 had the largest positive GCA effect for seedling weight followed by W64A and B73.

Maternal effects were larger than GCA effects although they followed similar trends for both warm and cold germinations in the high harvest
Table 21. Estimates of GCA effects for seed quality traits for low harvest moisture and 50 C drying temperature treatment

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm weight (g)</td>
<td>Cold weight (mg)</td>
<td></td>
<td>Warm weight (g)</td>
<td>Cold weight (mg)</td>
<td></td>
<td>Warm weight (g)</td>
<td>Cold weight (mg)</td>
<td></td>
</tr>
<tr>
<td>A641</td>
<td>-5.83</td>
<td>-5.46</td>
<td>-1.36</td>
<td>-0.94</td>
<td>13.46</td>
<td>22.71</td>
<td>-2.59</td>
<td>-2.30</td>
<td>4.04</td>
</tr>
<tr>
<td>B14A</td>
<td>5.42</td>
<td>10.42</td>
<td>0.86</td>
<td>-4.87</td>
<td>-1.04</td>
<td>-6.54</td>
<td>1.66</td>
<td>-5.88</td>
<td>1.42</td>
</tr>
<tr>
<td>B73</td>
<td>7.29</td>
<td>17.54</td>
<td>0.53</td>
<td>3.72</td>
<td>-5.79</td>
<td>-12.42</td>
<td>1.54</td>
<td>1.34</td>
<td>0.17</td>
</tr>
<tr>
<td>Mo17</td>
<td>-9.08</td>
<td>-3.96</td>
<td>3.31</td>
<td>3.52</td>
<td>0.33</td>
<td>3.08</td>
<td>2.29</td>
<td>3.76</td>
<td>-4.33</td>
</tr>
<tr>
<td>W64A</td>
<td>1.79</td>
<td>-3.32</td>
<td>-1.31</td>
<td>7.07</td>
<td>-2.79</td>
<td>-1.92</td>
<td>-2.19</td>
<td>-0.31</td>
<td>0.17</td>
</tr>
</tbody>
</table>

S.E.(+/-) 2.93 4.32 1.67 0.16 3.45 3.45 0.34 0.07 1.62 1.95 0.21 0.08
Table 22. Estimates of GCA effects for seed quality traits for low harvest moisture and 35 C drying temperature treatment

<table>
<thead>
<tr>
<th>Inbred</th>
<th>Germination</th>
<th>Kernel</th>
<th>Sdling</th>
<th>Germination</th>
<th>Kernel</th>
<th>Sdling</th>
<th>Germination</th>
<th>Kernel</th>
<th>Sdling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td></td>
<td>Warm</td>
<td>Cold</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weight</td>
<td>weight</td>
<td></td>
<td>weight</td>
<td>weight</td>
<td></td>
<td>weight</td>
<td>weight</td>
</tr>
<tr>
<td></td>
<td>1984</td>
<td></td>
<td></td>
<td>1985</td>
<td></td>
<td></td>
<td>Combined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>1.88</td>
<td>0.75</td>
<td>-2.61</td>
<td>-9.78</td>
<td>-0.83</td>
<td>-1.08</td>
<td>0.25</td>
<td>-3.84</td>
<td>-0.083</td>
</tr>
<tr>
<td>A641</td>
<td>-2.75</td>
<td>0.25</td>
<td>0.10</td>
<td>-2.53</td>
<td>-1.46</td>
<td>-1.33</td>
<td>-2.81</td>
<td>-2.64</td>
<td>-1.54</td>
</tr>
<tr>
<td>B14A</td>
<td>-2.50</td>
<td>0.75</td>
<td>-0.27</td>
<td>-2.25</td>
<td>0.54</td>
<td>0.33</td>
<td>0.95</td>
<td>-4.54</td>
<td>0.79</td>
</tr>
<tr>
<td>B73</td>
<td>-0.88</td>
<td>1.25</td>
<td>1.32</td>
<td>2.92</td>
<td>0.42</td>
<td>1.54</td>
<td>1.15</td>
<td>1.06</td>
<td>-0.417</td>
</tr>
<tr>
<td>Mo17</td>
<td>3.00</td>
<td>-0.25</td>
<td>3.29</td>
<td>5.50</td>
<td>0.67</td>
<td>0.67</td>
<td>1.89</td>
<td>6.61</td>
<td>1.33</td>
</tr>
<tr>
<td>W64A</td>
<td>1.25</td>
<td>0.25</td>
<td>-1.63</td>
<td>5.75</td>
<td>0.67</td>
<td>0.54</td>
<td>-1.43</td>
<td>3.34</td>
<td>1.33</td>
</tr>
<tr>
<td>S.E.(+/-)</td>
<td>1.08</td>
<td>0.69</td>
<td>0.13</td>
<td>0.57</td>
<td>0.58</td>
<td>0.58</td>
<td>0.30</td>
<td>0.08</td>
<td>0.43</td>
</tr>
</tbody>
</table>

GCA Effects
moisture and 50C drying treatment (Table 23). Both A632 and W64A showed very large maternal effects in warm germination. The largest maternal effect was displayed by Mo17 for kernel and seedling weights. B73 had the largest negative maternal effect for both kernel and seedling weights under this treatment. Most of the inbreds displayed positive maternal effects for seedling weight.

The high harvest moisture and 35C drying treatment showed that W64A had the largest maternal effects in both warm and cold germination (Table 24) even though it had negative GCA value from the same treatment (Table 20). A632 and B73 also displayed positive maternal effects in warm and cold germination. Mo17 displayed negative values for both germinations because it performed poorly as a seed parent. Values for kernel and seedling weights followed similar trends to those observed in the high moisture and 50C drying treatment. Mo17, however, had the largest positive maternal effect for both of these traits.

Maternal effects for seed quality traits in the combined analysis at the low harvest moisture and 50C drying treatment were unique (Table 25). All inbreds displayed large positive maternal effects except for Mo17 and W64A in warm germination. Similar results were obtained for cold germination except that A632 displayed a low negative value. Values for kernel and seedling weights followed similar trends, again Mo17 exhibiting the largest value for kernel weight but a negative value for seedling weight.

Only two of the lines showed negative maternal effects in warm germination for the low harvest moisture and 35C treatment (Table 26). In
Table 23. Estimation of maternal effects for seed quality traits for the high harvest moisture and 50°C drying temperature treatment

<table>
<thead>
<tr>
<th>Inbred</th>
<th>1984</th>
<th>1985</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Germination</td>
<td>Kernel</td>
<td>Sdling</td>
</tr>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>weight</td>
</tr>
<tr>
<td>A632</td>
<td>200.0</td>
<td>-22.0</td>
<td>-8.3</td>
</tr>
<tr>
<td>A641</td>
<td>-18.0</td>
<td>-11.0</td>
<td>1.7</td>
</tr>
<tr>
<td>B14A</td>
<td>-151.0</td>
<td>-90.0</td>
<td>14.0</td>
</tr>
<tr>
<td>B73</td>
<td>-244.0</td>
<td>-71.0</td>
<td>-21.3</td>
</tr>
<tr>
<td>Mo17</td>
<td>47.0</td>
<td>76.0</td>
<td>25.1</td>
</tr>
<tr>
<td>W64A</td>
<td>166.0</td>
<td>118.0</td>
<td>-11.2</td>
</tr>
</tbody>
</table>

S.E.(+/-) 4.00 4.99 0.56 0.20 2.84 1.54 0.27 0.16 1.73 1.83 0.15 0.09
Table 24. Estimation of maternal effects for seed quality traits for the high harvest moisture and 35 C drying temperature treatment

<table>
<thead>
<tr>
<th>Inbred</th>
<th>1984</th>
<th>1985</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Germination</td>
<td>Kernel</td>
<td>Sdling</td>
</tr>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>weight</td>
</tr>
<tr>
<td>A632</td>
<td>3.0</td>
<td>8.0</td>
<td>-12.7</td>
</tr>
<tr>
<td>A641</td>
<td>-18.0</td>
<td>-24.0</td>
<td>-4.5</td>
</tr>
<tr>
<td>B14A</td>
<td>12.0</td>
<td>29.0</td>
<td>22.7</td>
</tr>
<tr>
<td>B73</td>
<td>-2.0</td>
<td>17.0</td>
<td>-17.6</td>
</tr>
<tr>
<td>Mo17</td>
<td>-51.0</td>
<td>-75.0</td>
<td>-26.6</td>
</tr>
<tr>
<td>W64A</td>
<td>56.0</td>
<td>45.0</td>
<td>-14.5</td>
</tr>
</tbody>
</table>

S.E. (+/-) 2.42  2.52  0.42  0.18  0.24  0.78  0.29  0.07  0.37  0.92  0.18  0.07
Table 25. Estimation of maternal effects for seed quality traits for the low harvest moisture and 50 C drying temperature treatment

<table>
<thead>
<tr>
<th>Inbred</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Sdling weight</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Sdling weight</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Sdling weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984</td>
<td></td>
<td></td>
<td>1985</td>
<td></td>
<td></td>
<td>Combined</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
<td></td>
<td></td>
<td>(mg)</td>
<td></td>
<td>Warm</td>
</tr>
<tr>
<td>A632</td>
<td></td>
<td>-43.0</td>
<td>-205.0</td>
<td>-18.07</td>
<td>-50.8</td>
<td>88.0</td>
<td>-10.0</td>
<td>-0.9</td>
<td>38.5</td>
</tr>
<tr>
<td>A641</td>
<td></td>
<td>-9.0</td>
<td>47.0</td>
<td>-6.43</td>
<td>-20.4</td>
<td>76.0</td>
<td>161.0</td>
<td>7.5</td>
<td>77.6</td>
</tr>
<tr>
<td>B14A</td>
<td></td>
<td>31.0</td>
<td>98.0</td>
<td>-9.0</td>
<td>29.7</td>
<td>136.0</td>
<td>-1.0</td>
<td>11.1</td>
<td>-10.1</td>
</tr>
<tr>
<td>b73</td>
<td></td>
<td>69.0</td>
<td>89.0</td>
<td>-3.0</td>
<td>49.7</td>
<td>-20.0</td>
<td>-48.0</td>
<td>-12.3</td>
<td>-118.6</td>
</tr>
<tr>
<td>Mo17</td>
<td></td>
<td>-108.0</td>
<td>-25.0</td>
<td>44.4</td>
<td>9.9</td>
<td>-148.0</td>
<td>-34.0</td>
<td>9.9</td>
<td>-21.5</td>
</tr>
<tr>
<td>W64A</td>
<td></td>
<td>56.0</td>
<td>-4.0</td>
<td>-25.9</td>
<td>-9.1</td>
<td>-132.0</td>
<td>-68.0</td>
<td>-15.3</td>
<td>34.1</td>
</tr>
</tbody>
</table>

S.E. (+/-) 2.93 4.32 1.67 0.16 3.45 3.45 0.34 0.17 1.62 1.95 0.21 0.08
Table 26. Estimation of maternal effects for seed quality traits for the low harvest moisture and 35°C drying temperature treatment

<table>
<thead>
<tr>
<th>Inbred</th>
<th>Germination Warm</th>
<th>Germination Cold</th>
<th>Kernel Warm</th>
<th>Kernel Cold</th>
<th>Sdling Warm</th>
<th>Sdling Cold</th>
<th>Germination Warm</th>
<th>Germination Cold</th>
<th>Kernel Warm</th>
<th>Kernel Cold</th>
<th>Sdling Warm</th>
<th>Sdling Cold</th>
<th>Germination Warm</th>
<th>Germination Cold</th>
<th>Kernel Warm</th>
<th>Kernel Cold</th>
<th>Sdling Warm</th>
<th>Sdling Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(g)</td>
<td>(mg)</td>
<td>(g)</td>
<td>(mg)</td>
<td>(g)</td>
<td>(mg)</td>
<td>(g)</td>
<td>(mg)</td>
<td>(g)</td>
<td>(mg)</td>
<td>(g)</td>
<td>(mg)</td>
<td>(g)</td>
<td>(mg)</td>
<td>(g)</td>
<td>(mg)</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>A632</td>
<td>-18.0</td>
<td>-3.0</td>
<td>-18.4</td>
<td>-50.3</td>
<td>12.0</td>
<td>8.0</td>
<td>-5.5</td>
<td>33.3</td>
<td>15.0</td>
<td>2.0</td>
<td>-11.8</td>
<td>-6.7</td>
<td>12.0</td>
<td>8.0</td>
<td>10.0</td>
<td>-4.7</td>
<td>-11.5</td>
<td>-10.0</td>
</tr>
<tr>
<td>A641</td>
<td>-49.0</td>
<td>-17.0</td>
<td>-6.8</td>
<td>5.1</td>
<td>-13.0</td>
<td>-8.0</td>
<td>0.0</td>
<td>9.1</td>
<td>-22.0</td>
<td>-10.0</td>
<td>-3.0</td>
<td>-3.4</td>
<td>-13.0</td>
<td>-8.0</td>
<td>-11.5</td>
<td>15.0</td>
<td>-11.7</td>
<td>8.9</td>
</tr>
<tr>
<td>B14A</td>
<td>-15.0</td>
<td>-11.0</td>
<td>8.4</td>
<td>34.7</td>
<td>1.0</td>
<td>4.0</td>
<td>14.5</td>
<td>-11.5</td>
<td>15.0</td>
<td>8.0</td>
<td>11.7</td>
<td>8.9</td>
<td>15.0</td>
<td>-1.0</td>
<td>2.9</td>
<td>-7.6</td>
<td>2.9</td>
<td>7.6</td>
</tr>
<tr>
<td>B73</td>
<td>22.0</td>
<td>1.0</td>
<td>-0.2</td>
<td>17.3</td>
<td>10.0</td>
<td>-5.0</td>
<td>-4.7</td>
<td>-13.1</td>
<td>15.0</td>
<td>-1.0</td>
<td>-2.9</td>
<td>-7.6</td>
<td>15.0</td>
<td>-1.0</td>
<td>27.8</td>
<td>45.2</td>
<td>27.8</td>
<td>45.2</td>
</tr>
<tr>
<td>Mo17</td>
<td>3.0</td>
<td>-9.0</td>
<td>40.9</td>
<td>51.3</td>
<td>-4.0</td>
<td>2.0</td>
<td>16.4</td>
<td>16.9</td>
<td>1.0</td>
<td>-3.0</td>
<td>27.8</td>
<td>45.2</td>
<td>-4.0</td>
<td>2.0</td>
<td>16.4</td>
<td>16.9</td>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td>W64A</td>
<td>21.0</td>
<td>17.0</td>
<td>-25.4</td>
<td>-58.1</td>
<td>-6.0</td>
<td>-1.0</td>
<td>-20.7</td>
<td>-17.3</td>
<td>1.0</td>
<td>4.0</td>
<td>-21.8</td>
<td>36.8</td>
<td>1.0</td>
<td>4.0</td>
<td>16.4</td>
<td>16.9</td>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>S.E.(+/-)</td>
<td>1.08</td>
<td>0.69</td>
<td>0.96</td>
<td>0.13</td>
<td>0.58</td>
<td>0.58</td>
<td>0.30</td>
<td>0.14</td>
<td>0.43</td>
<td>0.32</td>
<td>0.22</td>
<td>0.43</td>
<td>0.32</td>
<td>0.22</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
cold germination, B14A, E73 and Mo17 had values of maternal effect opposite to that in warm germination. Both B14A and Mo17, the 'large-seeded' inbreds had the largest positive effects for kernel and seedling weights. W64A had large value for seedling weight but a negative value for kernel weight.

The inconsistency in the performance of the inbreds is also shown by their hybrid SCA values (Tables 27 to 30) in the combined analyses for four seed quality traits. However, hybrid seeds from the cross A632 x W64A (both tolerant of high drying temperature) had large SCA values for warm germination in all the four treatments. A632 x Mo17 (tolerant x intolerant) also resulted in either positive or zero SCA effects, in all treatments for warm germination.

At the high harvest moisture and 35C drying temperature treatment, hybrids with E73 and Mo17 as the pollen parents had positive SCA effects for warm germination (Table 28). A641 x W64A however, performed lower than expected in both warm and cold germinations at most of these treatments in that this cross resulted in negative SCA values.

SCA effects for kernel weight were generally smaller than those observed for the other traits in all treatments. This was perhaps due to the smaller variation among the hybrid means for this trait. The hybrid B14A x W64A however had positive SCA values in all treatments. For seedling weight, the cross B14A x Mo17 had the largest positive SCA at the high harvest moisture and 50C drying treatment as well at the low harvest moisture and 35C drying treatments. Even though SCA values were inconsistent for hybrids across all treatments, crosses of A632 as female x
Table 27. SCA effects for four seed quality traits at high harvest moisture and 50 C drying temperature treatment combined over both 1984 and 1985

<table>
<thead>
<tr>
<th>Female x Male</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
</tr>
<tr>
<td>A632 x A641</td>
<td>-1.30</td>
<td>4.95</td>
<td>-0.34</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>-2.30</td>
<td>1.95</td>
<td>-0.62</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>1.83</td>
<td>-4.80</td>
<td>0.33</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>0.46</td>
<td>-5.05</td>
<td>-0.09</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>1.21</td>
<td>2.95</td>
<td>0.72</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>0.83</td>
<td>-3.05</td>
<td>-0.33</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>4.96</td>
<td>5.70</td>
<td>0.71</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>5.08</td>
<td>2.95</td>
<td>-0.16</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>-9.07</td>
<td>-10.55</td>
<td>0.76</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>-4.05</td>
<td>-5.30</td>
<td>-0.16</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>0.58</td>
<td>2.45</td>
<td>0.62</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>4.83</td>
<td>3.95</td>
<td>0.48</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>-6.30</td>
<td>0.02</td>
<td>0.67</td>
</tr>
<tr>
<td>B73 x W64A</td>
<td>3.46</td>
<td>4.20</td>
<td>-0.92</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>0.08</td>
<td>-0.55</td>
<td>-1.04</td>
</tr>
<tr>
<td>S.E.(+/-)</td>
<td>2.93</td>
<td>3.10</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Table 28. SCA effects for four seed quality traits at high harvest moisture and 35 C drying temperature treatment combined over both 1984 and 1985

<table>
<thead>
<tr>
<th>Female x Male</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
</tr>
<tr>
<td>A632 x A641</td>
<td>-2.58</td>
<td>-0.43</td>
<td>-0.55</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>-1.95</td>
<td>-0.30</td>
<td>0.64</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>0.05</td>
<td>-1.18</td>
<td>-0.55</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>0.80</td>
<td>3.70</td>
<td>0.46</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>3.68</td>
<td>-1.80</td>
<td>-0.01</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>-1.58</td>
<td>-0.68</td>
<td>0.02</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>1.92</td>
<td>-0.55</td>
<td>0.53</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>1.68</td>
<td>0.33</td>
<td>-0.67</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>0.55</td>
<td>1.33</td>
<td>0.67</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>0.55</td>
<td>0.58</td>
<td>-0.32</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>0.80</td>
<td>-1.05</td>
<td>-0.38</td>
</tr>
<tr>
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<td>2.18</td>
<td>1.45</td>
<td>0.06</td>
</tr>
<tr>
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<td>0.30</td>
<td>-0.43</td>
<td>0.83</td>
</tr>
<tr>
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<td>-2.83</td>
<td>1.58</td>
<td>-0.48</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>-3.58</td>
<td>-2.55</td>
<td>-0.23</td>
</tr>
<tr>
<td>S.E.(+/-)</td>
<td>1.47</td>
<td>1.57</td>
<td>0.30</td>
</tr>
<tr>
<td>Female x Male</td>
<td>Germination</td>
<td>Kernel weight (g)</td>
<td>Seedling weight (mg)</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>-------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>warm cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632 x A641</td>
<td>1.05 -0.20</td>
<td>-0.97</td>
<td>-2.34</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>-0.33 -3.20</td>
<td>0.80</td>
<td>-4.44</td>
</tr>
<tr>
<td>A632 x E73</td>
<td>-7.08 -5.33</td>
<td>1.42</td>
<td>1.76</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>2.93 3.68</td>
<td>-0.36</td>
<td>2.55</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>3.43 5.05</td>
<td>-0.89</td>
<td>2.47</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>3.68 5.80</td>
<td>-0.29</td>
<td>-0.32</td>
</tr>
<tr>
<td>A641 x E73</td>
<td>0.93 3.18</td>
<td>0.43</td>
<td>-1.77</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>3.93 8.18</td>
<td>-0.10</td>
<td>7.07</td>
</tr>
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<td>A641 x W64A</td>
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<td>0.93</td>
<td>-2.65</td>
</tr>
<tr>
<td>B14A x E73</td>
<td>2.05 4.68</td>
<td>-1.1</td>
<td>2.19</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>-10.45 -7.63</td>
<td>-0.12</td>
<td>-0.63</td>
</tr>
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<td>0.70</td>
<td>3.20</td>
</tr>
<tr>
<td>E73 x Mo17</td>
<td>3.30 -8.95</td>
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<td>-4.08</td>
</tr>
<tr>
<td>E73 x W64A</td>
<td>0.80 6.43</td>
<td>-1.04</td>
<td>1.90</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>0.30 4.93</td>
<td>0.29</td>
<td>-4.32</td>
</tr>
</tbody>
</table>

S.E.(+/-)  2.75  3.30  0.36  0.14
Table 30. SCA effects for four seed quality traits at low harvest moisture and 35 C drying temperature treatment combined over both 1984 and 1985

<table>
<thead>
<tr>
<th>Female</th>
<th>Male</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
</tr>
<tr>
<td>A632 x A641</td>
<td></td>
<td>-3.13</td>
<td>-1.25</td>
<td>-0.81</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td></td>
<td>1.63</td>
<td>0.75</td>
<td>-0.37</td>
</tr>
<tr>
<td>A632 x B73</td>
<td></td>
<td>1.25</td>
<td>0.13</td>
<td>1.38</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td></td>
<td>0.00</td>
<td>0.13</td>
<td>0.02</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td></td>
<td>3.43</td>
<td>5.05</td>
<td>-0.89</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td></td>
<td>2.25</td>
<td>1.00</td>
<td>0.81</td>
</tr>
<tr>
<td>A641 x B73</td>
<td></td>
<td>2.66</td>
<td>1.88</td>
<td>0.01</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td></td>
<td>-0.38</td>
<td>0.38</td>
<td>0.30</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td></td>
<td>-1.38</td>
<td>-2.00</td>
<td>-0.23</td>
</tr>
<tr>
<td>B14A x B73</td>
<td></td>
<td>-5.38</td>
<td>-1.13</td>
<td>-0.53</td>
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<tr>
<td>B14A x Mo17</td>
<td></td>
<td>0.88</td>
<td>-0.63</td>
<td>-1.14</td>
</tr>
<tr>
<td>B14A x W64A</td>
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<td>0.88</td>
<td>0.00</td>
<td>1.23</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td></td>
<td>0.50</td>
<td>-1.25</td>
<td>0.41</td>
</tr>
<tr>
<td>B73 x W64A</td>
<td></td>
<td>1.00</td>
<td>0.38</td>
<td>-1.27</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td></td>
<td>-1.25</td>
<td>1.38</td>
<td>0.42</td>
</tr>
</tbody>
</table>

S.E.(+/-) 0.72 0.54 0.38 0.09
either Mo17 or W64A as males always resulted in positive SCA values for seedling weight.
DISCUSSION

The range in the means of seed quality traits were larger and significant ($P<0.05$) when the inbreds were used as females than when used as males (Tables 8, 11, 14, and 17). This indicated that perhaps most of the variability observed among inbreds and hybrids for tolerance of high drying temperatures was due to the performance of the seed parent.

The influence and contribution of an inbred as a male in germination is difficult to assess based on the mean analyses. This is because the Duncan Multiple Range Test did not reveal any significant differences among inbred means as males especially in the cold germination test at all four treatment combinations. Based on these results it could be postulated that the influence of the male parent is comparatively small and perhaps of no practical significance compared to that of the female (seed) parent in bringing about variability with regards to tolerance of high drying temperature expressed in warm and cold germinations.

The results of this experiment corroborate that of other workers. Burris (1977) found nonsignificant differences among males for shoot and root weights though such differences were significant among females in a diallel of five inbred lines. Tatum (1942) also reported that tests of single crosses or inbreds were rather unsatisfactory in revealing inherent differences in susceptibility of embryos to pathogens because of the masking effect of maternal factors.

Variability among males were, however, significant ($P<0.05$) for kernel and seedling weights and shoot/root ratios at all four treatment
combinations (Tables 8, 11, 14 and 17). This could have been due to heterosis effects or due to direct pollen effects. McConnell and Gardner (1979b) observed that maize genotypes with similar germination varied in seedling growth rate in the field. He suggested that these two traits may be controlled by different genetic systems. Dessureaux et al. (1948) reported that pollen of the inbred R₄ was found to contribute a tendency toward shortening the duration of dry matter translocation to the kernels with other inbreds as seed parents. Leng (1949), reported that significant differences, as large as 25% of the total hybrid kernel weight, resulted when certain inbreds were used as pollen parents. Such direct pollen effects could have brought about the significant differences in the male response in this experiment. Differences in kernel weight could have an effect on both seedling weight and shoot/root ratios. Results of my experiment did not, however, show a consistent relationship between kernel weight and either seedling weight or shoot/root ratios.

The comparatively high shoot/root ratios associated with 50°C drying temperatures (Tables 8 and 14) is in agreement with results of other workers (Navratil, 1981, Loeffler, 1983 and Meier, 1983). One possible reason for this high ratio in damaged seeds is that root development is more susceptible to dryer injury than shoot development (Navratil, 1981). The author observed that the susceptible genotype Mo17 dried at 50°C had higher shoot/root ratio values compared to A632 and that these were due to decreased transfer of original kernel weight to roots - transfer to shoots was unaffected. Also, a lack of primary root development was observed in treatments where injury was induced by 50°C drying. These data are
consistent with Washko's (1941) histological observations that drying damage resulted in disintegration of meristematic cells of the primary root.

Hybrid array means for all the traits at all four treatment combinations (Tables 9, 12, 15 and 18) clearly show the lack of a consistent relationship between the performance of an inbred as a female and its performance as a male. Pinnell (1949) was also unable to demonstrate a relationship between inbreds used as females or males in crosses.

The environment (year) of production, affects the performance of hybrids (crosses) for kernel weight and germinations very significantly (Table 6). Part of this effect could have been due to differences in sample harvest moistures in each year. Seed production environment is, however, known to affect seed quality generally. Significant year effects have been reported by Loeffler (1983), Meier (1983) and Navratil (1981).

The reduction in seed quality attributed to drying induced damage occurred when seeds were dried at 50 C irrespective of harvest moisture. The fact that low moisture seeds showed reduced germination values when dried at 50 C in this experiment indicates that perhaps some seeds were really still at a high moisture level. However, this harvest moisture by drying temperature interaction is consistent with that reported by other authors (Burris and Navratil, 1980). Higher C.V.s are also associated with 50 C drying temperatures because of the variability introduced by the depressed vigor and viability caused by this temperature (Tables 7 and 13).

General combining ability (GCA) and maternal sources of variation were
perhaps most important in the variation observed among crosses. This was true for all the seed quality traits measured at the high harvest moisture and 50°C drying temperature treatment (Table 7). When specific combining ability (SCA) and reciprocal components were significant, their mean square values were at least half that of either the maternal or GCA components. A similar situation was observed at the other three treatment combinations. Even when no significant differences were apparent among crosses for warm and cold germinations, GCA and maternal mean squares were by far the largest (e.g., high harvest moisture and 35°C drying temperature in Table 11).

GCA is the average performance of a line in a series of crosses (marginal means or totals). It indicates mainly additive gene effects. SCA is the deviation of individual crosses from the average performance of the parent lines. This deviation is mainly due to genes with nonadditive, dominant and epistatic effects. Maternal effect measures the overall differences between a parent's average (margin) performance as a female and as a male (sometimes referred to as general reciprocal effect, GRE). The reciprocal effect is the difference among reciprocal crosses from pairs of parents and is sometimes referred to as specific reciprocal effect, (SRE).

The results of my experiment, therefore, indicate that additive and maternal gene effects were more important than nonadditive, dominant and reciprocal gene effects in effecting the variation observed among crosses when seeds were injured by drying. The lines included in this experiment are inbred lines which have undergone selection for good general combining abilities. Therefore, variation due to SCA should be more important than
GCA since it involves dominance and epistatic gene effects. Sprague and Tatum (1942) proposed that, in a population of unselected lines for general combining ability, genes with additive effects (GCA) are either more common or produce greater effects than genes with dominance or epistatic effects. However, in previously selected material, genes with dominance and epistatic effect were more important than genes with additive effects for influencing yield and stalk lodging.

Selection for drying tolerance per se has not been practiced in the lines used in this study. This may have contributed to the large variation due to the GCA and maternal components in this experiment for most traits. It is therefore possible that alleles responsible for confering heat tolerance have not been fixed in these lines and they behave as an unselected populations. Another reason could be that the effect of dominance and epistatic genes were masked by the large effect of the genes with additive and maternal effects. SCA was found to have significant effects for some seed quality traits in some treatments. This indicates that for those traits, performance was not entirely determined by the frequency of favorable alleles that the lines possessed (as supposed by high GCA values) but by the interaction among and between the alleles.

The results of this experiment confirm those of Eagles and Hardacre (1979) who found that nonadditive or maternal genetic variance was of much greater importance for percentage emergence, seedling dry weight and time to emerge under cold environments than additive genetic variance in a CIMMYT pool five maize population. Burris (1977) reported both GCA and maternal components had larger mean squares than SCA and reciprocal for
germination, shoot and root dry weights in a diallel of five corn inbreds. Generation mean analysis of the inheritance of germination at 7.2 C in the laboratory and emergence, juvenile growth and yield in the field, indicated that most of the genetic variability was nonadditive for these traits (McConnell and Gardner, 1979). These results are in contrast to those presented here. The nonadditive gene effect as used in their experiment could have included the maternal effects.

Other workers, (Russell and Eberhart, 1975), have indicated that most of the variation within sets of crosses was attributable to the GCA of the lines included in the crosses for yield of corn. Even in crosses among elite corn lines which had undergone four generations of selection for SCA for yield, some lines showed high GCA with other elite lines for yield in corn (Hoegemeyer and Hallauer, 1976). The authors concluded that nonadditive gene effects seem to be small on the average but they may be important even for only one unique combination (Hallauer and Miranda, 1981). Results of this study is corroborated by these reports and serves to point out the relative importance of GCA versus SCA in influencing many seed quality traits.

The effects of both GCA and maternal sources of variation were not stable across years due to the significant interaction effects for most traits. It is therefore important to evaluate seed quality traits under several environments (years) before drawing conclusions about the relative importance of these genetic components.

Variation among crosses due to the reciprocal component was not significant for warm and cold germinations in any treatment except at the
LHM/50 C. This in itself would indicate that the differences in performance of lines as females or males were not significant. Except in treatments involving 50 C drying temperature (Tables 7 and 13), the absence of reciprocal gene effects was stable across years. Possible reasons for the nonsignificant effect of the reciprocal component include all lines used in this experiment being well adapted inbred lines. Pollmer et al. 1979, found that both reciprocal and reciprocal x environment interaction were nonsignificant for early vigor though highly significant for other traits. They stated that reciprocal effects were: 1) unstable, 2) of small magnitude relative to nuclear effects, 3) not easily exploitable and 4) that significant differences observed may have been due to extranuclear inheritance, maternal effects or cytoplasmic gene interactions.

Nonsignificance of reciprocal components for germinations in this experiment is consistent with their findings for early vigor.

Because marginal means were used in calculating gene effects, the GCA and maternal effects are related for all measured traits at all the four treatment combinations. In many cases where an inbred shows a positive GCA effect for a particular trait, the maternal effect is also positive for that trait in the same treatment. Maternal effects were, for most cases, of larger magnitude than GCA effects for those traits.

Although some lines showed high positive GCA effects, it is possible that they attain their high average performance by entirely different means. Some lines may uniformly transmit their heat tolerance ability to all their F1's. Others may have specific combinations with certain lines which are considerably more tolerant than would be expected and other
combinations which are much less tolerant than expected. This is the case observed with the SCA effects. Within an inbred, some crosses had high positive SCA effects while others had large negative values. No consistent trend could be established for a particular cross across years and treatment combinations.

Several possibilities could be given for the observation of significant maternal effects in this work. One possibility could be due to inheritance of cytoplasmic or extranuclear organelles. One organelle that could be important at the early seedling stage is the mitochondria which has been shown to be inherited maternally through the cytoplasm.

Some workers (Pinnell, 1949 and Pesev, 1970) have proposed that the effect of the maternal parent on germination and growth of its single crosses under cold-test conditions may be associated with double contribution (2n) from the female side at fertilization or with the importance of the quality and quantity of kernel endosperm. Such reasoning may be extended to explain results observed in the present study for the relative importance of maternal effect. Nass and Crane (1970) proposed that drying rate of corn seeds in the field is regulated in part by colloids in the endosperm. The amount and type of sugars, proteins and carbohydrates (all with hydrophilic properties) could bring about endosperm differences among inbreds and hybrids. These compounds would then determine the amount of water held and the rate of release from the endosperm. Seyedin et al. (1984) and Navratil (1981) have however shown that seedlings grown from "endosperm-free" embryos of Mo17 (heat intolerant) were similar to seedlings grown from the intact seeds. This
indicated that the ability of embryos to germinate and grow normally is affected by high drying temperature. In this study, the differential tolerance of both the endosperm and the embryo to heat could have contributed to the variation among crosses. Embryo damage may however have been more important. It has also been pointed out by Wortman (1950) that the endosperm appears to be important for gene and cytoplasm interaction in the expression of the maternal effect on the emergence of maize single crosses in the cold test.

The pericarp of the maize seed is of maternal origin. Differential rates of water uptake have been mainly attributed to the physical structure of the pericarp and not to metabolic processes within the kernel. Faster drying rates and greater permeability were also found to be associated with thinner pericarps (Purdy and Crane, 1967b). The nature (thickness, ability to withstand heat) of the pericarp could also have contributed to the importance of maternal effects in this study. Tatum (1942) concluded that seed borne infection or seed coat (pericarp) condition of the maternal parent were determining factors in the germination of single crosses. The pericarp is also important in regulating rate of water loss from the seed. Both rates of water uptake and loss could be modified also by susceptibility of the pericarps to cracking as a result of high drying temperature. The heat may also cause an abnormal hardening of the pericarp especially over the embryo which may result in difficulties in plumule emergence during germination. Damage to seed coat in other seeds has also been reported to reduce seed quality.

It should be pointed out that some of the maternal effects may be due
to possible differences in seed size among parents **per se**. This research
did not include seed size as a variable. It is hence not possible to say
how or what effects seed size would have on these components.
SUMMARY AND CONCLUSIONS

One objective of this study was to assess the effect of the male (pollinator) parent on the behavior of the seed parents with regards to tolerance of drying injury. Analyses of seed quality trait means indicate that most of the variability observed in germination among crosses was due to the seed parents used. Variability in germination due to male parents was nonsignificant for germination in most cases. Several conclusions may be drawn: 1) that the effect of the male parent is small and of minor practical significance in influencing the behavior of the seed parent. 2) The diallel mating design may not be the best method of studying the effect of the male parent per se. Perhaps the North Carolina design II may be the more appropriate design to use. 3) It is possible that male effects are operative but such effects are masked by the large effect of the female parents.

Additive and maternal gene effects seem to be more important or to contribute more than nonadditive, dominance, or reciprocal effects to the variation in seed quality traits among crosses for tolerance to high drying temperature. The large maternal effects noted could be due to 1) the double contribution of the female to the endosperm, 2) cytoplasmic or extranuclear inheritance of important organelles and 3) pericarp differences. The environment, however, had a significant effect on the contributions of these genetic components.

Inheritance of tolerance of drying injury is probably not a simple phenomenon. Tolerance or susceptibility transferred through the pollen was
not apparent in the $F_1$'s. Results of this experiment do not permit the
determination of the manner or inheritance of tolerance to drying
temperature.
LITERATURE CITED


Reiss, F. E. 1944. Relation of moisture content and drying temperature to the viability and seedling vigor of maize germinated by different methods. M.S. Thesis. Iowa State University, Ames, Iowa.


ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to my major professor, Dr. Joseph S. Burris for suggesting the topic and for his guidance and constant encouragement throughout the period of my study. His friendliness and understanding surely provided a very conducive atmosphere for learning. The help of Dr. A. R. Hallauer in the statistical analysis of this experiment is also very much appreciated. I am also thankful for the help and cooperation I received from the other members of my committee; Drs. I. C. Anderson, D. C. McGee and Allen D. Knapp. I am particularly appreciative of Dr. Knapp's generosity in allowing me to use his computer for the typing and printing of this thesis.

The financial support from University of Maiduguri is greatly appreciated. Without that it would not have been possible for me to come to the United States for higher degrees.

I acknowledge the sacrifice made by members of my family throughout the course of my entire education. Many thanks to my wife, Deborah, and our kids Kuclri and Danjuma. Each contributed in some way to the success of my studies.

I wish to thank my friends back home for their numerous help and support to my family. To my other friends around, I say thank you. The help received from members of the Church of the Brethren in Ankeny on many occasions is also greatly acknowledged. I particularly wish to thank Charles and Rozella Lunkley and Don and Nancy Miller as our special church and family friends.

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To Sue Fick, I say thank you for your patience and excellent typing of this thesis.
APPENDIX A: ANALYSES OF VARIANCE AND
MEANS TABLES FOR 1984
Table A1. Analysis of variance for GCA, SCA, maternal, and reciprocal effects for seed quality traits at high harvest moisture and 50 C drying temperature treatment in 1984

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio^a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>3355.3**</td>
<td>2523.3**</td>
<td>50.2**</td>
<td>6.6**</td>
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<tr>
<td>SCA</td>
<td>9</td>
<td>2968.9**</td>
<td>444.3ns</td>
<td>0.9ns</td>
<td>0.8ns</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>4298.1**</td>
<td>1541.6ns</td>
<td>66.8**</td>
<td>6.4**</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>1308.7**</td>
<td>881.2ns</td>
<td>18.4**</td>
<td>1.8ns</td>
</tr>
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<td>Error</td>
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<td>461.4</td>
<td>717.3</td>
<td>3.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

*Significant at 0.05 and 0.01 levels of probability, respectively. nsNonsignificant at the 0.05 level.
Table A2. Germination, kernel weight, seedling dry weight, shoot/root ratio means as affected by the inbred used either as female or male parent in 1984 for high harvest moisture and 50°C drying temperature treatment.

<table>
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<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
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<td>Cold</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
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<td></td>
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<td>18.7c</td>
<td>24.8bc</td>
</tr>
<tr>
<td>B14A</td>
<td>25.0c</td>
<td>9.0c</td>
<td>20.9b</td>
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</tr>
<tr>
<td>B73</td>
<td>14.0c</td>
<td>15.0c</td>
<td>16.6d</td>
<td>25.4bc</td>
</tr>
<tr>
<td>Mo17</td>
<td>60.0b</td>
<td>43.0ab</td>
<td>23.4a</td>
<td>46.0a</td>
</tr>
<tr>
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<td>17.0d</td>
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<td>Means</td>
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<td>19.0</td>
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<table>
<thead>
<tr>
<th>Male</th>
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</tr>
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<td>25.4b</td>
<td>3.8ab</td>
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<td>A641</td>
<td>51.0ab</td>
<td>26.0a</td>
<td>18.2b</td>
<td>31.8a</td>
<td>4.9a</td>
</tr>
<tr>
<td>B14A</td>
<td>60.0a</td>
<td>29.0a</td>
<td>18.4b</td>
<td>30.1a</td>
<td>3.2b</td>
</tr>
<tr>
<td>B73</td>
<td>62.0a</td>
<td>27.0a</td>
<td>20.9a</td>
<td>33.3a</td>
<td>3.6ab</td>
</tr>
<tr>
<td>Mo17</td>
<td>50.0ab</td>
<td>28.0a</td>
<td>18.4b</td>
<td>27.4ab</td>
<td>3.9ab</td>
</tr>
<tr>
<td>W64A</td>
<td>56.0a</td>
<td>29.0a</td>
<td>19.4b</td>
<td>34.3a</td>
<td>3.7ab</td>
</tr>
<tr>
<td>Means</td>
<td>52.6</td>
<td>26.6</td>
<td>19.0</td>
<td>30.7</td>
<td>3.9</td>
</tr>
</tbody>
</table>

*Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.*
Table A3. Effect of parentage on warm and cold germination, kernel weight, seedling dry weight and shoot/root ratio for seeds harvested at high moisture and dried at 50 C in 1984

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>female</td>
<td>male</td>
<td>warm</td>
<td>cold</td>
</tr>
<tr>
<td>A632 x A641</td>
<td>85.0</td>
<td>36.0</td>
<td>16.0</td>
<td>30.7</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>45.0</td>
<td>12.0</td>
<td>13.8</td>
<td>16.2</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>85.0</td>
<td>5.0</td>
<td>20.0</td>
<td>26.4</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>80.0</td>
<td>7.0</td>
<td>18.2</td>
<td>28.5</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>93.0</td>
<td>27.0</td>
<td>18.8</td>
<td>35.2</td>
</tr>
<tr>
<td>A641 x A632</td>
<td>35.0</td>
<td>11.0</td>
<td>18.5</td>
<td>18.5</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>60.0</td>
<td>23.0</td>
<td>17.8</td>
<td>23.4</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>61.0</td>
<td>48.0</td>
<td>18.5</td>
<td>38.9</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>65.0</td>
<td>34.0</td>
<td>20.6</td>
<td>28.9</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>19.0</td>
<td>4.0</td>
<td>17.5</td>
<td>13.9</td>
</tr>
<tr>
<td>B14A x A632</td>
<td>39.0</td>
<td>16.0</td>
<td>22.4</td>
<td>17.7</td>
</tr>
<tr>
<td>B14A x A641</td>
<td>17.0</td>
<td>1.0</td>
<td>19.4</td>
<td>19.2</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>21.0</td>
<td>5.0</td>
<td>21.4</td>
<td>30.9</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>8.0</td>
<td>13.0</td>
<td>19.0</td>
<td>22.0</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>43.0</td>
<td>11.0</td>
<td>22.5</td>
<td>23.5</td>
</tr>
<tr>
<td>B73 x A632</td>
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<td>0.0</td>
<td>16.8</td>
<td>--</td>
</tr>
<tr>
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<td>14.0</td>
<td>1.0</td>
<td>17.9</td>
<td>19.6</td>
</tr>
<tr>
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<td>0.0</td>
<td>15.3</td>
<td>--</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>11.0</td>
<td>33.0</td>
<td>16.0</td>
<td>20.4</td>
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<td>35.0</td>
<td>14.5</td>
<td>39.1</td>
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<tr>
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<td>21.0</td>
<td>21.4</td>
<td>30.2</td>
</tr>
<tr>
<td>Mo17 x A641</td>
<td>59.0</td>
<td>50.0</td>
<td>21.4</td>
<td>52.2</td>
</tr>
<tr>
<td>Mo17 x B14A</td>
<td>87.0</td>
<td>54.0</td>
<td>26.1</td>
<td>33.5</td>
</tr>
<tr>
<td>Mo17 x B73</td>
<td>46.0</td>
<td>31.0</td>
<td>25.2</td>
<td>40.5</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>71.0</td>
<td>58.0</td>
<td>23.2</td>
<td>55.6</td>
</tr>
<tr>
<td>W64A x A632</td>
<td>79.0</td>
<td>61.0</td>
<td>16.0</td>
<td>35.1</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>83.0</td>
<td>43.0</td>
<td>16.4</td>
<td>37.2</td>
</tr>
<tr>
<td>W64A x B14A</td>
<td>87.0</td>
<td>47.0</td>
<td>18.0</td>
<td>30.5</td>
</tr>
<tr>
<td>W64A x B73</td>
<td>97.0</td>
<td>51.0</td>
<td>18.7</td>
<td>33.6</td>
</tr>
<tr>
<td>W64A x Mo17</td>
<td>87.0</td>
<td>51.0</td>
<td>16.1</td>
<td>31.3</td>
</tr>
<tr>
<td>Means</td>
<td>52.6</td>
<td>26.6</td>
<td>19.1</td>
<td>30.7</td>
</tr>
<tr>
<td>L.S.D. (0.05)</td>
<td>35.1</td>
<td>43.7</td>
<td>2.9</td>
<td>1.8</td>
</tr>
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</table>
Table A4. Analysis of variance for GCA, SCA, maternal, and reciprocal effects for seed quality traits at high harvest moisture and 35°C drying temperature treatment in 1984

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination (warm)</th>
<th>Germination (cold)</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCA</td>
<td>5</td>
<td>228.2&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>260.5&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>38.3**</td>
<td>1.8&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>1.07**</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>88.2&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>76.3&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>2.5&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>1.3&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>0.60*</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>311.8&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>448.1*</td>
<td>93.4**</td>
<td>1.8&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>1.04**</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>78.4&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>75.3&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>11.0*</td>
<td>0.8</td>
<td>8.37&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>Error</td>
<td>56</td>
<td>169.1</td>
<td>182.2</td>
<td>5.0</td>
<td>0.9</td>
<td>0.26</td>
</tr>
</tbody>
</table>

*: Significant at 0.05 and 0.01 level of probability, respectively.  
ns: Nonsignificant at the 0.05 level.
Table A5. Germination, kernel weight, seedling dry weight and shoot/root ratio means as affected by the inbred used either as female or male parent in 1984 for high harvest moisture and 35 C drying temperature treatment

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
</tr>
<tr>
<td>A632</td>
<td>99.0a</td>
<td>99.0a</td>
<td>17.7bc</td>
<td>49.6ab</td>
</tr>
<tr>
<td>A641</td>
<td>93.0ab</td>
<td>91.0ab</td>
<td>18.6b</td>
<td>51.9ab</td>
</tr>
<tr>
<td>B14A</td>
<td>96.0a</td>
<td>98.0a</td>
<td>22.6a</td>
<td>55.7ab</td>
</tr>
<tr>
<td>B73</td>
<td>94.0ab</td>
<td>99.0a</td>
<td>17.3c</td>
<td>48.7b</td>
</tr>
<tr>
<td>Mo17</td>
<td>87.0b</td>
<td>83.0b</td>
<td>23.9a</td>
<td>56.7a</td>
</tr>
<tr>
<td>W64A</td>
<td>97.0ab</td>
<td>99.0a</td>
<td>17.4b</td>
<td>51.0ab</td>
</tr>
<tr>
<td>Means</td>
<td>94.7</td>
<td>94.9</td>
<td>19.6</td>
<td>52.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
</tr>
<tr>
<td>A632</td>
<td>98.0a</td>
<td>98.0a</td>
<td>20.1ab</td>
<td>49.1ab</td>
</tr>
<tr>
<td>A641</td>
<td>96.0ab</td>
<td>96.0a</td>
<td>19.4abc</td>
<td>53.5ab</td>
</tr>
<tr>
<td>B14A</td>
<td>96.0ab</td>
<td>92.0a</td>
<td>18.2c</td>
<td>46.1b</td>
</tr>
<tr>
<td>B73</td>
<td>95.0ab</td>
<td>95.0a</td>
<td>20.8a</td>
<td>55.4a</td>
</tr>
<tr>
<td>Mo17</td>
<td>98.0a</td>
<td>98.0a</td>
<td>18.5bc</td>
<td>54.8a</td>
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<tr>
<td>W64A</td>
<td>87.0a</td>
<td>91.0a</td>
<td>20.4a</td>
<td>55.2a</td>
</tr>
<tr>
<td>Means</td>
<td>94.7</td>
<td>94.9</td>
<td>19.6</td>
<td>52.4</td>
</tr>
</tbody>
</table>

Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table A6. Effects of parentage on warm and cold germination, kernel weight seedling weight and shoot/root ratio for seeds harvested at high moisture and dried at 35 C in 1964

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632 x A641</td>
<td>99.0</td>
<td>99.0</td>
<td>15.8</td>
<td>46.9</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>97.0</td>
<td>98.0</td>
<td>15.6</td>
<td>36.3</td>
</tr>
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<td>100.0</td>
<td>19.7</td>
<td>59.7</td>
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<tr>
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<td>97.0</td>
<td>99.0</td>
<td>18.0</td>
<td>51.2</td>
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<tr>
<td>A632 x W64A</td>
<td>100.0</td>
<td>97.0</td>
<td>18.8</td>
<td>59.4</td>
</tr>
<tr>
<td>A641 x A632</td>
<td>91.0</td>
<td>93.0</td>
<td>18.9</td>
<td>47.8</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>93.0</td>
<td>86.0</td>
<td>18.0</td>
<td>35.9</td>
</tr>
<tr>
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<td>89.0</td>
<td>19.6</td>
<td>52.4</td>
</tr>
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<td>A641 x Mo17</td>
<td>95.0</td>
<td>97.0</td>
<td>18.9</td>
<td>58.5</td>
</tr>
<tr>
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<td>89.0</td>
<td>90.0</td>
<td>17.3</td>
<td>55.0</td>
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<td>100.0</td>
<td>97.0</td>
<td>24.4</td>
<td>43.2</td>
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<tr>
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<td>97.0</td>
<td>99.0</td>
<td>22.0</td>
<td>53.0</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>99.0</td>
<td>99.0</td>
<td>23.5</td>
<td>48.5</td>
</tr>
<tr>
<td>B14A x Mo17</td>
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<td>98.0</td>
<td>19.3</td>
<td>57.9</td>
</tr>
<tr>
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<td>97.0</td>
<td>97.0</td>
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<td>66.4</td>
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<td>97.0</td>
<td>17.2</td>
<td>49.6</td>
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<tr>
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<td>98.0</td>
<td>98.0</td>
<td>18.4</td>
<td>53.0</td>
</tr>
<tr>
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<td>97.0</td>
<td>99.0</td>
<td>15.0</td>
<td>42.3</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>99.0</td>
<td>99.0</td>
<td>19.7</td>
<td>58.2</td>
</tr>
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<td>77.0</td>
<td>100.0</td>
<td>16.0</td>
<td>40.4</td>
</tr>
<tr>
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<td>100.0</td>
<td>24.3</td>
<td>58.1</td>
</tr>
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<td>90.0</td>
<td>85.0</td>
<td>22.7</td>
<td>59.8</td>
</tr>
<tr>
<td>Mo17 x B14A</td>
<td>93.0</td>
<td>78.0</td>
<td>23.3</td>
<td>42.3</td>
</tr>
<tr>
<td>Mo17 x B73</td>
<td>85.0</td>
<td>87.0</td>
<td>23.0</td>
<td>58.5</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>69.0</td>
<td>67.0</td>
<td>26.0</td>
<td>54.7</td>
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<tr>
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<td>100.0</td>
<td>98.0</td>
<td>15.8</td>
<td>46.7</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>97.0</td>
<td>99.0</td>
<td>18.3</td>
<td>54.5</td>
</tr>
<tr>
<td>W64A x B14A</td>
<td>99.0</td>
<td>100.0</td>
<td>18.2</td>
<td>50.6</td>
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<tr>
<td>W64A x B73</td>
<td>94.0</td>
<td>100.0</td>
<td>18.1</td>
<td>58.3</td>
</tr>
<tr>
<td>W64A x Mo17</td>
<td>98.0</td>
<td>95.0</td>
<td>16.8</td>
<td>49.4</td>
</tr>
<tr>
<td>Means</td>
<td>94.7</td>
<td>94.9</td>
<td>19.6</td>
<td>52.4</td>
</tr>
<tr>
<td>L.S.D. (0.05)</td>
<td>21.2</td>
<td>22.0</td>
<td>3.7</td>
<td>1.5</td>
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</table>
Table A7. Analysis of variance for GCA, SCA, maternal, and reciprocal effects for seed quality traits at low harvest moisture and 50 C drying temperature treatment in 1984

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>827.7**</td>
<td>2623.5**</td>
<td>88.0&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>9.3**</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>693.5**</td>
<td>1414.8*</td>
<td>61.5&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>1.0&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>935.3**</td>
<td>1549.5**</td>
<td>156.1**</td>
<td>3.5**</td>
</tr>
<tr>
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<td>370.1&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>15.7&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>0.8&lt;sup&gt;ns&lt;/sup&gt;</td>
</tr>
<tr>
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<td>246.8</td>
<td>536.6</td>
<td>80.7</td>
<td>0.7</td>
</tr>
</tbody>
</table>

*, **Significant at 0.05 and 0.01 levels of probability, respectively. 
<sup>ns</sup> Nonsignificant at the 0.05 level.
Table A8. Germination, kernel weight, seedling dry weight and shoot/root ratio means as affected by the inbred used either as female or male parent in 1984 for low harvest moisture and 50 °C drying temperature treatment.

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
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<td>25.0c</td>
<td>19.4d</td>
<td>33.7c</td>
</tr>
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<td>81.0b</td>
<td>64.0ab</td>
<td>20.8cd</td>
<td>44.8b</td>
</tr>
<tr>
<td>E14A</td>
<td>89.0ab</td>
<td>73.0ab</td>
<td>24.1b</td>
<td>46.1b</td>
</tr>
<tr>
<td>B73</td>
<td>95.0a</td>
<td>79.0a</td>
<td>22.8bc</td>
<td>55.1a</td>
</tr>
<tr>
<td>Mo17</td>
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<td>29.7a</td>
<td>50.0ab</td>
</tr>
<tr>
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<td>89.0ab</td>
<td>55.0b</td>
<td>19.0d</td>
<td>51.8ab</td>
</tr>
<tr>
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<td><strong>57.5</strong></td>
<td><strong>22.7</strong></td>
<td><strong>47.1</strong></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
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<td>50.0a</td>
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</tr>
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</tr>
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<tr>
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<td><strong>Means</strong></td>
<td><strong>57.5</strong></td>
<td><strong>22.7</strong></td>
<td><strong>47.1</strong></td>
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</tbody>
</table>

1 Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table A9. Effect of parentage on warm and cold germination, kernel weight, seedling weight and shoot/root ratio for seeds harvested at low moisture and dried at 50 C in 1984

<table>
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<th>Parent</th>
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<th></th>
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<tr>
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<td>19.9</td>
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<td></td>
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</tr>
<tr>
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<td>46.1</td>
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</tr>
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</tr>
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<td>87.0</td>
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<td></td>
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</tr>
<tr>
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<td>74.0</td>
<td>17.6</td>
<td></td>
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</tr>
<tr>
<td>A641 x E14A</td>
<td>85.0</td>
<td>22.5</td>
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<td>20.4</td>
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</tr>
<tr>
<td>B14A x A641</td>
<td>95.0</td>
<td>21.2</td>
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<tr>
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<tr>
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<tr>
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<td>28.9</td>
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<tr>
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<td>17.7</td>
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<tr>
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<tr>
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</table>
Table A10. Analysis of variance for GCA, SCA, maternal, and reciprocal effects for seed quality traits at low harvest moisture and 35 C drying temperature treatment in 1984

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<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>warm</td>
<td>cold</td>
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<td></td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>61.4(^{\text{ns}})</td>
<td>26.0(^{\text{ns}})</td>
<td>100.3**</td>
<td>10.0**</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>159.5**</td>
<td>31.3*</td>
<td>13.4(^{\text{ns}})</td>
<td>0.96(^{\text{ns}})</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>92.9*</td>
<td>18.1(^{\text{ns}})</td>
<td>136.9**</td>
<td>6.06**</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>41.7(^{\text{ns}})</td>
<td>11.6(^{\text{ns}})</td>
<td>5.3(^{\text{ns}})</td>
<td>0.55(^{\text{ns}})</td>
</tr>
<tr>
<td>Error</td>
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<td>33.5</td>
<td>13.9</td>
<td>9.3</td>
<td>0.49</td>
</tr>
</tbody>
</table>

\(^{*}\): Significant at 0.05 level of probability.
\(^{**}\): Significant at 0.01 level of probability.
\(^{\text{ns}}\): Nonsignificant at the 0.05 level.
Table A11. Germination, kernel weight, seedling dry weight and shoot/root ratio means as affected by the inbred used either as female or male parent in 1984 for high harvest moisture and 35°C drying temperature treatment.

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>Female</td>
<td>------------</td>
<td>--------------</td>
<td>----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>A632</td>
<td>99.0a</td>
<td>98.0ab</td>
<td>19.3c</td>
<td>47.5d</td>
</tr>
<tr>
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<td>92.0c</td>
<td>95.0a</td>
<td>22.4b</td>
<td>57.4c</td>
</tr>
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<td>94.0bc</td>
<td>99.0a</td>
<td>23.6b</td>
<td>60.8bc</td>
</tr>
<tr>
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<td>98.0abc</td>
<td>99.0a</td>
<td>24.1b</td>
<td>64.2b</td>
</tr>
<tr>
<td>Ko17</td>
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<td>97.0abc</td>
<td>29.7a</td>
<td>74.4a</td>
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<tr>
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<td>99.0a</td>
<td>99.0a</td>
<td>19.2c</td>
<td>59.0bc</td>
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<tr>
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<td><strong>Means</strong></td>
<td><strong>97.0</strong></td>
<td><strong>97.9</strong></td>
<td><strong>60.8</strong></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>96.0a</td>
<td>99.0a</td>
<td>22.8ab</td>
<td>57.4bc</td>
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<td>23.9ab</td>
<td>61.9b</td>
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<tr>
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<td>97.0a</td>
<td>22.0ab</td>
<td>54.9c</td>
</tr>
<tr>
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<td>94.0a</td>
<td>98.0a</td>
<td>24.1ab</td>
<td>60.9b</td>
</tr>
<tr>
<td>Ko17</td>
<td>98.0a</td>
<td>98.0a</td>
<td>21.6b</td>
<td>59.8bc</td>
</tr>
<tr>
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<td>24.5a</td>
<td>71.5a</td>
</tr>
<tr>
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<td><strong>Means</strong></td>
<td><strong>97.0</strong></td>
<td><strong>97.9</strong></td>
<td><strong>60.8</strong></td>
</tr>
</tbody>
</table>

1 Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table A12. Effect of parentage on warm and cold germination, kernel weight, seedling weight and shoot/root ratio for seeds harvested at low moisture and dried at 35 C in 1984

<table>
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<th>Germination warm</th>
<th>Germination cold</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>female</td>
<td>male</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>A632 x</td>
<td>A641</td>
<td>100.0</td>
<td>95.0</td>
<td>16.7</td>
<td>46.0</td>
</tr>
<tr>
<td>A632 x</td>
<td>B14A</td>
<td>99.0</td>
<td>98.0</td>
<td>16.6</td>
<td>38.1</td>
</tr>
<tr>
<td>A632 x</td>
<td>B73</td>
<td>96.0</td>
<td>99.0</td>
<td>21.7</td>
<td>47.0</td>
</tr>
<tr>
<td>A632 x</td>
<td>K0I7</td>
<td>99.0</td>
<td>98.0</td>
<td>20.2</td>
<td>46.3</td>
</tr>
<tr>
<td>A632 x</td>
<td>W64A</td>
<td>100.0</td>
<td>99.0</td>
<td>20.1</td>
<td>57.3</td>
</tr>
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<td>A632</td>
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<td>94.0</td>
<td>21.4</td>
<td>52.3</td>
</tr>
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<td>98.0</td>
<td>22.3</td>
<td>53.0</td>
</tr>
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<td>100.0</td>
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</tr>
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<td>99.0</td>
<td>21.9</td>
<td>49.9</td>
</tr>
<tr>
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<td>99.0</td>
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<td>98.0</td>
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<td>100.0</td>
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<td>71.3</td>
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<td>W64A</td>
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<td>100.0</td>
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</tr>
<tr>
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<td>99.0</td>
<td>28.4</td>
<td>74.5</td>
</tr>
<tr>
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<td>94.0</td>
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<td>100.0</td>
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<td>98.0</td>
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<td>B14A</td>
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<td>100.0</td>
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<tr>
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<td>K0I7</td>
<td>100.0</td>
<td>100.0</td>
<td>19.4</td>
<td>60.3</td>
</tr>
<tr>
<td>Means</td>
<td></td>
<td>97.0</td>
<td>97.9</td>
<td>23.1</td>
<td>60.8</td>
</tr>
<tr>
<td>L.S.D. (0.05)</td>
<td>9.4</td>
<td>6.1</td>
<td>12.3</td>
<td>1.1</td>
<td>0.57</td>
</tr>
</tbody>
</table>
APPENDIX B: ANALYSES OF VARIANCE AND MEANS TABLES for 1985
Table B1. Analysis of variance for GCA, SCA, maternal and reciprocal effects for seed quality traits at high harvest moisture and 50 C drying temperature treatment in 1985

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean Squares</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>2186.0**</td>
<td>45.5&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>77.5**</td>
<td>3.95**</td>
<td>10.1**</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>583.5*</td>
<td>63.7&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>11.6**</td>
<td>1.3&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>2.79*</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>2520.9**</td>
<td>107.7&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>21.3**</td>
<td>4.21**</td>
<td>6.15**</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>235.9&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>29.6&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>2.8&lt;sup&gt;ns&lt;/sup&gt;</td>
<td>1.64*</td>
<td>4.64**</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>232.9</td>
<td>68.2</td>
<td>2.1</td>
<td>0.76</td>
<td>1.1</td>
</tr>
</tbody>
</table>

* **Significant at 0.05 and 0.01 levels of probability, respectively.  
<sup>ns</sup> Nonsignificant at the 0.05 level.
Table B2. Germination, kernel weight, seedling dry weight and shoot/root ratio means as affected by the inbred used either as the female or male parent in 1985 for high harvest moisture and 50°C drying temperature treatment:

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>61.0a</td>
<td>6.0b</td>
<td>19.8b</td>
<td>25.1b</td>
</tr>
<tr>
<td>A641</td>
<td>19.0c</td>
<td>8.0ab</td>
<td>17.7c</td>
<td>34.7a</td>
</tr>
<tr>
<td>E14A</td>
<td>16.0c</td>
<td>8.0ab</td>
<td>20.5b</td>
<td>38.5a</td>
</tr>
<tr>
<td>E73</td>
<td>22.0c</td>
<td>7.0ab</td>
<td>17.4c</td>
<td>26.7b</td>
</tr>
<tr>
<td>Mo17</td>
<td>15.0c</td>
<td>9.0ab</td>
<td>21.7a</td>
<td>37.4a</td>
</tr>
<tr>
<td>W64A</td>
<td>38.0b</td>
<td>14.0a</td>
<td>16.3d</td>
<td>22.0b</td>
</tr>
<tr>
<td>Means</td>
<td>28.5</td>
<td>8.7</td>
<td>18.9</td>
<td>30.7</td>
</tr>
</tbody>
</table>

Male

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>A632</td>
<td>24.0bc</td>
<td>11.0a</td>
<td>18.9c</td>
<td>31.0a</td>
</tr>
<tr>
<td>A641</td>
<td>21.0c</td>
<td>10.0a</td>
<td>16.4d</td>
<td>28.3a</td>
</tr>
<tr>
<td>E14A</td>
<td>37.0a</td>
<td>7.0a</td>
<td>19.2bc</td>
<td>30.5a</td>
</tr>
<tr>
<td>E73</td>
<td>34.0ab</td>
<td>8.0a</td>
<td>20.3a</td>
<td>29.4a</td>
</tr>
<tr>
<td>Mo17</td>
<td>32.0abc</td>
<td>10.0a</td>
<td>20.2ab</td>
<td>28.0a</td>
</tr>
<tr>
<td>W64A</td>
<td>25.0bc</td>
<td>7.0a</td>
<td>18.5c</td>
<td>32.8a</td>
</tr>
<tr>
<td>Means</td>
<td>28.5</td>
<td>8.7</td>
<td>18.9</td>
<td>30.7</td>
</tr>
</tbody>
</table>

1Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table B3. Effect of parentage on seed quality traits measured in 1985 for seeds harvested at high moisture and dried at 50°C

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>female x male</td>
<td>%-----------</td>
<td>-------------------</td>
<td>----------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>A632 x A641</td>
<td>34.0</td>
<td>9.0</td>
<td>15.5</td>
<td>21.6</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>69.0</td>
<td>5.0</td>
<td>19.1</td>
<td>18.0</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>77.0</td>
<td>3.0</td>
<td>21.7</td>
<td>22.4</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>64.0</td>
<td>13.0</td>
<td>22.6</td>
<td>23.2</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>60.0</td>
<td>2.0</td>
<td>20.0</td>
<td>35.6</td>
</tr>
<tr>
<td>A641 x A632</td>
<td>23.0</td>
<td>11.0</td>
<td>17.3</td>
<td>36.5</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>11.0</td>
<td>5.0</td>
<td>17.3</td>
<td>40.0</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>31.0</td>
<td>15.0</td>
<td>18.0</td>
<td>33.1</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>14.0</td>
<td>6.0</td>
<td>18.1</td>
<td>27.5</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>19.0</td>
<td>3.0</td>
<td>17.1</td>
<td>35.8</td>
</tr>
<tr>
<td>B14A x A632</td>
<td>17.0</td>
<td>10.0</td>
<td>20.7</td>
<td>37.4</td>
</tr>
<tr>
<td>B14A x A641</td>
<td>19.0</td>
<td>5.0</td>
<td>17.7</td>
<td>36.8</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>7.0</td>
<td>5.0</td>
<td>21.8</td>
<td>34.1</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>17.0</td>
<td>10.0</td>
<td>22.5</td>
<td>36.9</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>21.0</td>
<td>13.0</td>
<td>19.6</td>
<td>46.1</td>
</tr>
<tr>
<td>B73 x A632</td>
<td>19.0</td>
<td>7.0</td>
<td>16.6</td>
<td>18.0</td>
</tr>
<tr>
<td>B73 x A641</td>
<td>17.0</td>
<td>13.0</td>
<td>14.9</td>
<td>27.5</td>
</tr>
<tr>
<td>B73 x B14A</td>
<td>40.0</td>
<td>1.0</td>
<td>19.1</td>
<td>23.5</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>28.0</td>
<td>7.0</td>
<td>21.0</td>
<td>21.7</td>
</tr>
<tr>
<td>B73 x W64A</td>
<td>7.0</td>
<td>9.0</td>
<td>15.6</td>
<td>26.0</td>
</tr>
<tr>
<td>Mo17 x A632</td>
<td>26.0</td>
<td>14.0</td>
<td>22.2</td>
<td>34.3</td>
</tr>
<tr>
<td>Mo17 x A641</td>
<td>9.0</td>
<td>10.0</td>
<td>18.5</td>
<td>30.6</td>
</tr>
<tr>
<td>Mo17 x B14A</td>
<td>16.0</td>
<td>8.0</td>
<td>24.7</td>
<td>56.8</td>
</tr>
<tr>
<td>Mo17 x B73</td>
<td>10.0</td>
<td>5.0</td>
<td>25.5</td>
<td>37.0</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>15.0</td>
<td>7.0</td>
<td>19.7</td>
<td>20.0</td>
</tr>
<tr>
<td>W64A x A632</td>
<td>33.0</td>
<td>14.0</td>
<td>16.8</td>
<td>20.2</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>25.0</td>
<td>11.0</td>
<td>15.4</td>
<td>25.4</td>
</tr>
<tr>
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<td>17.0</td>
<td>15.7</td>
<td>17.2</td>
</tr>
<tr>
<td>W64A x B73</td>
<td>43.0</td>
<td>13.0</td>
<td>16.5</td>
<td>23.1</td>
</tr>
<tr>
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<td>15.0</td>
<td>16.9</td>
<td>24.0</td>
</tr>
<tr>
<td>Means</td>
<td>28.5</td>
<td>8.7</td>
<td>18.9</td>
<td>30.7</td>
</tr>
<tr>
<td>L.S.D. (0.05)</td>
<td>24.9</td>
<td>13.5</td>
<td>2.4</td>
<td>1.4</td>
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</tbody>
</table>
Table B4. Analysis of variance for GCA, SCA, maternal and reciprocal effects for seed quality traits at high harvest moisture and 35 C drying temperature treatment in 1985

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>49.4 **</td>
<td>88.9 ns</td>
<td>68.5 **</td>
<td>3.23 **</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>13.5 ns</td>
<td>17.0 ns</td>
<td>7.3 **</td>
<td>0.68 **</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>44.3 **</td>
<td>44.3 *</td>
<td>25.5 **</td>
<td>3.06 **</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>22.6 **</td>
<td>76.3 **</td>
<td>2.7 ns</td>
<td>0.33 *</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>6.8</td>
<td>17.7</td>
<td>2.5</td>
<td>0.15</td>
</tr>
</tbody>
</table>

* **Significant at 0.05 and 0.01 levels of probability, respectively. ns Nonsignificant at the 0.05 level.
Table E5. Germination, kernel weight, seedling dry weight and shoot/root ratio means as affected by the inbred used either as female or male parent in 1985 for high harvest moisture and 35 C drying temperature treatment.

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>99.0a</td>
<td>98.0a</td>
<td>19.8a</td>
<td>60.6a</td>
</tr>
<tr>
<td>A641</td>
<td>96.0bc</td>
<td>92.0bc</td>
<td>17.8b</td>
<td>55.6b</td>
</tr>
<tr>
<td>B14A</td>
<td>94.0d</td>
<td>91.0c</td>
<td>20.6a</td>
<td>46.5d</td>
</tr>
<tr>
<td>B73</td>
<td>97.0ab</td>
<td>99.0a</td>
<td>17.7b</td>
<td>51.9c</td>
</tr>
<tr>
<td>Mo17</td>
<td>99.0a</td>
<td>98.0a</td>
<td>21.0a</td>
<td>58.7a</td>
</tr>
<tr>
<td>W64A</td>
<td>95.0cd</td>
<td>94.0b</td>
<td>15.8c</td>
<td>50.0c</td>
</tr>
<tr>
<td>Means</td>
<td>96.7</td>
<td>95.3</td>
<td>18.8</td>
<td>53.9</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>97.0a</td>
<td>92.0b</td>
<td>19.0a</td>
<td>52.6bc</td>
</tr>
<tr>
<td>A641</td>
<td>94.0b</td>
<td>94.0ab</td>
<td>16.3b</td>
<td>48.5d</td>
</tr>
<tr>
<td>B14A</td>
<td>96.0a</td>
<td>96.0a</td>
<td>19.1a</td>
<td>51.8c</td>
</tr>
<tr>
<td>B73</td>
<td>96.0a</td>
<td>96.0a</td>
<td>19.7a</td>
<td>58.0a</td>
</tr>
<tr>
<td>Mo17</td>
<td>97.0a</td>
<td>95.0ab</td>
<td>19.8a</td>
<td>55.1ab</td>
</tr>
<tr>
<td>W64A</td>
<td>97.0a</td>
<td>96.0a</td>
<td>18.9a</td>
<td>57.3a</td>
</tr>
<tr>
<td>Means</td>
<td>96.7</td>
<td>95.3</td>
<td>18.8</td>
<td>53.9</td>
</tr>
</tbody>
</table>

Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table E6. Effect of parentage on seed quality traits measured in 1985 for seed harvested at high moisture and dried at 35 C

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>female</td>
<td>male</td>
<td>warm</td>
<td>cold</td>
<td></td>
</tr>
<tr>
<td>A632 x A641</td>
<td>96.0</td>
<td>95.0</td>
<td>17.1</td>
<td>57.0</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>100.0</td>
<td>97.0</td>
<td>20.7</td>
<td>52.9</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>98.0</td>
<td>98.0</td>
<td>18.6</td>
<td>58.9</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>99.0</td>
<td>99.0</td>
<td>21.9</td>
<td>64.6</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>99.0</td>
<td>100.0</td>
<td>20.9</td>
<td>69.3</td>
</tr>
<tr>
<td>A641 x A632</td>
<td>93.0</td>
<td>90.0</td>
<td>16.8</td>
<td>52.9</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>99.0</td>
<td>95.0</td>
<td>18.2</td>
<td>52.2</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>95.0</td>
<td>95.0</td>
<td>18.9</td>
<td>59.0</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>97.0</td>
<td>88.0</td>
<td>18.0</td>
<td>57.1</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>97.0</td>
<td>91.0</td>
<td>17.0</td>
<td>56.9</td>
</tr>
<tr>
<td>B14A x A632</td>
<td>93.0</td>
<td>90.0</td>
<td>22.2</td>
<td>42.2</td>
</tr>
<tr>
<td>B14A x A641</td>
<td>87.0</td>
<td>85.0</td>
<td>17.6</td>
<td>38.4</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>95.0</td>
<td>92.0</td>
<td>21.8</td>
<td>52.1</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>97.0</td>
<td>95.0</td>
<td>22.5</td>
<td>52.8</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>97.0</td>
<td>91.0</td>
<td>19.0</td>
<td>47.1</td>
</tr>
<tr>
<td>E73 x A632</td>
<td>98.0</td>
<td>97.0</td>
<td>17.3</td>
<td>53.1</td>
</tr>
<tr>
<td>E73 x A641</td>
<td>97.0</td>
<td>96.0</td>
<td>14.5</td>
<td>48.1</td>
</tr>
<tr>
<td>E73 x B14A</td>
<td>97.0</td>
<td>99.0</td>
<td>18.4</td>
<td>48.3</td>
</tr>
<tr>
<td>E73 x Mo17</td>
<td>98.0</td>
<td>94.0</td>
<td>21.1</td>
<td>58.2</td>
</tr>
<tr>
<td>E73 x W64A</td>
<td>96.0</td>
<td>99.0</td>
<td>17.3</td>
<td>52.0</td>
</tr>
<tr>
<td>Mo17 x A632</td>
<td>99.0</td>
<td>98.0</td>
<td>22.5</td>
<td>60.0</td>
</tr>
<tr>
<td>Mo17 x A641</td>
<td>99.0</td>
<td>97.0</td>
<td>16.7</td>
<td>50.6</td>
</tr>
<tr>
<td>Mo17 x B14A</td>
<td>99.0</td>
<td>95.0</td>
<td>22.5</td>
<td>57.9</td>
</tr>
<tr>
<td>Mo17 x B73</td>
<td>97.0</td>
<td>100.0</td>
<td>22.6</td>
<td>65.6</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>98.0</td>
<td>100.0</td>
<td>20.4</td>
<td>61.1</td>
</tr>
<tr>
<td>W64A x A632</td>
<td>99.0</td>
<td>85.0</td>
<td>15.9</td>
<td>54.9</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>88.0</td>
<td>97.0</td>
<td>15.6</td>
<td>48.1</td>
</tr>
<tr>
<td>W64A x B14A</td>
<td>94.0</td>
<td>95.0</td>
<td>15.7</td>
<td>47.8</td>
</tr>
<tr>
<td>W64A x B73</td>
<td>96.0</td>
<td>96.0</td>
<td>16.4</td>
<td>56.1</td>
</tr>
<tr>
<td>W64A x Mo17</td>
<td>96.0</td>
<td>98.0</td>
<td>15.4</td>
<td>42.9</td>
</tr>
<tr>
<td>Means</td>
<td>96.7</td>
<td>95.3</td>
<td>18.8</td>
<td>53.9</td>
</tr>
<tr>
<td>L.S.D. (0.05)</td>
<td>4.3</td>
<td>6.9</td>
<td>2.6</td>
<td>0.64</td>
</tr>
</tbody>
</table>
Table B7. Analysis of variance for GCA, SCA, maternal and reciprocal effects for seed quality traits at low harvest moisture and 50 C drying temperature treatment in 1985

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination (Mean Squares)</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>972.0*</td>
<td>3482.9**</td>
<td>106.0**</td>
<td>5.7**</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>665.2ns</td>
<td>632.7ns</td>
<td>10.8**</td>
<td>2.6**</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>3263.9**</td>
<td>1664.4**</td>
<td>34.0**</td>
<td>12.73**</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>1507.8**</td>
<td>750.3*</td>
<td>8.4*</td>
<td>1.53ns</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>343.0</td>
<td>343.0</td>
<td>3.3</td>
<td>0.85</td>
</tr>
</tbody>
</table>

*,' **Significant at 0.05 and 0.01 levels of probability, respectively. ns. Nonsignificant at the 0.05 level.
Table E8. Germination, kernel weight, seedling dry weight and shoot/root ratio means as affected by the inbred used either as female or male parent in 1985 for low harvest moisture and 50 °C drying temperature treatment

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>56.0ab</td>
<td>16.0b</td>
<td>24.1b</td>
<td>45.0ab</td>
</tr>
<tr>
<td>A641</td>
<td>69.0a</td>
<td>55.0a</td>
<td>23.4b</td>
<td>51.3a</td>
</tr>
<tr>
<td>B14A</td>
<td>64.0a</td>
<td>15.0b</td>
<td>27.2a</td>
<td>32.6c</td>
</tr>
<tr>
<td>B73</td>
<td>44.0bc</td>
<td>6.0b</td>
<td>24.7b</td>
<td>23.3d</td>
</tr>
<tr>
<td>Mo17</td>
<td>38.0c</td>
<td>20.0b</td>
<td>27.5a</td>
<td>39.0bc</td>
</tr>
<tr>
<td>W64A</td>
<td>35.0c</td>
<td>13.0b</td>
<td>21.5c</td>
<td>44.2ab</td>
</tr>
<tr>
<td>Means</td>
<td>51.0</td>
<td>20.8</td>
<td>24.7</td>
<td>39.2</td>
</tr>
</tbody>
</table>

Male

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>41.0cd</td>
<td>18.0a</td>
<td>24.3b</td>
<td>39.1bc</td>
</tr>
<tr>
<td>A641</td>
<td>54.0abc</td>
<td>23.0a</td>
<td>21.9c</td>
<td>35.8bc</td>
</tr>
<tr>
<td>B14A</td>
<td>37.0d</td>
<td>16.0a</td>
<td>24.9b</td>
<td>34.6c</td>
</tr>
<tr>
<td>B73</td>
<td>48.0bcd</td>
<td>16.0a</td>
<td>27.2a</td>
<td>46.7a</td>
</tr>
<tr>
<td>Mo17</td>
<td>66.0a</td>
<td>27.0a</td>
<td>25.6b</td>
<td>42.8ab</td>
</tr>
<tr>
<td>W64A</td>
<td>62.0ab</td>
<td>26.0a</td>
<td>24.5b</td>
<td>37.3bc</td>
</tr>
<tr>
<td>Means</td>
<td>51.0</td>
<td>20.8</td>
<td>24.7</td>
<td>39.2</td>
</tr>
</tbody>
</table>

1 Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table B9. Effect of parentage on seed quality traits measured in 1985 for seed harvested at low moisture and dried at 50°C

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632 x A641</td>
<td>75.0</td>
<td>27.0</td>
<td>20.1</td>
<td>39.6</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>23.0</td>
<td>3.0</td>
<td>24.8</td>
<td>31.8</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>43.0</td>
<td>4.0</td>
<td>26.5</td>
<td>55.1</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>50.0</td>
<td>5.0</td>
<td>26.8</td>
<td>46.8</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>92.0</td>
<td>41.0</td>
<td>22.2</td>
<td>51.5</td>
</tr>
<tr>
<td>A641 x A632</td>
<td>68.0</td>
<td>56.0</td>
<td>20.9</td>
<td>47.8</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>74.0</td>
<td>51.0</td>
<td>22.9</td>
<td>42.6</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>69.0</td>
<td>45.0</td>
<td>27.8</td>
<td>54.4</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>66.0</td>
<td>65.0</td>
<td>24.3</td>
<td>59.6</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>71.0</td>
<td>59.0</td>
<td>21.2</td>
<td>52.1</td>
</tr>
<tr>
<td>B14A x A632</td>
<td>55.0</td>
<td>16.0</td>
<td>26.8</td>
<td>26.7</td>
</tr>
<tr>
<td>B14A x A641</td>
<td>52.0</td>
<td>15.0</td>
<td>25.0</td>
<td>26.0</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>64.0</td>
<td>12.0</td>
<td>27.9</td>
<td>33.3</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>75.0</td>
<td>17.0</td>
<td>29.2</td>
<td>39.4</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>75.0</td>
<td>18.0</td>
<td>27.0</td>
<td>37.8</td>
</tr>
<tr>
<td>B73 x A632</td>
<td>23.0</td>
<td>1.0</td>
<td>26.7</td>
<td>19.7</td>
</tr>
<tr>
<td>B73 x A641</td>
<td>40.0</td>
<td>5.0</td>
<td>22.5</td>
<td>23.0</td>
</tr>
<tr>
<td>B73 x B14A</td>
<td>31.0</td>
<td>7.0</td>
<td>25.9</td>
<td>26.0</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>65.0</td>
<td>5.0</td>
<td>25.9</td>
<td>20.6</td>
</tr>
<tr>
<td>B73 x W64A</td>
<td>63.0</td>
<td>13.0</td>
<td>22.7</td>
<td>25.9</td>
</tr>
<tr>
<td>Mo17 x A632</td>
<td>25.0</td>
<td>11.0</td>
<td>28.1</td>
<td>43.0</td>
</tr>
<tr>
<td>Mo17 x A641</td>
<td>75.0</td>
<td>67.0</td>
<td>21.0</td>
<td>52.8</td>
</tr>
<tr>
<td>Mo17 x B14A</td>
<td>23.0</td>
<td>11.0</td>
<td>28.2</td>
<td>37.2</td>
</tr>
<tr>
<td>Mo17 x B73</td>
<td>46.0</td>
<td>11.0</td>
<td>31.0</td>
<td>42.8</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>11.0</td>
<td>0.0</td>
<td>29.5</td>
<td>19.2</td>
</tr>
<tr>
<td>W64A x A632</td>
<td>23.0</td>
<td>6.0</td>
<td>18.8</td>
<td>51.8</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>29.0</td>
<td>1.0</td>
<td>21.0</td>
<td>37.5</td>
</tr>
<tr>
<td>W64A x B14A</td>
<td>30.0</td>
<td>7.0</td>
<td>23.0</td>
<td>35.7</td>
</tr>
<tr>
<td>W64A x B73</td>
<td>21.0</td>
<td>7.0</td>
<td>22.8</td>
<td>48.2</td>
</tr>
<tr>
<td>W64A x Mo17</td>
<td>75.0</td>
<td>42.0</td>
<td>21.7</td>
<td>47.8</td>
</tr>
<tr>
<td>Means</td>
<td>51.0</td>
<td>20.8</td>
<td>24.7</td>
<td>39.2</td>
</tr>
<tr>
<td>L.S.D. (0.05)</td>
<td>30.2</td>
<td>30.2</td>
<td>3.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Table E10. Analysis of variance for GCA, SCA, maternal and reciprocal effects for warm seed quality traits at low harvest moisture and 35 C drying temperature treatment in 1985

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCA</td>
<td>5</td>
<td>21.3*</td>
<td>33.8**</td>
<td>75.8**</td>
<td>4.7**</td>
</tr>
<tr>
<td>SCA</td>
<td>9</td>
<td>9.5*</td>
<td>7.4*</td>
<td>4.7*</td>
<td>0.46*</td>
</tr>
<tr>
<td>Maternal</td>
<td>5</td>
<td>22.4*</td>
<td>9.5*</td>
<td>49.9**</td>
<td>1.4**</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>10</td>
<td>9.3*</td>
<td>10.6*</td>
<td>10.9**</td>
<td>0.65**</td>
</tr>
<tr>
<td>Error</td>
<td>58</td>
<td>9.54</td>
<td>9.7</td>
<td>2.6</td>
<td>0.20</td>
</tr>
</tbody>
</table>

* ** Significant at 0.05 and 0.01 levels of probability, respectively.
* ns Nonsignificant at the 0.05 level.
Table B11. Germination, kernel weight, seedling dry weight and shoot/root ratio means as affected by the inbred used either as female or male parent in 1985 for low harvest moisture and 35 °C drying temperature treatment

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight</th>
<th>Seedling weight</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm</td>
<td>Cold</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A632</td>
<td>99.0a</td>
<td>97.0a</td>
<td>24.5b</td>
<td>65.2b</td>
</tr>
<tr>
<td>A641</td>
<td>96.0b</td>
<td>96.0b</td>
<td>22.6c</td>
<td>63.7bd</td>
</tr>
<tr>
<td>E14A</td>
<td>99.0a</td>
<td>98.0a</td>
<td>27.0a</td>
<td>60.2c</td>
</tr>
<tr>
<td>E73</td>
<td>100.0a</td>
<td>98.0a</td>
<td>25.3b</td>
<td>62.8bc</td>
</tr>
<tr>
<td>Mo17</td>
<td>99.0a</td>
<td>98.0a</td>
<td>28.0a</td>
<td>71.9a</td>
</tr>
<tr>
<td>W64A</td>
<td>98.0ab</td>
<td>98.0a</td>
<td>21.5c</td>
<td>65.9b</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>98.5</td>
<td>97.5</td>
<td>24.8</td>
<td>65.0</td>
</tr>
</tbody>
</table>

| Male   |       |       |     |      |               |
|--------|       |       |     |      |               |
| A632   | 96.0b | 96.0b | 25.6ab | 58.6c | 1.9a           |
| A641   | 98.0ab | 97.0ab | 22.5d | 61.9b | 2.0a           |
| E14A   | 99.0a | 97.0b | 24.1c | 62.5b | 2.1a           |
| E73    | 98.0ab | 99.0a | 26.2a | 68.9a | 1.7b           |
| Mo17   | 99.0a | 97.0ab | 24.6bc | 68.5a | 1.5c           |
| W64A   | 100.0a | 98.0ab | 25.7ab | 69.3a | 1.4c           |
|        |       |       |     |      |               |
| Means  | 98.5  | 97.5  | 24.8 | 65.0  | 1.8            |

1Means within a column followed by the same letter do not differ significantly at the 5% level of probability, according to Duncan's multiple range test.
Table E12. Effect of parentage on seed quality traits measured in 1985 for seeds harvested at low moisture and dried at 35 C

<table>
<thead>
<tr>
<th>Parent</th>
<th>Germination</th>
<th>Kernel weight (g)</th>
<th>Seedling weight (mg)</th>
<th>Shoot/root ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>female</td>
<td>male</td>
<td>warm</td>
<td>cold</td>
<td></td>
</tr>
<tr>
<td>A632 x A641</td>
<td>98.0</td>
<td>94.0</td>
<td>21.3</td>
<td>63.4</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>99.0</td>
<td>99.0</td>
<td>25.0</td>
<td>59.0</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>98.0</td>
<td>100.0</td>
<td>26.3</td>
<td>65.7</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>100.0</td>
<td>98.0</td>
<td>24.2</td>
<td>69.7</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>99.0</td>
<td>97.0</td>
<td>25.5</td>
<td>68.2</td>
</tr>
<tr>
<td>A641 x A632</td>
<td>89.0</td>
<td>95.0</td>
<td>21.5</td>
<td>59.0</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>97.0</td>
<td>92.0</td>
<td>22.4</td>
<td>58.8</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>95.0</td>
<td>98.0</td>
<td>25.7</td>
<td>72.1</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>99.0</td>
<td>99.0</td>
<td>22.8</td>
<td>69.1</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>99.0</td>
<td>97.0</td>
<td>27.5</td>
<td>59.7</td>
</tr>
<tr>
<td>B14A x A632</td>
<td>99.0</td>
<td>97.0</td>
<td>27.5</td>
<td>47.6</td>
</tr>
<tr>
<td>B14A x A641</td>
<td>99.0</td>
<td>98.0</td>
<td>26.1</td>
<td>56.5</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>97.0</td>
<td>99.0</td>
<td>26.6</td>
<td>60.1</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>99.0</td>
<td>96.0</td>
<td>27.5</td>
<td>68.0</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>100.0</td>
<td>99.0</td>
<td>27.4</td>
<td>68.4</td>
</tr>
<tr>
<td>B73 x A632</td>
<td>99.0</td>
<td>97.0</td>
<td>28.9</td>
<td>51.5</td>
</tr>
<tr>
<td>B73 x A641</td>
<td>100.0</td>
<td>100.0</td>
<td>19.8</td>
<td>55.5</td>
</tr>
<tr>
<td>B73 x B14A</td>
<td>99.0</td>
<td>97.0</td>
<td>25.1</td>
<td>64.2</td>
</tr>
<tr>
<td>B73 x Mo17</td>
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<td>98.0</td>
<td>27.4</td>
<td>69.6</td>
</tr>
<tr>
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<td>100.0</td>
<td>100.0</td>
<td>25.0</td>
<td>72.7</td>
</tr>
<tr>
<td>Mo17 x A632</td>
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<td>94.0</td>
<td>28.9</td>
<td>70.5</td>
</tr>
<tr>
<td>Mo17 x A641</td>
<td>98.0</td>
<td>98.0</td>
<td>25.0</td>
<td>68.0</td>
</tr>
<tr>
<td>Mo17 x B14A</td>
<td>99.0</td>
<td>100.0</td>
<td>26.6</td>
<td>68.3</td>
</tr>
<tr>
<td>Mo17 x B73</td>
<td>99.0</td>
<td>100.0</td>
<td>28.9</td>
<td>75.1</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>99.0</td>
<td>100.0</td>
<td>30.4</td>
<td>77.7</td>
</tr>
<tr>
<td>W64A x A632</td>
<td>98.0</td>
<td>97.0</td>
<td>21.0</td>
<td>63.9</td>
</tr>
<tr>
<td>W64A x A641</td>
<td>97.0</td>
<td>97.0</td>
<td>20.5</td>
<td>66.2</td>
</tr>
<tr>
<td>W64A x B14A</td>
<td>99.0</td>
<td>97.0</td>
<td>21.5</td>
<td>62.0</td>
</tr>
<tr>
<td>W64A x B73</td>
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<td>100.0</td>
<td>23.5</td>
<td>71.2</td>
</tr>
<tr>
<td>W64A x Mo17</td>
<td>98.0</td>
<td>99.0</td>
<td>21.1</td>
<td>66.1</td>
</tr>
<tr>
<td>Means</td>
<td>98.5</td>
<td>97.5</td>
<td>24.8</td>
<td>65.0</td>
</tr>
<tr>
<td>L.S.D. (0.05)</td>
<td>5.0</td>
<td>5.1</td>
<td>2.6</td>
<td>0.72</td>
</tr>
</tbody>
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APPENDIX C: SPECIFIC COMBINING ABILITY (SCA)

ESTIMATES FOR 1984 AND 1985
Table C1. SCA effects for four seed quality traits at high harvest moisture and 50 °C drying treatment in 1984 and 1985

<table>
<thead>
<tr>
<th>Female x Male</th>
<th>Germination</th>
<th></th>
<th>Germination</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>warm</td>
<td>cold</td>
<td>weight</td>
<td>mg</td>
</tr>
<tr>
<td>A632 x A641</td>
<td>3.40</td>
<td>7.08</td>
<td>1.10</td>
<td>-0.01</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>1.15</td>
<td>-8.68</td>
<td>-6.17</td>
<td>-0.85</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>-5.48</td>
<td>-15.05</td>
<td>-1.71</td>
<td>-0.66</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>4.15</td>
<td>10.45</td>
<td>5.11</td>
<td>0.41</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>5.90</td>
<td>6.45</td>
<td>4.46</td>
<td>0.40</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>8.76</td>
<td>6.08</td>
<td>3.97</td>
<td>0.40</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>-21.10</td>
<td>-16.93</td>
<td>-10.02</td>
<td>-0.29</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>-9.73</td>
<td>-6.93</td>
<td>-1.22</td>
<td>-0.69</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>5.65</td>
<td>6.20</td>
<td>-0.61</td>
<td>0.41</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>4.28</td>
<td>-2.80</td>
<td>-0.34</td>
<td>1.57</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>-9.48</td>
<td>1.33</td>
<td>-1.99</td>
<td>0.60</td>
</tr>
<tr>
<td>B73 x W64A</td>
<td>12.15</td>
<td>7.83</td>
<td>4.92</td>
<td>-0.94</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>0.53</td>
<td>1.45</td>
<td>0.33</td>
<td>0.74</td>
</tr>
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</table>

S.E. (+/-) 6.79 8.47 0.33 0.35 4.83 2.61 0.46 0.27
Table C2. SCA effects for four seed quality traits at high harvest moisture and 35 C drying treatment in 1984 and 1985

<table>
<thead>
<tr>
<th>Female</th>
<th>Male</th>
<th>Germination</th>
<th>Kernel Sdling</th>
<th>Germination</th>
<th>Kernel Sdling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td>weight</td>
<td>weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(g)</td>
<td>(mg)</td>
<td>(g)</td>
<td>(mg)</td>
</tr>
<tr>
<td>A632 x</td>
<td>A641</td>
<td>-3.63</td>
<td>-0.85</td>
<td>-0.64</td>
<td>-2.20</td>
</tr>
<tr>
<td>A632 x</td>
<td>B14A</td>
<td>-3.38</td>
<td>-1.48</td>
<td>0.39</td>
<td>-4.73</td>
</tr>
<tr>
<td>A632 x</td>
<td>B73</td>
<td>-1.48</td>
<td>0.44</td>
<td>4.61</td>
<td>0.10</td>
</tr>
<tr>
<td>A632 x</td>
<td>Mo17</td>
<td>2.00</td>
<td>5.98</td>
<td>0.40</td>
<td>1.14</td>
</tr>
<tr>
<td>A632 x</td>
<td>W64A</td>
<td>4.38</td>
<td>-0.98</td>
<td>-0.57</td>
<td>1.16</td>
</tr>
<tr>
<td>A641 x</td>
<td>B14A</td>
<td>2.25</td>
<td>-0.98</td>
<td>0.21</td>
<td>-2.28</td>
</tr>
<tr>
<td>A641 x</td>
<td>B73</td>
<td>2.75</td>
<td>-2.48</td>
<td>0.80</td>
<td>0.41</td>
</tr>
<tr>
<td>A641 x</td>
<td>Mo17</td>
<td>1.13</td>
<td>2.775</td>
<td>-0.13</td>
<td>3.39</td>
</tr>
<tr>
<td>A641 x</td>
<td>W64A</td>
<td>2.00</td>
<td>1.53</td>
<td>-0.24</td>
<td>0.68</td>
</tr>
<tr>
<td>B14A x</td>
<td>B73</td>
<td>1.00</td>
<td>1.40</td>
<td>-0.58</td>
<td>-1.83</td>
</tr>
<tr>
<td>B14A x</td>
<td>Mo17</td>
<td>0.88</td>
<td>-2.35</td>
<td>-1.25</td>
<td>-0.60</td>
</tr>
<tr>
<td>B14A x</td>
<td>W64A</td>
<td>3.75</td>
<td>3.40</td>
<td>1.24</td>
<td>9.44</td>
</tr>
<tr>
<td>B73 x</td>
<td>Mo17</td>
<td>0.88</td>
<td>0.65</td>
<td>0.39</td>
<td>2.09</td>
</tr>
<tr>
<td>B73 x</td>
<td>W64A</td>
<td>-5.25</td>
<td>2.90</td>
<td>-1.03</td>
<td>-5.27</td>
</tr>
<tr>
<td>Mo17 x</td>
<td>W64A</td>
<td>-4.88</td>
<td>-6.85</td>
<td>0.60</td>
<td>-5.03</td>
</tr>
</tbody>
</table>

S.E.(+/-) 4.11 4.27 0.71 0.30 0.82 1.33 0.50 0.12
Table C3. SCA effects for four seed quality traits at low harvest moisture and 50 C drying treatment in 1984 and 1985

<table>
<thead>
<tr>
<th>Female</th>
<th>Male</th>
<th>Germination</th>
<th>Kernel Sdling</th>
<th>Germination</th>
<th>Kernel Sdling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>warm</td>
<td>cold</td>
<td>weight</td>
<td>weight</td>
</tr>
<tr>
<td>A632 x A641</td>
<td>-9.25</td>
<td>-1.80</td>
<td>-1.67</td>
<td>-0.77</td>
<td>11.18</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>6.00</td>
<td>-8.68</td>
<td>1.05</td>
<td>-2.98</td>
<td>-6.83</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>-5.38</td>
<td>-11.80</td>
<td>1.32</td>
<td>-0.23</td>
<td>-8.08</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>11.50</td>
<td>18.20</td>
<td>0.30</td>
<td>6.02</td>
<td>-9.70</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>-2.88</td>
<td>4.08</td>
<td>-0.99</td>
<td>-2.03</td>
<td>13.43</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>8.25</td>
<td>16.58</td>
<td>-0.32</td>
<td>2.94</td>
<td>-0.45</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>5.89</td>
<td>13.45</td>
<td>-0.24</td>
<td>-1.86</td>
<td>-4.70</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>6.75</td>
<td>-0.05</td>
<td>1.08</td>
<td>5.29</td>
<td>5.68</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>-11.63</td>
<td>-28.18</td>
<td>1.15</td>
<td>-5.61</td>
<td>-11.70</td>
</tr>
<tr>
<td>E14A x B73</td>
<td>1.63</td>
<td>5.58</td>
<td>-0.96</td>
<td>2.73</td>
<td>3.30</td>
</tr>
<tr>
<td>E14A x Mo17</td>
<td>-21.50</td>
<td>-14.43</td>
<td>-0.79</td>
<td>-6.77</td>
<td>-0.33</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>5.63</td>
<td>0.95</td>
<td>1.02</td>
<td>4.08</td>
<td>4.30</td>
</tr>
<tr>
<td>E73 x Mo17</td>
<td>-3.88</td>
<td>-17.05</td>
<td>0.24</td>
<td>-4.37</td>
<td>9.93</td>
</tr>
<tr>
<td>E73 x W64A</td>
<td>1.75</td>
<td>9.83</td>
<td>-0.35</td>
<td>3.73</td>
<td>-0.45</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>7.13</td>
<td>13.33</td>
<td>-0.63</td>
<td>-0.17</td>
<td>-5.58</td>
</tr>
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</table>

S.E.(+/−) 4.97 7.33 2.84 0.26 5.86 5.68 0.57 0.29
Table C4. SCA effects for four seed quality traits at low harvest moisture and 35 C drying treatment in 1984 and 1985

<table>
<thead>
<tr>
<th>Female x Male</th>
<th>Germination</th>
<th>Kernel Sdling</th>
<th>Germination</th>
<th>Kernel Sdling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>warm</td>
<td>cold</td>
<td>weight</td>
<td>weight</td>
</tr>
<tr>
<td>A632 x A641</td>
<td>-2.03</td>
<td>-1.00</td>
<td>1.27</td>
<td>-1.28</td>
</tr>
<tr>
<td>A632 x B14A</td>
<td>2.73</td>
<td>-0.50</td>
<td>-4.16</td>
<td>-0.90</td>
</tr>
<tr>
<td>A632 x B73</td>
<td>1.10</td>
<td>0.00</td>
<td>-1.19</td>
<td>1.45</td>
</tr>
<tr>
<td>A632 x Mo17</td>
<td>-2.28</td>
<td>0.51</td>
<td>5.09</td>
<td>0.59</td>
</tr>
<tr>
<td>A632 x W64A</td>
<td>0.48</td>
<td>1.00</td>
<td>-1.01</td>
<td>0.15</td>
</tr>
<tr>
<td>A641 x B14A</td>
<td>1.85</td>
<td>3.00</td>
<td>1.04</td>
<td>0.24</td>
</tr>
<tr>
<td>A641 x B73</td>
<td>7.23</td>
<td>3.00</td>
<td>4.02</td>
<td>0.24</td>
</tr>
<tr>
<td>A641 x Mo17</td>
<td>-0.65</td>
<td>0.00</td>
<td>-6.86</td>
<td>0.67</td>
</tr>
<tr>
<td>A641 x W64A</td>
<td>-6.40</td>
<td>-5.00</td>
<td>0.54</td>
<td>0.14</td>
</tr>
<tr>
<td>B14A x B73</td>
<td>-11.03</td>
<td>-2.50</td>
<td>3.81</td>
<td>-0.19</td>
</tr>
<tr>
<td>B14A x Mo17</td>
<td>2.60</td>
<td>-1.00</td>
<td>-0.14</td>
<td>-1.55</td>
</tr>
<tr>
<td>B14A x W64A</td>
<td>3.85</td>
<td>1.00</td>
<td>7.07</td>
<td>2.41</td>
</tr>
<tr>
<td>B73 x Mo17</td>
<td>0.48</td>
<td>-1.50</td>
<td>4.74</td>
<td>0.75</td>
</tr>
<tr>
<td>B73 x W64A</td>
<td>2.23</td>
<td>1.00</td>
<td>-3.76</td>
<td>-2.24</td>
</tr>
<tr>
<td>Mo17 x W64A</td>
<td>-0.15</td>
<td>2.00</td>
<td>-2.84</td>
<td>-0.45</td>
</tr>
</tbody>
</table>

S.E.(+/-) 1.83 | 1.18 | 0.57 | 0.22 0.98 | 0.98 | 0.51 | 0.14