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Combining Ability among and within early, medium, and late maturity classes of maize (Zea mays L.) inbred lines

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Mohamed Barre Ahmed

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COMBINING ABILITY AMONG AND WITHIN EARLY, MEDIUM, AND LATE MATURITY CLASSES OF MAIZE (*Zea mays* L.) INBRED LINES

By

Mohamed Barre Ahmed

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ABSTRACT

COMBINING ABILITY AMONG AND WITHIN EARLY, MEDIUM, AND LATE MATURITY CLASSES OF MAIZE (Zea mays L.) INBRED LINES

By

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Twelve inbred lines consisting of four from each of three maturity classes, were studied. The lines were, early; A641, Cm105, W117Ht and Ms74; medium; W64A, Ms75, A619 and A632; late; B73Ht, Mo17Ht, B84 and Pa872. All possible single-crosses were produced among the twelve lines and evaluated at three locations in Michigan in three years. Data was obtained on grain yield, stalk lodging, root lodging, moisture content, plant height, ear height and stand count in all experiments. Days to 50% pollen shed and 50% silking were recorded at the Central location in all years.

The objectives of this research were to estimate the general and specific combining abilities of lines among and within maturity classes and how these effects were influenced by year and/or location and, to identify the lines with desirable general and/or specific combining ability for earliness and yield. The progeny means were used for combining ability analyses for nine characters, according to a modified version of Griffing's method four, model one.

The mean performance of the crosses revealed a wide

range of variation among entries for all characters. Maximum range was recorded for stalk lodging (2.6-30.1%). The mean yields of the line crosses showed late lines with the highest values, followed by medium maturity lines, but positive GCA effects were observed for B73Ht, Mo17Ht, A632, and W64A. All early lines gave the lowest cross means, but positive GCA effects were shown, except for Ms74.

The present study pointed out that GCA over all lines, and GCA among and within classes were significant for all characters, whereas SCA over all lines, and SCA among and within classes were significant only for yield, moisture content, plant height, ear height, days to pollen shed and silking date. The additive genetic effects were important for all characters as shown by consistently larger GCA mean squares than those for SCA.

The interaction of GCA by year, GCA by location, and GCA by year by location were significant for all characters, except stand counts (LXGCA, LXGCA among and within classes). The interactions of SCA by year were significant for yield, stalk lodging, moisture content and days to pollen shed, while SCA by year by location was significant only for moisture content. The magnitude of GCA by environment was less than those of the main effects, indicating that the additive gene effects were relatively insensitive to the effects of the environments.

Three early (A641, Cm105, W117Ht), two medium (W64A, A632) and two late lines (B73Ht, Mo17Ht) had desirable GCA's for at least four characters, including grain yield. Ms74 and Ms75 had desirable GCA's only for maturity-related characters. The line B84 had undesirable GCA effects for all characters. Early lines as a class were low-yielding, and showed lower moisture content, fewer days to pollen shed, earlier silking date, and higher lodging incidence, and produced shorter plants with low ear height, whereas late lines were the complete opposite as shown by their GCA effects. Out of the ten crosses with significant SCA effects, only four had positive values for yield. They were two medium by medium, one medium by late and one late by late. The remaining six crosses had negative values and consisted of two early by medium, one medium by medium, two medium by late and one late by late.

To my dear mother, who passed away in 1991, but will always stay with me in spirit.

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INTRODUCTION

The expansion of maize (Zea mays L.) production into the short-growing season areas in temperate zones is restricted by low spring temperatures and early fall frosts. The latter may terminate growth prior to physiological maturity and consequently decrease the effective growing season. In the tropics, particularly in semi-arid regions, successful maize production is constantly threatened by limited rainfall and lack of supplementary irrigation. Because of these effects, the most desirable maize genotypes may be those which can partially evade drought by having a shorter vegetative cycle. Maturity is therefore an essential attribute to consider when choosing maize hybrids or populations for use in regions with short growing seasons.

Recently intensified efforts have been exerted to study characteristics which constitute the components of earliness. These are number of effective growing days from planting to flowering, the length of the effective grain filling period and moisture content at harvest. Early maturing plant genotypes, however, have frequently been associated with reduced yield potential even when growing conditions are favorable. The reason for lower grain yields has been attributed to the inability of a genotype to take full advantage of the available growing season (Hallauer et al., zones has often resulted in an increase in the maturity range 1967). Selection for yield improvement *per se* in temperate of the material (Hallauer and Miranda, 1981).

Attempts have been made to reduce vegetative period and increase yield by selecting for the two characters simultaneously. Unfortunately, the breeder faces considerable difficulties in assigning subjective economic values or proper weights to the relative importance of each trait. A second problem exists in judging with confidence the best parents or crosses in the breeding program.

The presence of significant heterotic responses in crosses among unrelated populations of maize has been known for a long time and has stimulated the exploitation of genetic diversity. A search for efficient utilization of diversity in maize germplasm has created renewed interest in searching for heterotic responses based on geographical separation, climate adaptation, endosperm color, kernel texture, divergent selection, and, finally, maturity.

Diallel analysis has been used extensively to evaluate parents for their combining ability. Information on the relative size of general and specific combining ability effects is used to facilitate the selection of parents and to develop crossing plans that offer the best promise of obtaining elite hybrids or superior composites.

A widely accepted concept among maize breeders is that crosses between different maturity classes of maize often result in higher general combining ability (GCA) effects than crosses within maturity classes [Cross, 1991; Moll, 1991; Goodman, 1991; Hallauer (personal communication, 1991)]. However, a search of the literature failed to uncover comprehensive studies dealing directly with combining ability among and within different maturity classes. In general, maize breeders use diallel analyses to evaluate the combining ability of their advanced breeding lines without reporting the relative maturity of the lines. In addition, in most of the cases where maturity has been reported, the lines were either in a single maturity class or were of different maturity classes, but treated together as one group. In the latter case, total variances for general and specific combining ability were not partitioned among and within maturity classes (Bhala et al., 1977). Occasionally, when the lines were from various maturity classes they were divided into different diallel sets according to maturity (Cross 1977, Han 1991). Information on the combining ability among and within classes is of prime interest in progeny evaluation. Combining ability measurements among and within maturity classes were identified as an essential objective of this study. A twelve inbred line diallel set was created from four early maturity lines, four medium lines, and four late lines.

The objectives of this research were to: 1) obtain estimates of general and specific combining ability among and within maturity classes, 2) determine the effect of location and year on GCA and SCA effects, and 3) identify the best combination for earliness and yield in terms of combining ability.

LITERATURE REVIEW

MATURITY

Early maturity is very important in the short growing season areas of North America where frost damage is likely to occur before the crop reaches physiological maturity. Frost damage results in significant absolute loss of yield and greatly increases cost of production in terms of drying and storage problems. Moreover, harvesting may become difficult during inclement fall weather. Attention has been directed to the determination of what makes one variety or hybrid mature and ready for harvest sooner than another. Time to maturity is a complex trait that is difficult to assess. Various measures have been proposed to characterize relative maturity. Many of these estimates may be based on external appearances of the plant while others may rely on internal measurements made on either the tassel, the ear or the whole plant. Aldrich (1943) defined maturity (or readiness for harvest) as the point at which the maximum dry weight of the grain is first attained. This has also been referred to as "physiological" or "morphological maturity" (Shaw and Loomis, 1950; Anderson, 1955). Grain moisture content at harvest has become an accepted criterion of maturity, but its total acceptance has been eroded because of the wide ranges that have been associated with maximum dry matter accumulation and the failure to identify the rate at which dry down was taking place. There has been a growing dissatisfaction with the lack of a precise definition and consistent use of a given maturity index in order to obtain an accurate evaluation of breeding material for a proper maturity rating. Early work in Iowa indicated that the interval from silking to maturity appeared to be influenced little by environmental conditions with no significant differences between early and late varieties. Therefore, the time of maturity has frequently been predicted on the basis of the date of mid-silking to the date where physiological maturity occurred (Shaw and Thom, 1951).

Studies of the inheritance of maturity in maize have focused on the number of days from planting to mid-flowering. Jones (1955), using six early by late crosses of maize inbred lines, postulated that the minimum number of genes affecting date of silking ranged from five to nineteen. This work suggested that earliness was mainly due to dominant genes, with complete dominance for early silking. Giesbrecht (1960) calculated a low heritability estimate for flowering date, and indicated that maturity was controlled by more than two genes with some evidence of partial to complete dominance and epistasis effects. In another study involving genetic analysis of maize inbreds and the progeny of their crosses, Giesbrecht (1960) identified the existence of partial phenotypic dominance for earliness and interallelic interactions of maturity factors.

In a study of two inbred lines and their hybrid combinations, Hallauer and Russell (1962) defined maturity as the average time at which the maximum dry weight of the grain was attained, with maturity measured as the number of days from silking to that point. Although the lines were deliberately selected for their differences in date of silking and grain moisture at harvest, they reached maturity at approximately the same time (60 days) from silking to a grain moisture of 36.4%. These authors suggested that grain moisture alone could not be considered to be a true indicator of maturity for specific material. In the cases studied, the interval from silking to maturity was found to be relatively constant within years. Estimates of various components of genetic variance for grain moisture and kernel weight were obtained from six generation means. The results indicated that the largest portion of genetic variance was attributed to dominance effects, but the estimates may be confounded with epistatic effects. Hallauer (1965) examined the inheritance of time to flowering of the inbred lines B14 and Oh45, and their single crosses. He found that the estimate of additive (D) genetic variance was much greater than the dominance (H) variance. However, he pointed out that linkage might have biased the estimate of additive variance.

Based on the idea that various maturity groups of maize genotypes require different amounts of accumulated thermal energy to reach maturity, interest has been shown in expressing maturity in terms of accumulated thermal units (degree days) as a measure of the growing season. Gilmore and Rogers (1958) compared fifteen different methods of calculating heat units required for silking. They suggested that the common methods used for computing degree days (i. e., x -10^0C) could be improved by correcting for the effect of low or high temperatures on growth. They concluded that the maturity could be more accurately determined by calculating the degree days or "effective degrees" required to bring genotypes to silking than by calendar days.

A significant relationship between leaf number and maturity has been reported in maize (Chase and Nanda, 1967; Arnold, 1969; Allen et al., 1973; Ahmed, 1987). Evidence presented by Chase and Nanda revealed the existence of a highly significant correlation between leaf number and maturity, with late-maturity hybrids having more leaves than early-maturity hybrids. They suggested that the number of leaves characterizing maize hybrids provides a basis for maturity classification. However, leaf number is influenced by environmental variables and growing conditions (Allen et al., 1973). It has been observed that increasing temperature (over certain ranges) and high fertility tend to result in a slight increase in leaf number, whereas, increasing plant population may result in a decrease of leaf number. Increasing photoperiod may have a major effect on increasing leaf number. Bonaparte (1977) investigated the inheritance of leaf number and maturity as determined by the number of days from planting to mid-silking in a diallel cross. He used six inbred lines and their single cross hybrids which had differences in maturity and leaf number. He found that days to mid-silk and leaf number were controlled by at least one and four factors, respectively. Heritability estimates in both a broad sense and narrow sense for these characters were high.

Grain yield is the result of dry matter accumulation in the grain during the period from silk emergence to maximum kernel dry weight (grain filling period). Discrepancies exist in the literature regarding the length of this period. Shaw and Thom (1951) obtained a relatively constant time interval of about 51 days for three hybrids. In contrast, Dessureaux et al., (1948), found differences of at least seven days among four inbreds in the duration of the grain filling period. Recently, several workers reported sizable differences (eight days or more) among maize genotypes in the duration of this period (Carter and Poneleit 1973; Daynard et al., 1971; Daynard and Kanennberg 1976; Gunn and Christensen 1965). However, it is important to know when the kernels have ceased starch accumulation in order to determine the duration of filling period. Daynard and Duncan (1969) suggested that black layer formation at the kernel base was a good indicator of when total dry matter accumulation had been reached, and it is now accepted that the appearance of this black abscision layer signals the physiological maturity of the kernels. In this method, the termination of filling period is monitored by sampling kernels from the middle of the ear, because the kernels in the tip region tend to reach the black layer rather earlier than those from the rest of the ear.

In attempts to understand the differences for grain yield among various maturity classes of maize hybrids, considerable attention has been given to the rate of grain filling, as well as the duration of grain filling. Previous research reports indicated that a positive relationship exists between yield and the duration of grain filling. Gunn and Christensen (1965) found that later maturing hybrids had a longer filling period and larger kernels than earlier maturing hybrids. Daynard et al., (1971) observed that yield differences among hybrids could be more accurately described in terms of an effective filling period duration. Several hypotheses have been presented pertaining to mechanisms by which maize genotypes may regulate the duration of the grain filling period. Duncan (1975) extrapolated that one possible determinant of the duration of the filling period could be the relationship between photosynthetic rate and sink capacity (i.

e., where sink capacity is defined as the number of kernels per plant times the capacity of these kernels to accommodate assimilates). Others have speculated that kernel volume may be primarily responsible for the establishment of the duration of the filling period (Daynard and Kanennberg, 1976).

Tollenaar and Daynard (1978) studied kernel growth and development and suggested that kernel strength (i.e., where sink capacity is referred as the capacity to attract assimilates) may affect the rate of dry matter accumulation. Enhancement of photosynthetic supply during flowering and grain filling period may increase the rate of dry matter accumulation. This could result in the formation of larger kernels which contribute to improved grain yield in the short growing season areas of North America. Furthermore, Mock and Pearce (1975) included a longer grain filling period as a major component for the development of a maize ideotype. The authors suggested that this period, however, should not be so long that leaf senescence occurs before maximum grain dry matter is attained. In the northern Corn Belt, where the growing season is short, leaf senescence often does not occur prior to the accumulation of maximum dry matter in the grain. A higher rate of kernel development could lead to an advanced harvest date which could be of agronomic significance in that region. Carter and Poneleit (1973) observed that some inbred lines with similar duration of filling period, had differences in the duration of the vegetative phase as well as the period from planting to physiological maturity. Hillson and Penny (1965) studied the date of silking and the number of days from silking to physiological maturity as a measure of maturity. They found that some hybrids which silked earlier required more time for the filling period than some later silking hybrids. Other researchers have also found that some exceptional hybrids with a short filling period had attained a considerable kernel weight in a relatively short time as a result of a very high rate of grain dry matter accumulation (Daynard and Kannenberg 1976; Perenzin et al., 1980). Recent evidence suggests the presence of substantial genetic potential for grain yield improvement through either extension of the filling period (Daynard et al., 1971) and/or enhancement of kernel growth rate (Tollenaar 1977). These traits appear to have a high heritability (Perenzin et al., 1980) and are controlled primarily by genes with additive effects (Cross, 1975). However, the potential yield increase through extension of the filling period in the Northern latitudes is limited by the length of the frost free interval.

Cross (1975) used a diallel cross of seven inbreds to examine the duration and rate of filling and to determine the possibility of selection for these traits in breeding programs. He reported that general combining ability effects for these traits were larger than specific combining ability effects, indicating that simple selection procedures which take advantage of additive genetic variances should be effective in changing these traits. Unfortunately, the practical application of selection for these traits in a breeding program is often hindered by a lack of a simple and inexpensive screening method(s), especially for evaluation of a larger number of genotypes.

COMBINING ABILITY

The ability of a parent to transmit desirable performance to its hybrid progeny has been referred to as combining ability. Sprague and Tatum (1942) first introduced the partition of combining ability into general and specific effects. They defined general combining ability (GCA) as the average performance of a parent in hybrid combination with all other parents in a population, and interpreted its variance as a measure of the additive genetic portion. Specific combining ability (SCA) was designated as the deviation from the expected performance of a cross based on the average performance of its parents. The variance of SCA is interpreted as a measure of the non-additive genetic portion, and includes dominance and epistatic effects.

The method of evaluation for combining ability and the choice of material included in the test has been changed from topcross to diallel cross (Hallauer and Miranda, 1981). Diallel cross helps you to determine not only the average performance of a variety or a line in comparison with other varieties, but also a nicking of a particular pair of varieties. When specific crosses are important to the breeder, the diallel design provides more directly useful information related to that end than using random testers as in topcross procedure (Sprague, 1984). The relative importance of GCA and SCA in maize has been studied by numerous researchers. Sprague and Tatum (1942) utilized the diallel cross to evaluate the GCA and SCA of unselected lines. They found that GCA was more important than SCA in controlling grain yield. When they used single crosses that had been previously selected for general combining ability however, they found that the variance of SCA was greater than that of GCA. Rojas and Sprague (1952) obtained similar results from experiments involving two groups of previously selected material. The variance of non-additive genetic effects was consistently greater than the variance of additive genetic effects. The authors also extended the analysis for general and specific combining ability to include interactions among locations and years. They reported that the interaction components involving SCA was also greater than that for GCA, indicating that genotype by environment interaction may be an important contributing factor to the variance of SCA.

Matzinger (1952) later took the diallel cross analysis procedure one step further, by outlining the models for estimation of genetic variances for experiments repeated over years and locations. Matzinger et al., (1959) reported yields of 10 unselected lines from a maize synthetic variety evaluated at three locations for three years. A diallel set of crosses was used to compare the variances of GCA and SCA and their interactions with years and locations. When the data were combined over years and locations, the GCA variance components were decreased, suggesting a strong influence of SCA effects in developing stable yield over environments. They discussed estimates of general and specific combining ability more completely with respect to their expectations in terms of additive and dominance genetic effects. Hallauer (1971) reached conclusions similar to those of Rojas and Sprague (1952), and Matzinger et al., (1959). He pointed out that substantial genetic variance was lost to the non-additive genetic component when grain yield from two Iowa synthetic cultivars were combined over years and locations.

Estimates of GCA and SCA have been used by plant breeders to make decisions pertaining to the most suitable breeding method(s) and in selecting parents for breeding programs. The ratio of mean squares of GCA and SCA is used to determine which one of the two is more important. The prevalence of GCA facilitates the selection of parents to use for intrapopulation improvement. Furthermore, the presence of larger GCA also increases the chances of obtaining a superior synthetic variety because non-additive genetic variance diminishes in advanced generations of random mating. In contrast, a SCA of greater magnitude would help establish heterotic patterns among inbreds for potential hybrids or among parents selected for interpopulation improvement where divergent populations may eventually be used as a source of inbred lines.

The presence of a substantial quantity of genetic variability for most agronomic characters is a key factor in choosing source germplasm in any breeding program. The level of total genetic variability and the nature of gene action in the source germplasm will ultimately determine the optimal breeding methods, efficiency of selection, and final success. The level of genetic variability can be improved by increasing genetic diversity (Lonnquist, 1953; Lonnquist et al., 1961). It has been shown that materials of diverse genetic origin produce better hybrids than those more closely related (Moll et al., 1962; Moll et al., 1965; Paterniani et al., 1963). Genetic diversity has been associated with increased heterosis, which is an important factor in utilizing germplasm to maximize the cross-performance of source populations. Maize breeders have, therefore, devoted considerable effort and time to the development not only of genetically variable source populations, but also populations with unique heterotic patterns. Such source populations may be obtained in one of several possible ways; for example, by using populations of different geographic origin, of contrasting endosperm types, or of widely varying maturity.

The early literature describing maize improvement attempts indicate that crosses between varieties with contrasting endosperm type (dent x floury and dent x flint) were more likely to outyield the parental varieties than crosses between varieties from the same kernel texture group (Jenkins, 1978). A striking example was provided by the crosses of early Northern Flints with late Southern Dents which generated many excellent open-pollinated varieties such as Reid Yellow Dent. Another example is the development of Lancaster Surecrop in Pennsylvania which probably came from crosses between early flint and a late local variety. Early studies recognized that the crosses between the lines from Reid Yellow Dent and Lancaster Surecrop provided excellent hybrid combinations. Consequently, these two varieties have formed the basis of the most widely-used heterotic pattern in maize breeding, and have resulted in the most extensively used lines in temperate hybrids, especially in the U.S. cornbelt (Jenkins, 1978).

Wellhausen (1978) pointed out that crosses between Tuxpeno and its related Caribbean and US dents with Cuban flints and Coastal Tropical flints often exhibit a high level of population-cross performance. He suggested the development of two broad-based, high yielding populations consisting, respectively, of a dent and a flint composite. The dent composite could be from Tuxpeno and related dents, while the flint composite could be from the Cuban, Coastal Tropical and Cateto material. This recommendation stimulated the study of population crosses between dent and flint types with excellent heterotic patterns in different parts of the world. In the tropics several heterotic groups have been identified and used extensively to develop hybrids. The most important heterotic combinations are Tuxpeno by Cuban flint, Tuxpeno by Coastal Tropical Flints, and Tuxpeno by ETO (flint). In Kenya the heterotic pattern involving a Tuxpeno-derived Kitale selection (Kitale II) and a high altitude flint material from Ecuador (EC573) has been exploited for the East African highlands. Crosses between early European flints and US Corn Belt dents have been successfully utilized in Europe (Eberhart et al., 1991).

Moreno-Gonzalez (1988) produced a diallel cross of seven flint (F) and seven dent (D) inbred lines of maize. He divided the crosses into three subdiallel sets, namely FXF, DXD, FXD and partitioned the variance of each of the first two groups into that due to GCA and SCA, following the Griffing method four (1956). In the FXD subdiallel, he used the Comstock et al., (1952) design to partition the total variance into that for GCA of each F and D group and that for SCA of FXD. He found that the GCA effects for yield were higher in dent than in flint lines. The crosses of FXD predominantly had positive SCA effects but negative SCA effects were observed in FXF and DXD crosses. Similarly, Dhillon et al., (1979) presented data of crosses between five flint and five dent inbred lines of maize. An incomplete factorial design was employed to adjust for missing crosses. They followed the procedures presented by

Milliken et al., (1970) for the analysis of combining ability. These procedures partition the total variance into the variance of GCA for flint and dent lines. They found a significant mean square for GCA of both flint and dent lines for grain yield. However, they also reported that the interaction between GCA and environments for the dent lines was not significant, indicating that the dent lines were adapted to the region.

The superiority of crosses between flint and dent varieties have stimulated a search for a possible maximum benefit as well as an efficient utilization of diversity as reflected in differences of geographical separation and/or adaptation. A diallel study involving three Corn Belt synthetics and three exotic synthetics has shown positive GCA effects for the first group and negative effects for the second (Gerrish, 1983). This could be explained only in part to a lower frequency of favorable alleles for yield in the exotics. In fact, crosses within each group in the study showed that Corn Belt dents yielded substantially higher than their counterparts, and crosses among exotic groups were intermediate by comparison. Nevertheless, significant GCA has been observed which might indicate the consistent contribution of the synthetics to their crosses. This finding was in good agreement with what would have been expected if additive gene action was of prime importance. It is interesting to note that the best combiners in this study showed similar performance for grain yield in all environments (Gerrish, 1983).

In India, ten varieties were selected for differences of origin as well as for chromosome knob number and crossed in all possible single cross combinations. Estimates of GCA for grain yield were studied and accordingly the parental varieties were placed into three classes, high, average, and low combiners. Evaluation of the relationship between GCA and yield and knob number for the parents indicated that high and average combiners had high knob numbers, while low combining varieties always possessed low chromosome knob numbers (Kalsy et al., 1970) Utilization of this close association of high knob number with high GCA of the parents and the possibility of using knob number for determining the heterotic effects between crosses of the parents was discussed.

In a study based on an unrelated genetic relationship, Rinke and Hayes (1964) selected fifteen inbred lines and classified them into inferior (I), medium (M), and superior (S) GCA classes. The yield for each of the three I, M, and S, classes ranged from 93-103, 104-106, 110-113 % of the check, respectively. They concluded that according to the frequency distribution of the F_1 performances, the highest percentage of outstanding hybrids was most often derived from crosses of S by S GCA lines. They did, however, acknowledge the presence of one exceptional cross of M by S which gave a similar performance to those of S by S lines.

Beck et al., (1991) evaluated the performance of diallel crosses among nine of CIMMYT's subtropical and temperate intermediate-maturity maize gene pools and populations. The material was tested at five locations in Mexico and eleven in the USA. They reported highly significant and positive GCA effects for yield with Populations 42, 47, and 34 in Mexican environments. Only Pool 41, which had more temperate germplasm, exhibited positive GCA effects for yield in the US environments. The combining ability of eight parents as measured in their crosses was reported by Everett et al., (1987). These materials were divided into high- (3), mid- (1), and low-altitude (4) genotypes based on their known adaptation. Evaluation was carried out at four locations ranging in altitude from 1000 to 1600 meters in Cameroon. They found that the lowland material combined better with highland materials for yield, plant type, and resistance to lodging. The lowland populations were short in plant stature and probably early in maturity, whereas the highland populations were tall and late in maturity. The authors, however, did not indicate whether maturity had any influence on combining ability of the material. The results also show that the mid-elevation population (MSR) combined better with highland than with lowland populations in terms of yield and ear quality.

Diallel analysis has also been used to evaluate the improvement that has been made through several cycles of recurrent selection. Stangland et al., (1983) evaluated crosses of four populations and four selected S2 lines from each population for yield and other agronomic characters. They partitioned the total variation for GCA and SCA into variation due to population and variation attributed to the lines within a population. The GCA accounted for most of the genetic variation of the populations and the lines, but the corresponding SCA was also highly significant for all traits. A considerable portion of the variance for both GCA and SCA for yield, however, was accounted for in the populations. The majority of the lines within each population exhibited GCA effects similar in magnitude and direction to their population sources. Only the SCA for the lines and GCA for both populations and lines showed highly significant interactions with environments. In contrast, the SCA for the parental sources were not only non-significant but also very small relative to the SCA for the lines. The interaction variances involving GCA were much larger in magnitude than those involving SCA.

There has been a growing interest with regard to the combining ability of material developed through bidirectional selection. Crosses of the lines developed from these divergent populations may provide information of the underlying genetic mechanism and produce a more desirable result. The combining ability expressed in High X High (HH), High X Low (HL), and Low X Low (LL) single crosses of maize inbred lines from the Krug variety, obtained through divergent selection for yield in several generations, was studied by Lonnquist (1953). He indicated that the greatest possibility of obtaining a considerable number of high-yielding crosses was from crossing HH combining lines rather than either HL, or LL groups. The results of his study seemed to support the importance of dominant or partially dominant favorable gene effects in determining hybrid vigor. An analogous experiment was reported by Lamkey and Hallauer (1986). They produced three groups of crosses from 24 high (H) and 24 low (L) lines selected for yield per se from 247 random inbred lines of 'Iowa Stiff Stalk Synthetic' (BSSS). Single crosses were produced among and within groups. Significant differences among the three hybrid group means (HH, HL, LL) for grain yield were reported. The ranking of the hybrids (HH>HL>LL) was as expected under a model with partial-to-complete dominance. They concluded that GCA was more important for the variation observed than SCA, which indicated that additive type gene action was predominant.

Although maize breeders generally accept the premise that crosses among different maturity classes results in higher GCA effects than crosses within classes, empirical results in this area are lacking in the literature [Cross, 1991; Moll, 1991; Goodman, 1991; Hallauer, 1991,(personal communication)]. Diallel analysis has frequently been used to evaluate the combining ability of advanced breeding lines without reporting the relative maturity of the lines tested. In addition, in most of the cases where the maturity was reported, the lines were either in a single maturity class or were in different maturity classes but treated together as one group. In the latter case, the total variances for general and specific combining ability were not partitioned among and within maturity classes. Crosses of five early and five late maturing open-pollinated varieties has been reported by Bhalla et al., (1977). The material was selected on the basis of plant height (i.e. early were short and late were tall). The GCA effects pooled over environments indicated that four of the five late varieties were the best combiners for yield. However, more of the SCA was accounted for in crosses involving varieties from early by late groups, suggesting that these effects appeared to be greatly influenced by genetic diversity. Combining abilities for all characters revealed major interactions with locations, although the GCA was much larger than SCA. Nevado et al., (1989) reported a study of three diallel sets among eight synthetics by crossing early by late, medium by medium, and late by early flowering plants. They concluded that all groups had similar estimates of GCA and SCA for eight of the nine traits tested. Furthermore, the

GCA mean squares were of a larger magnitude than SCA mean squares for all traits, suggesting a predominance of additive genetic variance.

Results from a diallel cross among ten tropical early and intermediate gene pools and populations were reported by Beck et al., (1990). The materials were evaluated at nine locations in Mexico and other countries. Estimates of combining ability effects were obtained using Gardner and Eberhart's method III (1966). They found that the mean squares for GCA were highly significant for grain yield, days to silk, plant and ear height, while only ear height had a significant SCA. The interaction component of combining abilities and location indicated that the SCA's were relatively more stable than GCA's. Furthermore, a comparison of variation due to GCA and SCA showed that the additive genetic effects were predominant for all traits. It is important to note that all early maturing parents exhibited highly significant negative GCA effects for all traits. This indicated that these parents contributed not only earliness, but also a decrease of plant and ear height to their crosses. These effects were also accompanied by a reduction in grain yield.

Occasionally, when the lines have been drawn from various maturity classes they have been divided into different diallel sets by maturity. Cross (1977) tested two separate sets of diallel crosses involving a set of early and a set of late lines. He found that GCA in both sets was larger than SCA, and that the interaction of GCA with environments was significant.

Han et al., (1991) used 58 lines selected on the basis of their overall performance and divided them into six diallel sets. The lines were derived from 11 CIMMYT intermediate and late maturity gene pools and populations. Each diallel set contained only the lines from one maturity class, except diallel number 5 in which the lines were in both maturity classes. The SCA effects of each diallel were partitioned into effects due to intra- and interpopulation crosses to compare the cross performance of the lines from different populations. In each diallel the authors reported both significant negative and positive GCA effects for the lines derived from each of the parental pools and populations. The result suggested that the GCA effect of a line was not closely associated with the population involved. Furthermore, the SCA effects of the crosses produced from interpopulation lines had a positive sign whereas the intrapopulation line crosses had a negative sign. This would suggest that interpopulation crosses on the average had greater heterosis than intrapopulation line crosses.

Vasal et al., (1986) reported the combining ability of two separate diallel sets of CIMMYT's subtropical maize germplasm. The sets consisted of seven early and nine intermediate materials, and were evaluated at several locations in cooperating countries. They found that the GCA effects of early material were significant, but the SCA effects were not significant. However, they indicated that most of the best hybrid combinations were from crosses between materials of contrasting endosperm type or color (i. e., flint by dent and/or yellow by white). In the second diallel they reported that Population 42 had highly significant GCA effects and also the best performance in hybrid combination with Population 47.

DIALLEL ANALYSIS

Diallel crosses have been used extensively to obtain information concerning the inheritance of quantitative traits. The procedure involves crossing a set of N genotypes in all possible N^2 combinations. Genotypes may be individuals, clones, inbred lines, or open-pollinated varieties. Certain assumptions must be satisfied if this technique is to be considered appropriate for the genetic interpretation for a given data set. Some of the underlying assumptions are:

1. Diploid segregation in the parents,
2. Homozygous parents,
3. No difference between reciprocal crosses,
4. Genes are independently distributed between parents, and
5. No non-allelic interaction (Hayman 1954).

Numerous authors have examined the importance of these assumptions for a valid interpretation of diallel experiments and their utilization in a practical breeding program (Kepmthorne, 1956; Gilbert, 1958; Matzinger, and Cockerham, 1963; Sprague, 1966). They have agreed that some assumptions (4 and 5) are more critical than others and that it seems to be unrealistic to impose all of the assumptions in a practical situation. It is safe to assume, however, in the present study, the use of maize inbred lines fulfills the first three assumptions and that the remaining two, based on published experiments of similar materials, have been satisfied.

Several statistical techniques are available to the breeder for analyzing the data of a diallel experiment. The use of a particular technique depends on three basic factors: 1. the nature of the material under investigation, 2. the genetic hypothesis, and 3. the method of estimation. Generally, four lines of approach may be followed for diallel analyses (Baker, 1984).

1. Jinks and hayman's method (1953),
2. Kempthorne's method (1956),
3. Griffing's methods (1956), and
4. Gardner and Eberhart's methods (1966),

Hayman (1954a,b) has developed an analysis which is based on the biometrical analysis of quantitative variations presented by Mather, 1949. The method is useful for the study of genetic differences of fixed samples of inbred lines. The parameters in the analysis are the means and variances in generations derived from crosses of homozygous parents to get estimates of additive, dominance and epistasis gene effects. The method permits an interpretation of the regression of the array covariance {the covariance between all the offspring of the r_{th} parent and their non-recurrent parents (W_r)} on the array variance {the variance of these offspring (V_r)} which provide a graphical representation of the degree of dominance. It also offers the possibility of separating true dominance from spurious dominance caused by many types of non-allelic interaction. With dominance, the regression line has a slope of one. If the line has a slope of one and passes through the origin, the dominance is complete (H_1=D). Movement of the line with b=1 above or below the origin would reveal a decrease (H_1<D), or increase (H_1>D) of dominance, respectively. In the absence of dominance (H_1=0) the points would cluster about the position where there is no significant regression line passing through the origin.

In 1956, Griffing presented the analysis of four different diallel crossing systems and explained in detail their relationship with the concept of combining ability. These methods are:

1. All N^2 combinations,
2. 1/2 N(N+1)combinations,

3. N(N-1) combinations, and
4. 1/2 N(N-1) combinations.

The fundamental difference among these analyses is based on the genetic material included in the experiment. If the material consists of parental lines, F_1, and reciprocal F_1 progeny, the diallel is analyzed as Method one. When the F_1 reciprocals are excluded in the analysis Method two is utilized. Method three contains the F_1 and F_1 reciprocals, while Method four consists of only the F_1 progeny.

Griffing (1956) emphasized the significance of sampling procedure used to draw the parental lines. He pointed out that a breeder may choose a set of parental lines for the diallel and may be interested in the individual desirability of the material. Thus, any inferences from the results are limited to this particular set (fixed effects) of parents. On the other hand, a researcher may be concerned with the population in which the parents are considered a random sample and the inferences are applied to a larger population (random effects). From these sampling procedures, two different genetic models, Model one, and Model two were derived resulting in eight different analysis (4 methods and 2 models in each). Most of the time the parents are excluded from the analysis, because of the low yields of inbred lines compared to the hybrids produced from them. Thus, method 4, model 1 has been used extensively for the analysis of combining ability of maize. However, from Griffing's methods, it is possible to estimate the general (g_i) and specific (s_{ij}) combining ability effects for traits and identify the parents whose hybrid combinations are likely to give the maximum selection potential.

In 1966, Gardner and Eberhart developed three methods of analysis for diallel crosses. The authors pointed out that their methods are appropriate only when the parental lines comprise the entire population. They also suggested that most breeding materials in which breeders are interested have been highly selected in favor of economically important traits. Thus, estimation of variance components does not provide useful information if such materials are regarded as a random sample from a large base population. Gardner and Eberhart's methods are applicable not only for inbred lines, but also for open-pollinated varieties. Their analysis II is identical to those of Hayman and of Griffing's method 2, model 1), except that Gardner and Eberhart subdivided the specific combining ability into three levels of heterosis [average(h^{-}), variety(h_i), and specific heterosis(h_{ij})]. Analysis III of Gardner and Eberhart considers only F_1 progeny and is similar to Griffing's method 4, model 1, and that used by Sprague and Tatum in 1942.

MATERIAL AND METHODS

GENETIC MATERIALS

The genetic material investigated in this study consisted of twelve inbred lines, four selected from each of three maturity classes (early, medium, and late season). The lines are listed according to their maturity class, the first four are early, followed by medium and then late, as follows: A641, Cm105, W117Ht, Ms74, W64A, Ms75, A619, A632, B73Ht, Mo17Ht, B84, Pa872. The pedigree, origin, and year of release are listed in Table 1 (Henderson, 1980).

Diallel crosses among the twelve lines were obtained in 1988. Crosses were produced by making paired row crosses. The materials were sown at time intervals to facilitate crossing between the different maturity classes. The lines were increased by sib-pollination within two rows. All pollinated ears in a row were harvested by hand, and bulked for each cross. The ears were dried to 15.5% grain moisture, shelled in bulk, and thoroughly mixed before a sample of seed was taken for evaluation trials.

In 1989, the F_2 generation was obtained by sib-pollinating within two rows of F_1 hybrids. At the same time, the previously described crossing procedure was repeated to produce additional seed of parental lines and F_1 hybrids.

Table 1. Pedigree, origin, and release year of the twelve inbred lines used in the diallel.

Inbred line	Pedigree	Origin	Year
A641	(ND203XB14)	Minnesota	1966
Cm105	(V3XB14)	Canada, Manitoba	1970
W117Ht	(643XMinn#13)	Wisconsin	1964
Ms74	(Michigan Early Syn.)	Michigan	1979
W64A	(WF9X187-2)	Wisconsin	1956
Ms75	[Ms153XSD10)Ms142R]		
	[(SD10XB37)8670]	Michigan	1985
A619	(A171XOh43)Oh43	Minnesota	1961
A632	(Mt42XB14)B14	Minnesota	1964
B73Ht	(Iowa Stiff Stalk Syn.)	Iowa	1958
Mo17Ht	(187-2XC103)	Missouri	1964
B84	(BSSS13(S2))C0	Iowa	1978
Pa872	(75F-5XPa881P)	Pennsylvania	1979

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FIELD PROCEDURES

Yield trials were conducted at three locations in Michigan in 1989, 1990, and 1991 for a total of nine experiments. The three locations were the Crop and Soil Sciences Research Farm near East Lansing, the Michigan State University Potato Research Farm near Stanton, the Dave and Mel Cripe Farm near Cassopolis, and the Robert and August Oshe Farm near Custer. Cassopolis is located in the Southern (Cass County) part of the State, East Lansing is located in the Central (Ingham County), and Custer (Mason County) and Stanton (Montcalm County) are located in the Northern area. Hereafter, these locations will be referred to as the Southern, Central, and Northern locations respectively. The soil types and other information related to these experimental locations are presented in Table 2.

Entries in each experiment of 1989 consisted of 12 parental lines, the 66 F_1 hybrids, and 3 commercial check hybrids which represented the three maturity classes. The experimental design at each location was a 9 by 9 simple lattice with three replications.

A single row plot 9.12 m (30 feet) long was used in Central, and 11.25 m (37 feet) long in Southern and Northern locations. The rows were spaced 91.4 cm (36 inches) in Central, and 76.2 cm (30 inches) in other locations. The plots were overplanted and hand-thinned in the 8 to 10 leaf stage to a maximum of 50 plants per plot in all experiments. This gave a desired population density of close to 59,957 plants/ha in Central and 58,336 plants/ha in the other locations.

During the 1990 season, in addition to the previous material, 66 F_2 generation and 22 commercial checks were included for the evaluation trials. In that year, the Stanton location was substituted for Custer. The experiments were arranged as a 13 by 13 simple lattice design replicated three times in each location. The experimental unit in all locations was a two-row plot of 6.08 m (20 feet) in length, with a distance of 76.2 cm (30 inches) between rows. Each plot was overplanted and later thinned to a desired population density.

Because of the differences in vigor associated with the inbreds and F_1 generations, it was not possible to obtain a yield measurement from the inbreds in the first two test seasons (1989 and 1990). Therefore, it was necessary to use a blocking procedure to eliminate severe competition effects. In 1991 a separate randomized complete block design with three replications was utilized for the inbreds in all locations.

A 12 by 12 simple lattice design with three replications was employed for the evaluation of 66 entries in each of F_1 and F_2 generations, and 12 commercial hybrids. A two-row plot of 6.68 m (22 feet) long and between-row width of 0.76 m (30 inches) was used. The plots were overplanted and thinned to a maximum of 60 plants/plot in the Central, and 72 plants/plot in other locations to give the desired number of 58,867 and 70,640 plants/ha respectively. All nine experiments were machine-planted and harvested without gleaning the lodged plants. Recommended agronomic practices, including high fertility and weed control, were followed at all locations to promote high productivity. Supplemental irrigation was applied to all experiments at the Southern location consistent with the commercial farm practice where the test was located.

CHARACTERS MEASURED

Data were collected for the following nine agronomic characters.

Stand count (SC): Number of plants per plot at harvest were recorded and expressed as the number of plants per hectare.

Stalk lodging (SL): The percentage of plants in a given plot broken below the top ear were determined.

Root lodging (RL): The percentage of plants in a plot leaning 30 degrees or more from the vertical were determined.

Plant height (PH): measured to the nearest centimeter after anthesis as the distance from the ground to the flag leaf collar.

Ear height (EH): measured in centimeter as the distance from the ground to the uppermost ear-bearing node.

Five competitive plants were used for both plant and ear height determinations. The mean value of the five plants was used for the analysis of variance.

Days to pollen shed (DP): The number of days from planting to the day approximately 50% of the plants in a given plot were shedding pollen.

Silking date (SD): as the number of days from planting until 50% of the plants in a plot had emerged silks.

Moisture content (MO): was measured from the shelled grain for each machine-harvested plot by using a moisture tester mounted on the combine.

Grain weight (GW): was recorded in pounds per plot to the nearest two-tenth pound in the field at harvest.

Grain yield (GY): The adjusted grain weight was converted from pounds per plot into tons per hectare by using the following formula:

$$GY = GW * \frac{(100-MO\%)}{(100-15.5\%)} * \frac{4.54}{\text{plot area}}$$

All the characters described except for days to pollen shed and silking dates were recorded in all locations. These two characters were recorded only at the Central region location.

Table 2. Information describing the experimental locations

	Southern (Cassopolis)		Central (East Lansing)		Northern (Custer and Stanton)	
Soil Type	Oshtemo Sandy Loam		Capac Loam		Iosco Sandy Loam, M. M. Sandy Loam	
PH						
(1989)	6.1		6.1		6.5	
(1990)	6.0		6.1		5.4	
(1991)	6.1		6.8		6.2	
Fertility						
(1989)	very high		very high-high		very high-high	
(1990)	very high		high-medium		very high-medium	
(1991)	very high		medium-low		very high-low	
Temperature (C^0/day)						
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
(1989)	10.2	22.2	8.8	21.3	8.9	19.4
(1990)	9.8	21.2	9.5	21.2	8.3	21.0
(1991)	11.3	23.4	10.6	23.0	8.5	22.9
Solar Radiation (10^6 joules/m^2/day)						
(1989)	18.41		17.75		17.75	
(1990)	18.00		17.29		17.39	
Rainfall (mm/day)						
(1989)	614.9		578.8		425.9	
(1990)	932.7		597.4		565.7	
(1991)	808.5		511.6		675.1	
1st Killing freeze						
	25th Oct.		19th Oct.		25th & 17th Oct.	
Previous crop						
(1989)	corn		corn		snap beans-rye	
(1990)	corn		corn		potatoes	
(1991)	corn		soybeans		potatoes	

STATISTICAL PROCEDURES

ANALYSIS OF VARIANCE

A number of missing plots in the tests of the inbred lines and in some F_2 generations plots were observed in all experiments. Consequently, these entries were deleted from the analysis. A randomized complete block design with three replications was utilized for the analysis of the data, because assumptions related to a lattice design were violated by these missing data.

The statistical model used for the analysis of variance in each individual experiment was:

$$Y_{ij}=\mu+T_i+B_j+e_{ij};$$

Where Y_{ij}= observed value for the i_{th} entry in the j_{th} plot;
μ = overall mean effect :
T_i= effect of the i_{th} entry (i=1,..,68) ;
B_j= effect of the j_{th} replication (j=1,..,3) ; and
ϵ_{ij}= random error associated with ij_{th} observation.
Replications were considered random effects while entries were considered fixed effects.

The format of the analysis of variance is shown in Table 3. The analysis was then combined over locations or years according to the following model:

$$Y_{ijk}=\mu+T_i+B_j+E_k+(TE)_{ik}+\epsilon_{ijk};$$

Y_{ijk} = observed value of the ij_{th} plot, in the K_{th} environment ;

μ = overall mean;

T_i = the effect of the ith entry (i=1,..,68)

B_j = the effect of the j_{th} replication within the k_{th} location or year (j=1,..,3);

E_k is the effect of the k_{th} location or year (k=1,..,3);

$(TE)_{ik}$ is the effect of the interaction between the i_{th} entry and k_{th} location or year; and ϵ_{ijk} is the error associated with the ij_{kth} observation.

Table 3. Format of the analysis of variance for single experiment:

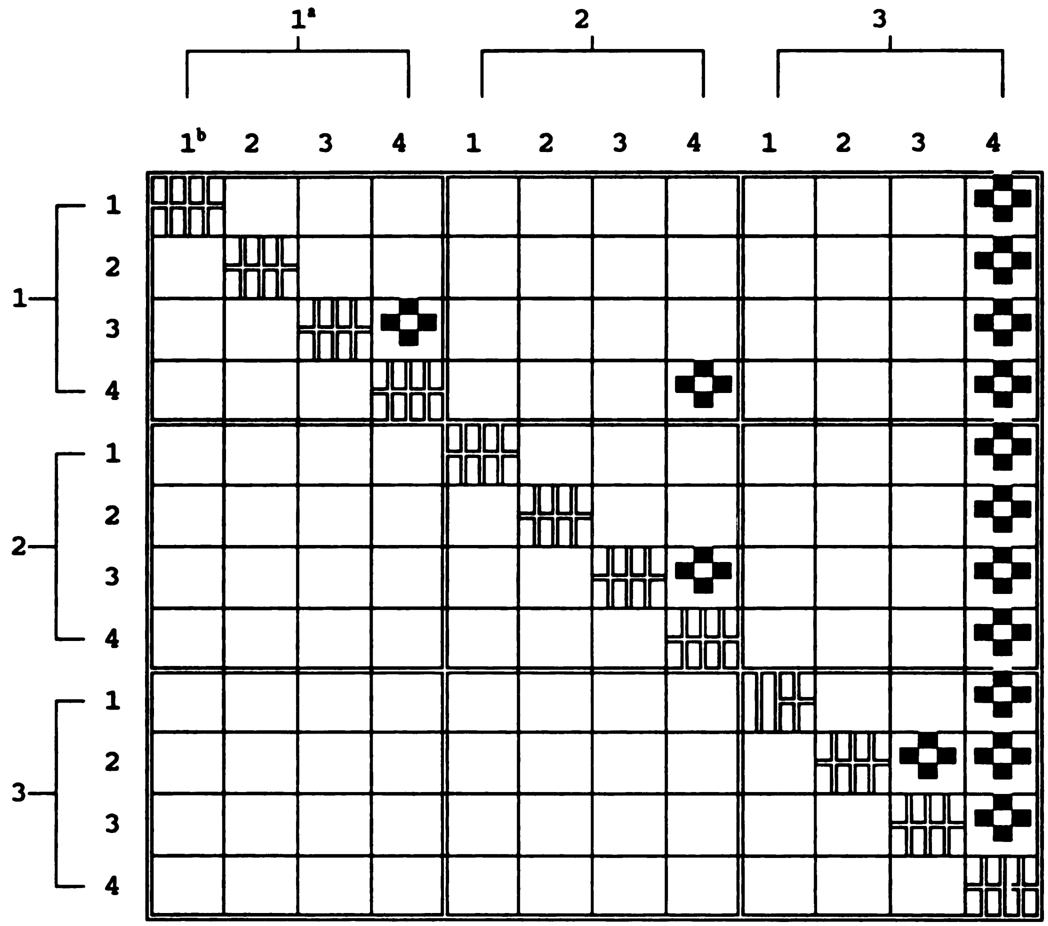
Source of Variation	Degrees of freedom [a]	Mean squares	Expected mean squares
Replications	(r-1)	M3	
Entries	(e-1)	M2	$\sigma^2+rK^2_E$
Error	(r-1) (e-1)	M1	σ^2
Total	(re-1)		

[a] r and e denote the number of replications and entries, respectively.

DIALLEL ANALYSIS

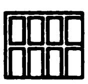
The method of statistical analysis used is an extension of the analysis given by Griffing (1950) model 1, method 4.

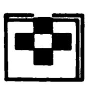
Figure 1. The crossing plan of twelve maize inbreds, four from each of three maturity classes (early, medium, and late)



a = indicates maturity classes.

b = indicates the lines within maturity classes.

 = indicates parental lines which were excluded in the analysis.

 = indicates the restrictions which were imposed by the model.

This analysis includes partition of general and specific combining ability into among- and within-class effects. The parents were not included in the combining ability analyses. The linear model for a diallel cross among cw lines, w from each of c classes, of F_1 crosses grown at a single location is:

$$Y_{ijkl}=\mu+g'_{ij}+g'_{kl}+s'_{ijkl}+e_{ijkl}$$

$$Y_{ijkl}=(G_i+g_{ij})+(G_k+gkl)+(S_{ik}+s_{ijkl})+e_{IJKL}$$

Where Y_{ijkl} is the value of the cross between the j_{th} parent of the i_{th} class and the l_{th} parent of the k_{th} class;

i=1,2,3,...,c; j=1,2,3,...,w;

μ is the population mean;

$$g'_{ij}=G_i+g_{ij};$$

$$\sum_{ij}^{cw} g'_{ij}=0$$

g'_{ij} is the general combining ability effect of the j_{th} parent of the i_{th} class;

G_i is the part of the general combining ability effect associated with the i_{th} class;

$$\sum_{i}^{c} G_i = 0$$

g_{ij} is the general combining ability effect associated with the j_{th} parent of the i_{th} class;

$$\sum_{j}^{w} g_{ij} = 0$$

s'_{ijkl} is the specific combining ability effect associated with the cross between the j_{th} parent of the i_{th} class and the l_{th} parent of the k_{th} class;

$$s'_{ijkl} = S_{iK} + s_{ijkl};$$

$$\sum_{kl \neq ij}^{cw-1} s'_{ijkl} = 0;$$

S_{ik} is the part of the specific combining ability effect associated with crosses between parents of the i_{th} and k_{th} class;

$$(w-1) S_{ii} + W \sum_{k \neq i}^{c-1} S_{ik};$$

S'_{ijkl} is the part of the specific combining ability effect associated with the cross of the j_{th} and l_{th} parents of the

i_{th} and k_{th} classes;

$$\sum_{kl \neq ij}^{cw-1} s_{ijkl} = 0;$$

$$\sum_{j<j'}^{w(w-1)/2} s_{ijij'} = 0;$$

$$\sum_{j}^{w} \sum_{l}^{w} s_{ijkl} = 0;$$

ϵ_{ijkl} is the effect of error on the cross value;

$$\epsilon_{ijkl} \sim NID(0, \sigma^2)$$

Because of the above constraints, some of the effects can be expressed as linear combinations of the others;

$$G_3 = -G_1 - G_2;$$

$$g_{14} = -g_{11} - g_{12} - g_{13};$$

$$g_{24} = -g_{21} - g_{22} - g_{23};$$

$$g_{34} = -g_{31} - g_{32} - g_{33};$$

$$S_{13} = -\frac{3}{4} S_{11} - S_{12};$$

$$S_{23}=-S_{12}-\frac{3}{4}S-22;$$

$$S_{1234}=-S_{1112}-S_{1213}-S_{1214}-S_{1221}-S_{1222}-S_{1223}-S_{1224}-S_{1231}-S_{1232}-S_{1233};$$

$$S_{1314}=-S_{1112}-S_{1113}-S_{1114}-S_{1213}-S_{1214};$$

$$S_{1334}=S_{1112}+S_{1114}+S_{1214}-S_{1321}-S_{1322}-S_{1323}-S_{1324}-S_{1331}-S_{1332}-S_{1333};$$

$$S_{1424}=-S_{1121}-S_{1122}-S_{1123}-S_{1124}-S_{1221}-S_{1222}-S_{1223}-S_{1224}-S_{1321}-S_{1322}-S_{1323}-$$

$$S_{1324}-S_{1421}-S_{1422}-S_{1423};$$

$$S_{1434}=S_{1112}+S_{1113}+S_{1121}+S_{1122}+S_{1123}+S_{1124}+S_{1213}+S_{1221}+S_{1222}+S_{1223}+S_{1224}+$$

$$S_{1321}+S_{1322}+S_{1323}+S_{1324}-S_{1431}-S_{1432}-S_{1433};$$

$$S_{2134}=-S_{1121}-S_{1221}-S_{1321}-S_{1421}-S_{2122}-S_{2123}-S_{2124}-S_{2131}-S_{2132}-S_{2133};$$

$$S_{2234}=-S_{1122}-S_{1222}-S_{1322}-S_{1422}-S_{2122}-S_{2223}-S_{2224}-S_{2231}-S_{2232}-S_{2233};$$

$$S_{2324}=-S_{2122}-S_{2123}-S_{2124}-S_{2223}-S_{2224};$$

$$S_{2334}=-S_{1123}-S_{1223}-S_{1323}-S_{1423}+S_{2122}+S_{2124}+S_{2224}-S_{2331}-S_{2332}-S_{2333};$$

$$S_{2434}=S_{1121}+S_{1122}+S_{1123}+S_{1221}+S_{1222}+S_{1223}+S_{1321}+S_{1322}+S_{1323}+S_{1421}+S_{1422}+$$

$$S_{1423}+S_{2122}+S_{2123}+S_{2223}-S_{2431}-S_{2432}-S_{2433};$$

$$S_{3134}=-S_{1131}-S_{1231}-S_{1331}-S_{1431}-S_{2131}-S_{2231}-S_{2331}-S_{2431}-S_{3132}-S_{3133};$$

$$S_{3233}=-S_{1131}-S_{1132}-S_{1133}-S_{1231}-S_{1232}-S_{1233}-S_{1331}-S_{1332}-S_{1333}-S_{1431}-S_{1432}-$$

$$S_{1433}-S_{2131}-S_{2132}-S_{2133}-S_{2231}-S_{2232}-S_{2233}-S_{2331}-S_{2332}-S_{2333}-S_{2431}-S_{2432}-$$

$$S_{2433}-S_{3132}-S_{3133};$$

$$S_{3234}=S_{1131}+S_{1133}+S_{1231}+S_{1233}+S_{1331}+S_{1333}+S_{1431}+S_{1433}+S_{2131}+S_{2133}+S_{2231}+$$

$$S_{2233}+S_{2331}+S_{2333}+S_{2431}+S_{2433}+S_{3133};$$

$$S_{3334}=S_{1131}+S_{1132}+S_{1231}+S_{1232}+S_{1331}+S_{1332}+S_{1431}+S_{1432}+S_{2131}+S_{2132}+S_{2231}+$$

$$S_{2232}+S_{2331}+S_{2332}+S_{2431}+S_{2432}+S_{3132};$$

When an experiment was carried out in only one location and/or year, the estimates of general and specific combining ability effects may be inflated by the interaction of genotype by location and/or year. Thus, it is better to repeat the experiment in several locations and years to remove this possible source of bias and estimate the relative magnitude of the interaction of the effects with the location and year.

The combined analysis of a diallel cross repeated in several locations was based on fitting the F_1 means to the following linear model:

$$Y_{ijklm}=\mu+g'_{ij}+g'_{kl}+s'_{ijkl}+d_m+(g'd)_{ijm}+(g'd)_{klm}+(s'd)_{ijklm}+e_{ijklm};$$

where i= 1,2,3,...,c; j=1,2,3,...,w; m=1,2,3,....,p;

d_m= effect of the m_{th} location;

$(g'd)_{ijm}$= effect of the general combining ability of the j_{th} parent of the i_{th} class at the m_{th} location.

$(g'd)_{klm}$= effect of the general combining ability of the l_{th} parent of the k_{th} class at the m_{th} location.

$(s'd)_{ijklm}$= effect of the specific combining ability of the cross between the j_{th} parent of the i_{th} class and the l_{th} parent of the k_{th} class at the m_{th} location.

Location and the crosses were both considered fixed effects, because the locations were specifically chosen, and the lines used to develop the entries in these experiments were selected inbred lines. The experiments were repeated in three years at the same locations and the model for combined analysis across locations was:

$$Y_{ijkln}=\mu+g'_{ij}+g'_{kl}+s'_{ijkl}+y_n+(g'y)_{ijn}+(g'y)_{kln}+(s'y)_{ijklm}+e_{ijkln}$$

where y_n= effect of the n_{th} year;

$(g'y)_{ijn}$= effect of the general combining ability of the j_{th} parent of the i_{th} class at the n_{th} year.

$(g'y)_{kln}$= effect of the general combining ability of the l_{th} parent of the k_{th} class at the n_{th} year.

$(s'y)_{ijkln}$= effect of the specific combining ability of the cross between the j_{th} parent of the i_{th} class and the l_{th} parent of the k_{th} class at the n_{th} year.

The model for combined analysis over locations and years is :

$$Y_{ijklnm}=\mu+g'_{ij}+g'_{kl}+s'_{ijkl}+d_m+y_n+(g'd)_{ijm}+(g'd)_{klm}+(s'd)_{ijklm}+(g'y)_{ijn}+$$

$$(g'y)_{kln}+(s'y)_{ijkln}+dy_{mn}+(g'dy)_{ijmn}+(g'dy)_{klmn}+(s'dy)_{ijklmn}+e_{ijklmn};$$

In this analysis, locations, classes and crosses were considered as fixed effects, while years were considered to be random samples of the possible years.

Table 4. Format of the analysis of variance for an individual experiment for diallel crosses.

Source of variation [a]	Degrees of freedom [b]
Replication	r-1
Genotype	1/2cw(cw-1)-1
GCA	cw-1
GCA among classes	c-1
GCA within classes	c(w-1)
GCA in Class 1	w-1
GCA in Class 2	w-1
GCA in Class 3	w-1
SCA	1/2cw(cw-3)
SCA among classes	1/2c(c-1)
SCA within classes	1/2c[w(cw-3)-(c-1)]
Error	[1/2cw(cw-1)-1](r-1)
Total	[1/2cw(cw-1)]r-1

a = GCA and SCA denote the General Combining ability, and Specific combining ability, respectively.
b = r, c, and w denote the number of replications, maturity classes, and lines within maturity classes respectively.

Table 5. Format of the analysis of variance combined over years for diallel crosses.

Source of variation [a]	Degrees of freedom [b]
Location (L)	l-1
Genotype (G)	1/2cw(cw-1)-1
GCA	cw-1
GCA among classes	c-1
GCA within classes	c(w-1)
GCA in Class 1	w-1
GCA in Class 2	w-1
GCA in Class 3	w-1
SCA	1/2cw(cw-3)
SCA among classes	1/2c(c-1)
SCA within classes	1/2c[w(cw-3)-(c-1)]
LXG	(l-1)[1/2cw(cw-1)-1]
LXGCA	(l-1)(cw-1)
LXGCA among classes	(l-1)(c-1)
LXGCA within classes	(l-1)[c(w-1)]
LXGCA in Class 1	(l-1)(w-1)
LXGCA in Class 2	(l-1)(w-1)
LXGCA in Class 3	(l-1)(w-1)
LXSCA	(l-1)[1/2cw(cw-3)]
LXSCA among classes	(l-1)[1/2c(c-1)]
LXSCA within classes	(l-1){1/2c[w(cw-3)-(c-1)]}

Continuation of Table 5.

Source of variation [a]	**Degrees of freedom** [b]
Pooled error	l[1/2cw(cw-1)-1](r-1)
Total	[1/2cw(cw-1)]l-1

a = GCA and SCA denote the General Combining ability, and Specific combining ability, respectively.
b = l, r, c, and w denote the number of locations, replications, maturity classes, and lines within maturity classes respectively.

Table 6. Format of the analysis of variance combined over locations for diallel crosses.

Source of variation [a]	Degrees of freedom [b]
Year (Y)	y-1
Genotype (G)	1/2cw(cw-1)-1
GCA	cw-1
GCA among classes	c-1
GCA within classes	c(w-1)
GCA in Class 1	w-1
GCA in Class 2	w-1
GCA in Class 3	w-1
SCA	1/2cw(cw-3)
SCA among classes	1/2c(c-1)
SCA within classes	1/2c[w(cw-3)-(c-1)]
YXG	(y-1)[1/2cw(cw-1)-1]
YXGCA	(y-1)(cw-1)
YXGCA among classes	(y-1)(c-1)
YXGCA within classes	(y-1)[c(w-1)]
YXGCA in Class 1	(y-1)(w-1)
YXGCA in Class 2	(y-1)(w-1)
YXGCA in Class 3	(y-1)(w-1)
YXSCA	(y-1)[1/2cw(cw-1)]
YXSCA among classes	(y-1)[1/2c(c-1)]
YXSCA within classes	(y-1){1/2c[w(cw-3)-(c-1)]}

Continuation of Table 6.

Source of variation[a]	**Degrees of freedom**[b]
Pooled error	y[1/2cw(cw-1)-1](r-1)
Total	[1/2cw(cw-1)]y-1

a = GCA, and SCA denote the General Combining ability, and Specific combining ability, respectively.
b = y, r, c, and w denote the number of years, replications, maturity classes, and lines within maturity classes respectively.

Table 7. Format of the analysis of variance combined over years and locations for diallel crosses.

Source of variation [a]	Degrees of freedom [b]
Year(Y)	y-1
Location(L)	l-1
YXL	(y-1)(L-1)
Genotype(G)	1/2cw(cw-1)-1
GCA	cw-1
GCA among classes	c-1
GCA within classes	c(w-1)
GCA in Class 1	w-1
GCA in Class 2	w-1
GCA in Class 3	w-1
SCA	1/2cw(cw-3)
SCA among classes	1/2c(c-1)
SCA within classes	1/2c[w(cw-3)-(c-1)]
YXG	(y-1)[1/2cw(cw-1)-1]
YXGCA	(y-1)(cw-1)
YXGCA among classes	(y-1)(c-1)
YXGCA within classes	(y-1)[c(w-1)]
YXGCA in Class 1	(y-1)(w-1)
YXGCA in Class 2	(y-1)(w-1)
YXGCA in Class 3	(y-1)(w-1)
YXSCA	(y-1)[1/2cw(cw-3)]

Continuation of Table 7.

Source of variation [a]	**Degrees of freedom** [b]
YXSCA among classes	(y-1)[1/2c(c-1)]
YXSCA within classes	(y-1){1/2c[w(cw-3)-(c-1)]}
LXG	(l-1)[1/2cw(cw-1)-1]
YXSCA within classes	(y-1){1/2c[w(cw-3)-(c-1)]}
LXG	(l-1)[1/2cw(cw-1)-1]
LXGCA	(l-1)(cw-1)
LXGCA among classes	(l-1)(c-1)
LXGCA within classes	(l-1)[c(w-1)]
LXGCA in Class 1	(l-1)(w-1)
LXGCA in Class 2	(l-1)(w-1)
LXGCA in Class 3	(l-1)(w-1)
LXSCA	(l-1)[1/2cw(cw-3)]
LXSCA among classes	(l-1)[1/2c(c-1)]
LXSCA within classes	(l-1){1/2c[w(cw-3)-(c-1)]}
YXLXG	(y-1)(l-1)[1/2cw(cw-1)-1]
YXLXGCA	(y-1)(l-1)(cw-1)
YXLXGCA among classes	(y-1)(l-1)(c-1)
YXLXGCA within classes	(y-1)(l-1)[c(w-1)]
YXLXGCA in Class 1	(y-1)(l-1)(w-1)
YXLXGCA in Class 2	(y-1)(l-1)(w-1)
YXLXGCA in Class 3	(y-1)(l-1)(w-1)

Continuation of Table 7.

Source of variation [a]	Degrees of freedom [b]
YXLXSCA	(y-1)(l-1)[1/2cw(cw-3)]
YXLXSCA among classes	(y-1)(l-1)[1/2c(c-1)]
YXLXSCA within classes	(y-1)(l-1){1/2c[w(cw-3)-(c-1)]}
Pooled error	yl[1/2cw(cw-1)-1](r-1)
Total	[1/2cw(cw-1)](y-1)(l-1)

a = GCA and SCA denote the General Combining ability, and Specific combining ability, respectively.
b = y, l, r, c, and w denote the number of years, locations, replications, maturity classes, and lines within maturity classes respectively.

RESULTS

Mean values for seven agronomic characters for each cross, combined either across three years or three locations, are given in Tables 8-13. In the Central location, the overall performance of the material was inferior to the two other locations. This indicates that the conditions were more favorable at the Northern and Southern locations, particularly in 1989 and 1991. The data showed that early by early and early by medium crosses had the lowest yield and the highest stalk lodging percentage in the Central location. The performance of the crosses in different years suggested that 1991 was the best year for grain yield, reduced moisture content, and reduced root lodging, but it was the worst year for stalk lodging incidence. The 1989 season was the poorest of all three years for all characters except stalk lodging incidence which showed the lowest values in this season. In actual agronomic performance, crosses involved with early by early or early by medium performed poorly in all three locations over each of the three years.

Tables 14 and 15 show the mean of nine agronomic characters pooled over three years and three locations. The mean performance of line crosses is given in Table 16.

The combined analysis of variance over years and locations for grain yield, stalk lodging, root lodging, plant

Table 8. Mean of seven agronomic characters of 1989 averaged over three locations.

Crosses	SC[1] #p/h	SL %	RL %	MC %	PH cm	EH cm	GY t/ha
E by E	48.7	9.4	6.5	18.0	193.2	90.1	4.9
E by M	50.6	8.8	4.1	19.4	199.4	96.1	6.2
E by L	53.8	5.3	3.5	20.3	215.9	108.3	8.9
M by M	55.8	4.7	1.5	21.7	207.6	99.5	7.6
M by L	54.3	2.3	1.5	23.5	220.7	111.8	8.5
L by L	56.4	2.4	1.6	28.3	231.4	120.9	8.7
Mean	53.2	5.5	3.1	21.9	211.4	104.5	7.5

E, M, L= early, medium and late respectively.

1= in thousands.

Table 9. Mean of seven agronomic characters of 1990 averaged over three locations.

Crosses	SC[1] #p/h	SL %	RL %	MC %	PH cm	EH cm	GY t/ha
E by E	50.6	17.5	0.8	19.6	180.1	75.7	5.7
E by M	53.1	10.9	0.2	21.9	190.4	82.2	7.1
E by L	49.9	7.7	0.4	22.7	204.4	92.9	8.3
M by M	55.3	7.7	0.1	24.1	202.9	89.6	8.2
M by L	52.6	6.1	0.6	26.5	215.8	100.7	8.8
L by L	46.7	7.0	1.2	29.7	216.4	106.9	7.8
Mean	51.4	9.5	0.6	24.1	201.7	91.3	7.7

E, M, L= early, medium and late respectively.

1 = in thousands.

Table 10. Mean of seven agronomic characters of 1991 averaged over three locations.

Crosses	SC[1] #p/h	SL %	RL %	MC %	PH cm	EH cm	GY t/ha
E by E	54.4	22.3	0.4	15.5	180.5	78.3	5.3
E by M	56.9	17.7	0.6	16.0	186.6	84.0	6.9
E by L	55.8	11.2	0.6	16.8	203.9	95.0	8.8
M by M	60.0	14.1	0.5	17.0	196.9	90.2	7.9
M by L	57.9	11.0	0.5	18.5	207.0	97.8	9.2
L by L	56.6	5.9	0.4	20.2	219.0	110.4	9.9
Mean	56.9	13.7	0.5	17.3	199.0	92.6	8.0

E, M, L= early, medium and late respectively.

1 = in thousands.

Table 11. Mean of seven agronomic characters of Southern location averaged over three years.

Crosses	SC[1] #p/h	SL %	RL %	MC %	PH cm	EH cm	GY t/ha
E by E	54.7	19.9	1.7	15.5	190.4	84.0	5.7
E by M	55.3	18.4	0.8	16.6	198.7	89.8	6.9
E by L	55.8	11.2	0.7	16.7	214.8	100.1	9.0
M by M	57.7	16.2	0.3	17.6	207.4	94.4	7.7
M by L	56.5	12.1	0.5	17.5	211.3	109.4	9.3
L by L	55.5	4.0	0.6	20.5	231.9	113.2	9.7
Mean	55.9	13.6	0.8	17.4	209.1	98.5	8.1

E, M, L= early, medium and late respectively.

1 = in thousands.

Table 12. Mean of seven agronomic characters of Central location averaged over three years.

Crosses	SC[1] #p/h	SL %	RL %	MC %	PH cm	EH cm	GY t/ha	DP dap	SD dap
E by E	47.4	14.4	5.2	18.2	176.9	76.7	4.0	70	72
E by M	50.9	8.9	2.8	19.5	182.2	81.4	5.8	72	75
E by L	49.4	6.7	2.9	20.8	199.0	94.6	8.0	75	77
M by M	54.1	4.9	1.1	22.0	192.2	86.4	7.2	74	77
M by L	51.4	6.3	1.4	23.2	197.2	102.4	8.5	75	80
L by L	50.2	4.3	2.3	27.9	215.2	110.2	8.6	81	84
Mean	50.6	7.6	2.6	21.9	193.8	92.0	7.0	74	78

E, M, L= early, medium and late respectively.

1 = in thousands.

Table 13. Mean of seven agronomic characters of Northern location averaged over three years.

Crosses	SC[1] #p/h	SL %	RL %	MC %	PH cm	EH cm	GY t/ha
E by E	51.6	15.0	0.7	19.4	186.4	83.4	6.2
E by M	54.3	10.1	1.3	21.1	195.6	91.1	7.5
E by L	54.3	6.4	1.0	22.2	210.5	101.5	8.9
M by M	59.2	5.4	0.6	23.3	207.8	98.6	8.7
M by L	57.0	7.2	0.7	24.2	210.9	113.0	8.9
L by L	53.9	7.1	0.4	29.8	219.7	114.8	8.1
Mean	55.1	8.5	0.8	23.3	205.2	100.4	8.1

E, M, L= early, medium and late respectively.

1 = in thousands.

Table 14. Mean of four agronomic characters averaged over three years and three locations.

Crosses	SC[1] #p/h	SL %	RL %	MC %
A641XCm105	52.9	11.9	1.9	16.7
A641XW117Ht	52.8	12.3	3.1	16.7
A641XMs74	44.0	30.1	5.7	17.4
A641XW64A	55.2	11.3	1.0	19.6
A641XMs75	52.8	10.1	1.5	17.3
A641XA619	54.2	7.9	1.5	18.2
A641XA632	52.4	11.3	0.6	17.2
A641XB73Ht	53.2	6.9	1.9	19.3
A641XMo17Ht	54.8	5.9	0.9	17.6
A641XB84	50.6	8.6	2.6	18.7
A641XPa872	53.8	5.3	1.2	18.2
Cm105XW117Ht	58.4	8.6	0.4	18.4
Cm105XMs74	50.3	16.2	1.3	17.7
Cm105XW64A	56.5	9.9	0.6	19.9
Cm105XMs75	56.4	8.2	0.2	19.8
Cm105XA619	54.1	7.4	0.6	22.6
Cm105XA632	53.7	11.5	0.3	18.5
Cm105XB73Ht	57.4	2.9	0.2	21.7
Cm105XMo17Ht	56.7	6.6	0.8	21.1
Cm105XB84	56.6	7.8	0.6	22.9
Cm105XPa872	53.2	7.5	0.4	19.3
W117HtXMs74	49.0	19.5	2.9	19.3
W117HtXW64A	54.9	11.8	0.7	19.2
W117HtXMs75	54.1	11.4	0.8	18.3
W117HtXA619	54.3	13.8	1.8	20.9
W117HtXA632	56.6	10.0	0.9	17.3
W117HtXB73Ht	53.5	5.5	0.7	21.3
W117HtXMo17Ht	54.6	5.9	0.5	20.2
W117HtXB84	51.6	7.2	0.5	20.6
W117HtXPa872	51.8	8.4	1.4	18.7
Ms74XW64A	52.6	19.7	4.9	18.9
Ms74XMs75	52.3	17.8	4.6	19.4
Ms74XA619	43.0	19.3	3.1	20.5
Ms74XA632	53.2	18.2	3.3	17.5
Ms74XB73Ht	50.5	12.3	1.5	20.3
Ms74XMo17Ht	50.6	10.5	2.8	19.1
Ms74XB84	49.4	15.4	3.7	20.6
Ms74XPa872	52.4	12.5	4.4	19.2
W64AXMs75	55.9	7.5	0.5	20.2
W64AXA619	58.4	6.0	0.6	23.6
W64AXA632	57.9	12.3	0.6	19.6
W64AXB73Ht	55.2	6.9	0.5	23.4

Table 14. Mean of four agronomic characters averaged over three years and three locations.

Crosses	SC[1] #p/h	SL %	RL %	MC %
W64AXMo17Ht	56.6	5.0	0.7	22.8
W64AXB84	54.4	7.2	1.2	22.4
W64AXPa872	57.1	4.5	1.1	21.7
Ms75XA619	56.2	5.7	1.2	21.4
Ms75XA632	55.8	12.4	1.1	19.2
Ms75XB73Ht	56.7	5.9	1.5	22.4
Ms75XMo17Ht	55.4	7.9	0.5	20.3
Ms75XB84	56.9	13.2	1.9	20.9
Ms75XPa872	57.4	5.8	0.8	20.1
A619XA632	57.9	9.0	0.1	21.7
A619XB73Ht	54.2	4.5	0.8	28.9
A619XMo17Ht	54.1	5.5	0.6	24.1
A619XB84	55.2	6.0	1.0	28.9
A619XPa872	47.3	4.6	0.4	22.3
A632XB73Ht	55.9	5.0	0.3	22.9
A632XMo17Ht	52.5	8.0	1.0	21.5
A632XB84	54.0	7.7	1.2	22.0
A632XPa872	55.8	5.3	0.6	20.4
B73HtXMo17Ht	56.8	2.6	0.5	26.2
B73HtXB84	54.1	10.4	1.3	29.6
B73HtXPa872	55.8	4.0	0.8	24.8
Mo17HtXB84	48.2	5.1	1.0	26.5
Mo17HtXPa872	53.7	4.3	1.4	22.2
B84XPa872	50.8	4.3	1.5	27.1
Mean	53.9	9.3	1.4	20.9
Range	43.0-58.4	2.6-30.1	0.1-5.7	16.7-29.6

1 = in thousands.

Table 15. Mean of five agronomic characters average over three years and three locations.

Crosses	PH cm	EH cm	GY t/ha	DP dap	SD dap
A641XCm105	188.4	82.5	5.3	71	73
A641XW117Ht	184.5	88.0	6.1	70	72
A641XMs74	178.0	75.9	4.4	68	70
A641XW64A	186.9	90.9	7.1	73	75
A641XMs75	193.5	94.4	7.0	71	73
A641XA619	175.6	72.2	7.0	70	73
A641XA632	189.3	90.5	5.9	75	76
A641XB73Ht	206.3	102.7	9.4	75	77
A641XMo17Ht	213.2	102.3	9.7	75	77
A641XB84	209.6	106.8	8.4	76	77
A641XPa872	194.6	85.9	8.3	73	75
Cm105XW117Ht	196.1	87.0	6.9	71	73
Cm105XMs74	181.4	74.8	4.7	68	71
Cm105XW64A	200.2	96.5	8.5	74	76
Cm105XMs75	201.2	89.9	7.7	74	77
Cm105XA619	189.1	70.8	6.6	74	77
Cm105XA632	198.5	98.9	6.3	77	80
Cm105XB73Ht	217.1	100.6	9.5	77	80
Cm105XMo17Ht	214.8	103.4	9.8	76	80
Cm105XB84	220.9	110.0	9.3	78	82
Cm105XPa872	204.0	89.1	8.2	74	76
W117HtXMs74	179.2	80.3	4.3	70	73
W117HtXW64A	184.5	89.7	7.5	72	74
W117HtXMs75	193.5	92.4	6.2	71	74
W117HtXA619	192.5	79.3	6.7	71	74
W117HtXA632	210.3	102.1	7.9	73	76
W117HtXB73Ht	211.1	103.0	9.4	75	78
W117HtXMo17Ht	202.4	104.1	8.5	75	78
W117HtXB84	212.6	108.7	9.3	76	78
W117HtXPa872	201.6	90.0	8.1	73	75
Ms74XW64A	186.0	86.1	6.5	70	73
Ms74XMs75	191.8	85.6	4.9	70	74
Ms74XA619	180.3	71.4	5.0	69	71
Ms74XA632	201.3	87.7	6.8	70	73
Ms74XB73Ht	204.9	94.2	8.1	72	76
Ms74XMo17Ht	197.3	93.5	7.4	73	75
Ms74XB84	219.7	102.8	7.9	73	75
Ms74XPa872	198.9	82.1	7.2	72	74
W64AXMs75	195.5	96.8	5.8	75	77
W64AXA619	187.5	79.8	8.2	74	77
W64AXA632	214.8	108.5	9.4	75	77
W64AXB73Ht	211.1	109.1	9.7	77	80
W64AXMo17Ht	216.4	114.1	8.6	80	83

Table 15. Mean of five agronomic characters averaged over three years and three locations.

Crosses	PH cm	EH cm	GY t/ha	DP dap	SD dap
W64AXB84	213.9	110.3	9.0	77	80
W64AXPa872	209.7	99.5	10.0	77	79
Ms75XA619	200.8	82.9	7.6	72	76
Ms75XA632	215.9	107.3	7.4	75	77
Ms75XB73Ht	225.1	112.6	8.8	78	80
Ms75XMo17Ht	209.9	105.1	9.2	76	79
Ms75XB84	229.0	119.4	8.8	77	79
Ms75XPa872	211.7	92.5	9.1	74	77
A619XA632	200.4	83.4	8.8	76	78
A619XB73Ht	210.4	94.7	9.3	78	80
A619XMo17Ht	205.6	91.5	8.8	77	81
A619XB84	223.4	102.3	8.8	78	82
A619XPa872	179.0	67.8	6.4	77	80
A632XB73Ht	215.2	102.3	8.4	79	81
A632XMo17Ht	233.2	122.5	9.5	80	81
A632XB84	224.4	115.3	7.9	79	83
A632XPa872	213.9	96.2	9.3	76	79
B73HtXMo17Ht	230.2	121.1	10.3	81	84
B73HtXB84	211.6	108.8	6.2	83	88
B73HtXPa872	222.6	104.9	9.9	79	82
Mo17HtXB84	231.0	125.7	9.0	82	85
Mo17HtXPa872	222.0	105.8	9.0	79	82
B84XPa872	216.4	110.2	8.4	81	83
Mean	204.4	96.3	7.9	75	77
Range	175.6-233.2	67.8-125.7	4.3-10.3	68-83	70-88

Table 16. Mean performance of line crosses for nine agronomic characters averaged over three years and three locations.

Lines	SC[1] #p/h	SL %	RL %	MC %	PH cm	EH cm	GY t/ha	DP dap	SD dap
Early									
A641	52.4	11.1	2.0	17.9	192.7	90.2	7.1	72	74
Cm105	55.1	9.0	0.7	19.9	201.1	91.2	7.4	74	77
W117Ht	53.8	10.4	1.2	19.2	197.1	93.1	7.3	72	75
Ms74	49.8	17.4	3.5	19.1	192.6	84.9	6.0	71	73
Mean	52.8	12.0	1.9	19.0	195.9	89.9	7.0	72	75
Medium									
W64A	55.9	9.3	1.1	21.0	200.6	98.3	8.2	75	77
Ms75	55.4	9.6	1.3	19.9	206.2	98.1	7.5	74	77
A619	53.5	8.2	1.1	23.0	195.0	81.5	7.5	74	77
A632	55.1	10.1	0.9	19.8	210.7	101.3	7.9	76	78
Mean	55.0	9.3	1.1	20.9	203.1	94.8	7.8	75	77
Late									
B73Ht	54.8	6.1	0.9	23.7	215.1	104.9	8.9	78	81
Mo17Ht	54.0	6.1	1.0	22.0	216.0	108.1	8.9	78	80
B84	52.9	8.4	1.5	23.7	219.3	110.9	8.4	78	81
Pa872	53.6	6.0	1.3	21.3	206.8	93.1	8.4	76	78
Mean	53.8	6.7	1.2	22.7	214.3	104.3	8.7	78	80
Mean	53.9	9.3	1.4	20.9	204.4	96.3	7.8	75	77

1 = in thousands.

Table 17. Analysis of variance for Grain Yield (t/ha) for 66 diallel crosses evaluated at three locations in 1989, 1990 and 1991.

Source	df	Mean squares
Year	2	19.624**
Location	2	57.096
YearxLocation	4	40.042**
Genotype	65	20.241**
GCA	11	75.166**
GCA among classes	2	312.924**
GCA within Classes	9	22.331**
GCA in Class 1	3	43.512**
GCA in Class 2	3	12.368**
GCA in Class 3	3	11.113*
SCA	54	9.052**
SCA among classes	3	55.839**
SCA within classes	51	6.300**
YearxGenotype	130	2.886**
YearxGCA	22	7.608**
YearxGCA among classes	4	15.837**
YearxGCA within classes	18	5.779**
YearxGCA in Class 1	6	8.018**
YearxGCA in Class 2	6	3.832**
YearxGCA in Class 3	6	5.486**
YearxSCA	108	1.924**
YearxSCA among classes	6	2.975**
YearxSCA within classes	102	1.862**
LocationxGenotype	130	1.869**
LocationxGCA	22	5.831**
LocationxGCA among classes	4	20.085**
LocationxGCA within classes	18	2.664**
LocationxGCA in Class 1	6	5.062**
LocationxGCA in Class 2	6	0.786
LocationxGCA in Class 3	6	2.143*
LocationxSCA	108	1.062
LocationxSCA among classes	6	0.845
LocationxSCA within classes	102	1.075
YearxLocationxGenotype	260	0.933
YearxLocationxGCA	44	1.827**
YearxLocationxGCA among classes	8	2.091*
YearxLocationxGCA within classes	36	1.769**
YearxLocationxGCA in Class 1	12	1.608*
YearxLocationxGCA in Class 2	12	2.875**
YearxLocationxGCA in Class 3	12	0.823
YearxLocationxSCA	216	0.750
YearxLocationxSCA among classes	12	0.628
YearxLocationxSCA within classes	203	0.761
Pooled error	1170	0.789

*, ** Significant at p=0.05 and 0.01 respectively.

Table 18. Analysis of variance for Stalk Lodging (%) for 66 diallel crosses evaluated at three locations in 1989, 1990 and 1991.

Source	df	Mean squares
Year	2	3224.431**
Location	2	2355.040
YearxLocation	4	869.142**
Genotype	65	218.576**
GCA	11	1029.337**
GCA among classes	2	3032.917**
GCA within Classes	9	584.098**
GCA in Class 1	3	1529.697**
GCA in Class 2	3	73.311
GCA in Class 3	3	149.285*
SCA	54	53.421
SCA among classes	3	159.004*
SCA within classes	51	47.210
YearxGenotype	130	40.545**
YearxGCA	22	87.916**
YearxGCA among classes	4	129.707**
YearxGCA within classes	18	78.629**
YearxGCA in Class 1	6	77.900**
YearxGCA in Class 2	6	83.041**
YearxGCA in Class 3	6	74.946**
YearxSCA	108	30.896**
YearxSCA among classes	6	59.807**
YearxSCA within classes	102	29.195**
LocationxGenotype	130	47.747**
LocationxGCA	22	141.412**
LocationxGCA among classes	4	314.052**
LocationxGCA within classes	18	103.048**
LocationxGCA in Class 1	6	245.762**
LocationxGCA in Class 2	6	22.105
LocationxGCA in Class 3	6	41.276
LocationxSCA	108	28.667
LocationxSCA among classes	6	29.684
LocationxSCA within classes	102	28.607
YearxLocationxGenotype	260	30.179**
YearxLocationxGCA	44	78.176**
YearxLocationxGCA among classes	8	155.065**
YearxLocationxGCA within classes	36	61.090**
YearxLocationxGCA in Class 1	12	83.419**
YearxLocationxGCA in Class 2	12	67.305**
YearxLocationxGCA in Class 3	12	32.547
YearxLocationxSCA	216	20.402
YearxLocationxSCA among classes	12	33.006
YearxLocationxSCA within classes	204	19.660
Pooled error	1170	19.001

*, ** Significant at p=0.05 and 0.01 respectively.

Table 19. Analysis of variance for Root Lodging (%) for 66 diallel crosses evaluated at three locations in 1989, 1990 and 1991.

Source	df	Mean squares
Year	2	440.761**
Location	2	207.594
YearxLocation	4	225.551**
Genotype	65	13.364
GCA	11	60.564**
GCA among classes	2	73.269**
GCA within Classes	9	57.741**
GCA in Class 1	3	161.334**
GCA in Class 2	3	3.496
GCA in Class 3	3	8.392
SCA	54	3.749
SCA among classes	3	2.385
SCA within classes	51	3.829
YearxGenotype	130	9.479**
YearxGCA	22	38.806**
YearxGCA among classes	4	81.207**
YearxGCA within classes	18	29.383**
YearxGCA in Class 1	6	76.987**
YearxGCA in Class 2	6	1.626
YearxGCA in Class 3	6	9.537*
YearxSCA	108	3.505
YearxSCA among classes	6	1.566
YearxSCA within classes	102	3.619
LocationxGenotype	130	7.976
LocationxGCA	22	21.561**
LocationxGCA among classes	4	21.714*
LocationxGCA within classes	18	21.527**
LocationxGCA in Class 1	6	44.052**
LocationxGCA in Class 2	6	4.129
LocationxGCA in Class 3	6	16.399*
LocationxSCA	108	5.209
LocationxSCA among classes	6	4.044
LocationxSCA within classes	102	5.278
YearxLocationxGenotype	260	7.183**
YearxLocationxGCA	44	17.437**
YearxLocationxGCA among classes	8	11.725**
YearxLocationxGCA within classes	36	18.706**
YearxLocationxGCA in Class 1	12	41.642**
YearxLocationxGCA in Class 2	12	1.407
YearxLocationxGCA in Class 3	12	13.070**
YearxLocationxSCA	216	5.095
YearxLocationxSCA among classes	12	2.346
YearxLocationxSCA within classes	204	5.256
Pooled error	1170	4.137

*, ** Significant at p=0.05 and 0.01 respectively.

Table 20. Analysis of variance for Moisture Content (%) for 66 diallel crosses evaluated at three locations in 1989, 1990 and 1991.

Source	df	Mean squares
Year	2	2285.571**
Location	2	1891.416
YearxLocation	4	601.520**
Genotype	65	78.450**
GCA	11	393.748**
GCA among classes	2	1450.517**
GCA within Classes	9	158.910**
GCA in Class 1	3	73.196**
GCA in Class 2	3	239.744**
GCA in Class 3	3	163.792**
SCA	54	14.223**
SCA among classes	3	82.565**
SCA within classes	51	10.203**
YearxGenotype	130	5.600**
YearxGCA	22	20.511**
YearxGCA among classes	4	58.927**
YearxGCA within classes	18	11.974**
YearxGCA in Class 1	6	5.660**
YearxGCA in Class 2	6	16.896**
YearxGCA in Class 3	6	13.366**
YearxSCA	108	2.563**
YearxSCA among classes	6	7.848**
YearxSCA within classes	102	2.252**
LocationxGenotype	130	4.871*
LocationxGCA	22	20.591**
LocationxGCA among classes	4	68.706**
LocationxGCA within classes	18	9.899**
LocationxGCA in Class 1	6	6.630*
LocationxGCA in Class 2	6	12.221**
LocationxGCA in Class 3	6	10.845**
LocationxSCA	108	1.668
LocationxSCA among classes	6	3.169
LocationxSCA within classes	102	1.580
YearxLocationxGenotype	260	2.294**
YearxLocationxGCA	44	4.923**
YearxLocationxGCA among classes	8	8.574**
YearxLocationxGCA within classes	36	4.112**
YearxLocationxGCA in Class 1	12	3.455**
YearxLocationxGCA in Class 2	12	4.291**
YearxLocationxGCA in Class 3	12	4.589**
YearxLocationxSCA	216	1.759**
YearxLocationxSCA among classes	12	3.180**
YearxLocationxSCA within classes	203	1.683**
Pooled error	1170	1.035

*, ** Significant at p=0.05 and 0.01 respectively.

Table 21. Analysis of variance for Plant Height (cm) for 66 diallel crosses evaluated at three locations in 1989, 1990 and 1991.

Source	df	Mean squares
Year	2	8351.332**
Location	2	13256.247
YearxLocation	4	3561.308**
Genotype	65	1949.831**
GCA	11	9522.628**
GCA among classes	2	37480.411**
GCA within Classes	9	3309.787**
GCA in Class 1	3	1784.532**
GCA in Class 2	3	5046.089**
GCA in Class 3	3	3098.741**
SCA	54	407.224**
SCA among classes	3	652.349**
SCA within classes	51	392.804**
YearxGenotype	130	109.439**
YearxGCA	22	289.946**
YearxGCA among classes	4	296.267**
YearxGCA within classes	18	288.542**
YearxGCA in Class 1	6	467.262**
YearxGCA in Class 2	6	245.844**
YearxGCA in Class 3	6	152.519*
YearxSCA	108	72.669
YearxSCA among classes	6	99.147
YearxSCA within classes	102	71.112
LocationxGenotype	130	65.465
LocationxGCA	22	147.593**
LocationxGCA among classes	4	179.703*
LocationxGCA within classes	18	140.458*
LocationxGCA in Class 1	6	89.482
LocationxGCA in Class 2	6	162.819*
LocationxGCA in Class 3	6	169.072*
LocationxSCA	108	48.736
LocationxSCA among classes	6	83.594
LocationxSCA within classes	102	46.685
YearxLocationxGenotype	260	72.274
YearxLocationxGCA	44	121.472**
YearxLocationxGCA among classes	8	181.122**
YearxLocationxGCA within classes	36	108.217**
YearxLocationxGCA in Class 1	12	82.813
YearxLocationxGCA in Class 2	12	106.540*
YearxLocationxGCA in Class 3	12	135.297**
YearxLocationxSCA	216	62.252
YearxLocationxSCA among classes	12	88.538
YearxLocationxSCA within classes	204	60.706
Pooled error	1170	57.757

*, ** Significant at p=0.05 and 0.01 respectively.

Table 22. Analysis of variance for Ear Height (cm) for 66 diallel crosses evaluated at three locations in 1989, 1990 and 1991.

Source	df	Mean squares
Year	2	10948.256**
Location	2	4149.567*
YearxLocation	4	585.225**
Genotype	65	1619.794**
GCA	11	8837.657**
GCA among classes	2	23286.137**
GCA within Classes	9	5626.883**
GCA in Class 1	3	1344.096**
GCA in Class 2	3	8844.504**
GCA in Class 3	3	6692.050**
SCA	54	149.489**
SCA among classes	3	59.213
SCA within classes	51	154.799**
YearxGenotype	130	69.222**
YearxGCA	22	128.882**
YearxGCA among classes	4	84.475
YearxGCA within classes	18	138.750**
YearxGCA in Class 1	6	268.320**
YearxGCA in Class 2	6	99.520*
YearxGCA in Class 3	6	48.409
YearxSCA	108	57.069
YearxSCA among classes	6	57.354
YearxSCA within classes	102	57.052
LocationxGenotype	130	53.301
LocationxGCA	22	96.327*
LocationxGCA among classes	4	152.172*
LocationxGCA within classes	18	83.917*
LocationxGCA in Class 1	6	80.103
LocationxGCA in Class 2	6	61.292
LocationxGCA in Class 3	6	110.357*
LocationxSCA	108	44.536
LocationxSCA among classes	6	14.308
LocationxSCA within classes	102	46.314
YearxLocationxGenotype	260	49.636
YearxLocationxGCA	44	53.080
YearxLocationxGCA among classes	8	73.950
YearxLocationxGCA within classes	36	48.443
YearxLocationxGCA in Class 1	12	61.631
YearxLocationxGCA in Class 2	12	59.241
YearxLocationxGCA in Class 3	12	24.455
YearxLocationxSCA	216	48.934
YearxLocationxSCA among classes	12	53.692
YearxLocationxSCA within classes	204	48.655
Pooled error	1170	44.904

*, ** Significant at p=0.05 and 0.01 respectively.

Table 23. Analysis of variance for Stand count (# of plants /ha) for 66 diallel crosses evaluated at three locations in 1989, 1990 and 1991.

Source	df	Mean squares
Year	2	1488.282**
Location	2	1667.486
YearxLocation	4	1482.734**
Genotype	65	87.086**
GCA	11	303.017**
GCA among classes	2	533.645**
GCA within Classes	9	251.767**
GCA in Class 1	3	570.223**
GCA in Class 2	3	112.011*
GCA in Class 3	3	73.066
SCA	54	43.100
SCA among classes	3	37.731
SCA within classes	51	43.416
YearxGenotype	130	34.134**
YearxGCA	22	77.144**
YearxGCA among classes	4	274.245**
YearxGCA within classes	18	33.344**
YearxGCA in Class 1	6	52.566**
YearxGCA in Class 2	6	30.137*
YearxGCA in Class 3	6	17.328
YearxSCA	108	25.373**
YearxSCA among classes	6	27.802
YearxSCA within classes	102	25.230**
LocationxGenotype	130	18.268
LocationxGCA	22	24.351
LocationxGCA among classes	4	42.054
LocationxGCA within classes	18	20.417
LocationxGCA in Class 1	6	13.120
LocationxGCA in Class 2	6	30.874
LocationxGCA in Class 3	6	17.255
LocationxSCA	108	17.029
LocationxSCA among classes	6	11.363
LocationxSCA within classes	102	17.362
YearxLocationxGenotype	260	21.570**
YearxLocationxGCA	44	48.220**
YearxLocationxGCA among classes	8	131.177**
YearxLocationxGCA within classes	36	29.785**
YearxLocationxGCA in Class 1	12	25.663*
YearxLocationxGCA in Class 2	12	54.628**
YearxLocationxGCA in Class 3	12	9.064
YearxLocationxSCA	216	16.142
YearxLocationxSCA among classes	12	20.633
YearxLocationxSCA within classes	204	15.878
Pooled error	1170	13.391

*, ** Significant at p=0.05 and 0.01 respectively.

Table 24. Analysis of variance for Days to pollen shed (dap) for 66 diallel crosses evaluated at Central location in 1989, 1990 and 1991.

Source	df	Mean squares
Year	2	5281.273**
Genotype	65	37.206**
GCA	11	207.376**
GCA among classes	2	921.808**
GCA within Classes	9	48.613**
GCA in Class 1	3	77.489**
GCA in Class 2	3	25.319**
GCA in Class 3	3	43.031**
SCA	54	2.541*
SCA among classes	3	3.420
SCA within classes	51	2.490*
YearxGenotype	130	1.580**
YearxGCA	22	2.676**
YearxGCA among classes	4	4.408**
YearxGCA within classes	18	2.291**
YearxGCA in Class 1	6	3.181**
YearxGCA in Class 2	6	1.611
YearxGCA in Class 3	6	2.081*
YearxSCA	108	1.357*
YearxSCA among classes	6	2.871**
YearxSCA within classes	102	1.268*
Pooled error	390	0.941

*, ** Significant at p=0.05 and 0.01 respectively.

Table 25. Analysis of variance for Silking Date (dap) for 66 diallel crosses evaluated at Central location in 1988, 1990 and 1991.

Source	df	Mean squares
Year	2	5274.652**
Genotype	65	40.673**
GCA	11	222.473**
GCA among classes	2	997.858**
GCA within Classes	9	50.165**
GCA in Class 1	3	76.964**
GCA in Class 2	3	19.789**
GCA in Class 3	3	53.742**
SCA	54	3.640**
SCA among classes	3	8.629**
SCA within classes	51	3.346**
YearxGenotype	130	1.816**
YearxGCA	22	2.988**
YearxGCA among classes	4	4.079*
YearxGCA within classes	18	2.745**
YearxGCA in Class 1	6	2.414
YearxGCA in Class 2	6	1.547
YearxGCA in Class 3	6	4.275**
YearxSCA	108	1.577
YearxSCA among classes	6	1.311
YearxSCA within classes	102	1.592*
Pooled error	390	1.178

*, ** Significant at p=0.05 and 0.01 respectively.

height, ear height and stand count are listed in Tables 17-23, respectively. Since days to pollen shed and silking date were recorded only at the central location in three years, they are presented in the analysis of variance combined only over years in Tables 24 and 25. Sum of squares of the entries for each character were partitioned according to a modified method of Griffing's Method four, Model one. In this method the general combining ability sum of squares was partitioned into among and within classes. Among classes is the average performance of the lines in a given maturity class as a group, and within classes is the average performance of a line within a given maturity class. The latter was further partitioned into the GCA of each maturity class. The sum of squares of SCA were also partitioned into among and within classes. Only the results of the modified method will be discussed.

Significant variation ($p=0.01$) for genotypes was observed for all characters except root lodging. The variation of GCA, GCA among classes, GCA within classes, and GCA in Class 1 were significant ($p=0.01$) for all characters studied. However, the magnitude of the GCA among classes was higher than the magnitude of within classes for all characters. Significant variation ($p\leq0.01$) for the GCA in Class 2 was obtained for grain yield, moisture content, plant height, ear height, stand count, days to pollen shed and silking date. The variation of GCA in Class 3 was not significant for root lodging and stand count. The GCA mean squares were consistently larger than SCA mean squares, suggested the prevalence of additive gene effects. Several workers have also reported the predominant role of GCA for yield and other agronomic characters (Sprague and Tatum, 1942; Gerrish, 1983; Stangland, 1983; Nevado et al., 1989; Cross, 1977; and Beck et al., 1990). Significant ($p \leq 0.01$) variation for SCA, and SCA within classes were found for grain yield, moisture content, plant height, ear height, days to pollen shed and silking date. Variation of SCA among classes was significant ($p \leq 0.01$) for grain yield, stalk lodging, moisture content, plant height and silking date. Variation of specific combining ability among classes was much larger than that within classes for yield, stalk lodging, moisture content, plant height, days to pollen shed and silking date.

Utilization of yield and maturity related characters as well as lodging resistance requires a clear understanding of how they are influenced by the environment. A study conducted over different locations and/or years is likely to bring out genotype by environment interaction effects. The magnitude of genotype by environment interaction variances are important to plant breeders, because they indicate the reliability of the results of any single environment, and assist in planning an efficient testing program.

In this study, year and year by location interaction were found to be significant (p=0.01) for all characters. However, location was significant (p=0.01) only for ear height. Interactions of year by genotype, year by GCA, year by GCA within classes, and year by GCA in Class 1 were significant (p=0.01) for all characters except silking date (YXGCA within class 1). The variation of year by GCA among classes interaction was not significant for ear height. The interaction of year by GCA in Class 2 was not significant for root lodging, days to pollen shed and silking date. The year by GCA in Class 3 interaction was not significant for ear height and stand count. The variation of year by SCA, and year by SCA within classes interactions were significant ($p \leq 0.01$) for grain yield, stalk lodging, moisture content, stand count, days to pollen shed and silking date (YXSCA within classes). Moreover, year by SCA among classes interaction was significant (p=0.01) for grain yield, stalk lodging, moisture content, and days to pollen shed. The variation of location by genotype interaction was significant ($p \leq 0.01$) for grain yield, stalk lodging and moisture content. The interactions of location by GCA, GCA among classes, and GCA within classes were significant ($p \leq 0.01$) for all characters studied except for stand count. The variation of location by GCA in Class 1 was significant ($p \leq 0.01$) for grain yield, stalk lodging, root lodging and moisture content. Interaction of location by GCA in Class 2 was significant ($p \leq 0.1$) for moisture content and plant height. Nonsignificant variation was found for location by GCA in Class 3 interaction for stalk lodging and stand count. The variation of location by SCA, SCA among classes, and SCA within classes were nonsignificant for all characters studied. The variation of year by location by genotype was significant (p=0.01) for stalk lodging, root lodging, moisture content and stand count. Nonsignificant variation were found for the interaction of year by location by GCA, GCA among classes and GCA within classes for ear height. The interaction of year by location by GCA in Class 1 were nonsignificant for plant height and ear height. Nonsignificant variation of year by location by GCA in Class 2 was obtained for root lodging and ear height. The variation for year by location by GCA in Class 3 was significant (p=0.01) for root lodging, moisture content and plant height. Significant variation (p=0.01) for the interactions of year by location by SCA, SCA among classes and SCA within classes were found for only moisture content.

When the interaction between GCA and location and/or year is large, it suggests that the lines need to be tested in more than one location and/or year. On the other hand, when the interaction of GCA by location and/or year is small, or nonsignificant it indicates that the additive gene effects were relatively insensitive to the effects of the environments. The results of the present study showed that the variances of GCA by location and/or year were much smaller than those of the main effect for all characters. This would indicate that preliminary evaluations aimed at the identification of lines with superior GCA effects can be carried out in fewer environments. The interaction of GCA by locations and/or years were greater, than those of SCA for all characters studied, indicating that non-additive genetic effects were much more stable than additive genetic effects. Matzinger et al., (1959) reported similar results for yield when they used unselected lines from synthetic variety of maize.

GRAIN YIELD

Estimates of combining ability effects, combined over years and locations for grain yield, are presented in Tables 26-27. Cm105 had the largest GCA effects (0.5503**) for grain yield implying a high frequency of favorable alleles and therefore, had the highest line cross mean (7.4 t/ha) among early lines. Other lines with positive significant GCA effects were one early, W117Ht (0.3469*), one medium, W64A (0.4503**) and one late line, Mo17Ht (0.3400*). Three lines had negative significant GCA effects, while two lines had negative nonsignificant GCA effects. These negative effects suggest a low frequency of favorable alleles in these lines. Ms74 was found to be the poorest line as indicated by not only its

Table 26. Estimates of general combining ability effects of Grain Yield (t/ha) over three years and three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-0.9138**	0.1103	-0.8035
2 Cm105	"	2		0.5503**	-0.3635
3 W117Ht	"	3		0.3469*	-0.5669
4 Ms74	"	4		-1.0075**	-1.9213*
5 W64A	Medium	1	-0.0360	0.4503**	0.4143
6 Ms75	"	2		-0.3197*	-0.3557
7 A619	"	3		-0.2875	-0.3235
8 A632	"	4		0.1569	0.1209
9 B73Ht	Late	1	0.9498**	0.2644	1.2143
10 Mo17Ht	"	2		0.3400*	1.2898
11 B84	"	3		-0.3356*	0.6143
12 Pa872	"	4		-0.2689	0.6809

$LSD_{0.05}(G_i-G_k)$=0.2481, $LSD_{0.05}(g_{ij}-g_{ij'})$=0.4963, $LSD_{0.05}(g_i-g_j)$=0.4963[1].

(1)= Griffing's method.

*, ** Significant at 0.05 and 0.01 respectively.

Table 27. Estimates of specific combining ability effects of Grain yield (t/ha) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.7157**	-0.6569	-1.3725
2	A641XW117Ht	EXE		0.2687	-0.4470
3	A641XMs74	EXE		0.0009	-0.7147
4	A641XW64A	EXM	-0.1814	-0.1022	-0.2836
5	A641XMs75	EXM		0.5233	0.3419
6	A641XA619	EXM		0.4800	0.2986
7	A641XA632	EXM		-1.1311*	-1.3125
8	A641XB73Ht	EXL	0.7182**	0.2538	0.9719
9	A641XMo17Ht	EXL		0.6226	1.3408
10	A641XB84	EXL		-0.0463	0.6719
11	A641XPa872	EXL		-0.2129	0.5053
12	Cm105XW117Ht	EXE		0.7954	0.0797
13	Cm105XMs74	EXE		-0.1502	-0.8659
14	Cm105XW64A	EXM		0.7578	0.5764
15	Cm105XMs75	EXM		0.7167	0.5353
16	Cm105XA619	EXM		-0.3822	-0.5636
17	Cm105XA632	EXM		-1.1711**	-1.3525
18	Cm105XB73Ht	EXL		0.1138	0.8319
19	Cm105XMo17Ht	EXL		0.3715	1.0897
20	Cm105XB84	EXL		0.4471	1.1653
21	Cm105XPa872	EXL		-0.8418	-0.1236
22	W117HtXMs74	EXE		-0.2580	-0.9736
23	W117HtXW64A	EXM		0.0056	-0.1759
24	W117HtXMs75	EXM		-0.5800	-0.7614
25	W117HtXA619	EXM		-0.0789	-0.2606
26	W117HtXA632	EXM		0.5989	0.4175
27	W117HtXB73Ht	EXL		0.1726	0.8908
28	W117HtXMo17Ht	EXL		-0.8807	-0.1625
29	W117HtXB84	EXL		0.5726	1.2908
30	W117HtXPa872	EXL		-0.6163	0.1019
31	Ms74XW64A	EXM		0.3378	0.1564
32	Ms74XMs75	EXM		-0.4478	-0.6292
33	Ms74XA619	EXM		-0.4800	-0.6614
34	Ms74XA632	EXM		0.9533	0.7719
35	Ms74XB73Ht	EXL		0.1715	0.8897
36	Ms74XMo17Ht	EXL		-0.5374	0.1808
37	Ms74XB84	EXL		0.5049	1.2230
38	Ms74XPa872	EXL		-0.0951	0.6230
39	W64AXMs75	MXM	0.1547	-2.1639**	-2.0092
40	W64AXA619	MXM		0.1706	0.3253
41	W64AXA632	MXM		0.9594*	1.1141

Table 27. Estimates of specific combining ability effects of Grain yield (t/ha) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.0654	0.0221	0.0875
43	W64AXMo17Ht	MXL		-1.0313*	-0.9659
44	W64AXB84	MXL		0.0332	0.0986
45	W64AXPa872	MXL		1.0110*	1.0764
46	Ms75XA619	MXM		0.3294	0.4841
47	Ms75XA632	MXM		-0.3483	-0.1936
48	Ms75XB73Ht	MXL		0.0810	0.1464
49	Ms75XMo17Ht	MXL		0.3499	0.4153
50	Ms75XB84	MXL		0.6588	0.7241
51	Ms75XPa872	MXL		0.8810	0.9464
52	A619XA632	MXM		1.0528*	1.2075
53	A619XB73Ht	MXL		0.4265	0.4919
54	A619XMo17Ht	MXL		-0.1490	-0.0836
55	A619XB84	MXL		0.6265	0.6919
56	A619XPa872	MXL		-1.9957**	-1.9303
57	A632XB73Ht	MXL		-0.9068	-0.8414
58	A632XMo17Ht	MXL		0.1399	0.2053
59	A632XB84	MXL		-0.6957	-0.6303
60	A632XPa872	MXL		0.5488	0.6141
61	B73HtXMo17Ht	LXL	-1.0447**	0.9011	-0.1436
62	B73HtXB84	LXL		-2.3567**	-3.4014
63	B73HtXPa872	LXL		1.1211*	0.0764
64	Mo17HtXB84	LXL		0.1344	-0.9103
65	Mo17HtXPa872	LXL		0.0789	-0.9659
66	B84XPa872	LXL		0.1211	-0.9236

$LSD_{0.05}(S_{ii}-S_{ij})=0.4698$, $LSD_{0.05}(S_{ii}-S_{jj})=0.4053$, $LSD_{0.05}(S_{ii}-S_{kl})=0.3122$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.3040$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.4890$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.4039$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.3442$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=1.4130$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.3230$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.3689$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.4578$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.3706$.

*, ** Significant at p=0.05 and 0.01 respectively.

(1) = Griffing's method.

largest negative GCA effect (-1.0075 **), but also its lowest line cross mean (6.1t/ha). The GCA effects for classes was significant as negative values for the early class and positive significant for the late class, suggesting that the average yield of the crosses involved in early lines(7.0 t/ha) were below the average yield (7.8 t/ha) of all the crosses.

The average yields for 66 diallel crosses ranged from 4.3 t/ha for W117Ht by Ms74 to 10.3 t/ha for B73Ht by Mo17Ht (Table 15). The early lines had the lowest line cross mean, followed by medium lines (Table 16). The seven lines with positive GCA effects constituted the crosses which were top-yielding. B73Ht by Mo17Ht and Cm105 by Mo17Ht were the first and the fourth highest yielding crosses, respectively. However, the second and third highest yielding crosses were also involved in crosses of W64A and B73Ht by Pa872, respectively. The latter line had a negative GCA effect. Only ten crosses had significant SCA effects for grain yield. Positive significant SCA effects were found for W64A X A632 (0.9594*), W64A X Pa872 (1.0110*), A619 X A632 (1.0528*) and B73Ht X Pa872 (1.1211*), while negative significant SCA effects were found for A641 X A632 (-1.1131*), Cm105 X A632 (-1.1711**), W64A X Ms75 (-2.1639**), W64A X Mo17Ht (-1.0313*), A619 X Pa872 (-1.9957**) and B73Ht X B84 (-2.3567**). It is evident that all crosses with significant SCA effects had at least one parent with positive GCA effects, except A619 X Pa872 cross where both parents had negative GCA effects. This indicated that the lines with positive significant GCA effects may not necessarily have positive significant SCA effects. When the modified Griffing's mothod is used the results are in contrast to some previous reports (Lonnquist, 1953; Rumbaugh and Lonnquist, 1959; Eberhart, 1971) which pointed out that crosses of known high X high general combiners on average tend to be higher yielding, followed by high X low general combiners.

Ten of the crosses showed positive SCA effects for grain yield greater than 0.70 t/ha; one was an early X early cross, three were early X medium, two were medium X medium, two were medium X late and two were late X late crosses.

The GCA effects of early lines were positive, except Ms74. The average yield of crosses among early lines ranged from 4.3 t/ha for W117Ht X Ms74 to 6.9t/ha for Cm105 X W117Ht. Crosses of Cm105 and A641 by W117Ht were the top-yielding crosses in the early class. None of the six early X early crosses had significant SCA effects. Half of them, namely, Cm105 X W117Ht (0.7954), A641 X W117Ht (0.2687) and A641 X Ms74 (0.0009), had positive SCA effects, while the other half, namely, A641 X Cm105 (-0.6569), W117Ht X Ms74 (-0.2580) and Cm105 X Ms74 (-0.1502), had negative SCA effects. Nevertheless, the SCA effect of early lines was negative and significant.

Two of the medium lines had positive GCA effects and two had negative GCA effects. The range of average yield of crosses within the medium class was between 5.8 t/ha for W64A X Ms74 and 9.4 t/ha for W64A X A632. The three crosses of line A632 were the four highest yielding crosses in this class. The SCA effects of W64A and A619 by A632 were found to be positive and significant. Other positive SCA effects were crosses of W64A X A619 and Ms75 X A619.

Among the late lines, Mo17Ht gave positive significant GCA effects, while B84 gave negative significant GCA effects. The GCA of the remaining two lines was positive for B73Ht and negative for Pa872. The average yield ranged from 6.2 t/ha for B73Ht by B84 to 10.3 t/ha for B73Ht by Mo17Ht. The parent of three of the four outstanding crosses was Mo17Ht. Significant SCA effects were found for B73Ht X B84 (-2.3567**) and B73Ht X Pa872 (1.1211*). The rest of the SCA effects among late lines were positive. Late lines as a class had negative significant SCA effect with a considerable magnitude.

The average yield of crosses between early and medium lines ranged from 4.9 t/ha for Ms74 by Ms75 to 8.5 t/ha for Cm105 by W64A. The parent of two of the three highest yielding crosses was Cm105. All SCA effects were nonsignificant except A641 and Cm105 by A632. W64A combined well with early lines while A619 combined poorly with the same lines. Negative significant SCA effects were obtained for early by medium classes.

The SCA effects of the crosses between medium and late lines were significant for W64A X Mo17Ht (-1.0313*), W64A X Pa872 (1.0110*), and A619 X Pa872 (-1.9957**). Three late lines (B73Ht, B84 and Pa872) had good SCA effects with medium lines. However, the Mo17Ht was in an intermediate position in terms of SCA effects with the medium lines. Medium by late classes had positive but very small, nonsignificant SCA effects.

Crosses of early by late lines were better than early by medium and medium by medium lines by an average of 1.9 t/ha and 0.7 t/ha respectively. Some of the SCA effects of early X late (B73Ht, Mo17Ht and B84) crosses were positive but not significant. B73Ht performed well with early lines, but Pa872 performed poorly with the same lines. All crosses involved early X B73Ht (late) showed positive SCA effects ranging from 0.11 t/ha to 0.25 t/ha. In contrast, the crosses involving early X Pa872 (late) showed negative SCA effects ranged from -0.1 t/ha to -0.84 t/ha. However, the SCA effect of early by late classes was positive significant (0.7182**).

STALK LODGING

The estimates of combining ability effects for stalk lodging are given in Tables 28-29. Eight lines had negative

Table 28. Estimates of general combining ability effects of Stalk Lodging (%) over three years and three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	2.9119**	-0.9861	1.9257**
2 Cm105	"	2		-3.3139**	0.4020
3 W117Ht	"	3		-1.7094**	1.2024
4 Ms74	"	4		6.0094**	8.9213**
5 W64A	Medium	1	-0.0187	-0.0122	-0.0309
6 Ms75	"	2		0.3889	0.3702
7 A619	"	3		-1.2422*	-1.2609*
8 A632	"	4		0.8656	0.8469
9 B73Ht	Late	1	-2.8931**	-0.6367	-3.5298**
10 Mo17Ht	"	2		-0.6033	-3.4965**
11 B84	"	3		1.9311**	-0.9620
12 Pa872	"	4		-0.6911	-3.5843**

$LSD_{0.05}(G_i-G_k)=0.9302$, $LSD_{0.05}(g_{ij}-g_{ij'})=1.8604$, $LSD_{0.05}(g_i-g_j)=1.8604$.[1]

(1) = Griffing's method.

*, ** Significant at p=0.05 and 0.01 respectively.

Table 29. Estimates of specific combining ability effects of Stalk lodging (%) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	1.3024*	-0.2704	1.0320
2	A641XW117Ht	EXE		-1.3970	-0.0946
3	A641XMs74	EXE		8.6841**	9.9865**
4	A641XW64A	EXM	0.2744	-0.1690	0.1054
5	A641XMs75	EXM		-1.7701	-1.4958
6	A641XA619	EXM		-2.3613	-2.0869
7	A641XA632	EXM		-1.0468	-0.7724
8	A641XB73Ht	EXL	-1.2512**	0.4999	-0.7513
9	A641XMo17Ht	EXL		-0.5890	-1.8402
10	A641XB84	EXL		-0.4457	-1.6969
11	A641XPa872	EXL		-1.1346	-2.3858
12	Cm105XW117Ht	EXE		-2.8137	-1.5113
13	Cm105XMs74	EXE		-2.9659	-1.6635
14	Cm105XW64A	EXM		0.7365	1.0109
15	Cm105XMs75	EXM		-1.3201	-1.0458
16	Cm105XA619	EXM		-0.5335	-0.2591
17	Cm105XA632	EXM		1.4365	1.7109
18	Cm105XB73Ht	EXL		-1.2613	-2.5124
19	Cm105XMo17Ht	EXL		2.4388	1.1876
20	Cm105XB84	EXL		1.0932	-0.1580
21	Cm105XPa872	EXL		3.4599	2.2087
22	W117HtXMs74	EXE		-1.2370	0.0654
23	W117HtXW64A	EXM		1.0654	1.3398
24	W117HtXMs75	EXM		0.2199	0.4942
25	W117HtXA619	EXM		4.2843*	4.5587*
26	W117HtXA632	EXM		-1.6457	-1.3713
27	W117HtXB73Ht	EXL		-0.2101	-1.4613
28	W117HtXMo17Ht	EXL		0.1121	-1.1391
29	W117HtXB84	EXL		-1.1110	-2.3624
30	W117HtXPa872	EXL		2.7332	1.4820
31	Ms74XW64A	EXM		1.1910	1.4654
32	Ms74XMs75	EXM		-1.0213	-0.7469
33	Ms74XA619	EXM		2.0765	2.3509
34	Ms74XA632	EXM		-1.1424	-0.8680
35	Ms74XB73Ht	EXL		-1.1068	-2.3580
36	Ms74XMo17Ht	EXL		-2.9290	-4.1802*
37	Ms74XB84	EXL		-0.6301	-1.8813
38	Ms74XPa872	EXL		-0.9190	-2.1702
39	W64AXMs75	MXM	-0.4309	-1.6637	-2.0946
40	W64AXA619	MXM		-1.5881	-2.0191
41	W64AXA632	MXM		2.6374	2.2065

Table 29. Estimates of specific combining ability effects of Stalk lodging (%) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL		1.0676	1.1165
43	W64AXMo17Ht	MXL		-0.8435	-0.7946
44	W64AXB84	MXL	0.0488	-1.2001	-1.1513
45	W64AXPa872	MXL		-1.2335	-1.1846
46	Ms75XA619	MXM		-2.2337	-2.6646
47	Ms75XA632	MXM		2.2807	1.8498
48	Ms75XB73Ht	MXL		-0.2668	-0.2180
49	Ms75XMo17Ht	MXL		1.6776	1.7265
50	Ms75XB84	MXL		4.4321*	4.4809*
51	Ms75XPa872	MXL		-0.3346	-0.2858
52	A619XA632	MXM		0.5674	0.1365
53	A619XB73Ht	MXL		-0.0468	0.0020
54	A619XMo17Ht	MXL		0.9088	0.9576
55	A619XB84	MXL		-1.1257	-1.0769
56	A619XPa872	MXL		0.0521	0.1009
57	A632XB73Ht	MXL		-1.6213	-1.5724
58	A632XMo17Ht	MXL		1.3343	1.3831
59	A632XB84	MXL		-1.5224	-1.4735
60	A632XPa872	MXL		-1.2779	-1.2291
61	B73HtXMo17Ht	LXL	1.6031**	-1.2656	0.3376
62	B73HtXB84	LXL		3.9556*	5.5587**
63	B73HtXPa872	LXL		0.2556	1.8587
64	Mo17HtXB84	LXL		-1.3444	0.2587
65	Mo17HtXPa872	LXL		0.5000	2.1031
66	B84XPa872	LXL		-2.1011	-0.4980

$LSD_{0.05}(S_{ii}-S_{ij})$=1.7609, $LSD_{0.05}(S_{ii}-S_{jj})$=1.5190, $LSD_{0.05}(S_{ii}-S_{kl})$=1.1705, $LSD_{0.05}(S_{ij}-S_{ij'})$=1.1393, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=5.5813, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=5.2622, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=5.0382, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})$=5.2963, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=4.9588, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=5.1303, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=5.4639, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=5.1374.

*, ** Significant at p=0.05 and 0.01 respectively.

(1) = Griffing's method.

GCA effects for stalk lodging, three of which were significant (Cm105, W117Ht and A619). Ms74 and B84 had positive significant GCA effects. Other positive GCA effects were Ms75 and A632. Cm105 and Ms74 had the most negative (-3.3139**) and most positive (6.0094**) GCA effects, respectively. Negative GCA effects are desirable for this character in order to improve the standability of the lines. The GCA effects among classes were positive and significant for the early class and negative significant for the late class. This was expected because early lines matured sooner than either medium or late ones, and stayed in the field longer until the lines of other two classes were ready for harvest. Therefore, delayed scoring of data could have contributed to the high incidence of stalk lodging for the early lines.

The range for stalk lodging among crosses was from 2.6% for B73Ht by Mo17Ht to 30.1% for A641 by Ms74 (Table 14). Only four SCA effects were significant; A641 X Ms74 (8.6841**), W117Ht X A619 (4.2843*), Ms75 X B84 (4.4321*) and B73Ht X B84 (3.9556*). The W117Ht X A619 cross is a clear deviation from the expected as both parents had negative significant GCA effects. Nevertheless, these crosses will result in progenies with higher incidences of stalk lodging. The SCA effect of the classes were found significant for early X early, late X late and early X late lines, but the latter was found negative (-1.2512**). Generally, early lines as a class tend to have higher line cross means for percentage of stalk lodging incident than do the other two classes (Table 16). In fact, A641, W117Ht and Ms74 had the highest line cross mean for stalk lodging incidence. The five crosses with the lowest incidence of stalk lodging were those from among late lines, except cross Cm105 X B73Ht. Pa872 and B73Ht were each involved as a parent in three of these crosses.

Five of the six crosses within the early class and three of each within medium and late classes showed negative SCA effects. In the early class, Cm105 and W117Ht proved to be excellent lines for stalk lodging as indicated not only by their favorable GCA effects, but also by their consistent negative SCA effects within their class. A majority of the SCA effects of both Cm105 by late lines and W117Ht by medium lines were positive. In contrast, all crosses of A641 by medium lines and Ms74 by late lines had negative SCA effects. This suggests that crosses of these two early lines (A641 and Ms74) with the respective medium and late lines can be used as a source of improving stalk quality.

For medium by medium crosses, A632 was the poorest line for stalk lodging, because it had positive GCA and SCA effects. However, it combined well with early and late lines as shown by its negative SCA effects. Ms75 and W64A also exhibited more negative SCA effects with early and late lines respectively.

In most of the crosses within late lines where Mo17Ht or B84 were one of the parents, the SCA effects were negative. Furthermore, three out of four crosses involving B73Ht and B84 by early or medium lines had negative SCA effects, while three out of four crosses involving Mo17Ht with medium lines had positive SCA effects.

ROOT LODGING

Tables 29-30 show combining ability effects for root lodging. Negative GCA effects are desirable for this character because substantial yield loss is often caused by a high incidence of root lodging. The GCA for root lodging was negative for Cm105, W117Ht, A619, A632, B73Ht and Mo17Ht, but was significant for Cm105 and W117Ht. Ms74 was the only line with positive significant GCA effect (1.7919**) for root lodging. Other lines with positive but not significant GCA effects were A641, W64A, Ms75, B84 and Pa872. The early class exhibited a high positive GCA effect (0.5197 **), while both medium and late classes exhibited negative GCA effects (-0.2906* and -0.2292). However, only the late class had a nonsignificant GCA effect.

The average root lodging incidence ranged from 0.1% for A619 by A632 to 5.7% for A641 by Ms74 (Table 14). Nevertheless, Cm105 had the lowest cross mean root lodging

Table 30. Estimates of general combining ability effects of Root Lodging (%) over three years and three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	0.5197**	0.1764	0.6961*
2 Cm105	"	2		-1.2992**	-0.7794*
3 W117Ht	"	3		-0.6692*	-0.1494
4 Ms74	"	4		1.7919**	2.3117**
5 W64A	Medium	1	-0.2906*	0.0389	-0.2517
6 Ms75	"	2		0.2456	-0.0450
7 A619	"	3		-0.0578	-0.3483
8 A632	"	4		-0.2267	-0.5172
9 B73Ht	Late	1	-0.2292	-0.2792	-0.5083
10 Mo17Ht	"	2		-0.2192	0.4483
11 B84	"	3		0.3708	0.1417
12 Pa872	"	4		0.1275	-0.1017

$LSD_{0.05}(G_i-G_k)=0.4498$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.8996$, $LSD_{0.05}(g_i-g_j)=0.8996$.[1]

(1) = Griffing's method.

*, ** Significant at p=0.05 and 0.01 respectively.

Table 31. Estimates of Specific Combining Ability effects of Root Lodging (%) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.1451	0.4013	0.6364
2	A641XW117Ht	EXE		1.0502	1.1953
3	A641XMs74	EXE		1.2002	1.3453
4	A641XW64A	EXM	0.0468	-0.8160	-0.7692
5	A641XMs75	EXM		-0.5226	-0.4759
6	A641XA619	EXM		-0.3082	-0.2614
7	A641XA632	EXM		-0.9726	-0.9259
8	A641XB73Ht	EXL	-0.1556	0.5431	0.3875
9	A641XMo17Ht	EXL		-0.5947	-0.7503
10	A641XB84	EXL		0.5153	0.3597
11	A641XPa872	EXL		-0.5858	-0.7414
12	Cm105XW117Ht	EXE		-0.1965	-0.0514
13	Cm105XMs74	EXE		-1.7465*	-1.6014
14	Cm105XW64A	EXM		0.2485	0.2953
15	Cm105XMs75	EXM		-0.4360	-0.3892
16	Cm105XA619	EXM		0.3340	0.3808
17	Cm105XA632	EXM		0.1363	0.1830
18	Cm105XB73Ht	EXL		0.2742	0.1186
19	Cm105XMo17Ht	EXL		0.8031	0.6475
20	Cm105XB84	EXL		0.0019	-0.1536
21	Cm105XPa872	EXL		0.0897	-0.0659
22	W117HtXMs74	EXE		-0.7987	-0.6536
23	W117HtXW64A	EXM		-0.3482	-0.3014
24	W117HtXMs75	EXM		-0.4215	-0.3747
25	W117HtXA619	EXM		0.8485	0.8953
26	W117HtXA632	EXM		0.1174	0.1641
27	W117HtXB73Ht	EXL		0.1108	-0.0447
28	W117HtXMo17Ht	EXL		-0.1047	-0.2603
29	W117HtXB84	EXL		-0.7169	-0.8725
30	W117HtXPa872	EXL		0.4597	0.3041
31	Ms74XW64A	EXM		1.4463	1.4930
32	Ms74XMs75	EXM		0.9063	0.9530
33	Ms74XA619	EXM		-0.2904	-0.2436
34	Ms74XA632	EXM		0.0785	0.1253
35	Ms74XB73Ht	EXL		-1.5169	-1.6725
36	Ms74XMo17Ht	EXL		-0.2992	-0.4547
37	Ms74XB84	EXL		0.0664	-0.0892
38	Ms74XPa872	EXL		0.9542	0.7986
39	W64AXMs75	MXM	-0.0973	-0.4863	-0.5836
40	W64AXA619	MXM		-0.0496	-0.1470
41	W64AXA632	MXM		0.1304	0.0330

Table 31. Estimates of Specific Combining Ability effects of Root Lodging (%) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.0262	-0.0910	-0.0647
43	W64AXMo17Ht	MXL		-0.0399	-0.0136
44	W64AXB84	MXL		-0.0743	-0.0481
45	W64AXPa872	MXL		0.0801	0.1064
46	Ms75XA619	MXM		0.3326	0.2353
47	Ms75XA632	MXM		0.4126	0.3153
48	Ms75XB73Ht	MXL		0.6357	0.6619
49	Ms75XMo17Ht	MXL		-0.3799	-0.3536
50	Ms75XB84	MXL		0.4301	0.4564
51	Ms75XPa872	MXL		-0.4710	-0.4447
52	A619XA632	MXM		-0.3396	-0.4370
53	A619XB73Ht	MXL		0.2724	0.2986
54	A619XMo17Ht	MXL		-0.0321	-0.0059
55	A619XB84	MXL		-0.2332	-0.2070
56	A619XPa872	MXL		-0.5343	-0.5081
57	A632XB73Ht	MXL		-0.1143	-0.0881
58	A632XMo17Ht	MXL		0.5813	0.6075
59	A632XB84	MXL		0.1579	0.1841
60	A632XPa872	MXL		-0.1876	-0.1614
61	B73HtXMo17Ht	LXL	0.1725	-0.1294	0.0430
62	B73HtXB84	LXL		0.1583	0.3308
63	B73HtXPa872	LXL		-0.1428	0.0297
64	Mo17HtXB84	LXL		-0.2239	-0.0514
65	Mo17HtXPa872	LXL		0.4194	0.5919
66	B84XPa872	LXL		-0.0817	0.0908

$LSD_{0.05}(S_{ii}-S_{ij})=0.8514$, $LSD_{0.05}(S_{ii}-S_{jj})=0.7344$, $LSD_{0.05}(S_{ii}-S_{kl})= 0.5660$,
$LSD_{0.05}(S_{ij}-S_{ij'})=0.5510$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=2.6987$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=2.5443$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.4361$,
$LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=2.5609$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=2.3977$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.4806$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=2.6419$,
$LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=2.4841$.

*, ** Significant at p=0.05 and 0.01 respectively.

(1) = Griffing's method.

percentage (0.7%), and Ms74 had the highest cross mean percentage (3.5%) of all crosses. Lower percentages of root lodging would be expected from crosses of Cm105. This early line showed the most favorable alleles for this character, with the highest negative significant GCA effect. In fact, five of the seven crosses with the lowest incidence of root lodging had Cm105 as one of their parents. The SCA's of all crosses were found to be nonsignificant, except for Cm105 X Ms74 (-1.7465*). Crosses of A641 X W117Ht, A641 X Ms74, and Ms74 X W64A are expected to have high percentages of root lodging, because they gave large positive SCA effects. The average incidence of root lodging for the late class was slightly higher than that for the medium class (Table 15). This was not expected, because late scoring of data would have jeopardized the incidence of root lodging for the medium class. High average incidences of this character for B84 and Pa872 suggests that they may have contributed more unfavorable alleles in the crosses and increased the average of the class. The SCA effects of early X late and medium classes were negative, but not significant.

Half of the SCA effects within each early and medium class and four of within the late class were negative. All crosses of within the early class in which A641 was one of the parents showed positive SCA, while all crosses of early by medium lines, which had A641 as a parent showed negative SCA effects. Crosses of Cm105 by either medium or late lines gave positive SCA effects. Ms75 performed well with early lines, while W64A and A619 performed well with late lines. Mo17Ht was the only late line with more negative SCA effects in crosses with medium lines. Furthermore, the SCA effects of Mo17Ht and Pa872 by early lines were mostly negative.

MOISTURE CONTENT

Two of the early lines (W117Ht and MS74) and one medium line (W64A) had positive nonsignificant GCA effects for grain moisture content (Tables 32-33). Among the lines with significant GCA effects, Cm105, A619, B73Ht and B84 had positive GCA effects, while A641, Ms75, A632, Mo17Ht and Pa872 had negative GCA effects. Early and late maturity classes showed greater (-2.0480** and 1.9640**) negative and positive GCA effects, respectively.

The average grain moisture content ranged from 16.7% for A641XCm105 and A641XW117Ht to 29.6% for B73HtXB84 (Table 14). Early lines had lower moisture contents than other lines. Negative SCA effects are preferred for this character in order to develop early material and reduce the cost of artificial drying. One exception to this was Cm105 which had a higher or equal percentage moisture than A632 and Ms75. Similar trends were observed in the line cross means of medium and late classes where A619 gave a larger moisture content than Mo17Ht

Table 32. Estimates of general combining ability effects of Moisture content (%) over three years and three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect (gi)	GCA[1] (gij)
1 A641	Early	1	-2.0480**	-1.2239**	-3.2719**
2 Cm105	"	2		0.9494**	-1.0985**
3 W117Ht	"	3		0.1750	-1.8730**
4 Ms74	"	4		0.0994	-1.9485**
5 W64A	Medium	1	0.0840	0.1097	0.1937
6 Ms75	"	2		-1.1103**	-1.0263**
7 A619	"	3		2.2675**	2.3515**
8 A632	"	4		-1.2669**	-1.1830**
9 B73Ht	Late	1	1.9640**	1.1786**	3.1426**
10 Mo17Ht	"	2		-0.7514**	1.2126**
11 B84	"	3		1.0931**	3.0570**
12 Pa872	"	4		-1.5203**	0.4437

$LSD_{0.05}(G_i-G_k)=0.3457$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.6915$, $LSD_{0.05}(g_i-g_j)=0.6915$[1].

(1) = Griffing's method.

*, ** Significant at p=0.05 and 0.01 respectively.

Table 33. Estimates of Specific Combining Ability effects of Moisture content (%) over three years and three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.9230	-0.7644	0.1586
2	A641XW117Ht	EXE		0.0100	0.9330
3	A641XMs74	EXE		0.8522	1.7753*
4	A641XW64A	EXM		1.6426*	1.8108*
5	A641XMs75	EXM	0.1682	0.5626	0.7308
6	A641XA619	EXM		-1.9263**	-1.7581*
7	A641XA632	EXM		0.6082	0.7764
8	A641XB73Ht	EXL	-0.8604	-0.6221	-1.4825*
9	A641XMo17Ht	EXL		-0.3588	-1.2192
10	A641XB84	EXL		-1.0476	-1.9081**
11	A641XPa872	EXL		1.0435	0.1830
12	Cm105XW117Ht	EXE		-0.4300	0.4930
13	Cm105XMs74	EXE		-1.0433	-0.1203
14	Cm105XW64A	EXM		-0.1863	-0.0181
15	Cm105XMs75	EXM		0.9115	1.0797
16	Cm105XA619	EXM		0.3226	0.4908
17	Cm105XA632	EXM		-0.2540	-0.0858
18	Cm105XB73Ht	EXL		-0.3288	-1.1892
19	Cm105XMo17Ht	EXL		0.9457	0.0853
20	Cm105XB84	EXL		0.9124	0.0519
21	Cm105XPa872	EXL		-0.0854	-0.9459
22	W117HtXMs74	EXE		1.3756*	2.2986
23	W117HtXW64A	EXM		-0.1118	0.0564
24	W117HtXMs75	EXM		0.1860	0.3541
25	W117HtXA619	EXM		-0.6585	-0.4903
26	W117HtXA632	EXM		-0.7240	-0.5559
27	W117HtXB73Ht	EXL		0.0013	-0.8592
28	W117HtXMo17Ht	EXL		0.8535	-0.0070
29	W117HtXB84	EXL		-0.6132	-1.4736
30	W117HtXPa872	EXL		0.1113	-0.7492
31	Ms74XW64A	EXM		-0.3474	-0.1792
32	Ms74XMs75	EXM		1.3504	1.5186
33	Ms74XA619	EXM		-0.9385	-0.7703
34	Ms74XA632	EXM		-0.4374	-0.2692
35	Ms74XB73Ht	EXL		-0.8565	-1.7170
36	Ms74XMo17Ht	EXL		-0.1376	-0.9981
37	Ms74XB84	EXL		-0.5488	-1.4092
38	Ms74XPa872	EXL		0.7313	-0.1292
39	W64AXMs75	MXM	-0.0872	0.2857	0.1986
40	W64AXA619	MXM		0.2969	0.2097
41	W64AXA632	MXM		-0.1465	-0.2336

Table 33. Estimates of specific combining ability effects of Moisture content (%) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
42	W64AXB73Ht	MXL	-0.1028	-0.6786	-0.7814
43	W64AXMo17Ht	MXL		0.6181	0.5153
44	W64AXB84	MXL		-1.6486*	-1.7514
45	W64AXPa872	MXL		0.2758	0.1730
46	Ms75XA619	MXM		-0.7498	-0.8370
47	Ms75XA632	MXM		0.5957	0.5086
48	Ms75XB73Ht	MXL		-0.4808	-0.5836
49	Ms75XMo17Ht	MXL		-0.6508	-0.7536
50	Ms75XB84	MXL		-1.8953**	-1.9981**
51	Ms75XPa872	MXL		-0.1153	-0.2181
52	A619XA632	MXM		-0.2820	-0.3692
53	A619XB73Ht	MXL		2.6747**	2.5719**
54	A619XMo17Ht	MXL		-0.2064	-0.3092
55	A619XB84	MXL		2.7603**	2.6575**
56	A619XPa872	MXL		-1.2931	-1.3959
57	A632XB73Ht	MXL		0.1647	0.0619
58	A632XMo17Ht	MXL		0.7503	0.6475
59	A632XB84	MXL		-0.6831	-0.7859
60	A632XPa872	MXL		0.4081	0.3053
61	B73HtXMo17Ht	LXL	1.2843	-0.2624	1.0219
62	B73HtXB84	LXL		1.2931	2.5775**
63	B73HtXPa872	LXL		-0.9046	0.3797
64	Mo17HtXB84	LXL		0.0454	1.3297
65	Mo17HtXPa872	LXL		-1.5969*	-0.3125
66	B84XPa872	LXL		1.4254*	2.7097**

$LSD_{0.05}(S_{ii}-S_{ij})=0.6544$, $LSD_{0.05}(S_{ii}-S_{jj})=0.5645$, $LSD_{0.05}(S_{ii}-S_{kl})=0.4349$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.4234$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=2.0743$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.9557$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.8724$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=1.9684$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.8430$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.9067$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=2.0306$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.9092$.

*, ** Significant at p=0.05 and 0.01 respectively.

(1) = Griffing's method.

and Pa872 (Table 16). Nine SCA effects were significant in which A641 X A619, W64A X B84, Ms75 X B84, and Mo17Ht X Pa872 were negative. A641 X W64A, W117Ht X Ms74, A619 X B73Ht A619 X B84 and B84 X Pa872 had positive SCA effects. Crosses with negative SCA effects are expected to contain progenies with lower moisture contents than those with positive effects. The SCA effects of early X late, medium and medium X late classes were negative but not significant.

Five of the crosses with the lowest moisture content at harvest were early by early and four of them had A641 as one parent. Moreover, A641 had the lowest cross line mean, while B73Ht and B84 had the highest cross line mean of all lines. However, the SCA effects of early by early were all negative for Cm105, and mostly positive for A641, W117Ht and Ms74. Early by medium, A641 and W117Ht had positive and negative SCA effects, respectively. The reverse was true for early by late crosses. Ms74 produced hybrids with lower moisture content in crosses with medium or late lines.

Among the medium lines, all crosses involving Ms75 by early and late lines had positive and negative SCA effects respectively. The other three medium lines gave more negative SCA effects in crosses with early lines, whereas only A632 gave positive SCA effects in crosses with late lines. B84 was the only line which increased moisture content in late by late crosses. In contrast, B84 consistently contributed alleles for lower moisture content in late by early and medium lines.

PLANT HEIGHT

The estimates of combining ability effects for plant height are given in Tables 34-35. The GCA effects were significant for all lines except for W117Ht and B73Ht. Within a given maturity class, short plants are expected from crosses of A641, Ms74, W64A, A619 and Pa872, while tall plants are expected from crosses of Cm105, Ms75, A632, Mo17Ht and B84 as resulted by their respective negative and positive GCA effects. However, the average plant heights of early and medium classes were below the average of all crosses (Table 16). The GCA effects all maturity classes were significant, though only the late class showed a positive effect (10.8535**).

The average plant height of 66 crosses ranged from 175.6 cm for A641 X A619 to 233.2 cm for A632 X Mo17Ht (Table 15). Twenty one SCA effects were significant. The ten negative SCA effects were obtained in crosses of A641, Cm105 and B73Ht by A632, W117Ht, and Ms75, by Mo17Ht, W117Ht, and Ms75 by W64A, Pa872 by A619, and B84 by B73Ht. Generally, crosses within early lines and in particular those involved in A641 tend to increase plant height. Similarly, Mo17Ht appears to produce

Table 34. Estimates of general combining ability effects of Plant Height (cm) over three years and three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect (gi)	GCA[1] (gij)
1 A641	Early	1	-9.3970**	-3.4722**	-12.8693**
2 Cm105	"	2		5.1722**	-3.6848**
3 W117Ht	"	3		1.3589	-8.0381**
4 Ms74	"	4		-3.5989**	-12.9959**
5 W64A	Medium	1	-1.4565**	-2.7628**	-4.2193**
6 Ms75	"	2		3.3906**	1.9341
7 A619	"	3		-8.9417**	-10.3981**
8 A632	"	4		8.3139**	6.8574**
9 B73Ht	Late	1	10.8535**	0.8572	11.7107**
10 Mo17Ht	"	2		1.8839*	12.7374**
11 B84	"	3		5.5306**	16.3841**
12 Pa872	"	4		-8.2717**	2.5819*

$LSD_{0.05}(G_i-G_k)=1.5282$, $LSD_{0.05}(g_{ij}-g_{ij'})=3.0566$, $LSD_{0.05}(g_i-g_j)=3.0566$[1].

(1) = Griffing's method.

*, ** Significant at p=0.05 and 0.01 respectively.

Table 35. Estimates of specific combining ability effects of Plant height (cm) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-1.0226	1.5137	0.4911
2	A641XW117Ht	EXE		2.0448	1.0222
3	A641XMs74	EXE		0.4359	-0.5867
4	A641XW64A	EXM	-1.4261	1.0406	-0.3856
5	A641XMs75	EXM		1.4094	-0.0167
6	A641XA619	EXM		-4.1250	-5.5511
7	A641XA632	EXM		-7.7028*	-9.1289**
8	A641XB73Ht	EXL	2.1931	0.8803	3.0733
9	A641XMo17Ht	EXL		6.7314*	8.9244**
10	A641XB84	EXL		-0.4931	1.7000
11	A641XPa872	EXL		-1.7353	0.4578
12	Cm105XW117Ht	EXE		4.4715	3.4489
13	Cm105XMs74	EXE		-5.2707	-6.2933*
14	Cm105XW64A	EXM		5.0783	3.6522
15	Cm105XMs75	EXM		-0.0083	-1.4344
16	Cm105XA619	EXM		0.1572	-1.2689
17	Cm105XA632	EXM		-7.6761*	-9.1022**
18	Cm105XB73Ht	EXL		2.4847	4.6778
19	Cm105XMo17Ht	EXL		-0.8531	1.3400
20	Cm105XB84	EXL		1.5669	3.7600
21	Cm105XPa872	EXL		-1.4642	0.7289
22	W117HtXMs74	EXE		-3.1952	-4.2178
23	W117HtXW64A	EXM		-6.2683*	-7.6944*
24	W117HtXMs75	EXM		-3.4106	-4.8367
25	W117HtXA619	EXM		7.9661*	6.5400*
26	W117HtXA632	EXM		8.4439**	7.0178*
27	W117HtXB73Ht	EXL		0.7714	2.9644
28	W117HtXMo17Ht	EXL		-8.9442**	-6.7511*
29	W117HtXB84	EXL		-2.3131	-0.1200
30	W117HtXPa872	EXL		0.4336	2.6267
31	Ms74XW64A	EXM		0.1783	-1.2478
32	Ms74XMs75	EXM		-0.1417	-1.5678
33	Ms74XA619	EXM		0.6572	-0.7689
34	Ms74XA632	EXM		4.4017	2.9756
35	Ms74XB73Ht	EXL		-0.3819	1.8111
36	Ms74XMo17Ht	EXL		-9.0642**	-6.8711*
37	Ms74XB84	EXL		9.7114**	11.9044**
38	Ms74XPa872	EXL		2.6692	4.8622
39	W64AXMs75	MXM	0.9889	-7.6222*	-6.6333*
40	W64AXA619	MXM		-3.2678	-2.2789
41	W64AXA632	MXM		6.7989*	7.7878*

Table 35. Estimates of specific combining ability effects of Plant height (cm) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.6844	-1.5167	-0.8322
43	W64AXMo17Ht	MXL		2.7456	3.4300
44	W64AXB84	MXL		-3.3900	-2.7056
45	W64AXPa872	MXL		6.2233*	6.9078*
46	Ms75XA619	MXM		3.8344	4.8233
47	Ms75XA632	MXM		1.7456	2.7344
48	Ms75XB73Ht	MXL		6.3967*	7.0811*
49	Ms75XMo17Ht	MXL		-9.8300**	-9.1456**
50	Ms75XB84	MXL		5.5344	6.2189*
51	Ms75XPa872	MXL		2.0922	2.7767
52	A619XA632	MXM		-1.4889	-0.5000
53	A619XB73Ht	MXL		4.0067	4.6911
54	A619XMo17Ht	MXL		-1.8200	-1.1356
55	A619XB84	MXL		12.3556**	13.0400**
56	A619XPa872	MXL		-18.2756**	-17.5911**
57	A632XB73Ht	MXL		-8.4489**	-7.7644*
58	A632XMo17Ht	MXL		8.5022**	9.1867**
59	A632XB84	MXL		-3.9778	-3.2933
60	A632XPa872	MXL		-0.5978	0.0867
61	B73HtXMo17Ht	LXL	-3.8361	5.1922	1.3556
62	B73HtXB84	LXL		-17.0989**	20.9356**
63	B73HtXPa872	LXL		7.7144**	3.8778
64	Mo17HtXB84	LXL		1.2522	-2.5844
65	Mo17HtXPa872	LXL		6.0878*	2.2511
66	B84XPa872	LXL		-3.1478	-6.9844*

$LSD_{0.05}(S_{ii}-S_{ij})$=2.8930, $LSD_{0.05}(S_{ii}-S_{jj})$=2.4957, $LSD_{0.05}(S_{ii}-S_{kl})$=1.9232, $LSD_{0.05}(S_{ij}-S_{ij'})$=1.8718, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=9.1697, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=8.6454, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=8.2773, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})$=8.7014, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=8.1469, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=8.4288, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=8.9766, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=8.4403.

*, ** Significant at p=0.05 and 0.01 respectively.

(1) = Griffing's method.

taller progenies when crossed with other late lines, but the similarity of the two lines ends there, because Mo17Ht shifts the plant height in the opposite direction when it is crossed with early lines, except A641. Ms75 contributed differently in crosses with early and late lines, by increasing or decreasing plant height, depending on whether early or late lines were involved.

EAR HEIGHT

Significant GCA effects were found for ear height among nine lines, but only Ms74, A619 and B84 had negative effects (Tables 36-37). Lower ear height was associated with negative GCA effects, while higher ear height was resulted in positive effects. The line cross mean of A619 and B84 were the lowest and the highest of all lines respectively (Table 16). Negative GCA effect is desirable for lower ear placement which reduces plant breakage caused by lowering the center of gravity of the plant. It also facilitates mechanical harvest. The GCA effects of the classes were negative for early and medium and positive for late class. Three of the late tall lines had higher line cross mean for ear height than both early and medium lines (Table 15).

The average ear height ranged from 67.8 cm for A619 X Pa872 to 125.7 cm for Mo17Ht X B84 (Table 15). Significant SCA

Table 36. Estimates of general combining ability effects of Ear Height (cm) over three years and three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect (gi)	GCA[(1)] (gij)
1 A641	Early	1	-7.0766**	0.3442	-6.7324**
2 Cm105	"	2		1.4842	-5.5924**
3 W117Ht	"	3		3.6031**	-3.4735**
4 Ms74	"	4		-5.4314**	-12.5080**
5 W64A	Medium	1	-1.6699**	3.8531**	2.1831**
6 Ms75	"	2		3.6275**	1.9576*
7 A619	"	3		-14.6681**	-16.3380**
8 A632	"	4		7.1875**	5.5176**
9 B73Ht	Late	1	8.7465**	0.7133	9.4598**
10 Mo17Ht	"	2		4.2233**	12.9698**
11 B84	"	3		7.3433**	16.0898**
12 Pa872	"	4		-12.2800**	-3.5335**

$LSD_{0.05}(G_i-G_k)$=1.2154, $LSD_{0.05}(g_{ij}-g_{ij'})$=2.4310, $LSD_{0.05}(g_i-g_j)$=2.4310[(1)].

(1) = Griffing's method.

*, ** Significant at p=0.05 and 0.01 respectively.

Table 37. Estimates of specific combining ability effects of Ear Height (cm) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.7711	-0.7487	-1.5198
2	A641XW117Ht	EXE		2.6213	1.8502
3	A641XMs74	EXE	-0.1613	-0.4443	-1.2154
4	A641XW64A	EXM		-0.7007	-0.8620
5	A641XMs75	EXM		3.0582	2.8969
6	A641XA619	EXM		-0.8574	-1.0187
7	A641XA632	EXM		-4.4018	-4.5631
8	A641XB73Ht	EXL	0.7396	2.9439	3.6835
9	A641XMo17Ht	EXL		-0.9439	-0.2042
10	A641XB84	EXL		0.3583	1.0980
11	A641XPa872	EXL		-0.8850	-0.1454
12	Cm105XW117Ht	EXE		0.4924	-0.2787
13	Cm105XMs74	EXE		-2.6176	-3.3887
14	Cm105XW64A	EXM		3.7260	3.5646
15	Cm105XMs75	EXM		-2.6151	-2.7765
16	Cm105XA619	EXM		-3.4529	-3.6142
17	Cm105XA632	EXM		2.8471	2.6858
18	Cm105XB73Ht	EXL		-0.2850	0.4546
19	Cm105XMo17Ht	EXL		-0.9950	-0.2554
20	Cm105XB84	EXL		2.4294	3.1691
21	Cm105XPa872	EXL		1.2194	1.9591
22	W117HtXMs74	EXE		0.6969	-0.0742
23	W117HtXW64A	EXM		-5.1151*	-5.2765*
24	W117HtXMs75	EXM		-2.2229	-2.3842
25	W117HtXA619	EXM		3.0060	2.8446
26	W117HtXA632	EXM		3.8615	3.7002
27	W117HtXB73Ht	EXL		0.0072	0.7469
28	W117HtXMo17Ht	EXL		-2.4028	-1.6631
29	W117HtXB84	EXL		-0.9450	-0.2054
30	W117HtXPa872	EXL		0.0006	0.7402
31	Ms74XW64A	EXM		0.2304	0.0691
32	Ms74XMs75	EXM		0.0449	-0.1165
33	Ms74XA619	EXM		4.0960	3.9346
34	Ms74XA632	EXM		-1.5040	-1.6654
35	Ms74XB73Ht	EXL		0.2306	0.9702
36	Ms74XMo17Ht	EXL		-4.0350	-3.2954
37	Ms74XB84	EXL		2.2117	2.9513
38	Ms74XPa872	EXL		1.0906	1.8302
39	W64AXMs75	MXM	0.1341	-3.7528	-3.6187
40	W64AXA619	MXM		-2.5239	-2.3898
41	W64AXA632	MXM		4.3650	4.4991

Table 37. Estimates of specific combining ability effects of Ear Height (cm) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
42	W64AXB73Ht	MXL	0.0608	1.0961	1.1569
43	W64AXMo17Ht	MXL		2.5306	2.5913
44	W64AXB84	MXL		-4.3561	-4.2954
45	W64AXPa872	MXL		4.5006	4.5613
46	Ms75XA619	MXM		0.8239	0.9580
47	Ms75XA632	MXM		3.3350	3.4691
48	Ms75XB73Ht	MXL		4.8217	4.8824
49	Ms75XMo17Ht	MXL		-6.2217	-6.1609*
50	Ms75XB84	MXL		5.0028	5.0635*
51	Ms75XPa872	MXL		-2.2739	-2.2131
52	A619XA632	MXM		-2.2472	-2.1131
53	A619XB73Ht	MXL		5.1728	5.2335*
54	A619XMo17Ht	MXL		-1.4706	-1.4098
55	A619XB84	MXL		6.1761	6.2369*
56	A619XPa872	MXL		-8.7228**	-8.6620**
57	A632XB73Ht	MXL		-9.0606**	8.9998**
58	A632XMo17Ht	MXL		7.5961**	7.6569**
59	A632XB84	MXL		-2.6572	-2.5965
60	A632XPa872	MXL		-2.1339	-2.0731
61	B73HtXMo17Ht	LXL	-1.0672	3.3930	2.3258
62	B73HtXB84	LXL		-12.0381**	-13.1054**
63	B73HtXPa872	LXL		3.7185	2.6513
64	Mo17HtXB84	LXL		1.4407	0.3735
65	Mo17HtXPa872	LXL		1.1085	0.0413
66	B84XPa872	LXL		2.3774	1.3102

$LSD_{0.05}(S_{ii}-S_{ij})$=2.3008, $LSD_{0.05}(S_{ii}-S_{jj})$=1.9849, $LSD_{0.05}(S_{ii}-S_{kl})$=1.5294, $LSD_{0.05}(S_{ij}-S_{ij'})$=1.4886, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=7.2928, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=6.8757, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=6.5831, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})$=6.9204, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=6.4794, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=6.7034, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=7.1393, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=6.7126.

*, ** Significant at p=0.05 and 0.01 respectively.

(1) = Griffing's method.

effects were obtained for five crosses, in which four (B73Ht X A632, B73Ht X B84, W117Ht X W64A, W117Ht X W64A, and A619 X Pa872) were negative. Only A632 by Mo17Ht had positive SCA effect for ear height. Crosses of W117Ht with other early lines and crosses of Ms74 by medium and late lines gave hybrids with high ear placement. The opposite is true for crosses of A641 by medium lines as suggested by their negative SCA effects. Among the medium lines, W64A and A632 gave more positive and negative SCA effects respectively in crosses with late lines. It is important to note that Mo17Ht behaved differently in crosses with the lines of various maturity classes. It reduced ear height in crosses with early lines, while the rest of the late lines reversed the direction in crosses with the same lines. Two out of the four crosses involved Mo17Ht by medium lines had negative SCA effects. All six late by late crosses, only B73Ht by B84 is expected to reduce ear height. Using either B73Ht or Pa872 as a parent in crosses with medium lines will result in progenies with either higher or lower ear height respectively.

STAND COUNT

The GCA effects for Cm105, W117Ht, Ms74, A619 and B73Ht were significant for stand count (Table 38). However, Ms74 had the largest negative (-3.3106) GCA effects for all lines.

Table 38. Estimates of general combining ability effects of Stand Count (# of plants/ha) over three years and three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-1.1983**	-0.3872	-1.5856**
2 Cm105	"	2		2.5772**	1.3789*
3 W117Ht	"	3		1.1206*	-0.0778
4 Ms74	"	4		-3.3106**	-4.5089**
5 W64A	Medium	1	1.2358**	0.9808	2.2167**
6 Ms75	"	2		0.5131	1.7489**
7 A619	"	3		-1.5814**	-0.3456
8 A632	"	4		0.0875	1.3233*
9 B73Ht	Late	1	-0.0375	1.1197*	1.0822
10 Mo17Ht	"	2		0.2031	0.1656
11 B84	"	3		-1.0258	-1.0633
12 Pa872	"	4		-0.2969	-0.3344

$LSD_{0.05}(G_i-G_k)=0.8536$, $LSD_{0.05}(g_{ij}-g_{ij'})=1.7070$, $LSD_{0.05}(g_i-g_j)=1.7070$.[1]

(1) = Griffing's method.

*, ** Significant at p=0.05 and 0.01 respectively.

Table 39. Estimates of specific combining ability effects of Stand count (# of plants/ha) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.2149	-0.5178	-0.7327
2	A641XW117Ht	EXE		0.8389	0.6239
3	A641XMs74	EXE		-3.5858*	-3.8005*
4	A641XW64	EXM	-0.3887	1.0626	0.6739
5	A641XMs75	EXM		-0.8696	-1.2593
6	A641XA619	EXM		2.6693	2.2806
7	A641XA632	EXM		-0.8107	-1.1994
8	A641XB73Ht	EXL	0.5499	-0.7082	-0.1583
9	A641XMo17Ht	EXL		1.8085	2.3584
10	A641XB84	EXL		-1.1960	-0.6461
11	A641XPa872	EXL		1.3085	1.8584
12	Cm105XW117Ht	EXE		3.5078*	3.2928
13	Cm105XMs74	EXE		-0.1722	-0.3872
14	Cm105XW64A	EXM		-0.5574	-0.9461
15	Cm105XMs75	EXM		-0.1563	-0.5449
16	Cm105XA619	EXM		-0.4396	-0.8283
17	Cm105XA632	EXM		-2.4640	-2.8527
18	Cm105XB73Ht	EXL		0.5163	1.0662
19	Cm105XMo17Ht	EXL		0.7218	1.2717
20	Cm105XB84	EXL		1.8396	2.3895
21	Cm105XPa872	EXL		-2.2792	-1.7283
22	W117HtXMs74	EXE		-0.0711	-0.2861
23	W117HtXW64A	EXM		-0.7451	-1.1338
24	W117HtXMs75	EXM		-1.0663	-1.4549
25	W117HtXA619	EXM		1.2949	0.9062
26	W117HtXA632	EXM		1.8704	1.4817
27	W117HtXB73Ht	EXL		-1.9382	-1.3883
28	W117HtXMo17Ht	EXL		0.1118	0.6617
29	W117HtXB84	EXL		-1.6593	-1.1094
30	W117HtXPa872	EXL		-2.1438	-1.5938
31	Ms74XW64A	EXM		1.4193	1.0306
32	Ms74XMs75	EXM		1.5649	1.1762
33	Ms74XA619	EXM		-5.6518**	-6.0405**
34	Ms74XA632	EXM		2.8793	2.4906
35	Ms74XB73Ht	EXL		-0.4293	0.1206
36	Ms74XMo17Ht	EXL		0.5874	1.1373
37	Ms74XB84	EXL		0.6051	1.1551
38	Ms74XPa872	EXL		2.8540	3.4039
39	W64AXMs75	MXM	0.6963	-2.5902	-1.8938
40	W64AXA619	MXM		1.9487	2.6451
41	W64AXA632	MXM		-0.2202	0.4762

Table 39. Estimates of specific combining ability effects of Stand count (# of plants/ha) over three years and three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.1336	-1.8158	-1.9494
43	W64AXMo17Ht	MXL		0.5231	0.3895
44	W64AXB84	MXL		-0.4925	-0.6261
45	W64AXPa872	MXL		1.4675	1.3339
46	Ms75XA619	MXM		0.2609	0.9573
47	Ms75XA632	MXM		-1.8090	-1.1116
48	Ms75XB73Ht	MXL		0.1742	0.0406
49	Ms75XMo17Ht	MXL		-0.2758	-0.4094
50	Ms75XB84	MXL		2.5308	2.3973
51	Ms75XPa872	MXL		2.2353	2.1017
52	A619XA632	MXM		2.4087	3.1051
53	A619XB73Ht	MXL		-0.2314	-0.3649
54	A619XMo17Ht	MXL		0.5853	0.4517
55	A619XB84	MXL		2.9253	2.7917
56	A619XPa872	MXL		-5.7703**	-5.9038**
57	A632XB73Ht	MXL		-0.2669	-0.4005
58	A632XMo17Ht	MXL		-2.6947	-2.8283
59	A632XB84	MXL		0.0119	-0.1216
60	A632XPa872	MXL		1.0942	0.9606
61	B73HtXMo17Ht	LXL	-0.5551	2.2124	1.6573
62	B73HtXB84	LXL		0.7413	0.1862
63	B73HtXPa872	LXL		1.7457	1.1906
64	Mo17HtXB84	LXL		-4.1865*	-4.4716**
65	Mo17HtXPa872	LXL		0.6069	0.0517
66	B84XPa872	LXL		-1.1198	-1.6749

$LSD_{0.05}(S_{ii}-S_{ij})=1.6156$, $LSD_{0.05}(S_{ii}-S_{jj})=1.3938$, $LSD_{0.05}(S_{ii}-S_{kl})=1.0741$, $LSD_{0.05}(S_{ij}-S_{ij'})=1.0453$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=5.1211$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=4.8283$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=4.6227$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=4.8596$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=4.5499$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=4.7073$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=5.0133$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=4.7138$.

*, ** Significant at p=0.05 and 0.01 respectively.

(1) = Griffing's method.

Positive GCA effect is desirable for stand count in order to tolerate high density. The GCA effects of early (-1.1983**) and medium (1.2358**) classes were significant for stand counts.

The average range for stand count of the 66 crosses were 43.0 for Ms74 X A619 to 58.4 plants/ha for W64A X A619 (Table 14). The average stand count of early by early was the lowest of among and within classes, in all three locations and two years (Tables 8-13). The SCA effects of A641 by Ms74, A619 by Ms74 and Pa872, and Mo17Ht by B84 were negative. Cm105 by W117Ht was the only cross with positive significant SCA effects (Table 39). Ms74 consistently contributed the alleles for low plant stands probably due to poor early establishment.

Days to Pollen Shed and Silking Date

The estimates of combining ability effects for days to pollen shed and silking date are given in Tables 40-41 and 42-43 respectively. Cm105, A632, B73Ht and B84 gave positive significant GCA effects for both characters, while Ms74, Ms75 and Pa872 gave negative significant GCA effects. A641 and A619 gave negative and negative significant GCA effects, respectively, for days to pollen shed and the vice versa for silking date. Other positive but not significant GCA effects for both characters were W117Ht, W64A and Mo17Ht. The average of the crosses involved in early lines for these characters as below than that of the crosses of all lines, as resulted in their negative significant GCA effect. Positive GCA effect was found for Late class and negative effect for medium class. Negative GCA effects are also desired for days to pollen shed and silking date, if the objective of the program is breeding for earliness.

The ranges for days to pollen shed and silking date for the diallels were 68 days for Ms74 by A641 and Cm105 to 83 days for B73Ht by B84, and 70 days for A641 by Ms74 to 88 for B73Ht by B84 (Table 15). Significant SCA effects were found in ten crosses for days to pollen shed and eight crosses for silking date. For each character three crosses had negative SCA effects (A641 X A619, Ms74 X A632 and W64A X B84) (Cm105 X Pa872, Ms74 X A619 and Ms75 X B84). Negative SCA effects were obtained in early by late crosses for both characters and positive effect was obtained in late by late crosses for silking date.

All crosses within early lines where Cm105 was one of the parents gave negative SCA effects for both characters. In In contrary, most of the SCA effects of early by medium and early by late lines where Cm105 was involved were positive. W117Ht by medium and Ms74 by medium or late lines will produce early maturing hybrids, whereas W117Ht by late will produce late maturing hybrids. The maturity of the progenies of A619 was influenced by the maturity class of the other parent in

Table 40. Estimates of general combining ability effects of Days to pollen shed (dap) over three years at Central location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-2.7333**	-0.0333	-2.7667**
2 Cm105	"	2		1.9333**	-0.8000**
3 W117Ht	"	3		0.1000	-2.6333**
4 Ms74	"	4		-2.0000**	-4.7333**
5 W64A	Medium	1	-0.0750	0.1083	0.0333
6 Ms75	"	2		-0.8583**	-0.9333**
7 A619	"	3		-0.4917*	-0.5667*
8 A632	"	4		1.2417**	1.1667**
9 B73Ht	Late	1	2.8083**	0.4250*	3.2333**
10 Mo17Ht	"	2		0.3250	3.1333**
11 B84	"	3		0.9917**	3.8000**
12 Pa872	"	4		-1.7417**	1.0667**

$LSD_{0.05}(G_i-G_k)=0.3181$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.6362$, $LSD_{0.05}(g_i-g_j)=0.6362$.[1]

(1) = Griffing's method.

*, ** Significant at p=0.05 and 0.01 respectively.

Table 41. Estimates of specific combining ability effects of Days to pollen shed (dap) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.2091	-0.4000	-0.1909
2	A641XW117Ht	EXE		0.1000	0.3091
3	A641XMs74	EXE		0.2000	0.4091
4	A641XW64A	EXM	0.1549	0.4875	0.6424
5	A641XMs75	EXM		-0.2125	-0.0576
6	A641XA619	EXM		-1.5792*	-1.4242*
7	A641XA632	EXM		1.3542*	1.5091*
8	A641XB73Ht	EXL	-0.3117*	0.0875	-0.2242
9	A641XMo17Ht	EXL		-0.1458	-0.4576
10	A641XB84	EXL		0.1875	-0.1242
11	A641XPa872	EXL		-0.0792	-0.3909
12	Cm105XW117Ht	EXE		-0.8667	-0.7576
13	Cm105XMs74	EXE		-1.1000	-0.8909
14	Cm105XW64A	EXM		-0.1458	0.0091
15	Cm105XMs75	EXM		1.1542	1.3091
16	Cm105XA619	EXM		0.7875	0.9424
17	Cm105XA632	EXM		1.3875*	1.5424*
18	Cm105XB73Ht	EXL		0.1208	-0.1909
19	Cm105XMo17Ht	EXL		-0.4458	-0.7576
20	Cm105XB84	EXL		0.5542	0.2424
21	Cm105XPa872	EXL		-1.0458	-1.3576*
22	W117HtXMs74	EXE		2.0667**	2.2758**
23	W117HtXW64A	EXM		-0.6458	-0.4909
24	W117HtXMs75	EXM		-0.6792	-0.5242
25	W117HtXA619	EXM		-0.3792	-0.2242
26	W117HtXA632	EXM		-0.1125	0.0424
27	W117HtXB73Ht	EXL		0.2875	-0.0242
28	W117HtXMo17Ht	EXL		0.0542	-0.2576
29	W117HtXB84	EXL		0.3875	0.0758
30	W117HtXPa872	EXL		-0.2125	-0.5242
31	Ms74XW64A	EXM		0.1208	0.2758
32	Ms74XMs75	EXM		0.7542	0.9091
33	Ms74XA619	EXM		-0.9458	-0.7909
34	Ms74XA632	EXM		-1.3458*	-1.1909
35	Ms74XB73Ht	EXL		-0.6125	-0.9242
36	Ms74XMo17Ht	EXL		0.1542	-0.1576
37	Ms74XB84	EXL		-0.1792	-0.4909
38	Ms74XPa872	EXL		0.8875	0.5758
39	W64AXMs75	MXM	-0.2742	1.0833	0.8091
40	W64AXA619	MXM		-0.2833	-0.5576
41	W64AXA632	MXM		-1.0167	-1.2909

Table 41. Estimates of specific combining ability effects of Days to pollen shed (dap) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.0508	-0.7417	-0.6909
43	W64AXMo17Ht	MXL		1.6917**	1.7424**
44	W64AXB84	MXL		-1.3083*	-1.2576*
45	W64AXPa872	MXL		0.7583	0.8091
46	Ms75XA619	MXM		-0.6500	-0.9242
47	Ms75XA632	MXM		0.2833	0.0091
48	Ms75XB73Ht	MXL		0.5583	0.6091
49	Ms75XMo17Ht	MXL		-1.0083	-0.9576
50	Ms75XB84	MXL		-0.6750	-0.6242
51	Ms75XPa872	MXL		-0.6083	-0.5576
52	A619XA632	MXM		0.5833	0.3091
53	A619XB73Ht	MXL		0.8583	0.9091
54	A619XMo17Ht	MXL		-0.3750	-0.3242
55	A619XB84	MXL		0.2917	0.3424
56	A619XPa872	MXL		1.6917**	1.7424**
57	A632XB73Ht	MXL		-0.2083	-0.1576
58	A632XMo17Ht	MXL		0.8917	0.9424
59	A632XB84	MXL		-1.1083	-1.0576
60	A632XPa872	MXL		-0.7083	-0.6576
61	B73HtXMo17Ht	LXL	0.3480	-0.4722	-0.1242
62	B73HtXB84	LXL		0.8611	1.2091
63	B73HtXPa872	LXL		-0.7389	-0.3909
64	Mo17HtXB84	LXL		0.2944	0.6424
65	Mo17HtXPa872	LXL		-0.6389	-0.2909
66	B84XPa872	LXL		0.6944	1.0424

$LSD_{0.05}(S_{ii}-S_{ij})=0.6021$, $LSD_{0.05}(S_{ii}-S_{jj})=0.5194$, $LSD_{0.05}(S_{ii}-S_{kl})=0.4002$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.3896$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.9086$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.7995$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.7228$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=1.8110$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.6958$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.7544$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.8685$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.7567$.

*, ** Significant at p=0.05 and 0.01 respectively.

(1) = Griffing's method.

Table 42. Estimates of general combining ability effects of Silking Date (dap) over three years at Central location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-2.8583**	-0.5083*	-3.3667**
2 Cm105	"	2		2.0583**	-0.8000**
3 W117Ht	"	3		0.2250	-2.6333**
4 Ms74	"	4		-1.7750**	-4.6333**
5 W64A	Medium	1	-0.0500	0.0500	0.0000
6 Ms75	"	2		-0.9167**	-0.9667**
7 A619	"	3		-0.1833	-0.2333
8 A632	"	4		1.0500**	1.0000**
9 B73Ht	Late	1	2.9083**	0.4583*	3.3667**
10 Mo17Ht	"	2		0.3583	3.2667**
11 B84	"	3		1.1250**	4.0333**
12 Pa872	"	4		-1.9417**	0.9667**

$LSD_{0.05}(G_i-G_k)=0.3410$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.6819$, $LSD_{0.05}(g_i-g_j)=0.6819$.[1]

(1) = Griffing's method.

*, ** Significant at p=0.05 and 0.01 respectively.

Table 43. Estimates of specific combining ability effects of Silking date (dap) over three years at Central location.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.2621	-0.5500	-0.2879
2	A641XW117Ht	EXE		-0.0500	0.2121
3	A641XMs74	EXE		0.6167	0.8788
4	A641XW64A	EXM	0.2663	0.6458	0.9121
5	A641XMs75	EXM		-0.3875	-0.1212
6	A641XA619	EXM		-0.7875	-0.5212
7	A641XA632	EXM		0.6458	0.9121
8	A641XB73Ht	EXL	-0.4629**	0.3417	-0.1212
9	A641XMo17Ht	EXL		-0.2250	-0.6879
10	A641XB84	EXL		-0.3250	-0.7879
11	A641XPa872	EXL		0.0750	-0.3879
12	Cm105XW117Ht	EXE		-1.1283	-1.0212
13	Cm105XMs74	EXE		-1.2833	-1.0212
14	Cm105XW64A	EXM		-0.5875	-0.3212
15	Cm105XMs75	EXM		1.0458	1.3121
16	Cm105XA619	EXM		0.3125	0.5788
17	Cm105XA632	EXM		2.0792**	2.3455**
18	Cm105XB73Ht	EXL		0.1083	-0.3545
19	Cm105XMo17Ht	EXL		0.2083	-0.2545
20	Cm105XB84	EXL		1.4417*	0.9788
21	Cm105XPa872	EXL		-1.4917*	-1.9545**
22	W117HtXMs74	EXE		2.5500**	2.8121**
23	W117HtXW64A	EXM		-0.7542	-0.4879
24	W117HtXMs75	EXM		-0.4542	-0.1879
25	W117HtXA619	EXM		-0.5208	-0.2545
26	W117HtXA632	EXM		-0.0875	0.1788
27	W117HtXB73Ht	EXL		0.2750	-0.1879
28	W117HtXMo17Ht	EXL		0.7083	0.2455
29	W117HtXB84	EXL		-0.3917	-0.8545
30	W117HtXPa872	EXL		0.0083	-0.4545
31	Ms74XW64A	EXM		-0.0875	0.1788
32	Ms74XMs75	EXM		1.5458*	1.8121*
33	Ms74XA619	EXM		-1.5208*	-1.2545
34	Ms74XA632	EXM		-1.0875	-0.8212
35	Ms74XB73Ht	EXL		-0.0583	-0.5212
36	Ms74XMo17Ht	EXL		-0.2917	-0.7545
37	Ms74XB84	EXL		-1.0583	-1.5212*
38	Ms74XPa872	EXL		0.6750	0.2121
39	W64AXMs75	MXM	-0.2434	0.7556	0.5121
40	W64AXA619	MXM		-0.3111	-0.5545
41	W64AXA632	MXM		-0.8778	-1.1212

Table 43. Estimates of specific combining ability effects of Silking date (dap) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.0837	-0.7375	-0.8212
43	W64AXMo17Ht	MXL		2.3625**	2.2788**
44	W64AXB84	MXL		-1.0708	-1.1545
45	W64AXPa872	MXL		0.6625	0.5788
46	Ms75XA619	MXM		-0.0111	-0.2545
47	Ms75XA632	MXM		0.0889	-0.1545
48	Ms75XB73Ht	MXL		0.2292	0.1455
49	Ms75XMo17Ht	MXL		-1.0042	-1.0879
50	Ms75XB84	MXL		-1.4375*	-1.5212*
51	Ms75XPa872	MXL		-0.3708	-0.4545
52	A619XA632	MXM		0.3556	0.1121
53	A619XB73Ht	MXL		-0.1708	-0.2545
54	A619XMo17Ht	MXL		0.2625	0.1788
55	A619XB84	MXL		0.4958	0.4121
56	A619XPa872	MXL		1.8958**	1.8121*
57	A632XB73Ht	MXL		-0.7375	-0.8212
58	A632XMo17Ht	MXL		-0.3042	-0.3879
59	A632XB84	MXL		0.2625	0.1788
60	A632XPa872	MXL		-0.3375	-0.4212
61	B73HtXMo17Ht	LXL	0.7288**	-0.8167	-0.0879
62	B73HtXB84	LXL		2.4167**	3.1455**
63	B73HtXPa872	LXL		-0.8500	-0.1212
64	Mo17HtXB84	LXL		-0.4833	0.2455
65	Mo17HtXPa872	LXL		-0.4167	0.3121
66	B84XPa872	LXL		0.1500	0.8788

$LSD_{0.05}(S_{ii}-S_{ij})=0.6454$, $LSD_{0.05}(S_{ii}-S_{jj})=0.5568$, $LSD_{0.05}(S_{ii}-S_{kl})=0.4290$,
$LSD_{0.05}(S_{ij}-S_{ij'})=0.4177$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=2.0457$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.9286$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.8465$,
$LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=1.9412$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.8175$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.8804$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=2.0027$,
$LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.8830$,

*, ** Significant at p=0.05 and 0.01 respectively.

(1) = Griffing's method.

the cross. For instance, A619 is expected to give early progenies when it crossed with early and other medium lines, but late genotypes when it crossed with late lines.

Among the late lines, all crosses involved B84 had positive SCA effects for days to pollen shed and all crosses involved Mo17Ht had negative SCA effects for silking date. The SCA effects of early by B73Ht were positive for characters. However, negative SCA effects were observed in crosses of B73Ht by medium lines for silking date. Pa872 by early will have early progenies for days to pollen shed and the reverse for silking date.

GRIFFING'S METHOD:

In this method, the GCA effects of the twelve lines were calculated without considering the maturity class effects. The GCA effects of early lines were negative and those of late lines were positive, while medium lines were equally divided for grain yield, moisture content, plant height, ear height, days to pollen shed and silking date. For stalk lodging one (Cm105) early, two medium and all late lines had negative GCA effects. Negative GCA effects were obtained for all medium and three late lines, but the situation for early lines remained unchanged. The trend of SCA effects for all characters were more or less similar to that of the modified method.

DISCUSSION

A diallel cross of four early (A641, Cm105, W117Ht and Ms74), four medium (W64A, Ms75, A619 and A632) and four late (B73Ht, Mo17Ht, B84 and Pa872) inbred lines were used to study the general (GCA) and specific (SCA) combining ability among and within the three maturity classes. The crosses and parental lines were evaluated at three locations in Michigan in 1989, 1990, and 1991.

Progeny means were used for the combining ability analysis of nine characters according to a modified version of Griffing's method four, model one. In this model the sum of squares for general and specific combining abilities were partitioned into, among, and within classes. The GCA within classes was further partitioned into that of each maturity class. The goal was to separate the effect of maturity on combining ability, because early genotypes tend to yield less than those of later maturity. The validity of this partitioning could be challenged in environments where later genotypes are limited by temperature during the growing season or killed by early frost before they reach physiological maturity. Separation of the class effect (class could be maturity, endosperm type, races, geographic and climatic adaptation, etc.,) from the effects of the lines *per se* can be achieved in several ways. For example, the variances for GCA may be partitioned just into classes and individual classes (Class 1, 2 etc.,) or further divided into interclass variances (i. e., GCA of Class 1 X Class 2). The modified Griffing's method was employed to explore the possibility of eliminating confounding effects and to elucidate directions for future work. Calculations of the combining ability effects based on the modified method are presented along with the Griffing's original method in order to observe the specific associations between combining ability values and class. Since the model used in the analysis was fixed, the findings of this study can be applied only to the 12 lines evaluated. It must be understood that these lines were selected on the bases of their maturity (class) and a degree of overlap may exist, however, the implications are far reaching and could be extrapolated to situations where early flowering and high yielding are urgent priorities.

Crosses among the three maturity classes revealed that early by early and early by medium lines had the poorest yield performance and stalk lodging incidence in all experiments. This is often observed when materials tested consist of different maturity classes. A common explanation for stalk lodging increases is that early lines remain in the field longer after reaching physiological maturity than do medium and late lines. Therefore, early genotypes are more exposed to environmental factors that may contribute to heavy stalk breakage.

A wide range of phenotypic variation has been observed for all characters among the 66 crosses (Table 14-15). Stalk lodging had the greatest range in values, 2.6% to 30.1%, while root lodging varied the least (0.1% - 5.7%) among the genotypes tested.

The results of this study show that GCA accounted for more than half of the genotypic variation measured, indicating a preponderance of additive genetic effects for all characters. The magnitude of the GCA variance was more pronounced among classes than within classes, especially for grain yield and maturity-related characters. In the present study, the magnitude of GCA values for these characters suggests that the average performances of hybrid combinations of these twelve lines would vary greatly. Based on genetic variances estimated from diallel cross analyses, it is theoretically possible to select parents and to predict their performance in cross combinations. Since GCA is primarily a function of additive gene action, selected lines could be used to initiate programs of mass selection or recurrent selection for the enhancement of a specific character or characters.

A study of the interaction of combining abilities by year and/or location revealed that the additive genetic effects were consistently larger than nonadditive genetic effects. The magnitude of the GCA effects by year and/or location interactions were much smaller than that of the GCA main effects suggesting that the additive effects were relatlvely insensitive to the environmental fluctuations. These results suggest that decreased emphasis could be placed on multi- location testing for the identification of potential sources of desirable and stable genetic variance in preliminary evaluations. While testing of the breeding materials is a major component of any plant improvement program it is very expensive and time consuming. Thus, if the strategy of the breeder is to develop improved material with broad adaptation consideration must be given to the best combination of year and/or location testing as well as the number of replications that can be managed within each environment.

The cross means of the twelve inbreds show that a clear distinction exists along the maturity classes in terms of their yield performance in cross combinations. The late lines were the top-yielding, while the early lines were the low-yielding as indicated by their GCA class effects. Thus, strong evidence exists to show that maturity is associated with the GCA effects at the class level. The early class had negative GCA's for plant and ear height as well as all characters related to maturity, but positive effects for stalk and root lodging. The GCA effects of the late class were completely the opposite. In the case of the lines within class, the association between maturity and grain yield is weaker, particularly in respect to the medium and late lines. No general trend related to maturity and GCA's was found for the remaining characters (Tables 26, 28, 30, 32, 34, 36, 38, 40, and 42).

Combining ability analysis assists in classifying parental lines in terms of their hybrid performance. These studies are, therefore, useful in identifying potential inbred lines that can be utilized as a sources of genes contributing additive effects to synthetics or composite varieties. The success of these breeding programs depends on additive gene action. Generally, some lines combine well and produce outstanding progenies, whereas others, involving apparently equally promising parents, produce poor progenies. The lines showing high GCA effects can be expected to be useful for producing synthetics. On the other hand, the inbreds exhibiting large SCA's would be most suitable for producing hybrids or for inclusion in complementary synthetics to initiate reciprocal recurrent selection programs.

In the present study, among the early lines, Cm105 exhibited a significant positive GCA effect and contributed favorable alleles in crosses more effectively than any other line in its maturity class. For instance, Cm105 was involved as one parent in the fourth highest yielding hybrid of all the 66 cross combinations, and was a parent in the highest yielding early by early, early by medium and early by late cross combinations. Moreover, three of the ten crosses with positive SCA effects for grain yield greater than 0.7t/ha had Cm105 as one of the parents. While Cm105 was classified as an early inbred it resulted in later maturing hybrids with higher harvest moisture contents in crosses with medium and late lines. In contrast, Ms74 was involved as a parent in the five lowest-yielding crosses and in most of the lowest yielding crosses in each of the early by early, early by medium and early by late combinations. Other lines involved in high yielding crosses were A641, W117Ht, W641, A632, B73Ht, Mo17Ht and Pa872. All these lines had positive GCA effects, except Pa872. It is interesting to note that Pa872 was the earliest line in the late class and performed poorly in crosses with early lines, but did well in crosses with late and medium lines, except A619. An examination of the SCA effects of Pa872 by early lines revealed that all effects were negative, while the corresponding effects in crosses with late and medium lines were positive, except the A619 by Pa872 cross.

In this study, B73Ht was confirmed as being a superior line by showing positive GCA and SCA values in crosses with Cm105, A641, W117Ht, W64A, Mo17Ht, and both positive and significant in crosses with Pa872 for yield (Table 26 and 27). Mo17Ht proved to be an excellent line as demonstrated by its significant positive GCA effects and positive SCA values in crosses with Cm105, A641, W117Ht and A632 (Table 26 and 27). These two late lines consistently gave high yields in crosses with all lines which had positive GCA's except for W117Ht and W64A by Mo17Ht, and A632 by B73Ht.

The results of this study indicated that most of the lines with positive GCA effects for yield will produce tall progenies, with increased ear height and higher harvest moisture contents, as well as being later in maturity. However, one of the early lines (A641) with desirable GCA effects for yield also had desirable GCA's for earliness (reduced moisture content, days to pollen shed and silking date) and plant height. Such an association would be advantageous in regions where early frost or late season droughts are more likely to occur. Similarly, Mo17Ht depicted a desirable GCA effect for grain moisture content at harvest by giving significant negative GCA values for that character. This may imply that Mo17Ht had favorable alleles for faster drying rate and transmitted this character along with higher yield to its progeny.

The evaluation of all the crosses with significant SCA effects established that no generalizations could be made concerning the SCA values on the basis of the GCA estimates of the parents. The present study confirms previous observations that the parents with positive GCA estimates also gave large average line cross mean values in each class for the different characters measured (Table 16). Consequently, the average line cross mean might conveniently be used as an indicator of the GCA as is commonly practiced in maize breeding programs.

Detection of the specifically favorable combinations of certain inbred lines suggests the development of hybrids with excellent performance for the specific character or characters. Identifying early flowering and high yield as being of high priority the study revealed that nine hybrid combinations among the eleven top-yielding crosses met these criteria. These nine hybrids consisted of five early by late, three medium by late and one medium by medium. All of these hybrids had positive SCA effects and the GCA values of their parents were positive for yield except in the case of Pa872. The late line, Pa872, in crosses with W64A gave the second highest yield (10t/ha) of all hybrids, but had negative SCA only for stalk lodging, with a maturity of medium to late season (77 and 79 days for pollen shed and silking). Since this high yield was associated with delayed maturity this single cross hybrid would be undesirable to select for short season areas. Evaluation of the SCA's for other characters in the remaining eight crosses indicated that only A641 by Mo17Ht, W64A by A632 and W64A by B73Ht had negative SCA values for early flowering. It is worth noting that the early by late single cross A641 by Mo17Ht exhibited a combination of higher yielding ability (9.7t/ha) and earlier maturity, expressed in moisture content at harvest (17.6%), days to pollen shed and silking date (75 and 77 days) than the medium by medium cross W64A by A632 or the medium by late cross A64A by B73Ht. While the A641 X Mo17Ht cross tended to be tall, it exhibited less lodging, had a low ear placement and was tolerant to higher planting densities. These qualities were confirmed by desirable SCA's for these characters. Thus, these two lines might be exploited in developing a superior single cross hybrid suited in short season environments.

The study of the GCA effects for high yield and for early flowering revealed that different sets of lines influenced each character. Furthermore, the majority of the SCA values associated with these sets were positive for yield and negative for maturity-related characters. This information would be very important in the choice of genetic materials used to produce complementary synthetics for the initiation of reciprocal recurrent selection programs.

It is the common experience in developing countries that conventional, highly selected hybrids demand costly production inputs to achieve their potential yield and to take advantage of their specific adaption. Seed production of these hybrids also requires development of very efficient seed industries and scientific capability which can continuously generate improved hybrids. Large numbers of farmers in the developing world still practice some form of subsistance farming and cannot afford to purchase seeds of F_1 hybrids based on single crosses between two highly selected lines. A more practical breeding procedure for developing high yield and relatively early maturity material in those regions would be through the formation of varietal hybrids derived from crosses of two specifically constructed composite varieties, one for high yielding and the other for early maturity. Such populations could become the foundation material in which the frequencies of favorable alleles for each character would gradually be increased. This dynamic breeding program would constantly improve each population by exploiting the additive genetic effects through population improvement schemes such as mass selection, bi-parental progeny testing and S_1 evaluation (Jenkins, 1935; Sprague, 1939; and 1946). Differences of flowering date between the parents may create difficulties of matching the flowering periods and require a staggered planting dates if the gap becomes too large. Such a breeding method has been put forward by Kalsy et al., 1970. Obviously, these varietal hybrid would not be as uniform as conventional, highly selected, single cross hybrids, but it would be the quickest way to meet the demand of early maturing and high yielding hybrids. Even in countries like Somalia where a hybrid seed industry does not exist, seed stocks must fall within the acceptance range of preferred characteristics of local producers. For example, precautions must be taken not to push the flowering date up or down beyond certain levels for either high yielding or early maturing populations. Generally, yield improvement in temperate areas is expected to result in later maturity with related changes of taller plants and higher ear placement unless emphasis on selection for early flowering is stressed to maintain the maturity of the material (Hallauer and Miranda, 1981). If other agronomic characteristics such as grain type are crucial for selection it will be necessary to sample large numbers of selected lines from different maturity classes and genetic background such as endosperm type and geographic origin. Several heterotic groups with excellent performance have been identified in the world maize collection and have been suggested by a number of researches (Lonnquist et al., 1961; Moll et al., 1962; Wellhausen, 1978) as source materials for recurrent selection studies.

Reciprocal recurrent selection is another possibility that could be explored to exploit two contrasting populations. The end point of such a program could be the development of varietal hybrids and eventually single cross hybrids. This could be accomplished by improving the cross performance between an early population and a high yielding population and/or their respective inbred lines. In this case each population serves as a tester for the other population in the evaluation of the character targeted for improvement. For example, the high yielding population would be crossed to the early flowering population to select superior families in terms of yield and vice-versa for the early flowering population. This raises the question of whether low yielding testers should be used for yield improvement and late testers for early maturing populations. If the operation of this breeding system is economically feasible and the nicking between the two parents does not impose serious limitations it could open a new avenue to achieve early flowering and high yielding hybrids.

Finally, the success of any breeding program is measured by the production increase in the farmer's field. Hence, the end product inevitably must be acceptable to the farmers and consumers. Most of the time farmers are reluctant to adapt new technology unless they know the level of risk involved. Generally speaking, they are forced to operate at a level of minimum risk rather than to seek maximum opportunity.
In actual practice, it will be important to consider problems that may arise during production of quality seed of these type of hybrids and their cost to make them affordable to the farmers. Often the farmers like to select the best ears from their fields for the seeds of the following season. If that is the case then it is necessary to determine whether yield reduction will fall below the profit line of the producer and what happens to maturity of the material. Dr. Eberhart

(personal communications, 1993) has pointed out that while this approach to varietal hybrid production is technically feasIble, the cost of research leading to seed production will be very high.

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APPENDIX

Table 44. Analysis of variance for Grain yield (t/ha) and Stalk lodging (%) for 66 diallel crosses evaluated at Southern location in 1989, 1990 and 1991.

Source	df	MS[1]	MS[2]
Year	2	26.883**	3646.875**
Genotype	65	8.776**	195.909**
GCA	11	35.435**	887.045**
GCA among classes	2	144.553**	2219.535**
GCA within classes	9	11.187**	590.936**
GCA in Class 1	3	22.882**	1544.897**
GCA in Class 2	3	5.186**	59.797
GCA in Class 3	3	5.492**	168.117*
SCA	54	3.345**	55.122
SCA among classes	3	12.039**	6.583
SCA within classes	51	2.833**	57.977
YearxGenotype	130	1.261**	45.634**
YearxGCA	22	2.437**	114.519**
YearxGCA among classes	4	4.147**	181.718**
YearxGCA within classes	18	2.057**	99.586**
YearxGCA in Class 1	6	1.555	80.503**
YearxGCA in Class 2	6	2.423**	167.588**
YearxGCA in Class 3	6	2.192*	50.665*
YearxSCA	108	1.022	31.682*
YearxSCA among classes	6	0.551	62.800*
YearxSCA within classes	102	1.050	29.767
Error	390	0.804	22.559

1 = grain yield, 2 = stalk lodging.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 45. Analysis of variance for Root lodging (%) and Moisture content (%) for 66 diallel crosses evaluated at Southern location in 1989, 1990 and 1991.

Source	df	MS[1]	MS[2]
Year	2	15.185**	67.967**
Genotype	65	2.774	10.955**
GCA	11	4.235	50.812**
GCA among classes	2	9.645*	155.335**
GCA within classes	9	3.032	27.585**
GCA in Class 1	3	7.810	11.802**
GCA in Class 2	3	0.130	47.008**
GCA in Class 3	3	1.153	23.945**
SCA	54	2.476	2.836**
SCA among classes	3	1.987	13.587**
SCA within classes	51	2.505	2.204**
YearxGenotype	130	3.187	1.148**
YearxGCA	22	3.990	3.999**
YearxGCA among classes	4	12.768**	12.589**
YearxGCA within classes	18	2.040	2.090**
YearxGCA in Class 1	6	3.908	2.190**
YearxGCA in Class 2	6	1.817	1.591**
YearxGCA in Class 3	6	0.395	2.490**
YearxSCA	108	3.023	0.567**
YearxSCA among classes	6	1.343	0.408
YearxSCA within classes	102	3.122	0.577**
Error	390	2.891	0.371

1 = root lodging, 2 = moisture content.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 46. Analysis of variance for Plant height (cm) and Ear height (cm) for 66 diallel crosses evaluated at Southern location in 1989, 1990 and 1991.

Source	df	MS[1]	MS[2]
Year	2	4082.900**	1941.848**
Genotype	65	669.242**	482.516**
GCA	11	3271.227**	2590.745**
GCA among classes	2	13625.290**	6580.105**
GCA within classes	9	15.215**	1704.221**
GCA in Class 1	3	426.333**	554.765**
GCA in Class 2	3	965.367**	2414.044**
GCA in Class 3	3	1519.270**	2110.519**
SCA	54	139.208**	53.062*
SCA among classes	3	101.460	14.468
SCA within classes	51	141.428**	55.333*
YearxGenotype	130	63.773**	35.926*
YearxGCA	22	136.820**	63.440**
YearxGCA among classes	4	55.535	21.287
YearxGCA within classes	18	154.884**	72.807**
YearxGCA in Class 1	6	243.317**	132.777**
YearxGCA in Class 2	6	139.925**	73.904*
YearxGCA in Class 3	6	81.410	11.739
YearxSCA	108	48.893	30.321
YearxSCA among classes	6	26.183	28.475
YearxSCA within classes	102	50.229	30.430
Error	390	40.702	26.348

1 = plant height, 2 = ear height.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 47. Analysis of variance for Stand count (# of plants/ha) for 66 diallel crosses evaluated at Southern location in 1989, 1990 and 1991.

Source	df	MS
Year	2	1564.850**
Genotype	65	32.336
GCA	11	75.064**
GCA among classes	2	41.805
GCA within classes	9	82.454**
GCA in Class 1	3	190.050**
GCA in Class 2	3	23.390
GCA in Class 3	3	33.923
SCA	54	23.633
SCA among classes	3	13.283
SCA within classes	51	24.241
YearxGenotype	130	18.796**
YearxGCA	22	33.849**
YearxGCA among classes	4	95.965**
YearxGCA within classes	18	20.046**
YearxGCA in Class 1	6	15.518
YearxGCA in Class 2	6	37.680**
YearxGCA in Class 3	6	6.938
YearxSCA	108	15.729**
YearxSCA among classes	6	22.660*
YearxSCA within classes	102	15.321**
Error	390	9.872

*, ** = significant at p=0.05 and 0.01 respectively.

Table 48. Analysis of variance for Grain yield (t/ha) and Stalk lodging (%) for 66 diallel crosses evaluated at Central location in 1989, 1990 and 1991.

Source	df	MS[1]	MS[2]
Year	2	13.479**	409.227**
Genotype	65	9.668**	44.135**
GCA	11	39.609**	188.645**
GCA among classes	2	173.335**	791.771**
GCA within classes	9	9.892**	54.617**
GCA in Class 1	3	20.848**	113.625**
GCA in Class 2	3	2.595**	35.692
GCA in Class 3	3	6.232**	14.533
SCA	54	3.569*	14.697
SCA among classes	3	21.759	51.488*
SCA within classes	51	2.499*	12.533
YearxGenotype	130	1.505**	13.797*
YearxGCA	22	3.794**	22.922**
YearxGCA among classes	4	7.091**	39.342**
YearxGCA within classes	18	3.061**	19.273*
YearxGCA in Class 1	6	4.370**	23.165*
YearxGCA in Class 2	6	3.556	18.192*
YearxGCA in Class 3	6	1.256*	16.462
YearxSCA	108	1.038*	11.938
YearxSCA among classes	6	0.694**	15.472
YearxSCA within classes	102	1.058*	11.731
Error	390	0.761	10.228

1 = grain yield, 2 = stalk lodging.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 49. Analysis of variance for Root lodging (%) and Moisture content (%) for 66 diallel crosses evaluated at Central location in 1989, 1990 and 1991.

Source	df	MS[1]	MS[2]
Year	2	859.143**	1399.325**
Genotype	65	21.435	35.643**
GCA	11	86.879**	177.987**
GCA among classes	2	102.251**	706.002**
GCA within classes	9	83.463**	60.650**
GCA in Class 1	3	177.953**	50.084**
GCA in Class 2	3	0.451	72.005**
GCA in Class 3	3	38.652	59.860**
SCA	54	8.104	6.647**
SCA among classes	3	5.085	34.432**
SCA within classes	51	8.281	5.013*
YearxGenotype	130	16.463**	3.172**
YearxGCA	22	64.524**	9.220**
YearxGCA among classes	4	80.451**	19.615**
YearxGCA within classes	18	60.985**	6.910**
YearxGCA in Class 1	6	148.321**	6.951**
YearxGCA in Class 2	6	0.262	4.891**
YearxGCA in Class 3	6	34.373**	8.888**
YearxSCA	108	6.673	1.940**
YearxSCA among classes	6	1.938	3.798**
YearxSCA within classes	102	6.951	1.830**
Error	390	6.173	1.003

1 = root lodging, 2 = moisture content.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 50. Analysis of variance for Plant height (cm) and Ear height (cm) for 66 diallel crosses evaluated at Central location in 1989, 1990 and 1991.

Source	df	MS[1]	MS[2]
Year	2	7137.781**	2749.613**
Genotype	65	707.170**	564.294**
GCA	11	3483.962**	3050.959**
GCA among classes	2	13122.356**	8891.722**
GCA within classes	9	1342.097**	1753.011**
GCA in Class 1	3	1069.319**	487.204**
GCA in Class 2	3	1768.381**	2689.608**
GCA in Class 3	3	1188.592**	2082.222**
SCA	54	141.528**	57.751
SCA among classes	3	144.716	17.354
SCA within classes	51	141.340**	60.128*
YearxGenotype	130	74.094**	40.866**
YearxGCA	22	192.936**	87.196**
YearxGCA among classes	4	348.673**	164.214**
YearxGCA within classes	18	158.327**	70.081**
YearxGCA in Class 1	6	125.692**	84.748**
YearxGCA in Class 2	6	304.407**	110.969**
YearxGCA in Class 3	6	44.884	14.525
YearxSCA	108	49.886	31.429
YearxSCA among classes	6	77.103	25.007
YearxSCA within classes	102	48.285	31.807
Error	390	38.828	24.088

1 = plant height, 2 = ear height.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 51. Analysis of variance for Stand count (# of plants/ha) for 66 diallel crosses evaluated at Central location in 1989, 1990 and 1991.

Source	df	MS
Year	2	475.993**
Genotype	65	38.353*
GCA	11	129.568**
GCA among classes	2	235.290**
GCA within classes	9	106.075**
GCA in Class 1	3	135.361**
GCA in Class 2	3	113.952**
GCA in Class 3	3	68.912*
SCA	54	19.772
SCA among classes	3	12.598
SCA within classes	51	20.194
YearxGenotype	130	24.114**
YearxGCA	22	58.268**
YearxGCA among classes	4	166.416**
YearxGCA within classes	18	34.235**
YearxGCA in Class 1	6	15.183
YearxGCA in Class 2	6	71.026**
YearxGCA in Class 3	6	16.495
YearxSCA	108	17.157**
YearxSCA among classes	6	20.869
YearxSCA within classes	102	16.939**
Error	390	10.343

*, ** = significant at p=0.05 and 0.01 respectively.

Table 52. Analysis of variance for Grain yield (t/ha) and Stalk lodging (%) for 66 diallel crosses evaluated at Northern location in 1989, 1990 and 1991.

Source	df	MS[1]	MS[2]
Year	2	59.346**	906.614**
Genotype	65	5.536**	74.027**
GCA	11	11.784**	236.472**
GCA among classes	2	35.207**	649.714**
GCA within classes	9	6.580**	144.640**
GCA in Class 1	3	9.905**	362.698**
GCA in Class 2	3	6.159*	22.032
GCA in Class 3	3	3.674	49.190
SCA	54	4.263**	40.936
SCA among classes	3	23.731**	160.300*
SCA within classes	51	3.118*	33.915
YearxGenotype	130	1.985**	41.472**
YearxGCA	22	5.032**	106.828**
YearxGCA among classes	4	8.782**	218.779**
YearxGCA within classes	18	4.199**	81.950**
YearxGCA in Class 1	6	5.310**	141.069**
YearxGCA in Class 2	6	3.604**	31.870
YearxGCA in Class 3	6	3.684**	72.911**
YearxSCA	108	1.365**	28.159
YearxSCA among classes	6	2.987**	47.547
YearxSCA within classes	102	1.269**	27.018
Error	390	0.800	24.217

1 = grai yield, 2 = stalk lodging.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 53. Analysis of variance for Root lodging (%) and Moisture content (%) for 66 diallel crosses evaluated at Northern location in 1989, 1990 and 1991.

Source	df	MS[1]	MS[2]
Year	2	17.552**	2021.319**
Genotype	65	5.108	41.593**
GCA	11	12.572**	206.131**
GCA among classes	2	4.800	726.592**
GCA within classes	9	14.300**	90.473**
GCA in Class 1	3	30.342**	24.569**
GCA in Class 2	3	11.173	145.173*
GCA in Class 3	3	1.384	101.677
SCA	54	3.587	8.076
SCA among classes	3	3.399	40.884**
SCA within classes	51	3.599	6.146
YearxGenotype	130	4.196	5.868**
YearxGCA	22	5.166	17.138**
YearxGCA among classes	4	11.439*	43.872**
YearxGCA within classes	18	3.771	11.197**
YearxGCA in Class 1	6	8.041	3.429
YearxGCA in Class 2	6	2.363	18.997**
YearxGCA in Class 3	6	0.910	11.165**
YearxSCA	108	3.999	3.573**
YearxSCA among classes	6	2.976	10.003**
YearxSCA within classes	102	4.059	3.194**
Error	390	3.346	1.731

1 = root lodging, 2 = moisture content.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 54. Analysis of variance for Plant height (cm) and Ear height (cm) for 66 diallel crosses evaluated at Northern location in 1989, 1990 and 1991.

Source	df	MS[1]	MS[2]
Year	2	4253.269**	7427.244**
Genotype	65	704.349**	679.585**
GCA	11	3062.625**	3388.607**
GCA among classes	2	11092.170**	8118.653**
GCA within classes	9	1278.282**	2337.486**
GCA in Class 1	3	467.845**	462.33**
GCA in Class 2	3	2637.977*	3863.437**
GCA in Class 3	3	729.023	2686.689**
SCA	54	223.960**	127.747
SCA among classes	3	573.362**	56.007
SCA within classes	51	203.407**	131.967*
YearxGenotype	130	116.120	91.702
YearxGCA	22	203.135**	84.407
YearxGCA among classes	4	254.303*	46.874
YearxGCA within classes	18	191.764**	92.747
YearxGCA in Class 1	6	263.881*	174.057
YearxGCA in Class 2	6	14.591	33.129
YearxGCA in Class 3	6	296.819**	71.056
YearxSCA	108	98.394	93.188
YearxSCA among classes	6	172.937	111.256
YearxSCA within classes	102	94.010	92.125
Error	390	93.742	84.276

1 = plant height, 2 = ear height.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 55. Analysis of variance for Stand count (# of plants/ha) for 66 diallel crosses evaluated at Northern location in 1989, 1990 and 1991.

Source	df	MS
Year	2	2412.907**
Genotype	65	52.932*
GCA	11	147.087**
GCA among classes	2	340.659**
GCA within classes	9	104.071**
GCA in Class 1	3	271.054**
GCA in Class 2	3	36.417
GCA in Class 3	3	4.742
SCA	54	33.752
SCA among classes	3	34.576
SCA within classes	51	33.704
YearxGenotype	130	34.365**
YearxGCA	22	81.467**
YearxGCA among classes	4	274.216**
YearxGCA within classes	18	38.634*
YearxGCA in Class 1	6	73.190**
YearxGCA in Class 2	6	30.688
YearxGCA in Class 3	6	12.022
YearxSCA	108	24.770
YearxSCA among classes	6	25.538
YearxSCA within classes	102	24.725
Error	390	19.959

*, ** = significant at p=0.05 and 0.01 respectively.

Table 56. Analysis of variance for Grain yield (t/ha) and Stalk lodging (%) for 66 diallel crosses evaluated at three locations in 1989.

Source	df	MS[1]	MS[2]
Year	2	53.728**	79.615*
Genotype	65	11.637**	59.334*
GCA	11	41.293**	267.110**
GCA among classes	2	132.201**	676.464**
GCA within classes	9	21.091**	176.142**
GCA in Class 1	3	39.341**	464.944**
GCA in Class 2	3	11.851**	40.195
GCA in Class 3	3	12.081**	23.288
SCA	54	5.596**	17.009
SCA among classes	3	32.967**	48.361
SCA within classes	51	3.986**	15.165
YearxGenotype	130	1.106**	21.178
YearxGCA	22	2.973**	39.565**
YearxGCA among classes	4	8.381**	48.178*
YearxGCA within classes	18	1.771**	37.651**
YearxGCA in Class 1	6	2.080*	48.059*
YearxGCA in Class 2	6	2.727**	35.044
YearxGCA in Class 3	6	0.505	29.850
YearxSCA	108	0.726	17.433
YearxSCA among classes	6	1.065	29.845
YearxSCA within classes	102	0.706	16.703
Error	390	0.705	18.179

1 = grain yield, 2 = stalk lodging.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 57. Analysis of variance for Root lodging (%) and Moisture content (%) for 66 diallel crosses evaluated at three locations in 1989.

Source	df	MS[1]	MS[2]
Year	2	644.531**	863.617**
Genotype	65	29.333**	42.264**
GCA	11	130.865**	198.012**
GCA among classes	2	230.435**	663.421**
GCA within classes	9	108.739**	94.588**
GCA in Class 1	3	298.953**	18.385**
GCA in Class 2	3	3.557	155.610**
GCA in Class 3	3	23.862	109.770**
SCA	54	8.651	10.538**
SCA among classes	3	2.528	61.704**
SCA within classes	51	9.011	7.528**
YearxGenotype	130	19.921**	5.273**
YearxGCA	22	53.023**	20.346**
YearxGCA among classes	4	41.825**	59.989**
YearxGCA within classes	18	55.512**	11.536**
YearxGCA in Class 1	6	121.995**	4.863**
YearxGCA in Class 2	6	3.176	16.102**
YearxGCA in Class 3	6	41.365**	13.643**
YearxSCA	108	13.178	2.202**
YearxSCA among classes	6	6.437	5.043**
YearxSCA within classes	102	13.575	2.035**
Error	390	10.887	0.661

1 = root lodging, 2 = moisture content.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 58. Analysis of variance for Plant height (cm) and Ear height (cm) for 66 diallel crosses evaluated at three locations in 1989.

Source	df	MS[1]	MS[2]
Year	2	7680.839**	2989.557**
Genotype	65	710.957**	643.512**
GCA	11	3377.998**	3278.255**
GCA among classes	2	12536.390**	7759.071**
GCA within classes	9	1342.799**	2282.519**
GCA in Class 1	3	803.427**	686.768**
GCA in Class 2	3	1677.024**	3345.660**
GCA in Class 3	3	1547.947**	2815.128**
SCA	54	167.670**	106.805**
SCA among classes	3	122.428*	58.760
SCA within classes	51	170.332**	109.631**
YearxGenotype	130	54.128	67.443
YearxGCA	22	86.865*	89.626
YearxGCA among classes	4	164.137**	180.835*
YearxGCA within classes	18	69.694	69.357
YearxGCA in Class 1	6	51.195	80.459
YearxGCA in Class 2	6	83.543	54.385
YearxGCA in Class 3	6	74.342	73.228
YearxSCA	108	47.459	62.924
YearxSCA among classes	6	87.438	50.766
YearxSCA within classes	102	45.107	63.639
Error	390	45.157	61.443

1 = plant height, 2 = ear height.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 59. Analysis of variance for Stand count (# of plants/ha) for 66 diallel crosses evaluated at three locations in 1989.

Source	df	MS
Year	2	214.820**
Genotype	65	51.705**
GCA	11	193.761**
GCA among classes	2	433.664**
GCA within classes	9	140.450**
GCA in Class 1	3	334.233**
GCA in Class 2	3	66.182**
GCA in Class 3	3	20.934
SCA	54	22.767**
SCA among classes	3	66.063**
SCA within classes	51	20.221**
YearxGenotype	130	16.946**
YearxGCA	22	27.925**
YearxGCA among classes	4	72.798**
YearxGCA within classes	18	17.953*
YearxGCA in Class 1	6	30.526*
YearxGCA in Class 2	6	19.642
YearxGCA in Class 3	6	3.691
YearxSCA	108	14.710*
YearxSCA among classes	6	27.358*
YearxSCA within classes	102	13.966
Error	390	10.851

*, ** = significant at p=0.05 and 0.01 respectively.

Table 60. Analysis of variance for Grain yield (t/ha) and Stalk lodging (%) for 66 diallel crosses evaluated at three locations in 1990.

Source	df	MS[1]	MS[2]
Year	2	0.906	959.662
Genotype	65	5.946**	74.650**
GCA	11	14.941**	282.629**
GCA among classes	2	54.918**	819.059**
GCA within classes	9	6.057**	163.422**
GCA in Class 1	3	12.629**	360.294**
GCA in Class 2	3	0.467	76.615**
GCA in Class 3	3	5.075**	53.357**
SCA	54	4.114**	32.285**
SCA among classes	3	19.739**	144.596**
SCA within classes	51	3.195**	25.678**
YearxGenotype	130	1.163**	41.011
YearxGCA	22	3.310**	125.291**
YearxGCA among classes	4	11.671**	344.464**
YearxGCA within classes	18	1.453**	76.585**
YearxGCA in Class 1	6	2.020*	158.359**
YearxGCA in Class 2	6	1.256	38.616**
YearxGCA in Class 3	6	1.082*	32.781**
YearxSCA	108	0.726	23.843
YearxSCA among classes	6	0.520	10.258
YearxSCA within classes	102	0.738	24.642
Error	390	0.760	15.372

1 = grain yield, 2 = stalk lodging.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 61. Analysis of variance for Root lodging (%) and Moisture content (%) for 66 diallel crosses evaluated at three locations in 1990.

Source	df	MS[1]	MS[2]
Year	2	3.578	2107.510**
Genotype	65	1.493**	37.592**
GCA	11	2.771**	189.081**
GCA among classes	2	5.194**	726.776**
GCA within classes	9	2.232**	69.593**
GCA in Class 1	3	3.022**	53.083**
GCA in Class 2	3	0.346**	90.883**
GCA in Class 3	3	3.329	64.813**
SCA	54	1.233**	6.733**
SCA among classes	3	2.717**	28.184**
SCA within classes	51	1.146**	5.271**
YearxGenotype	130	1.368	2.743**
YearxGCA	22	1.446**	6.496**
YearxGCA among classes	4	2.082*	15.707**
YearxGCA within classes	18	1.304**	4.450**
YearxGCA in Class 1	6	1.777	5.638**
YearxGCA in Class 2	6	1.176	4.196*
YearxGCA in Class 3	6	0.961**	3.516
YearxSCA	108	1.353	1.979
YearxSCA among classes	6	1.855	3.084
YearxSCA within classes	102	1.323	1.914
Error	390	0.722	1.706

1 = root lodging, 2 = moisture content.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 62. Analysis of variance for Plant height (cm) and Ear height (cm) for 66 diallel crosses evaluated at three locations in 1990.

Source	df	MS[1]	MS[2]
Year	2	181.677	949.703**
Genotype	65	851.271**	629.256**
GCA	11	3843.045**	3221.981**
GCA among classes	2	13301.024**	8460.686**
GCA within classes	9	1741.272**	2057.824**
GCA in Class 1	3	1548.653**	994.888**
GCA in Class 2	3	3098.055**	3299.137**
GCA in Class 3	3	577.109**	1879.448**
SCA	54	241.835**	101.108**
SCA among classes	3	514.676**	59.591
SCA within classes	51	225.786**	103.550**
YearxGenotype	130	88.226	51.065
YearxGCA	22	176.993**	50.003
YearxGCA among classes	4	250.380*	52.867
YearxGCA within classes	18	160.685**	49.367
YearxGCA in Class 1	6	31.656	35.865
YearxGCA in Class 2	6	118.043	49.482
YearxGCA in Class 3	6	332.357**	62.754
YearxSCA	108	70.144	51.281
YearxSCA among classes	6	71.390	46.528
YearxSCA within classes	102	70.071	51.561
Error	390	73.729	47.691

1 = plant height, 2 = ear height.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 63. Analysis of variance for Stand count (# of plants/ha) for 66 diallel crosses evaluated at three locations in 1990.

Source	df	MS
Year	2	166.847**
Genotype	65	53.841**
GCA	11	114.685**
GCA among classes	2	454.483**
GCA within classes	9	39.175*
GCA in Class 1	3	86.933**
GCA in Class 2	3	5.487
GCA in Class 3	3	25.104
SCA	54	41.447**
SCA among classes	3	24.073
SCA within classes	51	42.469**
YearxGenotype	130	23.223
YearxGCA	22	40.446**
YearxGCA among classes	4	97.404**
YearxGCA within classes	18	27.788
YearxGCA in Class 1	6	20.409
YearxGCA in Class 2	6	37.067
YearxGCA in Class 3	6	25.890
YearxSCA	108	19.715
YearxSCA among classes	6	10.496
YearxSCA within classes	102	20.257
Error	390	17.771

*, ** = significant at p=0.05 and 0.01 respectively.

Table 64. Analysis of variance for Grain yield (t/ha) and Stalk lodging (%) for 66 diallel crosses evaluated at three locations in 1991.

Source	df	MS[1]	MS[2]
Year	2	82.547**	3054.047**
Genotype	65	8.430**	165.683**
GCA	11	34.148**	655.431**
GCA among classes	2	157.481*	1796.809**
GCA within classes	9	6.741*	401.791**
GCA in Class 1	3	7.578*	860.259**
GCA in Class 2	3	7.714*	122.582**
GCA in Class 3	3	4.930	222.532**
SCA	54	3.191	65.919**
SCA among classes	3	9.082*	85.661*
SCA within classes	51	2.844	64.758**
YearxGenotype	130	1.466	45.916**
YearxGCA	22	3.203	132.909**
YearxGCA among classes	4	4.216	231.541**
YearxGCA within classes	18	2.978	110.991**
YearxGCA in Class 1	6	4.178	206.181**
YearxGCA in Class 2	6	2.553	83.054**
YearxGCA in Class 3	6	2.202	43.738
YearxSCA	108	1.112	28.195
YearxSCA among classes	6	0.516	55.593*
YearxSCA within classes	102	1.147	26.584
Error	390	2.700	23.453

1 = grain yield, 2 = stalk lodging.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 65. Analysis of variance for Root lodging (%) and Moisture content (%) for 66 diallel crosses evaluated at three locations in 1991.

Source	df	MS[1]	MS[2]
Year	2	10.587**	123.328**
Genotype	65	1.495**	9.794**
GCA	11	4.539**	47.676**
GCA among classes	2	0.054	178.174**
GCA within classes	9	5.536**	18.677**
GCA in Class 1	3	13.333**	13.048**
GCA in Class 2	3	2.846*	27.043**
GCA in Class 3	3	0.430	15.939**
SCA	54	0.875	2.077**
SCA among classes	3	0.272	8.373**
SCA within classes	51	0.911	1.707**
YearxGenotype	130	1.053	1.443**
YearxGCA	22	1.966**	3.595**
YearxGCA among classes	4	1.257	10.159**
YearxGCA within classes	18	2.123**	2.136**
YearxGCA in Class 1	6	3.564**	3.039**
YearxGCA in Class 2	6	2.592**	0.506
YearxGCA in Class 3	6	0.213	2.864**
YearxSCA	108	0.868	1.004*
YearxSCA among classes	6	0.444	1.403
YearxSCA within classes	102	0.893	0.981
Error	390	0.801	0.739

1 = root lodging, 2 = moisture content.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 66. Analysis of variance for Plant height (cm) and Ear height (cm) for 66 diallel crosses evaluated at three locations in 1991.

Source	df	MS[1]	MS[2]
Year	2	12516.347**	1380.757**
Genotype	65	606.482**	485.470**
GCA	11	2881.478**	2595.184**
GCA among classes	2	12235.532**	7235.332**
GCA within classes	9	802.799**	1564.040**
GCA in Class 1	3	366.975**	199.080**
GCA in Class 2	3	762.697**	2398.747**
GCA in Class 3	3	1278.725**	2094.292**
SCA	54	143.057**	55.713**
SCA among classes	3	213.539*	55.570
SCA within classes	51	138.911**	55.722**
YearxGenotype	130	67.659	34.065
YearxGCA	22	126.679**	62.858**
YearxGCA among classes	4	127.430	66.368*
YearxGCA within classes	18	126.512**	62.078**
YearxGCA in Class 1	6	172.258**	87.041**
YearxGCA in Class 2	6	174.312**	75.907**
YearxGCA in Class 3	6	32.967	23.286
YearxSCA	108	55.637	28.200
YearxSCA among classes	6	101.842	24.399
YearxSCA within classes	102	52.919	28.423
Error	390	54.385	25.578

1 = plant height, 2 = ear height.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 67. Analysis of variance for Stand count (# of plants/ha) for 66 diallel crosses evaluated at three locations in 1991.

Source	df	MS
Year	2	4251.288**
Genotype	65	49.809**
GCA	11	148.858**
GCA among classes	2	193.989**
GCA within classes	9	138.829**
GCA in Class 1	3	254.190**
GCA in Class 2	3	100.616**
GCA in Class 3	3	61.682**
SCA	54	29.632**
SCA among classes	3	3.198
SCA within classes	51	31.187**
YearxGenotype	130	21.239**
YearxGCA	22	52.420**
YearxGCA among classes	4	134.206**
YearxGCA within classes	18	34.245**
YearxGCA in Class 1	6	13.511
YearxGCA in Class 2	6	83.422**
YearxGCA in Class 3	6	5.803
YearxSCA	108	14.887
YearxSCA among classes	6	14.775
YearxSCA within classes	102	14.894
Error	390	11.551

*, ** = significant at p=0.05 and 0.01 respectively.

Table 68. Estimates of general combining ability effects of Grain yield (t/ha) over three years at Southern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-0.9586**	0.1392	-0.8194**
2 Cm105	"	2		0.5425**	-0.4161*
3 W117Ht	"	3		0.5925**	-0.3661
4 Ms74	"	4		-1.2742**	-2.2328**
5 W64A	Medium	1	-0.2386**	0.5392**	0.3006
6 Ms75	"	2		-0.4542*	-0.6928**
7 A619	"	3		-0.1375	-0.3761
8 A632	"	4		0.0525	-0.1861
9 B73Ht	Late	1	1.1972**	0.4533*	1.6506**
10 Mo17Ht	"	2		0.2767	1.4739**
11 B84	"	3		-0.3833*	0.8139**
12 Pa872	"	4		-0.3467	0.8506**

$LSD_{0.05}(G_i-G_k)=0.2842$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.5684$, $LSD_{0.05}(g_i-g_j)=0.5684$[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 69. Estimates of specific combining ability effects of Grain yield (t/ha) over three years at Southern location.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.6085	-1.3706**	-1.9791**
2	A641XW117Ht	EXE		-0.1539	-0.7624
3	A641XMs74	EXE		0.5128	-0.0958
4	A641XW64A	EXM	-0.0966	0.3342	0.2376
5	A641XMs75	EXM		0.5608	0.4642
6	A641XA619	EXM		0.3775	0.2809
7	A641XA632	EXM		-0.7125	-0.8091
8	A641XB73Ht	EXL	0.5530	-0.0321	0.5209
9	A641XMo17Ht	EXL		1.0446	1.5976**
10	A641XB84	EXL		0.2713	0.8242
11	A641XPa872	EXL		-0.8321	-0.2791
12	Cm105XW117Ht	EXE		0.7761	0.1676
13	Cm105XMs74	EXE		-0.0239	-0.6324
14	Cm105XW64A	EXM		0.7308	0.6342
15	Cm105XMs75	EXM		0.1908	0.0942
16	Cm105XA619	EXM		-0.6258	-0.7224
17	Cm105XA632	EXM		-0.4492	-0.5458
18	Cm105XB73Ht	EXL		-0.1354	0.4176
19	Cm105XMo17Ht	EXL		0.3413	0.8942
20	Cm105XB84	EXL		0.7679	1.3209*
21	Cm105XPa872	EXL		-0.2021	0.3509
22	W117HtXMs74	EXE		0.2594	-0.3491
23	W117HtXW64A	EXM		0.1142	0.0176
24	W117HtXMs75	EXM		-0.5592	-0.6558
25	W117HtXA619	EXM		0.5575	0.4609
26	W117HtXA632	EXM		-0.0992	-0.1958
27	W117HtXB73Ht	EXL		0.7479	1.3009*
28	W117HtXMo17Ht	EXL		-1.2421*	-0.6891
29	W117HtXB84	EXL		-0.2488	0.3042
30	W117HtXPa872	EXL		-0.1521	0.4009
31	Ms74XW64A	EXM		0.1808	0.0842
32	Ms74XMs75	EXM		0.4075	0.3109
33	Ms74XA619	EXM		-1.5758**	-1.6724**
34	Ms74XA632	EXM		0.5675	0.4709
35	Ms74XB73Ht	EXL		0.6146	1.1676*
36	Ms74XMo17Ht	EXL		-0.3754	0.1776
37	Ms74XB84	EXL		0.3179	0.8709
38	Ms74XPa872	EXL		-0.8854	-0.3324
39	W64AXMs75	MXM	-0.0096	-2.2794**	-2.2891**
40	W64AXA619	MXM		0.2372	0.2276
41	W64AXA632	MXM		1.1139	1.1042

Table 69. Estimates of specific combining ability effects of Grain yield (t/ha) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.1038	-0.1029	0.0009
43	W64AXMo17Ht	MXL		-0.9596	-0.8558
44	W64AXB84	MXL		-0.2996	-0.1958
45	W64AXPa872	MXL		0.9304	1.0342
46	Ms75XA619	MXM		0.4306	0.4209
47	Ms75XA632	MXM		-0.6261	-0.6358
48	Ms75XB73Ht	MXL		0.3904	0.4942
49	Ms75XMo17Ht	MXL		0.9004	1.0042
50	Ms75XB84	MXL		0.0271	0.1309
51	Ms75XPa872	MXL		0.5571	0.6609
52	A619XA632	MXM		1.1239*	1.1142
53	A619XB73Ht	MXL		1.1071	1.2109*
54	A619XMo17Ht	MXL		-1.1163	-1.0124
55	A619XB84	MXL		1.2771*	1.3809*
56	A619XPa872	MXL		-1.7929**	-1.6891**
57	A632XB73Ht	MXL		-2.0163**	-1.9124**
58	A632XMo17Ht	MXL		0.6938	0.7976
59	A632XB84	MXL		-0.6796	-0.5758
60	A632XPa872	MXL		1.0837	1.1876*
61	B73HtXMo17Ht	LXL	-0.8758	0.6367	-0.2391
62	B73HtXB84	LXL		-2.4033**	-3.2791**
63	B73HtXPa872	LXL		1.1933	0.3176
64	Mo17HtXB84	LXL		0.4733	-0.4024
65	Mo17HtXPa872	LXL		-0.3967	-1.2724*
66	B84XPa872	LXL		0.4967	-0.3791

$LSD_{0.05}(S_{ii}-S_{ij})=0.5380$, $LSD_{0.05}(S_{ii}-S_{jj})=0.4641$, $LSD_{0.05}(S_{ii}-S_{kl})=0.3577$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.3481$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.7052$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.6076$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.5392$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=1.6182$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.5149$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.5674$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.6693$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=1.5696$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 70. Estimates of general combining ability effects of Stalk lodging (%) over three years at Southern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	3.2092**	-2.7142*	0.4950
2 Cm105	"	2		-4.5742**	-1.3650
3 W117Ht	"	3		-3.4142**	-0.2050
4 Ms74	"	4		10.7025**	13.9117**
5 W64A	Medium	1	1.6775**	-0.0325	1.6450
6 Ms75	"	2		-0.1492	1.5283
7 A619	"	3		-1.6325	0.0450
8 A632	"	4		1.8142	3.4917**
9 B73Ht	Late	1	-4.8867**	-0.7550	-5.6417**
10 Mo17Ht	"	2		-0.2583	-5.1450**
11 B84	"	3		3.3050**	-1.5817
12 Pa872	"	4		-2.2917*	-7.1783**

$LSD_{0.05}(G_i-G_k)=1.7093$, $LSD_{0.05}(g_{ij}-g_{ij'})=3.4186$, $LSD_{0.05}(g_i-g_j)=3.4186$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 71. Estimates of specific combining ability effects of Stalk lodging (%) over three years at Southern location.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.2029	-2.0617	-1.8588
2	A641XW117Ht	EXE		0.3117	0.5145
3	A641XMs74	EXE		12.4283**	12.6312**
4	A641XW64A	EXM	0.2616	-1.4638	-1.2021
5	A641XMs75	EXM		0.1196	0.3812
6	A641XA619	EXM		-5.2304	-4.9688
7	A641XA632	EXM		-4.6104	-4.3488
8	A641XB73Ht	EXL	-0.4138	0.5650	0.1512
9	A641XMo17Ht	EXL		0.5350	0.1212
10	A641XB84	EXL		-0.3283	-0.7421
11	A641XPa872	EXL		-0.2650	-0.6788
12	Cm105XW117Ht	EXE		-1.6950	-1.4921
13	Cm105XMs74	EXE		-12.2783**	-12.0755**
14	Cm105XW64A	EXM		-0.1038	0.1579
15	Cm105XMs75	EXM		0.6463	0.9079
16	Cm105XA619	EXM		-0.5371	-0.2755
17	Cm105XA632	EXM		5.2496	5.5112
18	Cm105XB73Ht	EXL		-1.2750	-1.6888
19	Cm105XMo17Ht	EXL		5.9950	5.5812
20	Cm105XB84	EXL		2.0650	1.6512
21	Cm105XPa872	EXL		3.9950	3.5812
22	W117HtXMs74	EXE		3.2950	3.4979
23	W117HtXW64A	EXM		2.5363	2.7979
24	W117HtXMs75	EXM		-5.0138	-4.7521
25	W117HtXA619	EXM		7.2029*	7.4645*
26	W117HtXA632	EXM		-1.3771	-1.1155
27	W117HtXB73Ht	EXL		-0.1683	-0.5821
28	W117HtXMo17Ht	EXL		-1.6983	-2.1121
29	W117HtXB84	EXL		-2.0950	-2.5088
30	W117HtXPa872	EXL		-1.2983	-1.7121
31	Ms74XW64A	EXM		7.1529*	7.4145*
32	Ms74XMs75	EXM		-3.7971	-3.5355
33	Ms74XA619	EXM		3.6529	3.9145
34	Ms74XA632	EXM		-4.4271	-4.1655
35	Ms74XB73Ht	EXL		-2.5183	-2.9321
36	Ms74XMo17Ht	EXL		-3.8483	-4.2621
37	Ms74XB84	EXL		3.7217	3.3079
38	Ms74XPa872	EXL		-3.3817	-3.7955
39	W64AXMs75	MXM	-0.3782	-1.5572	-1.9355
40	W64AXA619	MXM		-3.3406	-3.7188
41	W64AXA632	MXM		4.6461	4.2679

Table 71. Estimates of specific combining ability effects of Stalk lodging (%) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.0220	1.6468	1.6679
43	W64AXMo17Ht	MXL		-3.1508	-3.1288
44	W64AXB84	MXL		-3.2142	-3.1921
45	W64AXPa872	MXL		-3.1508	-3.1288
46	Ms75XA619	MXM		-3.6239	-4.0021
47	Ms75XA632	MXM		0.3961	0.0179
48	Ms75XB73Ht	MXL		-0.5708	-0.5488
49	Ms75XMo17Ht	MXL		1.4325	1.4545
50	Ms75XB84	MXL		10.2025*	10.2245**
51	Ms75XPa872	MXL		1.7658	1.7879
52	A619XA632	MXM		3.4794	3.1012
53	A619XB73Ht	MXL		0.2458	0.2679
54	A619XMo17Ht	MXL		2.4825	2.5045
55	A619XB84	MXL		-4.1475	-4.1255
56	A619XPa872	MXL		-0.1842	-0.1621
57	A632XB73Ht	MXL		-0.5342	-0.5121
58	A632XMo17Ht	MXL		2.5025	2.5245
59	A632XB84	MXL		-3.4608	-3.4388
60	A632XPa872	MXL		-1.8642	-1.8421
61	B73HtXMo17Ht	LXL	0.5223	-2.3978	-1.8755
62	B73HtXB84	LXL		1.6722	2.1945
63	B73HtXPa872	LXL		3.3356	3.8579
64	Mo17HtXB84	LXL		-3.6578	-3.1355
65	Mo17HtXPa872	LXL		1.8056	2.3279
66	B84XPa872	LXL		-0.7578	-0.2355

$LSD_{0.05}(S_{ii}-S_{ij})=3.2358$, $LSD_{0.05}(S_{ii}-S_{jj})=2.7912$, $LSD_{0.05}(S_{ii}-S_{kl})=2.1509$, $LSD_{0.05}(S_{ij}-S_{ij'})=2.0935$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=10.2559$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=9.6695$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=9.2577$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=9.7322$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=9.1120$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=9.4272$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=10.0401$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=9.4401$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 72. Estimates of general combining ability effects of Root lodging (%) over three years at Southern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	0.3264*	0.2742	0.6006
2 Cm105	"	2		-0.7458**	-0.4194
3 W117Ht	"	3		0.0975	0.4239
4 Ms74	"	4		0.3742	0.7006*
5 W64A	Medium	1	-0.1853	0.0558	-0.1294
6 Ms75	"	2		-0.0275	-0.2128
7 A619	"	3		0.0525	-0.1328
8 A632	"	4		-0.0808	-0.2661
9 B73Ht	Late	1	-0.1411	-0.1317	-0.2728
10 Mo17Ht	"	2		0.2117	0.0706
11 B84	"	3		-0.1983	-0.3394
12 Pa872	"	4		0.1183	-0.0228

$LSD_{0.05}(G_i-G_k)$=0.4484, $LSD_{0.05}(g_{ij}-g_{ij'})$=0.8969, $LSD_{0.05}(g_i-g_j)$=0.8969.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 73. Estimates of Specific Combining Ability effects of Root lodging (%) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.3624	-0.6339	-0.2715
2	A641XW117Ht	EXE		4.8228**	5.1852**
3	A641XMs74	EXE		-0.8539	-0.4915
4	A641XW64A	EXM	-0.0461	-0.5488	-0.5948
5	A641XMs75	EXM		-0.8321	-0.8782
6	A641XA619	EXM		-0.8454	-0.8915
7	A641XA632	EXM		-0.7788	-0.8248
8	A641XB73Ht	EXL	-0.2257	-0.2925	-0.5182
9	A641XMo17Ht	EXL		0.7308	0.5052
10	A641XB84	EXL		-0.2592	-0.4848
11	A641XPa872	EXL		-0.5092	-0.7348
12	Cm105XW117Ht	EXE		-1,0572	-0.6948
13	Cm105XMs74	EXE		-1.1672	-0.8048
14	Cm105XW64A	EXM		0.6046	0.5585
15	Cm105XMs75	EXM		-0.0121	-0.0582
16	Cm105XA619	EXM		0.8746	0.8285
17	Cm105XA632	EXM		0.0413	-0.0048
18	Cm105XB73Ht	EXL		0.2275	0.0018
19	Cm105XMo17Ht	EXL		0.4842	0.2585
20	Cm105XB84	EXL		0.4608	0.2352
21	Cm105XPa872	EXL		0.1775	-0.0482
22	W117HtXMs74	EXE		-1.1106	-0.7482
23	W117HtXW64A	EXM		-0.5054	-0.5515
24	W117HtXMs75	EXM		-0.1888	-0.2348
25	W117HtXA619	EXM		-0.9354	-0.9815
26	W117HtXA632	EXM		0.5979	0.5518
27	W117HtXB73Ht	EXL		-0.6158	-0.8415
28	W117HtXMo17Ht	EXL		-0.5592	-0.7848
29	W117HtXB84	EXL		-0.2825	-0.5082
30	W117HtXPa872	EXL		-0.1658	-0.3915
31	Ms74XW64A	EXM		0.1513	0.1052
32	Ms74XMs75	EXM		1.2013	1.1552
33	Ms74XA619	EXM		1.2879	1.2418
34	Ms74XA632	EXM		-0.1121	-0.1582
35	Ms74XB73Ht	EXL		0.8408	0.6152
36	Ms74XMo17Ht	EXL		0.0642	-0.1615
37	Ms74XB84	EXL		-0.6258	-0.8515
38	Ms74XPa872	EXL		0.3242	0.0985
39	W64AXMs75	MXM	-0.0198	-0.0617	-0.0815
40	W64AXA619	MXM		0.0583	0.0385
41	W64AXA632	MXM		-0.2750	-0.2948

Table 73. Estimates of Specific Combining Ability effects of Root lodging (%) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.0610	0.0842	0.1452
43	W64AXMo17Ht	MXL		0.2408	0.3018
44	W64AXB84	MXL		0.6175	0.6785
45	W64AXPa872	MXL		-0.3658	-0.3048
46	Ms75XA619	MXM		0.5750	0.5552
47	Ms75XA632	MXM		-0.1917	-0.2115
48	Ms75XB73Ht	MXL		-0.2658	-0.2148
49	Ms75XMo17Ht	MXL		-0.6092	-0.5448
50	Ms75XB84	MXL		-0.1992	-0.1382
51	Ms75XPa872	MXL		0.5842	0.6452
52	A619XA632	MXM		-0.1050	-0.1248
53	A619XB73Ht	MXL		-0.3458	-0.2848
54	A619XMo17Ht	MXL		-0.3892	-0.3282
55	A619XB84	MXL		-0.1125	-0.0515
56	A619XPa872	MXL		-0.0625	-0.0015
57	A632XB73Ht	MXL		0.3208	0.3818
58	A632XMo17Ht	MXL		0.4775	0.5385
59	A632XB84	MXL		0.2875	0.3485
60	A632XPa872	MXL		-0.2625	-0.2015
61	B73HtXMo17Ht	LXL	0.2196	-0.0078	0.2118
62	B73HtXB84	LXL		-0.0311	0.1885
63	B73HtXPa872	LXL		0.0856	0.3052
64	Mo17HtXB84	LXL		-0.2411	-0.0215
65	Mo17HtXPa872	LXL		-0.1911	0.0285
66	B84XPa872	LXL		0.3856	0.6052

$LSD_{0.05}(S_{ii}-S_{ij})=0.8489$, $LSD_{0.05}(S_{ii}-S_{jj})=0.7323$, $LSD_{0.05}(S_{ii}-S_{kl})=0.5643$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.5492$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=2.6905$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=2.5366$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.4286$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=2.5531$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=2.3904$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.4731$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=2.6338$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=2.4765$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 74. Estimates of general combining ability effects of Moisture content (%) over three years at Southern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-1.1911**	-0.8167**	-2.0078**
2 Cm105	"	2		0.5233**	-0.6678**
3 W117Ht	"	3		-0.1667	-1.3578**
4 Ms74	"	4		0.4600**	-0.7311**
5 W64A	Medium	1	0.1156	0.5800**	0.6956**
6 Ms75	"	2		-0.9367**	-0.8211**
7 A619	"	3		1.4867**	1.6022**
8 A632	"	4		-1.1300**	-1.0144**
9 B73Ht	Late	1	1.0756**	0.9833**	2.0589**
10 Mo17Ht	"	2		-0.3367*	0.7389**
11 B84	"	3		0.4200*	1.4956**
12 Pa872	"	4		-1.0667**	0.0089

$LSD_{0.05}(G_i - G_k) = 0.2711$, $LSD_{0.05}(g_{ij} - g_{ij'}) = 0.5423$, $LSD_{0.05}(g_i - g_j) = 0.5423$[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 75. Estimates of Specific Combining Ability effects of Moisture content (%) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.4342*	-0.5233	-0.0891
2	A641XW117Ht	EXE		0.5333	0.9676
3	A641XMs74	EXE		-0.3933	0.0409
4	A641XW64A	EXM	0.2359*	1.4117*	1.6476**
5	A641XMs75	EXM		0.9617	1.1976*
6	A641XA619	EXM		-1.5617**	-1.3258*
7	A641XA632	EXM		-0.1783	0.0576
8	A641XB73Ht	EXL	-0.5616**	-0.6208	-1.1824*
9	A641XMo17Ht	EXL		-0.0342	-0.5958
10	A641XB84	EXL		-0.1242	-0.6858
11	A641XPa872	EXL		0.5292	-0.0324
12	Cm105XW117Ht	EXE		-0.4400	-0.0058
13	Cm105XMs74	EXE		-0.1667	0.2676
14	Cm105XW64A	EXM		-0.0617	0.1742
15	Cm105XMs75	EXM		0.8550	1.0909
16	Cm105XA619	EXM		0.5317	0.7676
17	Cm105XA632	EXM		-0.5183	-0.2824
18	Cm105XB73Ht	EXL		-0.2275	-0.7891
19	Cm105XMo17Ht	EXL		0.6258	0.0642
20	Cm105XB84	EXL		0.1692	-0.3924
21	Cm105XPa872	EXL		-0.2442	-0.8058
22	W117HtXMs74	EXE		0.9900	1.4242*
23	W117HtXW64A	EXM		-0.3383	-0.1024
24	W117HtXMs75	EXM		-0.2550	-0.0191
25	W117HtXA619	EXM		-0.5450	-0.3091
26	W117HtXA632	EXM		-0.1283	0.1076
27	W117HtXB73Ht	EXL		0.4958	-0.0658
28	W117HtXMo17Ht	EXL		0.0825	-0.4791
29	W117HtXB84	EXL		-0.4742	-1.0358
30	W117HtXPa872	EXL		0.0792	-0.4824
31	Ms74XW64A	EXM		-0.5650	-0.3291
32	Ms74XMs75	EXM		0.7850	1.0209
33	Ms74XA619	EXM		-0.2050	0.0309
34	Ms74XA632	EXM		-0.1883	0.0476
35	Ms74XB73Ht	EXL		-0.4308	-0.9924
36	Ms74XMo17Ht	EXL		-0.1108	-0.6724
37	Ms74XB84	EXL		-0.5008	-1.0624*
38	Ms74XPa872	EXL		0.7858	0.2242
39	W64AXMs75	MXM	-0.0680	0.1289	0.0609
40	W64AXA619	MXM		0.7056	0.6376
41	W64AXA632	MXM		-0.0778	-0.1458

Table 75. Estimates of specific combining ability effects of Moisture content (%) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
42	W64AXB73Ht	MXL	-0.1849	-0.5008	-0.6858
43	W64AXMo17Ht	MXL		0.0525	-0.1324
44	W64AXB84	MXL		-1.1375*	-1.3224*
45	W64AXPa872	MXL		0.3825	0.1976
46	Ms75XA619	MXM		-1.2111*	-1.2791*
47	Ms75XA632	MXM		0.6056	0.5376
48	Ms75XB73Ht	MXL		-0.7175	-0.9024
49	Ms75XMo17Ht	MXL		0.2358	0.0509
50	Ms75XB84	MXL		-1.2875*	-1.4724**
51	Ms75XPa872	MXL		-0.1008	-0.2858
52	A619XA632	MXM		-0.1511	-0.2191
53	A619XB73Ht	MXL		2.0258**	1.8409**
54	A619XMo17Ht	MXL		-0.2875	-0.4724
55	A619XB84	MXL		2.3558**	2.1709**
56	A619XPa872	MXL		-1.6575**	-1.8424**
57	A632XB73Ht	MXL		0.0425	-0.1424
58	A632XMo17Ht	MXL		0.9625	0.7778
59	A632XB84	MXL		-0.6942	-0.8791
60	A632XPa872	MXL		0.3258	0.1409
61	B73HtXMo17Ht	LXL	0.9954**	-0.0911	0.9042
62	B73HtXB84	LXL		0.6856	1.6809**
63	B73HtXPa872	LXL		-0.6611	0.3342
64	Mo17HtXB84	LXL		-0.4944	0.5009
65	Mo17HtXPa872	LXL		-0.9411	0.0542
66	B84XPa872	LXL		1.5022**	2.4976**

$LSD_{0.05}(S_{ii}-S_{ij})=0.5133$, $LSD_{0.05}(S_{ii}-S_{jj})=0.4428$, $LSD_{0.05}(S_{ii}-S_{kl})=0.3412$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.3320$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.6268$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.5337$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.4684$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=1.5437$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.4453$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.4953$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.5925$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.4974$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 76. Estimates of general combining ability effects of Plant height (cm) over three years at Southern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-9.3847	-3.1942*	-12.5789
2 Cm105	"	2		4.6658**	-4.7189**
3 W117Ht	"	3		1.4525	-7.9322**
4 Ms74	"	4		-2.9242*	-12.3089**
5 W64A	Medium	1	-2.1989	-1.7567	-3.9556**
6 Ms75	"	2		3.2100*	1.0111
7 A619	"	3		-7.1333**	-9.3322**
8 A632	"	4		5.6800**	3.4811*
9 B73Ht	Late	1	11.5836	-0.7258	10.8578**
10 Mo17Ht	"	2		3.0575*	14.6411**
11 B84	"	3		7.1808**	18.7644**
12 Pa872	"	4		-9.5125**	2.0711

$LSD_{0.05}(G_i-G_k)=2.0208$, $LSD_{0.05}(g_{ij}-g_{ij'})=4.0413$, $LSD_{0.05}(g_i-g_j)=4.0413$[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 77. Estimates of specific combining ability effects of Plant height (cm) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-1.5881	-4.5495	-6.1367
2	A641XW117Ht	EXE		1.7639	0.1758
3	A641XMs74	EXE		3.9496	2.3614
4	A641XW64A	EXM	-0.5580	2.5238	1.9658
5	A641XMs75	EXM		2.1571	1.5991
6	A641XA619	EXM		-6.2996	-6.8576
7	A641XA632	EXM		-9.3796*	-9.9376*
8	A641XB73Ht	EXL	1.7491*	-0.1300	1.6191
9	A641XMo17Ht	EXL		6.3533	8.1024
10	A641XB84	EXL		4.0300	5.7791
11	A641XPa872	EXL		-0.4190	1.3301
12	Cm105XW117Ht	EXE		4.5372	2.9491
13	Cm105XMs74	EXE		-3.5194	-5.1076
14	Cm105XW64A	EXM		3.4638	2.9058
15	Cm105XMs75	EXM		0.7304	0.1724
16	Cm105XA619	EXM		1.1404	0.5824
17	Cm105XA632	EXM		-5.5729	-6.1309
18	Cm105XB73Ht	EXL		6.9100	8.6591*
19	Cm105XMo17Ht	EXL		0.2933	2.0424
20	Cm105XB84	EXL		-1.0633	0.6858
21	Cm105XPa872	EXL		-2.3700	-0.6209
22	W117HtXMs74	EXE		-2.1818	-3.7699
23	W117HtXW64A	EXM		-5.7229	-6.2809
24	W117HtXMs75	EXM		-4.4896	-5.0476
25	W117HtXA619	EXM		10.3204*	9.7624*
26	W117HtXA632	EXM		5.6071	5.0491
27	W117HtXB73Ht	EXL		3.7233	5.4724
28	W117HtXMo17Ht	EXL		-7.1933	-5.4442
29	W117HtXB84	EXL		-6.5833	-4.8342
30	W117HtXPa872	EXL		0.2190	1.9681
31	Ms74XW64A	EXM		4.3204	3.7624
32	Ms74XMs75	EXM		-0.8129	-1.3709
33	Ms74XA619	EXM		-4.8696	-5.4276
34	Ms74XA632	EXM		6.8837	6.3258
35	Ms74XB73Ht	EXL		-2.2333	-0.4842
36	Ms74XMo17Ht	EXL		-8.6500*	-6.9009
37	Ms74XB84	EXL		7.6267	9.3758*
38	Ms74XPa872	EXL		-0.5133	1.2358
39	W64AXMs75	MXM	1.0069	-7.5311	-6.5242
40	W64AXA619	MXM		-5.6878	-4.6809
41	W64AXA632	MXM		6.2322	7.2391

Table 77. Estimates of specific combining ability effects of Plant height (cm) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.1972	-0.9071	-1.1042
43	W64AXMo17Ht	MXL		3.3763	3.1791
44	W64AXB84	MXL		-3.7471	-3.9442
45	W64AXPa872	MXL		3.6796	3.4824
46	Ms75XA619	MXM		3.9456	4.9524
47	Ms75XA632	MXM		-1.7678	-0.7609
48	Ms75XB73Ht	MXL		8.7263*	8.5291*
49	Ms75XMo17Ht	MXL		-9.0904*	-9.2876*
50	Ms75XB84	MXL		5.9529	5.7558
51	Ms75XPa872	MXL		2.1796	1.9824
52	A619XA632	MXM		4.8089	5.8158
53	A619XB73Ht	MXL		1.5363	1.3391
54	A619XMo17Ht	MXL		-0.0471	-0.2442
55	A619XB84	MXL		14.2629**	14.0658**
56	A619XPa872	MXL		-19.1104**	-19.3076**
57	A632XB73Ht	MXL		-12.6438**	-12.8409**
58	A632XMo17Ht	MXL		7.4396	7.2424
59	A632XB84	MXL		-4.1504	-4.3476
60	A632XPa872	MXL		2.5429	2.3458
61	B73HtXMo17Ht	LXL	-2.0692	0.8350	-1.2342
62	B73HtXB84	LXL		-12.4217**	-14.4909**
63	B73HtXPa872	LXL		6.6050	4.5358
64	Mo17HtXB84	LXL		-2.2050	-4.2742
65	Mo17HtXPa872	LXL		8.8883*	6.8191
66	B84XPa872	LXL		-1.7017	-3.7709

$LSD_{0.05}(S_{ii}-S_{ij})$=3.8251, $LSD_{0.05}(S_{ii}-S_{jj})$=3.2999, $LSD_{0.05}(S_{ii}-S_{kl})$=2.5427, $LSD_{0.05}(S_{ij}-S_{ij'})$=2.4749, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=12.1242, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=11.4307, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=10.9441, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})$=11.5050, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=10.7718, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=11.1444, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=11.8688, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})$=11.1597.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 78. Estimates of general combining ability effects of Ear height (cm) over three years at Southern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-6.4181**	0.5692	-5.8489**
2 Cm105	"	2		-0.5542	-6.9722**
3 W117Ht	"	3		5.2292**	-1.1889
4 Ms74	"	4		-5.2442**	-11.6622**
5 W64A	Medium	1	-1.6839**	4.3850**	2.7011**
6 Ms75	"	2		2.9650**	1.2811
7 A619	"	3		-13.3283**	-15.0122**
8 A632	"	4		5.9783**	4.2944**
9 B73Ht	Late	1	8.1019**	-1.3975	6.7044**
10 Mo17Ht	"	2		7.7425**	13.0644**
11 B84	"	3		-11.3075**	15.8444**
12 Pa872	"	4		0.9477**	-3.2056**

$LSD_{0.05}(G_i-G_k)$=1.5166, $LSD_{0.05}(g_{ij}-g_{ij'})$=3.0333, $LSD_{0.05}(g_i-g_j)$=3.0333[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 79. Estimates of specific combining ability effects of Ear height (cm) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.9194	-1.6706	-2.5900
2	A641XW117Ht	EXE		0.5794	-0.3400
3	A641XMs74	EXE		-1.1806	-2.100
4	A641XW64A	EXM	0.0783	2.1917	2.2700
5	A641XMs75	EXM		1.5450	1.6233
6	A641XA619	EXM		-3.0617	-2.9833
7	A641XA632	EXM		-3.5017	-3.4233
8	A641XB73Ht	EXL	0.6113	3.3554	3.9667
9	A641XMo17Ht	EXL		-1.5379	-0.9267
10	A641XB84	EXL		3.6488	4.2600
11	A641XPa872	EXL		-0.3679	0.2433
12	Cm105XW117Ht	EXE		0.2694	-0.6500
13	Cm105XMs74	EXE		1.5428	0.6233
14	Cm105XW64A	EXM		4.4817	4.5600
15	Cm105XMs75	EXM		-2.1650	-2.0867
16	Cm105XA619	EXM		0.0283	0.1067
17	Cm105XA632	EXM		-2.7783	-2.7000
18	Cm105XB73Ht	EXL		0.3454	0.9567
19	Cm105XMo17Ht	EXL		-0.6146	-0.0033
20	Cm105XB84	EXL		2.5054	3.1167
21	Cm105XPa872	EXL		-1.9446	-1.3333
22	W117HtXMs74	EXE		0.5494	-0.4600
23	W117HtXW64A	EXM		-5.5017	-5.4233
24	W117HtXMs75	EXM		-2.5817	-2.5033
25	W117HtXA619	EXM		7.6450*	7.7233*
26	W117HtXA632	EXM		2.6717	2.7500
27	W117HtXB73Ht	EXL		3.4621	4.0733
28	W117HtXMo17Ht	EXL		-1.6979	-1.0867
29	W117HtXB84	EXL		-3.2446	-2.6333
30	W117HtXPa872	EXL		-2.0613	-1.4500
31	Ms74XW64A	EXM		3.0383	3.1167
32	Ms74XMs75	EXM		0.1250	0.2033
33	Ms74XA619	EXM		-2.1483	-2.0700
34	Ms74XA632	EXM		0.0117	0.0900
35	Ms74XB73Ht	EXL		-0.0646	0.5467
36	Ms74XMo17Ht	EXL		-1.9913	-1.3800
37	Ms74XB84	EXL		1.1954	1.8067
38	Ms74XPa872	EXL		-0.9879	-0.3767
39	W64AXMs75	MXM	-0.0267	-4.9667	-4.9933
40	W64AXA619	MXM		-2.8733	-2.9000
41	W64AXA632	MXM		4.2533	4.2267

Table 79. Estimates of specific combining ability effects of Ear height (cm) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.0583	0.3083	0.2500
43	W64AXMo17Ht	MXL		0.3483	0.2900
44	W64AXB84	MXL		-6.9650*	-7.0233*
45	W64AXPa872	MXL		5.6850	5.6267
46	Ms75XA619	MXM		-0.5533	-0.5800
47	Ms75XA632	MXM		1.6400	1.6133
48	Ms75XB73Ht	MXL		6.1617*	6.1033
49	Ms75XMo17Ht	MXL		-2.9650	-3.0233
50	Ms75XB84	MXL		7.9217**	7.8633*
51	Ms75XPa872	MXL		-4.1617	-4.2200
52	A619XA632	MXM		2.5000	2.4733
53	A619XB73Ht	MXL		3.4883	3.4300
54	A619XMo17Ht	MXL		-0.7383	-0.7967
55	A619XB84	MXL		4.9817	4.9233
56	A619XPa872	MXL		-9.2683**	-9.3267**
57	A632XB73Ht	MXL		-9.2183**	-9.2767**
58	A632XMo17Ht	MXL		6.7883*	6.7300*
59	A632XB84	MXL		-3.1250	-3.1833
60	A632XPa872	MXL		0.7583	0.7000
61	B73HtXMo17Ht	LXL	-0.7372	-1.8428	-2.5800
62	B73HtXB84	LXL		-9.6228**	-10.3600**
63	B73HtXPa872	LXL		3.6272	2.8900
64	Mo17HtXB84	LXL		-0.8828	-1.6200
65	Mo17HtXPa872	LXL		5.1339	4.3967
66	B84XPa872	LXL		3.5872	2.8500

$LSD_{0.05}(S_{ii}-S_{ij})$=2.8710, $LSD_{0.05}(S_{ii}-S_{jj})$=2.4767, $LSD_{0.05}(S_{ii}-S_{kl})$=1.9085, $LSD_{0.05}(S_{ij}-S_{ij'})$=1.8575, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=9.0999, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=8.5795, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=8.2142, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})$=8.6352, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=8.0848, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=8.3645, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=0, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})$=8.3759.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 80. Estimates of general combining ability effects of Stand count (# of plants/ha) over three years at Southern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-0.6303	-0.4325	-1.0628
2 Cm105	"	2		2.0308**	1.4006*
3 W117Ht	"	3		1.7908**	1.1606*
4 Ms74	"	4		-3.3892**	-4.0194**
5 W64A	Medium	1	0.5397	0.1875	0.7272
6 Ms75	"	2		0.8303	1.3701*
7 A619	"	3		-1.2493	-0.7095
8 A632	"	4		0.2314	0.7712
9 B73Ht	Late	1	0.0906	1.2700	1.3606*
10 Mo17Ht	"	2		0.2767	0.3672
11 B84	"	3		-1.2767	-1.1861*
12 Pa872	"	4		-0.2700	-1.1794

$LSD_{0.05}(G_i-G_k)=1.0970$, $LSD_{0.05}(g_{ij}-g_{ij'})=2.1940$, $LSD_{0.05}(g_i-g_j)=2.1940$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 81. Estimates of specific combining ability effects of Stand count (# of plants/ha) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.1101	1.9072	2.0173
2	A641XW117Ht	EXE		-0.0528	0.0573
3	A641XMs74	EXE		-2.4061	-2.2961
4	A641XW64A	EXM	-0.5336	0.0575	-0.4761
5	A641XMs75	EXM		-3.3858	-4.9194
6	A641XA619	EXM		0.7608	0.2273
7	A641XA632	EXM		1.1475	0.6139
8	A641XB73Ht	EXL	0.4510	-1.0271	-0.5761
9	A641XMo17Ht	EXL		3.8996	4.3506
10	A641XB84	EXL		-1.1471	-0.6961
11	A641XPa872	EXL		1.2463	1.6973
12	Cm105XW117Ht	EXE		0.0172	0.1273
13	Cm105XMs74	EXE		0.0306	0.1406
14	Cm105XW64A	EXM		0.9942	0.4606
15	Cm105XMs75	EXM		0.3175	-0.2161
16	Cm105XA619	EXM		-1.4025	-1.9361
17	Cm105XA632	EXM		-2.7825	-3.3161
18	Cm105XB73Ht	EXL		0.8096	1.2606
19	Cm105XMo17Ht	EXL		0.1029	0.5539
20	Cm105XB84	EXL		1.6229	2.0739
21	Cm105XPa872	EXL		-1.6171	-1.1661
22	W117HtXMs74	EXE		0.5039	0.6139
23	W117HtXW64A	EXM		0.1342	-0.3994
24	W117HtXMs75	EXM		1.2575	0.7239
25	W117HtXA619	EXM		2.7375	2.2039
26	W117HtXA632	EXM		0.9908	0.4573
27	W117HtXB73Ht	EXL		-2.6504	-2.1994
28	W117HtXMo17Ht	EXL		2.1096	2.5606
29	W117HtXB84	EXL		-3.1038	-2.6527
30	W117HtXPa872	EXL		-1.9437	-1.4927
31	Ms74XW64A	EXM		1.8475	1.3139
32	Ms74XMs75	EXM		6.2375**	5.7039
33	Ms74XA619	EXM		-9.7492**	-10.2827*
34	Ms74XA632	EXM		1.8375	1.3039
35	Ms74XB73Ht	EXL		1.6296	2.0806
36	Ms74XMo17Ht	EXL		1.7229	2.1739
37	Ms74XB84	EXL		0.7763	1.2273
38	Ms74XPa872	EXL		-2.4304	-1.9794
39	W64AXMs75	MXM	0.7812	-1.2239	-0.4427
40	W64AXA619	MXM		-0.2106	0.5706
41	W64AXA632	MXM		-0.2572	0.5239

Table 81. Estimates of specific combining ability effects of Stand count (# of plants/ha) over three years at Southern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.0523	-1.3804	-1.4327
43	W64AXMo17Ht	MXL		-0.8204	-0.8727
44	W64AXB84	MXL		-1.4671	-1.5194
45	W64AXPa872	MXL		2.3263	2.2739
46	Ms75XA619	MXM		0.1128	0.8939
47	Ms75XA632	MXM		-1.7672	-0.9861
48	Ms75XB73Ht	MXL		-1.6238	-1.6761
49	Ms75XMo17Ht	MXL		-0.6638	-0.7161
50	Ms75XB84	MXL		0.2896	0.2373
51	Ms75XPa872	MXL		1.4496	1.3973
52	A619XA632	MXM		3.3461	4.1273
53	A619XB73Ht	MXL		2.4563	2.4039
54	A619XMo17Ht	MXL		0.4596	0.4073
55	A619XB84	MXL		5.5029*	5.4506
56	A619XPa872	MXL		-4.0137	-4.0661
57	A632XB73Ht	MXL		-3.1238	-3.1761
58	A632XMo17Ht	MXL		-2.1304	-2.1827
59	A632XB84	MXL		-0.7438	-0.7961
60	A632XPa872	MXL		3.4829	3.4306
61	B73HtXMo17Ht	LXL	-0.5316	1.8589	1.3273
62	B73HtXB84	LXL		2.2789	1.7473
63	B73HtXPa872	LXL		0.7722	0.2406
64	Mo17HtXB84	LXL		-5.6378**	-6.1694
65	Mo17HtXPa872	LXL		-0.9011	-1.4327
66	B84XPa872	LXL		1.6289	1.0973

$LSD_{0.05}(S_{ii}-S_{ij})=2.0766$, $LSD_{0.05}(S_{ii}-S_{jj})=1.7914$, $LSD_{0.05}(S_{ii}-S_{kl})=1.3804$, $LSD_{0.05}(S_{ij}-S_{ij'})=1.3436$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=6.5821$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=6.2056$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.9413$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=6.2459$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=5.8479$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=6.0501$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=6.4435$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=6.0584$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 82. Estimates of general combining ability effects of Grain yield (t/ha) over three years at Central location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-1.1722**	-0.3017	-1.4739**
2 Cm105	"	2		1.0483**	-0.1239
3 W117Ht	"	3		0.1817	-0.9906**
4 Ms74	"	4		-0.9283**	-2.1006**
5 W64A	Medium	1	-0.0572	0.2867	0.2294
6 Ms75	"	2		-0.1133	-0.1706
7 A619	"	3		-0.3600	-0.4172
8 A632	"	4		0.1867	0.1294
9 B73Ht	Late	1	1.2294**	0.3633	1.5928**
10 Mo17Ht	"	2		0.3700	1.5994**
11 B84	"	3		-0.1600	1.0694**
12 Pa872	"	4		-0.5733**	0.6561**

$LSD_{0.05}(G_i-G_k)=0.3105$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.6207$, $LSD_{0.05}(g_i-g_j)=0.6207$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 83. Estimates of specific combining ability effects of Grain yield (t/ha) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.8268**	-0.3578	-1.1845
2	A641XW117Ht	EXE		0.4089	-0.4179
3	A641XMs74	EXE		-0.2144	-1.0412
4	A641XW64A	EXM	-0.1654	0.3275	0.1621
5	A641XMs75	EXM		0.0275	-0.1379
6	A641XA619	EXM		0.0408	-0.1245
7	A641XA632	EXM		-0.9058	-1.0712
8	A641XB73Ht	EXL	0.7855**	0.4467	1.2321
9	A641XMo17Ht	EXL		1.0733	1.8588**
10	A641XB84	EXL		-0.5633	0.2221
11	A641XPa872	EXL		-0.2833	0.5021
12	Cm105XW117Ht	EXE		0.8256	-0.0012
13	Cm105XMs74	EXE		-0.5311	-1.3579*
14	Cm105XW64A	EXM		0.2442	0.0788
15	Cm105XMs75	EXM		1.0442	0.8788
16	Cm105XA619	EXM		-0.0425	-0.2079
17	Cm105XA632	EXM		-1.4225*	-1.5879*
18	Cm105XB73Ht	EXL		0.3300	1.1155
19	Cm105XMo17Ht	EXL		0.5233	1.3088
20	Cm105XB84	EXL		0.3200	1.1055
21	Cm105XPa872	EXL		-0.9333	-0.1479
22	W117HtXMs74	EXE		-0.1311	-0.9579
23	W117HtXW64A	EXM		-0.3558	-0.5212
24	W117HtXMs75	EXM		-0.2225	-0.3879
25	W117HtXA619	EXM		-0.4092	-0.5745
26	W117HtXA632	EXM		0.8775	0.7121
27	W117HtXB73Ht	EXL		0.4633	1.2488
28	W117HtXMo17Ht	EXL		-1.1100	-0.3245
29	W117HtXB84	EXL		0.4200	1.2055
30	W117HtXPa872	EXL		-0.7667	0.0188
31	Ms74XW64A	EXM		0.6542	0.4888
32	Ms74XMs75	EXM		-0.8125	-0.9779
33	Ms74XA619	EXM		-0.2658	-0.4312
34	Ms74XA632	EXM		1.2208	1.0555
35	Ms74XB73Ht	EXL		-0.2600	0.5255
36	Ms74XMo17Ht	EXL		-0.6000	0.1855
37	Ms74XB84	EXL		0.1300	0.9155
38	Ms74XPa872	EXL		0.8100	1.5955*
39	W64AXMs75	MXM	0.1766	-2.4178**	-2.2412**
40	W64AXA619	MXM		0.3289	0.5055
41	W64AXA632	MXM		0.8156	0.9921

Table 83. Estimates of specific combining ability effects of Grain yield (t/ha) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL		0.0958	0.1288
43	W64AXMo17Ht	MXL	0.0330	-0.9775	-0.9445
44	W64AXB84	MXL		0.5858	0.6188
45	W64AXPa872	MXL		0.6992	0.7321
46	Ms75XA619	MXM		0.8956	1.0721
47	Ms75XA632	MXM		-0.1511	0.0255
48	Ms75XB73Ht	MXL		-0.1042	-0.0712
49	Ms75XMo17Ht	MXL		0.2558	0.2888
50	Ms75XB84	MXL		0.5525	0.5855
51	Ms75XPa872	MXL		0.9325	0.9655
52	A619XA632	MXM		0.5289	0.7055
53	A619XB73Ht	MXL		-0.1575	-0.1245
54	A619XMo17Ht	MXL		0.0025	0.0355
55	A619XB84	MXL		1.0325	1.0656
56	A619XPa872	MXL		-1.9542**	-1.9211**
57	A632XB73Ht	MXL		-0.0708	-0.0379
58	A632XMo17Ht	MXL		-0.6442	-0.6112
59	A632XB84	MXL		-0.3475	-0.3145
60	A632XPa872	MXL		0.0992	0.1321
61	B73HtXMo17Ht	LXL	-1.0914**	1.1167	0.0255
62	B73HtXB84	LXL		-2.8533**	-3.9447**
63	B73HtXPa872	LXL		0.9933	-0.0979
64	Mo17HtXB84	LXL		0.3400	-0.7512
65	Mo17HtXPa872	LXL		0.0200	-1.0712
66	B84XPa872	LXL		0.3833	-0.7079

$LSD_{0.05}(S_{ii}-S_{ij})=0.5876$, $LSD_{0.05}(S_{ii}-S_{jj})=0.5069$, $LSD_{0.05}(S_{ii}-S_{kl})=0.3906$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.3800$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.8622$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.7558$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.6809$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=1.7671$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.6544$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.7117$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.8230$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=1.7140$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 84. Estimates of general combining ability effects of Stalk lodging (%) over three years at Central location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	2.8969**	0.5325	3.4294**
2 Cm105	"	2		-1.9242**	0.9728
3 W117Ht	"	3		-1.0942	1.8028**
4 Ms74	"	4		2.4858**	5.3828**
5 W64A	Medium	1	-0.8972**	-0.6200	-1.5172**
6 Ms75	"	2		0.4900	-0.4072
7 A619	"	3		-1.1467	-2.0439**
8 A632	"	4		1.2767*	0.3794
9 B73Ht	Late	1	-1.9997**	-0.8442	-2.8439**
10 Mo17Ht	"	2		-0.2675	-2.2672**
11 B84	"	3		0.7158	-1.2839*
12 Pa872	"	4		0.3958	-1.6039*

$LSD_{0.05}(G_i-G_k)=0.9398$, $LSD_{0.05}(g_{ij}-g_{ij'})=1.8798$, $LSD_{0.05}(g_i-g_j)=1.8798$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 85. Estimates of Specific Combining Ability effects of Stalk lodging (%) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	1.6718**	-0.0472	1.6245
2	A641XW117Ht	EXE		0.4228	2.0945
3	A641XMs74	EXE		3.0094	4.6812*
4	A641XW64A	EXM	-0.0438	-0.1417	-0.1855
5	A641XMs75	EXM		-1.6850	-1.7288
6	A641XA619	EXM		1.7517	1.7079
7	A641XA632	EXM		1.6283	1.5845
8	A641XB73Ht	EXL	-1.2100**	0.9179	-0.2921
9	A641XMo17Ht	EXL		-1.7921	-3.0021
10	A641XB84	EXL		-0.2421	-1.4521
11	A641XPa872	EXL		-3.8221*	-5.0321**
12	Cm105XW117Ht	EXE		-2.3872	-0.7155
13	Cm105XMs74	EXE		2.8994	4.5712*
14	Cm105XW64A	EXM		0.9817	0.9379
15	Cm105XMs75	EXM		-2.3950	-2.4388
16	Cm105XA619	EXM		-0.5917	-0.6355
17	Cm105XA632	EXM		-0.5817	-0.6255
18	Cm105XB73Ht	EXL		-2.0921	-3.3021
19	Cm105XMo17Ht	EXL		-0.3354	-1.5455
20	Cm105XB84	EXL		-0.1188	-1.3288
21	Cm105XPa872	EXL		4.6679*	3.4579
22	W117HtXMs74	EXE		-3.8972*	-2.2255
23	W117HtXW64A	EXM		-0.4483	-0.4921
24	W117HtXMs75	EXM		-0.0583	-0.1021
25	W117HtXA619	EXM		0.8450	0.8012
26	W117HtXA632	EXM		-0.8117	-0.8555
27	W117HtXB73Ht	EXL		0.1113	-1.0988
28	W117HtXMo17Ht	EXL		2.7679	1.5579
29	W117HtXB84	EXL		-0.3154	-1.5255
30	W117HtXPa872	EXL		3.7712*	2.5612
31	Ms74XW64A	EXM		-3.6617	-3.7055
32	Ms74XMs75	EXM		0.9617	0.9179
33	Ms74XA619	EXM		0.4650	0.4212
34	Ms74XA632	EXM		3.7417	3.6979
35	Ms74XB73Ht	EXL		1.7979	0.5879
36	Ms74XMo17Ht	EXL		-0.2454	-1.4555
37	Ms74XB84	EXL		-1.9621	-3.1721
38	Ms74XPa872	EXL		-3.1088	-4.3188*
39	W64AXMs75	MXM	-0.2788	-1.0033	-1.2821
40	W64AXA619	MXM		-0.1000	-0.3788
41	W64AXA632	MXM		1.5767	1.2979

Table 85. Estimates of Specific Combining Ability effects of Stalk lodging (%) over three years at Central locations (Central).

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
42	W64AXB73Ht	MXL	0.2529	1.1350	1.3879
43	W64AXMo17Ht	MXL		-0.2083	0.0445
44	W64AXB84	MXL		0.6083	0.8612
45	W64AXPa872	MXL		1.2617	1.5145
46	Ms75XA619	MXM		-1.3100	-1.5888
47	Ms75XA632	MXM		1.6000	1.3212
48	Ms75XB73Ht	MXL		0.6917	0.9445
49	Ms75XMo17Ht	MXL		0.9817	1.2345
50	Ms75XB84	MXL		3.1983	3.4512
51	Ms75XPa872	MXL		-0.9817	-0.7288
52	A619XA632	MXM		-0.7633	-1.0421
53	A619XB73Ht	MXL		-0.5383	-0.2855
54	A619XMo17Ht	MXL		-0.0817	0.1712
55	A619XB84	MXL		0.8017	1.0545
56	A619XPa872	MXL		-0.4783	-0.2255
57	A632XB73Ht	MXL		-2.9283	-2.6755
58	A632XMo17Ht	MXL		-2.4050	-2.1521
59	A632XB84	MXL		-1.1883	-0.9355
60	A632XPa872	MXL		0.1317	0.3845
61	B73HtXMo17Ht	LXL	1.2762*	0.6617	1.9379
62	B73HtXB84	LXL		0.4783	1.7545
63	B73HtXPa872	LXL		-0.2350	1.0412
64	Mo17HtXB84	LXL		0.3017	1.5779
65	Mo17HtXPa872	LXL		0.3550	1.6312
66	B84XPa872	LXL		-1.5617	-0.2855

$LSD_{0.05}(S_{ii}-S_{ij})=1.7791$, $LSD_{0.05}(S_{ii}-S_{jj})=1.5349$, $LSD_{0.05}(S_{ii}-S_{kl})=1.1827$, $LSD_{0.05}(S_{ij}-S_{ij'})=1.1511$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=5.6393$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=5.3169$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=6.6904$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=7.0333$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=6.5850$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.8127$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=7.2557$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=6.8220$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 86. Estimates of general combining ability effects of Root lodging (%) over three years at Central location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	1.0442**	0.4675	1.5117*
2 Cm105	"	2		-2.2558**	-1.2117
3 W117Ht	"	3		-1.7725**	-0.7283
4 Ms74	"	4		3.5608**	4.6050**
5 W64A	Medium	1	-0.7075*	0.1692	-0.5383
6 Ms75	"	2		-0.1108	-0.8183
7 A619	"	3		0.0058	-0.7017
8 A632	"	4		-0.0642	-0.7717
9 B73Ht	Late	1	-0.3367	-0.9250	-1.2617
10 Mo17Ht	"	2		-0.7583	-1.0950
11 B84	"	3		1.5550*	1.2183
12 Pa872	"	4		0.1283	-0.2083

$LSD_{0.05}(G_i-G_k)=1.0266$, $LSD_{0.05}(g_{ij}-g_{ij'})=2.0533$, $LSD_{0.05}(g_i-g_j)=2.0533$[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 87. Estimates of Specific Combining Ability effects of Root lodging (%) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.5758	1.5106	2.0864
2	A641XW117Ht	EXE		-1.4728	-0.8970
3	A641XMs74	EXE		5.3606**	5.9364**
4	A641XW64A	EXM	-0.0753	-1.1117	-1.1870
5	A641XMs75	EXM		0.4683	0.3930
6	A641XA619	EXM		0.8183	0.7430
7	A641XA632	EXM		-2.4783	-2.5536
8	A641XB73Ht	EXL	-0.3566	-2.0071	-2.3636
9	A641XMo17Ht	EXL		-2.3738	-2.7303
10	A641XB84	EXL		1.6463	1.2897
11	A641XPa872	EXL		-0.3604	-0.7170
12	Cm105XW117Ht	EXE		-0.0161	0.5597
13	Cm105XMs74	EXE		-3.1161	-2.5403*
14	Cm105XW64A	EXM		0.4783	0.4030
15	Cm105XMs75	EXM		0.0250	-0.0503
16	Cm105XA619	EXM		0.3417	0.2664
17	Cm105XA632	EXM		0.2783	0.2030
18	Cm105XB73Ht	EXL		0.8829	0.5264
19	Cm105XMo17Ht	EXL		0.7829	0.4264
20	Cm105XB84	EXL		-1.1971	-1.5536
21	Cm105XPa872	EXL		0.0296	-0.3270
22	W117HtXMs74	EXE		-2.2661	-1.6903
23	W117HtXW64A	EXM		-0.6383	-0.7136
24	W117HtXMs75	EXM		-0.1917	-0.2670
25	W117HtXA619	EXM		3.0250	2.9497
26	W117HtXA632	EXM		-0.0050	-0.0803
27	W117HtXB73Ht	EXL		1.5996	1.2430
28	W117HtXMo17Ht	EXL		0.7663	0.4097
29	W117HtXB84	EXL		-1.4804	-1.8370
30	W117HtXPa872	EXL		0.6796	0.3230
31	Ms74XW64A	EXM		2.5283	2.4530
32	Ms74XMs75	EXM		-1.9250	-2.0003
33	Ms74XA619	EXM		-1.5083	-1.5836
34	Ms74XA632	EXM		-0.1050	-0.1803
35	Ms74XB73Ht	EXL		-3.3338	-3.6903
36	Ms74XMo17Ht	EXL		0.6996	0.3430
37	Ms74XB84	EXL		1.9863	1.6297
38	Ms74XPa872	EXL		1.6796	1.3230
39	W64AXMs75	MXM	0.0125	-0.2028	-0.1903
40	W64AXA619	MXM		-0.4194	-0.4070
41	W64AXA632	MXM		0.3172	0.3297

Table 87. Estimates of Specific Combining Ability effects of Root lodging (%) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.0659	-0.2796	-0.2136
43	W64AXMo17Ht	MXL		-0.5129	-0.4470
44	W64AXB84	MXL		-0.5596	-0.4936
45	W64AXPa872	MXL		0.4004	0.4664
46	Ms75XA619	MXM		-0.8061	-0.7936
47	Ms75XA632	MXM		2.1972	2.2097
48	Ms75XB73Ht	MXL		1.0338	1.0997
49	Ms75XMo17Ht	MXL		-0.6996	-0.6336
50	Ms75XB84	MXL		1.2204	1.2864
51	Ms75XPa872	MXL		-1.1196	-1.0536
52	A619XA632	MXM		-1.0861	-1.0736
53	A619XB73Ht	MXL		1.7838	1.8497
54	A619XMo17Ht	MXL		0.2504	0.3164
55	A619XB84	MXL		-0.9963	-0.9303
56	A619XPa872	MXL		-0.4029	-1.3370
57	A632XB73Ht	MXL		-0.3463	-0.2803
58	A632XMo17Ht	MXL		1.2538	1.3197
59	A632XB84	MXL		0.0404	0.1064
60	A632XPa872	MXL		-0.0663	-0.0003
61	B73HtXMo17Ht	LXL	0.3875	-0.1111	0.2764
62	B73HtXB84	LXL		0.8422	1.2297
63	B73HtXPa872	LXL		-0.0644	0.3230
64	Mo17HtXB84	LXL		-0.8911	-0.5036
65	Mo17HtXPa872	LXL		0.8356	1.2236
66	B84XPa872	LXL		-0.6111	-0.2236

$LSD_{0.05}(S_{ii}-S_{ij})=1.9435$, $LSD_{0.05}(S_{ii}-S_{jj})=1.6766$, $LSD_{0.05}(S_{ii}-S_{kl})=1.2918$, $LSD_{0.05}(S_{ij}-S_{ij'})=1.2573$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=6.1601$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=5.8077$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.5605$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=5.8455$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=5.4729$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.6622$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=6.0303$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=5.6701$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 88. Estimates of general combining ability effects of Moisture content (%) over three years at Central location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-2.4717**	-1.6033**	-4.0750**
2 Cm105	"	2		1.5500**	-0.9217**
3 W117Ht	"	3		0.1567	-2.3150**
4 Ms74	"	4		-0.1033	-2.5750**
5 W64A	Medium	1	0.0950**	0.2967	0.3917
6 Ms75	"	2		-1.2367**	-1.1417**
7 A619	"	3		2.0733**	2.1683**
8 A632	"	4		-1.1333**	-1.0383**
9 B73Ht	Late	1	2.3767**	1.4050**	3.7817**
10 Mo17Ht	"	2		-1.1483**	1.2283**
11 B84	"	3		1.0250**	3.4017**
12 Pa872	"	4		-1.2817**	1.0950**

$LSD_{0.05}(G_i - G_k) = 0.4506$, $LSD_{0.05}(g_{ij} - g_{ij'}) = 0.9012$, $LSD_{0.05}(g_i - g_j) = 0.9012$[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 89. Estimates of Specific Combining Ability effects of Moisture content (%) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	1.2605**	-1.3411	-0.0806
2	A641XW117Ht	EXE		0.1522	1.4127
3	A641XMs74	EXE		1.2789	2.5394**
4	A641XW64A	EXM	0.0265	1.7129	1.7394
5	A641XMs75	EXM		0.3796	0.4061
6	A641XA619	EXM		-1.9304*	-1.9039*
7	A641XA632	EXM		0.6096	0.6361
8	A641XB73Ht	EXL	-0.9719**	-0.9788	-1.9506*
9	A641XMo17Ht	EXL		0.2413	-0.7306
10	A641XB84	EXL		-1.0988	-2.0706*
11	A641XPa872	EXL		0.9746	0.0027
12	Cm105XW117Ht	EXE		-1.5011	-0.2406
13	Cm105XMs74	EXE		-1.6078	-0.3473
14	Cm105XW64A	EXM		-0.5404	-0.5139
15	Cm105XMs75	EXM		0.2596	1.2861
16	Cm105XA619	EXM		0.9829	1.0094
17	Cm105XA632	EXM		-0.1104	-0.0839
18	Cm105XB73Ht	EXL		0.2013	-0.7706
19	Cm105XMo17Ht	EXL		1.1879	0.2161
20	Cm105XB84	EXL		2.1813*	1.2094
21	Cm105XPa872	EXL		-0.7121	-1.6839
22	W117HtXMs74	EXE		3.0189**	4.2794**
23	W117HtXW64A	EXM		-0.0138	0.0127
24	W117HtXMs75	EXM		-0.0804	-0.0539
25	W117HtXA619	EXM		-0.8571	-0.8306
26	W117HtXA632	EXM		-0.5504	-0.5239
27	W117HtXB73Ht	EXL		-0.5721	-1.5439
28	W117HtXMo17Ht	EXL		1.3813	0.4094
29	W117HtXB84	EXL		-1.1588	-2.1306*
30	W117HtXPa872	EXL		0.1813	-0.7906
31	Ms74XW64A	EXM		-0.4871	-0.4606
32	Ms74XMs75	EXM		2.1463*	2.1727*
33	Ms74XA619	EXM		-1.7971*	-1.7706
34	Ms74XA632	EXM		-0.7237	-0.6973
35	Ms74XB73Ht	EXL		-1.4121	-2.3839*
36	Ms74XMo17Ht	EXL		-0.2921	-1.2639
37	Ms74XB84	EXL		-0.4988	-1.4706
38	Ms74XPa872	EXL		0.3746	-0.5973
39	W64AXMs75	MXM	-0.0562	0.9622	0.9061
40	W64AXA619	MXM		-0.2811	-0.3373
41	W64AXA632	MXM		-0.0411	-0.0973

Table 89. Estimates of specific combining ability effects of Moisture content (%) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
42	W64AXB73Ht	MXL	0.0156	-1.1996	-1.1839
43	W64AXMo17Ht	MXL		0.6871	0.7027
44	W64AXB84	MXL		-1.5863	-1.5706
45	W64AXPa872	MXL		0.7871	0.8027
46	Ms75XA619	MXM		-0.6478	-0.7039
47	Ms75XA632	MXM		0.1589	0.1027
48	Ms75XB73Ht	MXL		-0.4996	-0.4839
49	Ms75XMo17Ht	MXL		-1.6796	-1.6639
50	Ms75XB84	MXL		-1.5196	-1.5039
51	Ms75XPa872	MXL		-0.4796	-0.4639
52	A619XA632	MXM		-0.1511	-0.2073
53	A619XB73Ht	MXL		2.7904**	2.8061**
54	A619XMo17Ht	MXL		0.5771	0.5927
55	A619XB84	MXL		2.1038*	2.1194*
56	A619XPa872	MXL		-0.7896	-0.7739
57	A632XB73Ht	MXL		0.5971	0.6127
58	A632XMo17Ht	MXL		-0.1496	-0.1339
59	A632XB84	MXL		-0.1896	-0.1739
60	A632XPa872	MXL		0.5504	0.5661
61	B73HtXMo17Ht	LXL	1.2749**	-0.0622	1.2127
62	B73HtXB84	LXL		0.6644	1.9394*
63	B73HtXPa872	LXL		0.4711	1.7461
64	Mo17HtXB84	LXL		0.2844	1.5594
65	Mo17HtXPa872	LXL		-2.1756*	-0.9006
66	B84XPa872	LXL		0.8178	2.0927*

$LSD_{0.05}(S_{ii}-S_{ij})=0.8530$, $LSD_{0.05}(S_{ii}-S_{jj})=0.7360$, $LSD_{0.05}(S_{ii}-S_{kl})=0.5670$,
$LSD_{0.05}(S_{ij}-S_{ij'})=0.5519$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=2.7038$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=2.5492$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.4406$,
$LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=2.5658$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=2.4022$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.4853$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=2.6470$,
$LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=2.4888$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 90. Estimates of general combining ability effects of Plant height (cm) over three years at Central location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-9.1631**	-4.8475**	-14.0106**
2 Cm105	"	2		8.3825**	-0.7806
3 W117Ht	"	3		0.0925	-9.0706**
4 Ms74	"	4		-3.6275**	-12.7906**
5 W64A	Medium	1	-2.2289**	-4.3850**	-6.6139**
6 Ms75	"	2		2.2450	0.0161
7 A619	"	3		-7.5983**	-9.8272**
8 A632	"	4		9.7383**	7.5094**
9 B73Ht	Late	1	11.3919**	2.8875*	14.2794**
10 Mo17Ht	"	2		-1.1258	10.2661**
11 B84	"	3		6.4575**	17.8494**
12 Pa872	"	4		-8.2192**	3.1728*

$LSD_{0.05}(G_i-G_k)$=2.1781, $LSD_{0.05}(g_{ij}-g_{ij'})$=4.3561, $LSD_{0.05}(g_i-g_j)$=4.3561.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 91. Estimates of specific combining ability effects of Plant height (cm) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.0706	-2.6739	-2.6033
2	A641XW117Ht	EXE		2.6828	2.7533
3	A641XMs74	EXE		0.0361	0.1067
4	A641XW64A	EXM	-1.6233	3.7867	2.1633
5	A641XMs75	EXM		-1.3100	-2.9333
6	A641XA619	EXM		3.1000	1.4767
7	A641XA632	EXM		-5.4367	-7.0600
8	A641XB73Ht	EXL	1.5704	-0.2004	1.3700
9	A641XMo17Ht	EXL		8.7096	9.6500*
10	A641XB84	EXL		-5.0704	-3.5000
11	A641XPa872	EXL		-2.9937	-1.4233
12	Cm105XW117Ht	EXE		3.7194	3.7900
13	Cm105XMs74	EXE		-1.1606	-1.0900
14	Cm105XW64A	EXM		3.2567	1.6333
15	Cm105XMs75	EXM		2.2933	0.6700
16	Cm105XA619	EXM		-2.3633	-3.9867
17	Cm105XA632	EXM		-8.1000	-9.7233*
18	Cm105XB73Ht	EXL		0.4029	1.9733
19	Cm105XMo17Ht	EXL		0.2829	1.8533
20	Cm105XB84	EXL		3.4996	5.0700
21	Cm105XPa872	EXL		0.8429	2.4133
22	W117HtXMs74	EXE		-2.6039	-2.5333
23	W117HtXW64A	EXM		-7.8200	-9.4433*
24	W117HtXMs75	EXM		-1.2500	-2.8733
25	W117HtXA619	EXM		4.7267	3.1033
26	W117HtXA632	EXM		12.5567**	10.9333*
27	W117HtXB73Ht	EXL		-2.2404	-0.6700
28	W117HtXMo17Ht	EXL		-7.2271	-5.6567
29	W117HtXB84	EXL		-4.2438	-2.6733
30	W117HtXPa872	EXL		1.6996	3.2700
31	Ms74XW64A	EXM		2.1000	0.4767
32	Ms74XMs75	EXM		0.5033	-1.1200
33	Ms74XA619	EXM		-4.5533	-6.1767
34	Ms74XA632	EXM		-1.4900	-3.1133
35	Ms74XB73Ht	EXL		2.2796	3.8500
36	Ms74XMo17Ht	EXL		-10.8708*	-9.3004*
37	Ms74XB84	EXL		10.9429*	12.5133**
38	Ms74XPa872	EXL		4.8167	6.3871
39	W64AXMs75	MXM	1.5022	-8.9322*	-7.4300
40	W64AXA619	MXM		-1.7556	-0.2533
41	W64AXA632	MXM		4.8078	6.3100

Table 91. Estimates of specific combining ability effects of Plant height (cm) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.4967	-0.9000	0.4067
43	W64AXMo17Ht	MXL		-1.3433	-0.8467
44	W64AXB84	MXL		-3.8933	-3.3967
45	W64AXPa872	MXL		9.8833*	10.3800*
46	Ms75XA619	MXM		5.7478	7.2500
47	Ms75XA632	MXM		1.8444	3.3467
48	Ms75XB73Ht	MXL		1.8467	2.3433
49	Ms75XMo17Ht	MXL		-7.3400	-6.8433
50	Ms75XB84	MXL		7.4767	7.9733
51	Ms75XPa872	MXL		-0.8800	-0.3833
52	A619XA632	MXM		-1.7122	-0.2100
53	A619XB73Ht	MXL		4.0567	4.5533
54	A619XMo17Ht	MXL		1.5367	2.0333
55	A619XB84	MXL		11.4867**	11.9833**
56	A619XPa872	MXL		-20.2700**	-19.7733**
57	A632XB73Ht	MXL		-6.4133	-5.9167
58	A632XMo17Ht	MXL		7.1667	7.6633
59	A632XB84	MXL		-2.4833	-1.9867
60	A632XPa872	MXL		-0.7400	-0.2433
61	B73HtXMo17Ht	LXL	-2.7561	9.1828*	6.4267
62	B73HtXB84	LXL		-17.4339**	-20.1900**
63	B73HtXPa872	LXL		8.6094*	5.8533
64	Mo17HtXB84	LXL		0.6099	-2.1463
65	Mo17HtXPa872	LXL		-0.0772	-2.8333
66	B84XPa872	LXL		-0.8910	-3.6471

$LSD_{0.05}(S_{ii}-S_{ij})$=4.1231, $LSD_{0.05}(S_{ii}-S_{jj})$=3.5568, $LSD_{0.05}(S_{ii}-S_{kl})$=2.7407, $LSD_{0.05}(S_{ij}-S_{ij'})$=2.6676, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=13.0685, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=12.3210, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=11.7965, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})$=12.4009, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=11.6106, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=12.0124, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=12.7933, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})$=12.0287.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 92. Estimates of general combining ability effects of Ear height (cm) over three years at Central location.

	Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1	A641 .	Early	1	-6.8686**	-0.7058	-7.5744**
2	Cm105	"	2		3.7942**	-3.0744**
3	W117Ht	"	3		2.2675*	-4.6011**
4	Ms74	"	4		-5.3558**	-12.2244**
5	W64A	Medium	1	-2.7878**	2.8733**	0.0856
6	Ms75	"	2		4.1633**	1.3756
7	A619	"	3		-13.9733**	-16.7611**
8	A632	"	4		6.9367**	4.1489**
9	B73Ht	Late	1	9.6564**	2.4792*	12.1356**
10	Mo17Ht	"	2		1.6658	11.3222**
11	B84	"	3		7.6925**	17.3489**
12	Pa872	"	4		-11.8375**	-2.1811

$LSD_{0.05}(G_i-G_k)=1.6176$, $LSD_{0.05}(g_{ij}-g_{ij'})=2.2352$, $LSD_{0.05}(g_i-g_j)=3.2352$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 93. Estimates of specific combining ability effects of Ear height (cm) over three years at Central location.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.7148	-5.0495	-5.7642
2	A641XW117Ht	EXE		0.8106	0.0958
3	A641XMs74	EXE		2.3006	1.5858
4	A641XW64A	EXM	-0.1276	-1.2300	-1.3576
5	A641XMs75	EXM		4.8800	4.7524
6	A641XA619	EXM		3.4833	3.3558
7	A641XA632	EXM		-2.6933	-2.8209
8	A641XB73Ht	EXL	0.6637	0.7288	1.3924
9	A641XMo17Ht	EXL		1.4421	2.1058
10	A641XB84	EXL		-3.2513	-2.5876
11	A641XPa872	EXL		-1.4213	-0.7576
12	Cm105XW117Ht	EXE		0.6772	-0.0376
13	Cm105XMs74	EXE		-1.2328	-1.9476
14	Cm105XW64A	EXM		4.0700	3.9424
15	Cm105XMs75	EXM		-2.5200	-2.6476
16	Cm105XA619	EXM		-4.9167	-5.0442
17	Cm105XA632	EXM		-3.8600	-3.9876
18	Cm105XB73Ht	EXL		0.7954	1.4591
19	Cm105XMo17Ht	EXL		-2.6913	-2.0276
20	Cm105XB84	EXL		7.4488*	8.1124*
21	Cm105XPa872	EXL		7.2788*	7.9424*
22	W117HtXMs74	EXE		2.4939	1.7791
23	W117HtXW64A	EXM		-4.1033	-4.2309
24	W117HtXMs75	EXM		-0.1600	-0.2876
25	W117HtXA619	EXM		1.0100	0.8824
26	W117HtXA632	EXM		7.2333*	7.1058*
27	W117HtXB73Ht	EXL		-3.2446	-2.5809
28	W117HtXMo17Ht	EXL		-5.0979	-4.4342
29	W117HtXB84	EXL		-2.1913	-1.5276
30	W117HtXPa872	EXL		2.5721	3.2358
31	Ms74XW64A	EXM		2.3533	2.2258
32	Ms74XMs75	EXM		0.0300	-0.0976
33	Ms74XA619	EXM		-1.9667	-2.0942
34	Ms74XA632	EXM		-1.6100	-1.7376
35	Ms74XB73Ht	EXL		0.7121	1.3758
36	Ms74XMo17Ht	EXL		-7.7413*	-7.0776*
37	Ms74XB84	EXL		1.4321	2.0958
38	Ms74XPa872	EXL		3.2288	3.8924
39	W64AXMs75	MXM	0.7513	-5.1922	-4.4409
40	W64AXA619	MXM		-0.2556	0.4958
41	W64AXA632	MXM		3.4678	4.2191

Table 93. Estimates of specific combining ability effects of Ear height (cm) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.4359	0.1017	-0.3342
43	W64AXMo17Ht	MXL		2.2817	1.8458
44	W64AXB84	MXL		-6.6783*	-7.1142*
45	W64AXPa872	MXL		5.1850	4.7491
46	Ms75XA619	MXM		2.9778	3.7291
47	Ms75XA632	MXM		-0.2550	-0.6909
48	Ms75XB73Ht	MXL		-3.6417	-4.0776
49	Ms75XMo17Ht	MXL		4.4650	4.0291
50	Ms75XB84	MXL		-3.4050	-3.8409
51	Ms75XPa872	MXL		-3.8189	-3.0676
52	A619XA632	MXM		5.7817	5.3458
53	A619XB73Ht	MXL		1.6283	1.1924
54	A619XMo17Ht	MXL		4.6683	4.2324
55	A619XB84	MXL		-8.4350*	-8.8709**
56	A619XPa872	MXL		-6.4950*	-6.9309*
57	A632XB73Ht	MXL		6.5517*	6.1158
58	A632XMo17Ht	MXL		0.0917	-0.3442
59	A632XB84	MXL		-1.8450	-2.2809
60	A632XPa872	MXL		7.8994*	7.5958*
61	B73HtXMo17Ht	LXL	-0.3037	-7.1606*	-7.4642*
62	B73HtXB84	LXL		1.1361	0.8324
63	B73HtXPa872	LXL		2.4194	2.1158
64	Mo17HtXB84	LXL		-3.0506	-3.3542
65	Mo17HtXPa872	LXL		-1.2439	-1.5476
66	B84XPa872		LXL		

$LSD_{0.05}(S_{ii}-S_{ij})=3.0621$, $LSD_{0.05}(S_{ii}-S_{jj})=2.6415$, $LSD_{0.05}(S_{ii}-S_{kl})=2.0355$, $LSD_{0.05}(S_{ij}-S_{ij'})=1.9812$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=9.7053$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=9.1505$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=8.7608$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=9.2096$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=8.6228$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=8.8211$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=9.5011$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=8.9333$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 94. Estimates of general combining ability effects of Plant stand (# of plants/ha) over three years at Central location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-1.2522**	-0.5033	-1.7556*
2 Cm105	"	2		2.5800**	1.3278
3 W117Ht	"	3		0.4567	-0.7956
4 Ms74	"	4		-2.5333**	-3.7856**
5 W64A	Medium	1	1.5119**	1.7425*	3.2544**
6 Ms75	"	2		1.4525	2.9644**
7 A619	"	3		-2.3542**	-0.8422
8 A632	"	4		-0.8408	0.6711
9 B73Ht	Late	1	-0.2597	2.1575**	1.8978*
10 Mo17Ht	"	2		-0.1625	-0.4222
11 B84	"	3		-1.3292	-1.5889
12 Pa872	"	4		-0.6658	-0.9256

$LSD_{0.05}(G_i-G_k)$=1.2426, $LSD_{0.05}(g_{ij}-g_{ij'})$=2.4851, $LSD_{0.05}(g_i-g_j)$=2.4851[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 95. Estimates of specific combining ability effects of Stand count (# of plants/ha) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
1	A641XCm105	EXE	-0.6718	-2.0267	-2.6985
2	A641XW117Ht	EXE		-0.2033	-0.8752
3	A641XMs74	EXE		-2.2800	-2.9518
4	A641XW64A	EXM	0.1182	1.3900	1.5082
5	A641XMs75	EXM		0.3800	0.4982
6	A641XA619	EXM		2.5200	2.6382
7	A641XA632	EXM		-1.0600	-0.9418
8	A641XB73Ht	EXL	0.3857	-0.1208	0.2648
9	A641XMo17Ht	EXL		4.4325	4.8182
10	A641XB84	EXL		-2.9342	-2.5485
11	A641XPa872	EXL		-0.0975	0.2882
12	Cm105XW117Ht	EXE		5.8467*	5.1748*
13	Cm105XMs74	EXE		-3.3300	-4.0018
14	Cm105XW64A	EXM		-2.3600	-2.2418
15	Cm105XMs75	EXM		-1.7700	-1.6518
16	Cm105XA619	EXM		-0.6633	-0.5452
17	Cm105XA632	EXM		-2.0767	-1.9585
18	Cm105XB73Ht	EXL		2.2625	2.6482
19	Cm105XMo17Ht	EXL		2.5825	2.9682
20	Cm105XB84	EXL		2.9825	3.3682
21	Cm105XPa872	EXL		-1.4475	-1.0618
22	W117HtXMs74	EXE		1.9933	1.3215
23	W117HtXW64A	EXM		-1.1033	-0.9852
24	W117HtXMs75	EXM		-1.2467	-1.1285
25	W117HtXA619	EXM		0.4600	0.5782
26	W117HtXA632	EXM		0.8467	0.9648
27	W117HtXB73Ht	EXL		-1.1475	-0.7618
28	W117HtXMo17Ht	EXL		-3.2608	-2.8752
29	W117HtXB84	EXL		-1.6942	-1.3085
30	W117HtXPa872	EXL		-0.4908	-0.1052
31	Ms74XW64A	EXM		0.1533	0.2715
32	Ms74XMs75	EXM		1.4100	1.5282
33	Ms74XA619	EXM		0.8167	0.9348
34	Ms74XA632	EXM		2.3033	2.4215
35	Ms74XB73Ht	EXL		-3.1575	-2.7718
36	Ms74XMo17Ht	EXL		-1.1708	-0.7852
37	Ms74XB84	EXL		-0.9375	-0.5518
38	Ms74XPa872	EXL		4.1992	4.5848
39	W64AXMs75	MXM	0.5832	-4.1283	-3.5452
40	W64AXA619	MXM		2.9783	3.5615
41	W64AXA632	MXM		0.4650	1.0482

Table 95. Estimates of specific combining ability effects of Stand count (# of plants/ha) over three years at Central location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.5556	-1.2896	-1.8452
43	W64AXMo17Ht	MXL		1.6638	1.1082
44	W64AXB84	MXL		1.1638	0.6082
45	W64AXPa872	MXL		1.0671	0.5115
46	Ms75XA619	MXM		0.8017	1.3848
47	Ms75XA632	MXM		-1.5783	-0.9952
48	Ms75XB73Ht	MXL		-1.5996	-2.1552
49	Ms75XMo17Ht	MXL		1.3538	0.7982
50	Ms75XB84	MXL		3.6871	3.1315
51	Ms75XPa872	MXL		2.6904	2.1348
52	A619XA632	MXM		1.4617	2.0448
53	A619XB73Ht	MXL		-0.7263	-1.2818
54	A619XMo17Ht	MXL		-1.4729	-2.0285
55	A619XB84	MXL		0.1938	-0.3618
56	A619XPa872	MXL		-6.3696*	-6.9252**
57	A632XB73Ht	MXL		3.7604	3.2048
58	A632XMo17Ht	MXL		-3.8196	-4.3752
59	A632XB84	MXL		1.4471	0.8915
60	A632XPa872	MXL		-1.7496	-2.3052
61	B73HtXMo17Ht	LXL	0.2265	0.3717	0.5982
62	B73HtXB84	LXL		-0.3617	-0.1352
63	B73HtXPa872	LXL		2.0083	2.2348
64	Mo17HtXB84	LXL		-2.2083	-1.9818
65	Mo17HtXPa872	LXL		1.5283	1.7548
66	B84XPa872	LXL		-1.3383	-1.1118

$LSD_{0.05}(S_{ii}-S_{ij})=0.1234$, $LSD_{0.05}(S_{ii}-S_{jj})=0.1234$, $LSD_{0.05}(S_{ii}-S_{kl})=0.1234$,
$LSD_{0.05}(S_{ij}-S_{ij'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=0.1234$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=0.1234$,
$LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=0.1234$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=0.1234$,
$LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=0.1234$,

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 96. Estimates of general combining ability effects of Grain yield (t/ha) over three years at Northern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-0.6106**	0.4933	-0.1172
2 Cm105	"	2		0.0600	-0.5506*
3 W117Ht	"	3		0.2667	-0.3439
4 Ms74	"	4		-0.8200**	-1.4306**
5 W64A	Medium	1	0.1878	0.5250*	0.7128**
6 Ms75	"	2		-0.3917	-0.2039
7 A619	"	3		-0.3650	-0.1772
8 A632	"	4		0.2317	0.4194
9 B73Ht	Late	1	0.4228**	-0.0233	0.3994
10 Mo17Ht	"	2		0.3733	0.7961**
11 B84	"	3		-0.4633*	-0.0406
12 Pa872	"	4		0.1133	0.5361*

$LSD_{0.05}(G_i-G_k)=0.3565$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.7130$, $LSD_{0.05}(g_i-g_j)=0.7130$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 97. Estimates of specific combining ability effects of Grain yield (t/ha) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.7117**	-0.2422	-0.9539
2	A641XW117Ht	EXE		0.5511	-0.1606
3	A641XMs74	EXE		-0.2956	-1.0073
4	A641XW64A	EXM	-0.2823	-0.9683	-1.2506
5	A641XMs75	EXM		0.9817	0.6994
6	A641XA619	EXM		1.0217	0.7394
7	A641XA632	EXM		-1.7750*	-2.0573**
8	A641XB73Ht	EXL	0.8161**	0.3467	1.1627
9	A641XMo17Ht	EXL		-0.2500	0.5661
10	A641XB84	EXL		0.1533	0.9694
11	A641XPa872	EXL		0.4767	1.2927
12	Cm105XW117Ht	EXE		0.7844	0.0727
13	Cm105XMs74	EXE		0.1044	-0.6073
14	Cm105XW64A	EXM		1.2983	1.0161
15	Cm105XMs75	EXM		0.9150	0.6327
16	Cm105XA619	EXM		-0.4783	-0.7606
17	Cm105XA632	EXM		-1.6417*	-1.9239**
18	Cm105XB73Ht	EXL		0.1467	0.9627
19	Cm105XMo17Ht	EXL		0.2500	1.0661
20	Cm105XB84	EXL		0.2533	0.0694
21	Cm105XPa872	EXL		-1.3900	-0.5739
22	W117HtXMs74	EXE		-0.9022	-1.6139*
23	W117HtXW64A	EXM		0.2583	-0.0239
24	W117HtXMs75	EXM		-0.9583	-1.2406
25	W117HtXA619	EXM		-0.3850	-0.6673
26	W117HtXA632	EXM		1.0183	0.7361
27	W117HtXB73Ht	EXL		-0.6933	0.1227
28	W117HtXMo17Ht	EXL		-0.2900	0.5261
29	W117HtXB84	EXL		1.5467*	2.3627**
30	W117HtXPa872	EXL		-0.9300	-0.1139
31	Ms74XW64A	EXM		0.1783	-0.1039
32	Ms74XMs75	EXM		-0.9383	-1.2206
33	Ms74XA619	EXM		0.4017	0.1194
34	Ms74XA632	EXM		1.0717	0.7894
35	Ms74XB73Ht	EXL		0.1600	0.9761
36	Ms74XMo17Ht	EXL		-0.6367	0.1794
37	Ms74XB84	EXL		1.0667	1.8827**
38	Ms74XPa872	EXL		-0.2100	0.6061
39	W64AXMs75	MXM	0.2972	-1.7944**	-1.4973*
40	W64AXA619	MXM		-0.0544	0.2427
41	W64AXA632	MXM		0.9489	1.2461

Table 97. Estimates of specific combining ability effects of Grain yield (t/ha) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.0594	0.0733	0.1327
43	W64AXMo17Ht	MXL		-1.1567	-1.0973
44	W64AXB84	MXL		-0.1867	-0.1273
45	W64AXPa872	MXL		1.4033	1.4627*
46	Ms75XA619	MXM		-0.3378	-0.0406
47	Ms75XA632	MXM		-0.2678	0.0294
48	Ms75XB73Ht	MXL		-0.0433	0.0161
49	Ms75XMo17Ht	MXL		-0.1067	-0.0473
50	Ms75XB84	MXL		1.3967	1.4561*
51	Ms75XPa872	MXL		1.1533	1.2127
52	A619XA632	MXM		1.5056*	1.8027*
53	A619XB73Ht	MXL		0.3300	0.3894
54	A619XMo17Ht	MXL		0.6667	0.7261
55	A619XB84	MXL		-0.4300	-0.3706
56	A619XPa872	MXL		-2.2400**	-2.1806**
57	A632XB73Ht	MXL		-0.6333	-0.5739
58	A632XMo17Ht	MXL		0.3700	0.4294
59	A632XB84	MXL		-1.0600	-1.0006
60	A632XPa872	MXL		0.4633	0.5227
61	B73HtXMo17Ht	LXL	-1.1673**	0.9500	-0.2173
62	B73HtXB84	LXL		-1.8133**	-2.9806**
63	B73HtXPa872	LXL		1.1767	0.0094
64	Mo17HtXB84	LXL		-0.4100	-1.5773*
65	Mo17HtXPa872	LXL		0.6133	-0.5539
66	B84XPa872	LXL		-0.5167	-1.6839*

$LSD_{0.05}(S_{ii}-S_{ij})=0.6748$, $LSD_{0.05}(S_{ii}-S_{jj})=0.5823$, $LSD_{0.05}(S_{ii}-S_{kl})=0.4486$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.4367$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=2.1393$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=2.0168$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.9310$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=2.0300$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.9006$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.9663$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=2.0943$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.9690$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 98. Estimates of general combining ability effects of Stalk lodging (%) over three years at Northern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	2.6294**	-0.7767	1.8528
2 Cm105	"	2		-3.4433**	-0.8139
3 W117Ht	"	3		-0.6200	2.0094
4 Ms74	"	4		4.8400**	7.4694**
5 W64A	Medium	1	-0.8364	0.6158	-0.2206
6 Ms75	"	2		0.8258	-0.0106
7 A619	"	3		-0.9475	-1.7839
8 A632	"	4		-0.4942	-1.3306
9 B73Ht	Late	1	-1.7931**	-0.3108	-2.1039
10 Mo17Ht	"	2		-1.2842	-3.0772**
11 B84	"	3		1.7725	-0.0206
12 Pa872	"	4		-0.1775	-1.9706

$LSD_{0.05}(G_i - G_k) = 1.6295$, $LSD_{0.05}(g_{ij} - g_{ij'}) = 3.2591$, $LSD_{0.05}(g_i - g_j) = 3.2591$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 99. Estimates of Specific Combining Ability effects of Stalk lodging (%) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	2.0325	1.2978	3.3303
2	A641XW117Ht	EXE		-4.9256	-2.8930
3	A641XMs74	EXE		10.6144**	12.6470**
4	A641XW64A	EXM	0.6053	1.0983	1.7036
5	A641XMs75	EXM		-3.7450	-3.1397
6	A641XA619	EXM		-3.6050	-2.9997
7	A641XA632	EXM		-0.1583	0.4470
8	A641XB73Ht	EXL	-2.1297**	0.0167	-2.1130
9	A641XMo17Ht	EXL		-0.5100	-2.6397
10	A641XB84	EXL		-0.7667	-2.8964
11	A641XPa872	EXL		0.6833	-1.4464
12	Cm105XW117Ht	EXE		-4.3589	-2.3264
13	Cm105XMs74	EXE		0.4811	2.5136
14	Cm105XW64A	EXM		1.3317	1.9370
15	Cm105XMs75	EXM		-2.2117	-1.6064
16	Cm105XA619	EXM		-0.4717	0.1336
17	Cm105XA632	EXM		-0.3583	0.2470
18	Cm105XB73Ht	EXL		-0.4167	-2.5464
19	Cm105XMo17Ht	EXL		1.6567	-0.4730
20	Cm105XB84	EXL		1.3333	-0.7964
21	Cm105XPa872	EXL		1.7167	-0.4130
22	W117HtXMs74	EXE		-3.1089	-1.0764
23	W117HtXW64A	EXM		1.1083	1.7136
24	W117HtXMs75	EXM		5.7317	6.3370
25	W117HtXA619	EXM		4.8050	5.4103
26	W117HtXA632	EXM		-2.7483	-2.1430
27	W117HtXB73Ht	EXL		-0.5733	-2.7030
28	W117HtXMo17Ht	EXL		-0.7333	-2.8630
29	W117HtXB84	EXL		-0.9233	-3.0530
30	W117HtXPa872	EXL		5.7267	3.5970
31	Ms74XW64A	EXM		0.0817	0.6870
32	Ms74XMs75	EXM		-0.2283	0.3770
33	Ms74XA619	EXM		2.1117	2.7170
34	Ms74XA632	EXM		-2.7417	-2.1364
35	Ms74XB73Ht	EXL		-2.6000	-4.7297
36	Ms74XMo17Ht	EXL		-4.6933	-6.8230*
37	Ms74XB84	EXL		-3.6500	-5.7797
38	Ms74XPa872	EXL		3.7333	1.6036
39	W64AXMs75	MXM	-0.6358	-2.4306	-3.0664
40	W64AXA619	MXM		-1.3239	-1.9597
41	W64AXA632	MXM		1.6894	1.0536

Table 99. Estimates of Specific Combining Ability effects of Stalk lodging (%) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.1284	0.4221	0.2936
43	W64AXMo17Ht	MXL		0.8288	0.7003
44	W64AXB84	MXL		-0.9946	-1.1230
45	W64AXPa872	MXL		-1.8112	-1.9397
46	Ms75XA619	MXM		-1.7672	-2.4030
47	Ms75XA632	MXM		4.8461	4.2103
48	Ms75XB73Ht	MXL		-0.9213	-2.0497
49	Ms75XMo17Ht	MXL		2.6188	2.4903
50	Ms75XB84	MXL		-0.1046	-0.2330
51	Ms75XPa872	MXL		-1.7879	-1.9164
52	A619XA632	MXM		-1.0139	-1.6497
53	A619XB73Ht	MXL		0.1521	0.0236
54	A619XMo17Ht	MXL		0.3254	0.1970
55	A619XB84	MXL		-0.0313	-0.1597
56	A619XPa872	MXL		0.8187	0.6903
57	A632XB73Ht	MXL		-1.4013	-1.5297
58	A632XMo17Ht	MXL		3.9054	3.7770
59	A632XB84	MXL		0.0821	-0.0464
60	A632XPa872	MXL		-2.1013	-2.2297
61	B73HtXMo17Ht	LXL	3.0109**	-2.0606	0.9503
62	B73HtXB84	LXL		9.7161**	12.7270**
63	B73HtXPa872	LXL		-2.3339	0.6770
64	Mo17HtXB84	LXL		-0.6772	2.3336
65	Mo17HtXPa872	LXL		-0.6606	2.3503
66	B84XPa872	LXL		-3.9839	-0.9730

$LSD_{0.05}(S_{ii}-S_{ij})=3.0846$, $LSD_{0.05}(S_{ii}-S_{jj})=2.6609$, $LSD_{0.05}(S_{ii}-S_{kl})=2.0504$, $LSD_{0.05}(S_{ij}-S_{ij'})=1.9957$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=9.7771$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=9.2179$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=8.8255$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=9.2779$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=8.6865$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=8.9870$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=9.5713$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=8.9993$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 100. Estimates of general combining ability effects of Root lodging (%) over three years at Northern location.

Parent		Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1	A641	Early	1	0.1886	-0.2125	-0.0239
2	Cm105	"	2		-0.8958**	-0.7072
3	W117Ht	"	3		-0.3325	-0.1439
4	Ms74	"	4		1.4408**	1.6294**
5	W64A	Medium	1	0.0211	-0.1083	-0.0872
6	Ms75	"	2		0.8750**	0.8961*
7	A619	"	3		-0.2317	-0.2106
8	A632	"	4		-0.5350	-0.5139
9	B73Ht	Late	1	-0.2097	0.2192	0.0094
10	Mo17Ht	"	2		-0.1108	-0.3206
11	B84	"	3		-0.2442	-0.4539
12	Pa872	"	4		0.1358	-0.0739

$LSD_{0.05}(G_i-G_k)=0.5184$, $LSD_{0.05}(g_{ij}-g_{ij'})=1.0366$, $LSD_{0.05}(g_i-g_j)=1.0366$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 101. Estimates of Specific Combining Ability effects of Root lodging (%) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.5030	0.5972	0.0942
2	A641XW117Ht	EXE		-0.1994	-0.7024
3	A641XMs74	EXE		-0.9061	-1.4091
4	A641XW64A	EXM	0.2617	-0.7875	-0.5258
5	A641XMs75	EXM		-1.2042	-0.9424
6	A641XA619	EXM		-0.8975	-0.6358
7	A641XA632	EXM		0.3391	0.6008
8	A641XB73Ht	EXL	0.1155	3.9288	4.0442
9	A641XMo17Ht	EXL		-0.1413	-0.0258
10	A641XB84	EXL		0.1588	0.2742
11	A641XPa872	EXL		-0.8879	-0.7724
12	Cm105XW117Ht	EXE		0.4839	-0.0191
13	Cm105XMs74	EXE		-0.9561	-1.4591
14	Cm105XW64A	EXM		-0.3375	-0.0758
15	Cm105XMs75	EXM		-1.3208	-1.0591
16	Cm105XA619	EXM		-0.2142	0.0476
17	Cm105XA632	EXM		0.0892	0.3509
18	Cm105XB73Ht	EXL		-0.2879	-0.1724
19	Cm105XMo17Ht	EXL		1.1421	1.2576
20	Cm105XB84	EXL		0.7421	0.8576
21	Cm105XPa872	EXL		0.0621	0.1776
22	W117HtXMs74	EXE		0.9806	0.4776
23	W117HtXW64A	EXM		0.0992	0.3609
24	W117HtXMs75	EXM		-0.8842	-0.6224
25	W117HtXA619	EXM		0.4558	0.7176
26	W117HtXA632	EXM		-0.2408	0.0209
27	W117HtXB73Ht	EXL		-0.6513	-0.5358
28	W117HtXMo17Ht	EXL		-0.5213	-0.4058
29	W117HtXB84	EXL		-0.3879	-0.2724
30	W117HtXPa872	EXL		0.8654	0.9809
31	Ms74XW64A	EXM		1.6592	1.9209
32	Ms74XMs75	EXM		3.4425**	3.7042**
33	Ms74XA619	EXM		-0.6508	-0.3891
34	Ms74XA632	EXM		0.4526	0.7143
35	Ms74XB73Ht	EXL		-2.0579*	-1.9424
36	Ms74XMo17Ht	EXL		-1.6613	-1.5458
37	Ms74XB84	EXL		-1.1613	-1.0458
38	Ms74XPa872	EXL		0.8587	0.9742
39	W64AXMs75	MXM	-0.2846	-1.1944	-1.4791
40	W64AXA619	MXM		0.2122	-0.0724
41	W64AXA632	MXM		0.3489	0.0642

Table 101. Estimates of Specific Combining Ability effects of Root lodging (%) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.0483	-0.0775	-0.1258
43	W64AXMo17Ht	MXL		0.1525	0.1042
44	W64AXB84	MXL		-0.2808	-0.3291
45	W64AXPa872	MXL		0.2058	0.1576
46	Ms75XA619	MXM		1.2289	0.9442
47	Ms75XA632	MXM		-0.7678	-1.0524
48	Ms75XB73Ht	MXL		1.1392	1.0909
49	Ms75XMo17Ht	MXL		0.1692	0.1209
50	Ms75XB84	MXL		0.2692	0.2209
51	Ms75XPa872	MXL		-0.8775	-0.9258
52	A619XA632	MXM		0.1722	-0.1124
53	A619XB73Ht	MXL		-0.6208	-0.6691
54	A619XMo17Ht	MXL		0.0425	-0.0058
55	A619XB84	MXL		0.4092	0.3609
56	A619XPa872	MXL		-0.1375	-0.1858
57	A632XB73Ht	MXL		-0.3175	-0.3658
58	A632XMo17Ht	MXL		0.0125	-0.0358
59	A632XB84	MXL		0.1458	0.0976
60	A632XPa872	MXL		-0.2342	-0.2824
61	B73HtXMo17Ht	LXL	-0.0896	-0.2694	-0.3591
62	B73HtXB84	LXL		-0.3361	-0.4258
63	B73HtXPa872	LXL		-0.4494	-0.5391
64	Mo17HtXB84	LXL		0.4606	0.3709
65	Mo17HtXPa872	LXL		0.6139	0.5242
66	B84XPa872	LXL		-0.0194	-0.1091

$LSD_{0.05}(S_{ii}-S_{ij})=0.9812$, $LSD_{0.05}(S_{ii}-S_{jj})=0.8463$, $LSD_{0.05}(S_{ii}-S_{kl})=0.6523$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.6348$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=3.1099$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=2.9322$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.8073$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=2.9512$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=2.7630$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.8587$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=3.0445$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=2.8626$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 102. Estimates of general combining ability effects of Moisture content (%) over three years at Northern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-2.4811**	-1.2517**	-3.7328**
2 Cm105	"	2		0.7750*	-1.7061**
3 W117Ht	"	3		0.5350	-1.9461**
4 Ms74	"	4		-0.0583	-2.5394**
5 W64A	Medium	1	0.0414	-0.5475	-0.5061
6 Ms75	"	2		-1.1575**	-1.1161**
7 A619	"	3		3.2425**	3.2839**
8 A632	"	4		-1.5375**	-1.4961**
9 B73Ht	Late	1	2.4397**	1.1475**	3.5872**
10 Mo17Ht	"	2		-0.7692*	1.6706**
11 B84	"	3		1.8342**	4.2739**
12 Pa872	"	4		-2.2125**	0.2272

$LSD_{0.05}(G_i-G_k)=0.6129$, $LSD_{0.05}(g_{ij}-g_{ij'})=1.2260$, $LSD_{0.05}(g_i-g_j)=1.2260$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 103. Estimates of Specific Combining Ability effects of Moisture content (%) over three years at Northern location.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	1.0743**	-0.4289	0.6455
2	A641XW117Ht	EXE		-0.6556	0.4188
3	A641XMs74	EXE		1.6711	2.7455*
4	A641XW64A	EXM	0.2421	1.8033	2.0455
5	A641XMs75	EXM		0.3467	0.5888
6	A641XA619	EXM		-2.2867	-2.0445
7	A641XA632	EXM		1.3933	1.6355
8	A641XB73Ht	EXL	-1.0479**	-0.2667	-1.3145
9	A641XMo17Ht	EXL		-1.2833	-2.3312
10	A641XB84	EXL		-1.9200	-2.9679*
11	A641XPa872	EXL		1.6267	0.5788
12	Cm105XW117Ht	EXE		0.6511	1.7255
13	Cm105XMs74	EXE		-1.3556	-0.2812
14	Cm105XW64A	EXM		0.0433	0.2855
15	Cm105XMs75	EXM		0.6200	0.8621
16	Cm105XA619	EXM		-0.5467	-0.3045
17	Cm105XA632	EXM		-0.1333	0.1088
18	Cm105XB73Ht	EXL		-0.9600	-2.0079
19	Cm105XMo17Ht	EXL		1.0233	-0.0245
20	Cm105XB84	EXL		0.3867	-0.6612
21	Cm105XPa872	EXL		0.7000	-0.3479
22	W117HtXMs74	EXE		0.1178	1.1921
23	W117HtXW64A	EXM		0.0167	0.2588
24	W117HtXMs75	EXM		0.8933	1.1355
25	W117HtXA619	EXM		-0.5733	-0.3312
26	W117HtXA632	EXM		-1.4933	-1.2512
27	W117HtXB73Ht	EXL		0.0800	-0.9679
28	W117HtXMo17Ht	EXL		1.0967	0.0488
29	W117HtXB84	EXL		-0.2067	-1.2545
30	W117HtXPa872	EXL		0.0733	-0.9745
31	Ms74XW64A	EXM		0.0100	0.2521
32	Ms74XMs75	EXM		1.1200	1.3621
33	Ms74XA619	EXM		-0.8133	-0.5712
34	Ms74XA632	EXM		-0.4000	-0.1579
35	Ms74XB73Ht	EXL		-0.7267	-1.7745
36	Ms74XMo17Ht	EXL		-0.0100	-1.0579
37	Ms74XB84	EXL		-0.6467	-1.6945
38	Ms74XPa872	EXL		1.0333	-0.0145
39	W64AXMs75	MXM	-0.1373	-0.2339	-0.3712
40	W64AXA619	MXM		0.4661	0.3288
41	W64AXA632	MXM		-0.3206	-0.4579

Table 103. Estimates of specific combining ability effects of Moisture content (%) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	-0.1391	-0.3354	-0.4745
43	W64AXMo17Ht	MXL		1.1146	0.9755
44	W64AXB84	MXL		-2.2221	-2.3612
45	W64AXPa872	MXL		-0.3421	-0.4812
46	Ms75XA619	MXM		-0.3906	-0.5279
47	Ms75XA632	MXM		1.0228	0.8855
48	Ms75XB73Ht	MXL		-0.2254	-0.3645
49	Ms75XMo17Ht	MXL		-0.5088	-0.6479
50	Ms75XB84	MXL		-2.8788*	-3.0179*
51	Ms75XPa872	MXL		0.2346	0.0955
52	A619XA632	MXM		-0.5439	-0.6812
53	A619XB73Ht	MXL		3.2079**	3.0688*
54	A619XMo17Ht	MXL		-0.9088	-1.0479
55	A619XB84	MXL		3.8213**	3.6821**
56	A619XPa872	MXL		-1.4321	-1.5712
57	A632XB73Ht	MXL		-0.1454	-0.2845
58	A632XMo17Ht	MXL		1.4379	1.2988
59	A632XB84	MXL		-1.1654	-1.3045
60	A632XPa872	MXL		0.3479	0.2088
61	B73HtXMo17Ht	LXL	1.5827**	-0.6339	0.9488
62	B73HtXB84	LXL		2.5294*	4.1121**
63	B73HtXPa872	LXL		2.5239*	-0.9412
64	Mo17HtXB84	LXL		0.3461	1.9288
65	Mo17HtXPa872	LXL		-1.6739	-0.0912
66	B84XPa872	LXL		1.9561	3.5388**

$LSD_{0.05}(S_{ii}-S_{ij})=1.1603$, $LSD_{0.05}(S_{ii}-S_{jj})=1.0010$, $LSD_{0.05}(S_{ii}-S_{kl})=0.7713$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.7507$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=3.6777$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=3.4674$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=3.3198$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=3.4900$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=3.2675$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=3.3806$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=3.6003$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=3.3851$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 104. Estimates of general combining ability effects of Plant height (cm) over three years at Northern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-9.6433**	-2.3750	-12.0183**
2 Cm105	"	2		4.0883*	-5.5550**
3 W117Ht	"	3		2.5317	-7.1117**
4 Ms74	"	4		-4.2450*	-12.8883**
5 W64A	Medium	1	0.0583	-2.1467	-2.0883
6 Ms75	"	2		4.7167**	4.7750*
7 A619	"	3		-12.0933**	-12.0350**
8 A632	"	4		9.5233**	9.5817**
9 B73Ht	Late	1	0.8032**	0.4100	9.9950**
10 Mo17Ht	"	2		3.7200*	13.3050**
11 B84	"	3		2.9533	12.5383**
12 Pa872	"	4		-7.0833**	2.5017

$LSD_{0.05}(G_i-G_k)$=2.7268, $LSD_{0.05}(g_{ij}-g_{ij'})$=5.4533, $LSD_{0.05}(g_i-g_j)$=5.4533[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 105. Estimates of specific combining ability effects of Plant height (cm) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-1.5502	11.7644*	10.2142
2	A641XW117Ht	EXE		1.6878	0.1376
3	A641XMs74	EXE		-2.6689	-4.2191
4	A641XW64A	EXM	-2.0970	-3.1888	-5.2858
5	A641XMs75	EXM		3.3813	1.2842
6	A641XA619	EXM		-9.1754	-11.2724*
7	A641XA632	EXM		-8.2921	-10.3891
8	A641XB73Ht	EXL	3.2597	2.9713	6.2309
9	A641XMo17Ht	EXL		5.7613	9.0209
10	A641XB84	EXL		-0.4388	2.8209
11	A641XPa872	EXL		-1.8021	1.4576
12	Cm105XW117Ht	EXE		5.1578	3.6076
13	Cm105XMs74	EXE		-11.1322*	-12.6824*
14	Cm105XW64A	EXM		8.5146	6.4176
15	Cm105XMs75	EXM		-3.0488	-5.1458
16	Cm105XA619	EXM		1.6946	-0.4024
17	Cm105XA632	EXM		-9.3554	-11.4524*
18	Cm105XB73Ht	EXL		0.1413	3.4009
19	Cm105XMo17Ht	EXL		-3.1354	0.1242
20	Cm105XB84	EXL		2.2646	5.5242
21	Cm105XPa872	EXL		-2.8654	0.3942
22	W117HtXMs74	EXE		-4.8089	-6.3591
23	W117HtXW64A	EXM		-5.2621	-7.3591
24	W117HtXMs75	EXM		-4.4921	-6.5891
25	W117HtXA619	EXM		8.8513	6.7542
26	W117HtXA632	EXM		7.1679	5.0709
27	W117HtXB73Ht	EXL		0.8313	4.0909
28	W117HtXMo17Ht	EXL		-12.4121*	-9.1524
29	W117HtXB84	EXL		3.8879	7.1476
30	W117HtXPa872	EXL		-0.6088	2.6509
31	Ms74XW64A	EXM		-5.8854	-7.9824
32	Ms74XMs75	EXM		-0.1154	-2.2124
33	Ms74XA619	EXM		11.3946*	9.2976
34	Ms74XA632	EXM		7.8113	5.7142
35	Ms74XB73Ht	EXL		-1.1921	2.0676
36	Ms74XMo17Ht	EXL		-7.7354	-4.4758
37	Ms74XB84	EXL		10.5646*	13.8242*
38	Ms74XPa872	EXL		3.7679	7.0276
39	W64AXMs75	MXM	0.4576	-6.4033	-5.9458
40	W64AXA619	MXM		-2.3600	-1.9024
41	W64AXA632	MXM		9.3567	9.8142

Table 105. Estimates of specific combining ability effects of Plant height (cm) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	1.7538	-3.5529	-1.7991
43	W64AXMo17Ht	MXL		6.2038	7.9576
44	W64AXB84	MXL		-2.5296	-0.7758
45	W64AXPa872	MXL		5.1071	6.8609
46	Ms75XA619	MXM		1.8100	2.2676
47	Ms75XA632	MXM		5.1600	5.6176
48	Ms75XB73Ht	MXL		8.6171	10.3709
49	Ms75XMo17Ht	MXL		-13.0596*	-11.3058*
50	Ms75XB84	MXL		3.1738	4.9276
51	Ms75XPa872	MXL		4.9771	6.7309
52	A619XA632	MXM		-7.5633	-7.1058
53	A619XB73Ht	MXL		6.4271	8.1809
54	A619XMo17Ht	MXL		-6.9496	-5.1958
55	A619XB84	MXL		11.3171*	13.0709*
56	A619XPa872	MXL		-15.4462**	-13.6924*
57	A632XB73Ht	MXL		-6.2896	-4.5358
58	A632XMo17Ht	MXL		10.9004*	12.6542*
59	A632XB84	MXL		-5.2996	-3.5458
60	A632XPa872	MXL		-3.5963	-1.8424
61	B73HtXMo17Ht	LXL	-6.6846**	5.5589	-1.1258
62	B73HtXB84	LXL		-21.4411**	-28.1258**
63	B73HtXPa872	LXL		7.9289	1.2442
64	Mo17HtXB84	LXL		5.4156	-1.2691
65	Mo17HtXPa872	LXL		9.4522	2.7676
66	B84XPa872	LXL		-6.9144	-13.5991*

$LSD_{0.05}(S_{ii}-S_{ij})$=5.1615, $LSD_{0.05}(S_{ii}-S_{jj})$=4.4527, $LSD_{0.05}(S_{ii}-S_{kl})$=3.4310, $LSD_{0.05}(S_{ij}-S_{ij'})$=3.3394, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=16.3601, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=15.4244, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=14.7678, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})$=15.5246, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=14.5352, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=15.0379, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=16.0156, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})$=15.0585.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 106. Estimates of general combining ability effects of Ear height (cm) over three years at Northern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-7.9431**	1.1692	-6.7739**
2 Cm105	"	2		1.2125	-6.7306**
3 W117Ht	"	3		3.3125*	-4.6306**
4 Ms74	"	4		-5.6942**	-13.6372**
5 W64A	Medium	1	-0.5381	4.3008**	3.7628*
6 Ms75	"	2		3.7542**	3.2161
7 A619	"	3		-16.7025**	-17.2406**
8 A632	"	4		8.6475**	8.1094**
9 B73Ht	Late	1	8.4811**	1.0583	9.5394**
10 Mo17Ht	"	2		6.0417**	14.5228**
11 B84	"	3		6.5950**	15.0761**
12 Pa872	"	4		-13.6950**	-5.2139**

$LSD_{0.05}(G_i-G_k)=2.4231$, $LSD_{0.05}(g_{ij}-g_{ij'})=4.8461$, $LSD_{0.05}(g_i-g_j)=4.8461$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 107. Estimates of specific combining ability effects of Ear height (cm) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.6790	4.4739	3.7948
2	A641XW117Ht	EXE		6.4739	5.7948
3	A641XMs74	EXE		-2.4528	-3.1318
4	A641XW64A	EXM	-0.4347	-3.0638	-3.4985
5	A641XMs75	EXM		2.7496	2.3148
6	A641XA619	EXM		-2.9938	-3.4285
7	A641XA632	EXM		-7.0104	-7.4452
8	A641XB73Ht	EXL	0.9440	4.7475	5.6915
9	A641XMo17Ht	EXL		-2.7358	-1.7918
10	A641XB84	EXL		0.6775	1.6215
11	A641XPa872	EXL		-0.8658	0.0782
12	Cm105XW117Ht	EXE		0.5306	-0.1485
13	Cm105XMs74	EXE		-8.1628	-8.8418
14	Cm105XW64A	EXM		2.6263	2.1915
15	Cm105XMs75	EXM		-3.1604	-3.5952
16	Cm105XA619	EXM		-5.4704	-5.9052
17	Cm105XA632	EXM		15.1796**	14.7448**
18	Cm105XB73Ht	EXL		-1.9958	-1.0518
19	Cm105XMo17Ht	EXL		0.3208	1.2648
20	Cm105XB84	EXL		-2.6658	-1.7218
21	Cm105XPa872	EXL		-1.6758	-0.7318
22	W117HtXMs74	EXE		-0.8628	-1.5418
23	W117HtXW64A	EXM		-5.7404	-6.1752
24	W117HtXMs75	EXM		-3.9271	-4.3618
25	W117HtXA619	EXM		0.3629	-0.0718
26	W117HtXA632	EXM		1.6796	1.2448
27	W117HtXB73Ht	EXL		-0.1958	0.7482
28	W117HtXMo17Ht	EXL		-0.4125	0.5315
29	W117HtXB84	EXL		2.6008	3.5448
30	W117HtXPa872	EXL		-0.5092	0.4348
31	Ms74XW64A	EXM		-4.7004	-5.1352
32	Ms74XMs75	EXM		0.0204	-0.4552
33	Ms74XA619	EXM		16.4029**	15.9682**
34	Ms74XA632	EXM		-2.9137	-3.3485
35	Ms74XB73Ht	EXL		0.0442	0.9882
36	Ms74XMo17Ht	EXL		-2.3725	-1.4285
37	Ms74XB84	EXL		4.0075	4.9515
38	Ms74XPa872	EXL		1.0308	1.9748
39	W64AXMs75	MXM	-0.3224	-1.0994	-1.4218
40	W64AXA619	MXM		-4.4428	-4.7652
41	W64AXA632	MXM		5.3739	5.0515

Table 107. Estimates of specific combining ability effects of Ear height (cm) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.6765	2.8783	3.5548
43	W64AXMo17Ht	MXL		4.9617	5.6382
44	W64AXB84	MXL		0.5750	1.2515
45	W64AXPa872	MXL		2.6317	3.3082
46	Ms75XA619	MXM		0.2039	-0.1185
47	Ms75XA632	MXM		5.3872	5.0648
48	Ms75XB73Ht	MXL		8.5583	9.2348
49	Ms75XMo17Ht	MXL		-12.0583*	-11.3818*
50	Ms75XB84	MXL		2.6217	3.2982
51	Ms75XPa872	MXL		0.7450	1.4215
52	A619XA632	MXM		-5.4228	-5.7452
53	A619XB73Ht	MXL		6.2483	6.9248
54	A619XMo17Ht	MXL		-5.3017	-4.6252
55	A619XB84	MXL		8.8783	9.5548
56	A619XPa872	MXL		-8.4650	-7.7885
57	A632XB73Ht	MXL		-11.4683*	-10.7918*
58	A632XMo17Ht	MXL		9.4483	10.1248*
59	A632XB84	MXL		-4.9383	-4.2618
60	A632XPa872	MXL		-5.3150	-4.6385
61	B73HtXMo17Ht	LXL	-0.1607	4.1222	1.9615
62	B73HtXB84	LXL		-19.3311**	-21.4918**
63	B73HtXPa872	LXL		6.3922	4.2315
64	Mo17HtXB84	LXL		2.7856	0.6248
65	Mo17HtXPa872	LXL		1.2422	-0.9185
66	B84XPa872	LXL		4.7889	2.6282

$LSD_{0.05}(S_{ii}-S_{ij})=4.5868$, $LSD_{0.05}(S_{ii}-S_{jj})=3.9568$, $LSD_{0.05}(S_{ii}-S_{kl})=3.0490$, $LSD_{0.05}(S_{ij}-S_{ij'})=2.9676$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=14.5385$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=13.7071$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=13.1236$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=13.7960$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=12.9168$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=13.3637$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=14.2323$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=13.3819$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 108. Estimates of general combining ability effects of Stand count (# of plants/ha) over three years at Northern location.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-1.1725**	-0.2258	-1.3983
2 Cm105	"	2		3.1208**	1.9483
3 W117Ht	"	3		1.1142	-0.0583
4 Ms74	"	4		-4.0092**	-5.1817**
5 W64A	Medium	1	1.6558**	1.0125	2.6683**
6 Ms75	"	2		-0.7442	0.9117
7 A619	"	3		-1.1408	0.5150
8 A632	"	4		0.8725	2.5283*
9 B73Ht	Late	1	-0.4833	-0.0683	-0.5517
10 Mo17Ht	"	2		0.4950	0.0117
11 B84	"	3		-0.4717	-0.9550
12 Pa872	"	4		0.0450	-0.4383

$LSD_{0.05}(G_i-G_k)=1.4833$, $LSD_{0.05}(g_{ij}-g_{ij'})=2.9667$, $LSD_{0.05}(g_i-g_j)=2.9667$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 109. Estimates of Specific Combining Ability effects of Stand count (# of plants/ha) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.0831	-1.4339	-1.5170
2	A641XW117Ht	EXE		2.7728	2.6897
3	A641XMs74	EXE		-6.0706*	-6.1536*
4	A641XW64A	EXM	-0.7507	1.7404	0.9897
5	A641XMs75	EXM		1.3971	0.6464
6	A641XA619	EXM		4.7271	3.9764
7	A641XA632	EXM		-2.5196	-3.2703
8	A641XB73Ht	EXL	0.8130	-0.9767	-0.1636
9	A641XMo17Ht	EXL		-2.9067	-2.0936
10	A641XB84	EXL		0.4933	1.3064
11	A641XPa872	EXL		2.7767	3.5897
12	Cm105XW117Ht	EXE		4.6594	4.5764
13	Cm105XMs74	EXE		2.7828	2.6997
14	Cm105XW64A	EXM		-0.3063	-1.0570
15	Cm105XMs75	EXM		0.9838	0.2330
16	Cm105XA619	EXM		0.7471	-0.0036
17	Cm105XA632	EXM		-2.5329	-3.2836
18	Cm105XB73Ht	EXL		-1.5233	-0.7103
19	Cm105XMo17Ht	EXL		-0.5200	0.2930
20	Cm105XB84	EXL		0.9133	1.7264
21	Cm105XPa872	EXL		-3.7700	-2.9570
22	W117HtXMs74	EXE		-2.7106	-2.7936
23	W117HtXW64A	EXM		-1.2663	-2.0170
24	W117HtXMs75	EXM		-3.2096	-3.9603
25	W117HtXA619	EXM		0.6871	-0.0636
26	W117HtXA632	EXM		3.7738	3.0230
27	W117HtXB73Ht	EXL		-2.0167	-1.2036
28	W117HtXMo17Ht	EXL		1.4867	2.2997
29	W117HtXB84	EXL		-0.1800	0.6330
30	W117HtXPa872	EXL		-3.9967	-3.1836
31	Ms74XW64A	EXM		2.2571	1.5064
32	Ms74XMs75	EXM		-2.9529	-3.7036
33	Ms74XA619	EXM		-8.0229**	-8.7736**
34	Ms74XA632	EXM		4.4971	3.7464
35	Ms74XB73Ht	EXL		0.2400	1.0530
36	Ms74XMo17Ht	EXL		1.2100	2.0230
37	Ms74XB84	EXL		1.9767	2.7897
38	Ms74XPa872	EXL		6.7933*	7.6064*
39	W64AXMs75	MXM	0.7247	-2.4183	-1.6936
40	W64AXA619	MXM		3.0783	3.8030
41	W64AXA632	MXM		-0.8683	-0.1436

Table 109. Estimates of Specific Combining Ability effects of Stand count (# of plants/ha) over three years at Northern location.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXL	0.2072	-2.7775	-2.5703
43	W64AXMo17Ht	MXL		0.7258	0.9330
44	W64AXB84	MXL		-1.1742	-0.9670
45	W64AXPa872	MXL		1.0092	1.2164
46	Ms75XA619	MXM		-0.1317	0.5930
47	Ms75XA632	MXM		-2.0783	-1.3536
48	Ms75XB73Ht	MXL		3.7458	3.9530
49	Ms75XMo17Ht	MXL		-1.5175	-1.3103
50	Ms75XB84	MXL		3.6158	3.8230
51	Ms75XPa872	MXL		2.5658	2.7730
52	A619XA632	MXM		2.4183	3.1430
53	A619XB73Ht	MXL		-2.4242	-2.2170
54	A619XMo17Ht	MXL		2.6792	2.8864
55	A619XB84	MXL		3.0792	3.2864
56	A619XPa872	MXL		-6.8375*	-6.6303*
57	A632XB73Ht	MXL		-1.4375	-1.2303
58	A632XMo17Ht	MXL		-2.1342	-1.9270
59	A632XB84	MXL		-0.6675	-0.4603
60	A632XPa872	MXL		1.5492	1.7564
61	B73HtXMo17Ht	LXL	-1.3603	4.4067	3.0464
62	B73HtXB84	LXL		0.3067	-1.0536
63	B73HtXPa872	LXL		2.4567	1.0964
64	Mo17HtXB84	LXL		-4.6233	-5.9836
65	Mo17HtXPa872	LXL		1.1933	-0.1670
66	B84XPa872	LXL		-3.7400	-5.1003

$LSD_{0.05}(S_{ii}-S_{ij})=0.1234$, $LSD_{0.05}(S_{ii}-S_{jj})=0.1234$, $LSD_{0.05}(S_{ii}-S_{kl})=0.1234$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=8.9000$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=8.3910$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=8.0338$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=8.4454$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=7.9072$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=8.1808$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=8.7126$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=8.1920$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 110. Estimates of general combining ability effects of Grain yield (t/ha) in 1989, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-0.9022**	0.4817**	-0.4206**
2 Cm105	"	2		0.6050**	-0.2972*
3 W117Ht	"	3		0.6283**	-0.2739
4 Ms74	"	4		-1.7150**	-2.6172**
5 W64A	Medium	1	-0.2497**	0.6092**	0.3594*
6 Ms75	"	2		-0.3675**	-0.6172**
7 A619	"	3		-0.6908**	-0.9406**
8 A632	"	4		0.4492**	0.1994
9 B73Ht	Late	1	1.1519**	0.4908**	1.6428**
10 Mo17Ht	"	2		0.5808**	1.7328**
11 B84	"	3		-0.3692**	0.7828**
12 Pa872	"	4		-0.7025**	0.4494**

$LSD_{0.05}(G_i-G_k)=0.2125$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.4249$, $LSD_{0.05}(g_i-g_j)=0.4249$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 111. Estimates of specific combining ability effects of Grain yield (t/ha) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.8991**	-1.3867**	-2.2858**
2	A641XW117Ht	EXE		0.2567	-0.6424
3	A641XMs74	EXE		0.3000	-0.5991
4	A641XW64A	EXM	-0.3099**	-0.2325	-0.5424
5	A641XMs75	EXM		-0.1225	-0.4324
6	A641XA619	EXM		0.5675	0.2576
7	A641XA632	EXM		-0.0392	-0.3491
8	A641XB73Ht	EXL	0.9842**	-0.3433	0.6409
9	A641XMo17Ht	EXL		1.1000*	2.0842**
10	A641XB84	EXL		-0.1833	0.8009
11	A641XPa872	EXL		0.0833	1.0676*
12	Cm105XW117Ht	EXE		0.9000*	0.0009
13	Cm105XMs74	EXE		0.9100*	0.0109
14	Cm105XW64A	EXM		1.1108**	0.8009
15	Cm105XMs75	EXM		1.1208**	0.8109
16	Cm105XA619	EXM		-0.1558	-0.4658
17	Cm105XA632	EXM		-0.8292	-1.1391**
18	Cm105XB73Ht	EXL		-0.4333	0.5509
19	Cm105XMo17Ht	EXM		0.0767	1.0609*
20	Cm105XB84	EXM		-0.2733	0.7109
21	Cm105XPa872	EXL		-1.0400*	-0.0558
22	W117HtXMs74	EXL		-0.9800*	-1.8791**
23	W117HtXW64A	EXL		0.1208	-0.1891
24	W117HtXMs75	EXL		-0.8025	-1.1124*
25	W117HtXA619	EXE		-1.0125*	-1.3224**
26	W117HtXA632	EXM		0.0808	-0.2291
27	W117HtXB73Ht	EXM		0.9767*	1.9609**
28	W117HtXMo17Ht	EXM		-0.3467	0.6376
29	W117HtXB84	EXM		0.9367*	1.9209**
30	W117HtXPa872	EXL		-0.1300	0.8542
31	Ms74XW64A	EXL		0.0975	-0.2124
32	Ms74XMs75	EXL		-0.9925*	-1.3024**
33	Ms74XA619	EXL		0.0975	-0.2124
34	Ms74XA632	EXM		0.9908*	0.6809
35	Ms74XB73Ht	EXM		0.6200	1.6042**
36	Ms74XMo17Ht	EXM		-0.8367	0.1476
37	Ms74XB84	EXM		1.0467*	2.0309**
38	Ms74XPa872	EXL		-1.2533**	-0.2691
39	W64AXMs75	EXL		-3.1194**	-2.6791**
40	W64AXA619	EXL		0.2372	0.6776
41	W64AXA632	EXL		0.7639	1.2042**
42	W64AXB73Ht	MXM	0.4404**	0.1813	0.1609

Table 111. Estimates of specific combining ability effects of Grain yield (t/ha) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		-0.3754	-0.3958
44	W64AXB84	MXM		0.2746	0.2542
45	W64AXPa872	MXL	-0.0203	0.9413*	0.9209*
46	Ms75XA619	MXL		1.3139**	1.7542**
47	Ms75XA632	MXL		-0.9928*	-0.5524
48	Ms75XB73Ht	MXL		1.2246**	1.2042**
49	Ms75XMo17Ht	MXM		1.0346*	1.0142*
50	Ms75XB84	MXM		1.3513**	1.3309**
51	Ms75XPa872	MXL		-0.0154	-0.0358
52	A619XA632	MXL		1.7972**	2.2376**
53	A619XB73Ht	MXL		0.6479	0.6276
54	A619XMo17Ht	MXL		-1.7088**	-1.7291**
55	A619XB84	MXM		-0.0588	-0.0791
56	A619XPa872	MXL		-1.7254**	-1.7458**
57	A632XB73Ht	MXL		-0.9921*	-1.0124*
58	A632XMo17Ht	MXL		0.6513	0.6309
59	A632XB84	MXL		-1.4321**	-1.4524**
60	A632XPa872	MXL		0.0012	-0.0191
61	B73HtXMo17Ht	MXL		-0.1606	-1.4458**
62	B73HtXB84	MXL		-3.3439**	-4.6291**
63	B73HtXPa872	MXL		1.6228**	0.3376
64	Mo17HtXB84	LXL	-1.2852**	0.3661	-0.9191*
65	Mo17HtXPa872	LXL		0.1994	-1.0858*
66	B84XPa872	LXL		1.3161**	0.0309

$LSD_{0.05}(S_{ii}-S_{ij})=0.4022$, $LSD_{0.05}(S_{ii}-S_{jj})=0.3471$, $LSD_{0.05}(S_{ii}-S_{kl})=0.2673$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.2603$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.2750$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.2021$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.1509$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=1.2099$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.1329$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.1721$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.2481$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=1.1736$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 112. Estimates of general combining ability effects of Stalk lodging (%) in 1989, over three locations .

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	2.4653**	-2.6858**	-0.2206
2 Cm105	"	2		-2.2492**	0.2161
3 W117Ht	"	3		-0.8525	1.6128*
4 Ms74	"	4		5.7875**	8.2528**
5 W64A	Medium	1	-0.1939	-0.6867	-0.8806
6 Ms75	"	2		1.6533*	1.4594
7 A619	"	3		-0.0667	-0.2606
8 A632	"	4		-0.9000	-1.0939
9 B73Ht	Late	1	-2.2714**	-0.8492	-3.1206**
10 Mo17Ht	"	2		-0.3858	-2.6572**
11 B84	"	3		0.0275	-2.2439**
12 Pa872	"	4		1.2075	-1.0639

$LSD_{0.05}(G_i-G_k)=1.0788$, $LSD_{0.05}(g_{ij}-g_{ij'})=2.1578$, $LSD_{0.05}(g_i-g_j)=2.1578$[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 113. Estimates of Specific Combining Ability effects of Stalk lodging (%) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.9790	3.0072	2.0282
2	A641XW117Ht	EXE		-1.1561	-2.1352
3	A641XMs74	EXE		4.9706*	3.9915
4	A641XW64A	EXM	1.0628*	-1.1713	-0.1085
5	A641XMs75	EXM		-3.9446	-2.8818
6	A641XA619	EXM		-2.8246	-1.7618
7	A641XA632	EXM		-2.5579	-1.4952
8	A641XB73Ht	EXL	-0.3285	0.8933	0.5648
9	A641XMo17Ht	EXL		0.7300	0.4015
10	A641XB84	EXL		3.3500	3.0215
11	A641XPa872	EXL		-1.2967	-1.6252
12	Cm105XW117Ht	EXE		-1.1928	-2.1718
13	Cm105XMs74	EXE		0.4006	-0.5785
14	Cm105XW64A	EXM		-2.7079	-1.6452
15	Cm105XMs75	EXM		0.3188	1.3815
16	Cm105XA619	EXM		-1.1946	-0.1318
17	Cm105XA632	EXM		0.8388	1.9015
18	Cm105XB73Ht	EXL		-0.5767	-0.9052
19	Cm105XMo17Ht	EXM		0.2933	-0.0352
20	Cm105XB84	EXM		0.3467	0.0182
21	Cm105XPa872	EXL		0.4667	0.1382
22	W117HtXMs74	EXL		-6.0294**	-7.0085**
23	W117HtXW64A	EXL		1.7288	2.7915
24	W117HtXMs75	EXL		4.6888*	5.7515**
25	W117HtXA619	EXE		2.1754	3.2382
26	W117HtXA632	EXM		-0.5579	0.5048
27	W117HtXB73Ht	EXM		-0.6067	-0.9352
28	W117HtXMo17Ht	EXM		-0.0033	-0.3318
29	W117HtXB84	EXM		-1.6833	-2.0118
30	W117HtXPa872	EXL		2.6367	2.3082
31	Ms74XW64A	EXL		0.0221	1.0848
32	Ms74XMs75	EXL		1.8488	2.9115
33	Ms74XA619	EXL		5.4354*	6.4982**
34	Ms74XA632	EXM		-2.0979	-1.0352
35	Ms74XB73Ht	EXM		-0.6467	-0.9752
36	Ms74XMo17Ht	EXM		-4.6767*	-5.0052*
37	Ms74XB84	EXM		-0.3900	-0.7185
38	Ms74XPa872	EXL		1.1633	0.8348
39	W64AXMs75	EXL		1.6167	1.2115
40	W64AXA619	EXL		-1.3633	-1.7685
41	W64AXA632	EXL		1.6033	1.1982

Table 113. Estimates of Specific Combining Ability effects of Stalk lodging (%) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXM	-0.4052	1.1838	0.4248
43	W64AXMo17Ht	MXM		-0.4796	-1.2385
44	W64AXB84	MXM		0.1071	-0.6518
45	W64AXPa872	MXL	-0.7589	-0.5396	-1.2985
46	Ms75XA619	MXL		-1.7033	-2.1085
47	Ms75XA632	MXL		-0.0367	-0.4418
48	Ms75XB73Ht	MXL		-0.7229	-1.4818
49	Ms75XMo17Ht	MXM		-0.9196	-1.6785
50	Ms75XB84	MXM		-0.4663	-1.2252
51	Ms75XPa872	MXL		-0.6796	-1.4385
52	A619XA632	MXL		-0.1167	-0.5218
53	A619XB73Ht	MXL		-0.0696	-0.8285
54	A619XMo17Ht	MXL		0.4671	-0.2918
55	A619XB84	MXM		-0.5129	-1.2718
56	A619XPa872	MXL		-0.2929	-1.0518
57	A632XB73Ht	MXL		0.7304	-0.0285
58	A632XMo17Ht	MXL		1.1671	0.4082
59	A632XB84	MXL		0.5871	-0.1718
60	A632XPa872	MXL		0.4404	-0.3185
61	B73HtXMo17Ht	MXL		1.2183	2.6682
62	B73HtXB84	MXL		0.0383	1.4882
63	B73HtXPa872	MXL		-1.4417	0.0082
64	Mo17HtXB84	LXL	1.4498 *	0.6417	2.0915
65	Mo17HtXPa872	LXL		1.5617	3.0115
66	B84XPa872	LXL		-2.0183	-0.5685

$LSD_{0.05}(S_{ii}-S_{ij})=2.0423$, $LSD_{0.05}(S_{ii}-S_{jj})=1.7618$, $LSD_{0.05}(S_{ii}-S_{kl})=1.3575$,
$LSD_{0.05}(S_{ij}-S_{ij'})=1.3212$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=6.4731$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=6.1029$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.8432$,
$LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=6.1426$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=5.7510$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.9500$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=6.3369$,
$LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=5.9582$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 114. Estimates of general combining ability effects of Root lodging (%) in 1989, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	1.5964**	0.3458	1.9422**
2 Cm105	"	2		-3.1642**	-1.5678**
3 W117Ht	"	3		-1.4008**	0.1956
4 Ms74	"	4		4.2192**	5.8156**
5 W64A	Medium	1	-0.7036**	0.0692	-0.6344
6 Ms75	"	2		0.4392	-0.2644
7 A619	"	3		-0.1342	-0.8378
8 A632	"	4		-0.3742	-1.0778
9 B73Ht	Late	1	-0.8928**	-0.5650	-1.4578*
10 Mo17Ht	"	2		-0.5183	-1.4111*
11 B84	"	3		1.3150*	0.4222
12 Pa872	"	4		-0.2317	-1.1244

$LSD_{0.05}(G_i-G_k)=0.8350$, $LSD_{0.05}(g_{ij}-g_{ij'})=1.6697$, $LSD_{0.05}(g_i-g_j)=1.6697$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 115. Estimates of Specific Combining Ability effects of Root lodging (%) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.1820	1.6517	1.8336
2	A641XW117Ht	EXE		3.9217*	4.1036*
3	A641XMs74	EXE		0.7350	0.9170
4	A641XW64A	EXM	0.1320	-2.3650	-2.2330
5	A641XMs75	EXM		-0.7350	-0.6030
6	A641XA619	EXM		-0.5617	-0.4297
7	A641XA632	EXM		-3.3550*	-3.2230
8	A641XB73Ht	EXL	-0.2684	1.8254	1.5570
9	A641XMo17Ht	EXL		-1.2546	-1.5230
10	A641XB84	EXL		1.1788	0.9103
11	A641XPa872	EXL		-1.0413	-1.3097
12	Cm105XW117Ht	EXE		-0.7350	-0.5530
13	Cm105XMs74	EXE		-3.7883*	-3.6064*
14	Cm105XW64A	EXM		0.4450	0.5770
15	Cm105XMs75	EXM		-1.1250	-0.9930
16	Cm105XA619	EXM		1.0483	1.1803
17	Cm105XA632	EXM		0.1883	0.3203
18	Cm105XB73Ht	EXL		0.2021	-0.0664
19	Cm105XMo17Ht	EXM		2.1554	1.8870
20	Cm105XB84	EXM		-0.4446	-0.7130
21	Cm105XPa872	EXL		0.4021	0.1336
22	W117HtXMs74	EXL		-1.7850	-1.6030
23	W117HtXW64A	EXL		-1.2183	-1.0864
24	W117HtXMs75	EXL		-1.2883	-1.1564
25	W117HtXA619	EXE		2.7183	2.8503
26	W117HtXA632	EXM		-0.3417	-0.2097
27	W117HtXB73Ht	EXM		0.2388	-0.0297
28	W117HtXMo17Ht	EXM		-0.4746	-0.7430
29	W117HtXB84	EXM		-1.9746	-2.2430
30	W117HtXPa872	EXL		0.9388	0.6703
31	Ms74XW64A	EXL		4.6950**	4.8270**
32	Ms74XMs75	EXL		2.4583	2.5903
33	Ms74XA619	EXL		-1.9350	-1.8030
34	Ms74XA632	EXM		1.3717	1.5036
35	Ms74XB73Ht	EXM		-4.0479*	-4.3164*
36	Ms74XMo17Ht	EXM		0.4721	0.2036
37	Ms74XB84	EXM		0.6721	0.4036
38	Ms74XPa872	EXL		1.1521	0.8836
39	W64AXMs75	EXL		-0.9028	-1.1264
40	W64AXA619	EXL		-0.0294	-0.2530
41	W64AXA632	EXL		0.4106	0.1870
42	W64AXB73Ht	MXM	-0.2236	-0.5021	-0.4664

Table 115. Estimates of Specific Combining Ability effects of Root lodging (%) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		-0.6154	-0.5797
44	W64AXB84	MXM		0.5179	0.5536
45	W64AXPa872	MXL	0.0357	-0.4354	-0.3997
46	Ms75XA619	MXL		-0.1661	-0.3897
47	Ms75XA632	MXL		1.6406	1.4170
48	Ms75XB73Ht	MXL		0.1613	0.1970
49	Ms75XMo17Ht	MXM		-1.0188	-0.9830
50	Ms75XB84	MXM		1.3813	1.4170
51	Ms75XPa872	MXL		-0.4054	-0.3697
52	A619XA632	MXL		-0.9528	-1.1764
53	A619XB73Ht	MXL		0.8013	0.8370
54	A619XMo17Ht	MXL		0.4879	0.5236
55	A619XB84	MXM		-0.7788	-0.7430
56	A619XPa872	MXL		-0.6321	-0.5964
57	A632XB73Ht	MXL		-0.3588	-0.3230
58	A632XMo17Ht	MXL		1.1279	1.1636
59	A632XB84	MXL		-0.3721	-0.3364
60	A632XPa872	MXL		0.6412	0.6770
61	B73HtXMo17Ht	MXL		-0.0667	0.2436
62	B73HtXB84	MXL		1.3667	1.6770
63	B73HtXPa872	MXL		0.3800	0.6903
64	Mo17HtXB84	LXL	0.3103	-0.6800	-0.3697
65	Mo17HtXPa872	LXL		-0.1333	0.1770
66	B84XPa872	LXL		-0.8667	-0.5564

$LSD_{0.05}(S_{ii}-S_{ij})=1.5803$, $LSD_{0.05}(S_{ii}-S_{jj})=1.3634$, $LSD_{0.05}(S_{ii}-S_{kl})=1.0506$,
$LSD_{0.05}(S_{ij}-S_{ij'})=1.0225$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=5.0094$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=4.7228$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=4.5217$,
$LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=4.7536$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=4.4506$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=4.6046$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=4.9039$,
$LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=4.6109$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 116. Estimates of general combining ability effects of Moisture content(%) in 1989, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-2.3578**	-1.0333**	-3.3911**
2 Cm105	"	2		0.8667**	-1.4911**
3 W117Ht	"	3		0.1367	-2.2211**
4 Ms74	"	4		0.0300	-2.3278**
5 W64A	Medium	1	0.0131	-0.0775	-0.0644
6 Ms75	"	2		-1.5975**	-1.5844**
7 A619	"	3		3.2458**	3.2589**
8 A632	"	4		-1.5708**	-1.5578**
9 B73Ht	Late	1	2.3447**	1.4475**	3.7922**
10 Mo17Ht	"	2		-1.2625**	1.0822**
11 B84	"	3		1.8142**	4.1589**
12 Pa872	"	4		-1.9992**	0.3456*

$LSD_{0.05}(G_i-G_k)=0.2056$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.4114$, $LSD_{0.05}(g_i-g_j)=0.4114$. [1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 117. Estimates of Specific Combining Ability effects of Moisture content (%) in1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	1.2741**	-0.8111*	0.4630
2	A641XW117Ht	EXE		-0.3478	0.9264*
3	A641XMs74	EXE		-0.2744	0.9997*
4	A641XW64A	EXM	0.2297**	1.6733**	1.9030**
5	A641XMs75	EXM		1.4933**	1.7230**
6	A641XA619	EXM		-2.0167**	-1.7870**
7	A641XA632	EXM		0.3667	0.5964
8	A641XB73Ht	EXL	-1.1853**	-0.6017	-1.7870**
9	A641XMo17Ht	EXL		0.0417	-1.1436**
10	A641XB84	EXL		-1.5017**	-2.6870**
11	A641XPa872	EXL		1.9783**	0.7930
12	Cm105XW117Ht	EXE		0.1522	1.4264**
13	Cm105XMs74	EXE		-0.8078*	0.4664
14	Cm105XW64A	EXM		0.3067	0.5364
15	Cm105XMs75	EXM		0.1267	0.3564
16	Cm105XA619	EXM		-0.2167	0.0130
17	Cm105XA632	EXM		-0.2333	-0.0036
18	Cm105XB73Ht	EXL		-0.4683	-1.6536**
19	Cm105XMo17Ht	EXM		0.7083	-0.4770
20	Cm105XB84	EXM		1.3317**	0.1464
21	Cm105XPa872	EXL		-0.0883	-1.2736**
22	W117HtXMs74	EXL		2.0889**	3.3630**
23	W117HtXW64A	EXL		-0.0967	0.1330
24	W117HtXMs75	EXL		0.2900	0.5196
25	W117HtXA619	EXE		-1.8867**	-1.6570**
26	W117HtXA632	EXM		0.0633	0.2930
27	W117HtXB73Ht	EXM		0.5283	-0.6570
28	W117HtXMo17Ht	EXM		0.3050	0.8803*
29	W117HtXB84	EXM		-1.4383**	-2.6236**
30	W117HtXPa872	EXL		0.3417	-0.8436*
31	Ms74XW64A	EXL		-0.3233	-0.0936
32	Ms74XMs75	EXL		1.0967**	1.3264**
33	Ms74XA619	EXL		-0.9800*	-0.7503
34	Ms74XA632	EXM		0.3367	0.5664
35	Ms74XB73Ht	EXM		-1.4983**	-2.6836**
36	Ms74XMo17Ht	EXM		-0.1550	-1.3403**
37	Ms74XB84	EXM		-0.7317	-1.9170**
38	Ms74XPa872	EXL		1.2418**	0.0630
39	W64AXMs75	EXL		1.2639	1.4630**
40	W64AXA619	EXL		-0.3794	-0.1803
41	W64AXA632	EXL		-0.0294	0.1697
42	W64AXB73Ht	MXM	0.1991	-1.3679**	-1.7470**

Table 117. Estimates of specific combining ability effects of Moisture content (%) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		1.3088**	0.9297*
44	W64AXB84	MXM		-2.7346**	-3.1136**
45	W64AXPa872	MXL	-0.3791**	0.3787	-0.0003
46	Ms75XA619	MXL		-0.1261	0.0730
47	Ms75XA632	MXL		-0.0094	0.1897
48	Ms75XB73Ht	MXL		-0.9479*	-1.3270**
49	Ms75XMo17Ht	MXM		0.3288	-0.0503
50	Ms75XB84	MXM		-2.9813**	-3.3603**
51	Ms75XPa872	MXL		-0.5346	-0.9136*
52	A619XA632	MXL		-0.7194	-0.5203
53	A619XB73Ht	MXL		3.2421**	2.8630**
54	A619XMo17Ht	MXL		-0.2479	-0.6270
55	A619XB84	MXM		4.9421**	4.5630**
56	A619XPa872	MXL		-1.6112**	-1.9903**
57	A632XB73Ht	MXL		-0.0746	-0.4536
58	A632XMo17Ht	MXL		0.7688	0.3897
59	A632XB84	MXL		-1.6079**	-1.9870**
60	A632XPa872	MXL		1.1387**	0.7597
61	B73HtXMo17Ht	MXL		-0.1461	1.9397**
62	B73HtXB84	MXL		3.3439**	5.4297**
63	B73HtXPa872	MXL		-2.0094**	0.0764
64	Mo17HtXB84	LXL	2.0858**	-0.3461	1.7397**
65	Mo17HtXPa872	LXL		-2.5661**	-0.4803
66	B84XPa872	LXL		1.7239**	3.8097**

$LSD_{0.05}(S_{ii}-S_{ij})=0.3893$, $LSD_{0.05}(S_{ii}-S_{jj})=0.3359$, $LSD_{0.05}(S_{ii}-S_{kl})=0.2587$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.2519$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.2340$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.1635$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.1139$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=1.1709$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.0964$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.1343$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.2079$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=1.1358$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 118. Estimates of general combining ability effects of Plant height (cm) in 1989, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-8.7439**	-4.0133**	-12.7572**
2 Cm105	"	2		7.2900**	-1.4539
3 W117Ht	"	3		0.0533	-8.6906**
4 Ms74	"	4		-3.3300**	-12.0739**
5 W64A	Medium	1	-2.4931**	-2.1842*	-4.6772**
6 Ms75	"	2		1.8392	-0.6539
7 A619	"	3		-8.7575**	-11.2506**
8 A632	"	4		9.1025**	6.6094**
9 B73Ht	Late	1	11.2369**	3.6625**	14.8994**
10 Mo17Ht	"	2		0.5725	11.8094**
11 B84	"	3		6.0092**	17.2461**
12 Pa872	"	4		-10.2442**	0.9928

$LSD_{0.05}(G_i-G_k)$=1.7003, $LSD_{0.05}(g_{ij}-g_{ij'})$=3.7232, $LSD_{0.05}(g_i-g_j)$=3.7232.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 119. Estimates of specific combining ability effects of Plant height (cm) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.9445	-4.9267	-5.8712
2	A641XW117Ht	EXE		-0.8567	-0.8012
3	A641XMs74	EXE		3.2267	2.2821
4	A641XW64A	EXM	-1.0329	-1.2483	-2.2812
5	A641XMs75	EXM		-4.7717	-5.8045
6	A641XA619	EXM		1.6583	0.6255
7	A641XA632	EXM		-4.3350	-5.3679
8	A641XB73Ht	EXL	1.7413*	0.9008	2.6421
9	A641XMo17Ht	EXL		8.9242**	10.6655**
10	A641XB84	EXL		0.6542	2.3955
11	A641XPa872	EXL		0.7742	2.5155
12	Cm105XW117Ht	EXE		2.7400	1.7955
13	Cm105XMs74	EXE		-0.6100	-1.5545
14	Cm105XW64A	EXM		6.3817	5.3488
15	Cm105XMs75	EXM		2.1250	1.0921
16	Cm105XA619	EXM		-3.5450	-4.5779
17	Cm105XA632	EXM		-2.8383	-3.8712
18	Cm105XB73Ht	EXL		1.7308	3.4721
19	Cm105XMo17Ht	EXM		2.3875	4.1288
20	Cm105XB84	EXM		-2.7492	-1.0079
21	Cm105XPa872	EXL		-0.6958	1.0455
22	W117HtXMs74	EXL		0.4267	-0.5179
23	W117HtXW64A	EXL		-1.2150	-2.2479
24	W117HtXMs75	EXL		-5.2383	-6.2712
25	W117HtXA619	EXE		9.4583**	8.4255*
26	W117HtXA632	EXM		8.6983*	7.6655*
27	W117HtXB73Ht	EXM		3.2008	4.9421
28	W117HtXMo17Ht	EXM		-11.1425**	-9.4012**
29	W117HtXB84	EXM		-4.8125	-3.0712
30	W117HtXPa872	EXL		-1.2592	0.4821
31	Ms74XW64A	EXL		-2.4983	-3.5312
32	Ms74XMs75	EXL		-6.4883	-7.5213*
33	Ms74XA619	EXL		1.0083	-0.0245
34	Ms74XA632	EXM		2.8483	1.8155
35	Ms74XB73Ht	EXM		-0.2492	1.4921
36	Ms74XMo17Ht	EXM		-9.6925**	-7.9512*
37	Ms74XB84	EXM		7.4042*	9.1455**
38	Ms74XPa872	EXL		4.6242	6.3655
39	W64AXMs75	EXL		-5.9661	-4.9845
40	W64AXA619	EXL		-7.4694*	-6.4879
41	W64AXA632	EXL		6.4039	7.3855*
42	W64AXB73Ht	MXM	0.9816	-3.8679	-3.5712

Table 119. Estimates of specific combining ability effects of Plant height (cm) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		6.2554	6.5521
44	W64AXB84	MXM		-4.5146	-4.2179
45	W64AXPa872	MXL	0.2967	7.7387*	8.0355*
46	Ms75XA619	MXL		3.4072	4.3888
47	Ms75XA632	MXL		-2.2194	-1.2379
48	Ms75XB73Ht	MXL		12.1754**	12.4721**
49	Ms75XMo17Ht	MXM		-7.1346*	-6.8379
50	Ms75XB84	MXM		12.8621**	13.1588**
51	Ms75XPa872	MXL		1.2487	1.5455
52	A619XA632	MXL		5.8439	6.8255
53	A619XB73Ht	MXL		0.6054	0.9021
54	A619XMo17Ht	MXL		2.6621	2.9588
55	A619XB84	MXM		11.9588**	12.2555**
56	A619XPa872	MXL		-25.5879**	-25.2912**
57	A632XB73Ht	MXL		-10.8213**	-10.5245**
58	A632XMo17Ht	MXL		3.2021	3.4988
59	A632XB84	MXL		-5.4679	-5.1712
60	A632XPa872	MXL		-1.3146	-1.0179
61	B73HtXMo17Ht	MXL		0.8928	-1.8245
62	B73HtXB84	MXL		-16.2772**	-18.9945**
63	B73HtXPa872	MXL		11.7094**	8.9921*
64	Mo17HtXB84	LXL	-2.7173*	0.9128	-1.8045
65	Mo17HtXPa872	LXL		2.7328	0.0155
66	B84XPa872	LXL		0.0294	-2.6879

$LSD_{0.05}(S_{ii}-S_{ij})=3.2187$, $LSD_{0.05}(S_{ii}-S_{jj})=2.7767$, $LSD_{0.05}(S_{ii}-S_{kl})=2.1395$,
$LSD_{0.05}(S_{ij}-S_{ij'})=2.0825$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=10.2022$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=9.6187$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=9.2093$,
$LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=9.6812$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=9.0642$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=9.3778$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=9.9874$,
$LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=9.3906$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 120. Estimates of general combining ability effects of Ear height (cm) in 1989, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-6.5919**	1.1242	-5.4676**
2 Cm105	"	2		4.2575**	-2.3344
3 W117Ht	"	3		1.4808	-5.1111**
4 Ms74	"	4		-6.8625**	-13.4544**
5 W64A	Medium	1	-2.3669**	4.4692**	2.1022
6 Ms75	"	2		2.3892	0.0222
7 A619	"	3		-15.3742**	-17.7411**
8 A632	"	4		8.5158**	6.1489**
9 B73Ht	Late	1	8.9589**	1.4733	10.4322**
10 Mo17Ht	"	2		4.1367**	13.0956**
11 B84	"	3		8.2967**	17.2556**
12 Pa872	"	4		-13.9067**	-4.9478**

$LSD_{0.05}(G_i-G_k)=1.9835$, $LSD_{0.05}(g_{ij}-g_{ij'})=3.9668$, $LSD_{0.05}(g_i-g_j)=3.9668$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 121. Estimates of specific combining ability effects of Ear height (cm) in 1989, over three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-1.5656	-7.6150*	-9.1806*
2	A641XW117Ht	EXE		2.2950	0.7294
3	A641XMs74	EXE		4.0717	2.5061
4	A641XW64A	EXM	0.1281	-4.1121	-3.9839
5	A641XMs75	EXM		3.9679	4.0961
6	A641XA619	EXM		1.0646	1.1927
7	A641XA632	EXM		-3.7588	-3.6306
8	A641XB73Ht	EXL	1.0461	0.9067	1.9527
9	A641XMo17Ht	EXL		-0.2900	0.7561
10	A641XB84	EXL		2.3833	3.4294
11	A641XPa872	EXL		1.0867	2.1327
12	Cm105XW117Ht	EXE		-1.6383	-3.2039
13	Cm105XMs74	EXE		0.0050	-1.5606
14	Cm105XW64A	EXM		3.3213	3.4494
15	Cm105XMs75	EXM		-2.9321	-2.8039
16	Cm105XA619	EXM		-5.4021	-5.2739
17	Cm105XA632	EXM		16.1413**	16.2694**
18	Cm105XB73Ht	EXL		-2.7600	-1.7139
19	Cm105XMo17Ht	EXM		-3.5233	-2.4773
20	Cm105XB84	EXM		-2.4167	-1.3706
21	Cm105XPa872	EXL		6.8200	7.8661
22	W117HtXMs74	EXL		2.8817	1.3161
23	W117HtXW64A	EXL		-2.1354	-2.0073
24	W117HtXMs75	EXL		-1.4554	-1.3273
25	W117HtXA619	EXE		2.1413	2.2694
26	W117HtXA632	EXM		-1.7821	-1.6539
27	W117HtXB73Ht	EXM		2.9500	3.9961
28	W117HtXMo17Ht	EXM		-2.4133	-1.3673
29	W117HtXB84	EXM		2.6933	3.7394
30	W117HtXPa872	EXL		-3.5367	-2.4906
31	Ms74XW64A	EXL		-4.4921	-4.3639
32	Ms74XMs75	EXL		-5.1121	-4.9839
33	Ms74XA619	EXL		4.6179	4.7461
34	Ms74XA632	EXM		-0.0721	0.0561
35	Ms74XB73Ht	EXM		-0.2067	0.8394
36	Ms74XMo17Ht	EXM		-7.2700	-6.2239
37	Ms74XB84	EXM		2.1367	3.1827
38	Ms74XPa872	EXL		3.4400	4.4861
39	W64AXMs75	EXL		-4.4750	-5.1406
40	W64AXA619	EXL		-5.8783	-6.5439
41	W64AXA632	EXL		5.8983	5.2327
42	W64AXB73Ht	MXM	-0.6656	0.9783	1.3494

Table 121. Estimates of specific combining ability effects of Ear height (cm) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		9.0150*	9.3861*
44	W64AXB84	MXM		-6.3783	-6.0073
45	W64AXPa872	MXL	0.3711	8.2583*	8.6294*
46	Ms75XA619	MXL		2.7017	2.0361
47	Ms75XA632	MXL		1.4783	0.8127
48	Ms75XB73Ht	MXL		8.3917*	8.7627*
49	Ms75XMo17Ht	MXM		-5.9717	-5.6006
50	Ms75XB84	MXM		9.1683*	9.5394*
51	Ms75XPa872	MXL		-5.7617	-5.3906
52	A619XA632	MXL		0.2750	-0.3906
53	A619XB73Ht	MXL		2.8883	3.2594
54	A619XMo17Ht	MXL		1.9917	2.3627
55	A619XB84	MXM		6.9983	7.3694
56	A619XPa872	MXL		-11.3983**	-11.0273**
57	A632XB73Ht	MXL		-10.6350**	-10.2639*
58	A632XMo17Ht	MXL		2.3017	2.6727
59	A632XB84	MXL		-4.6250	-4.2539
60	A632XPa872	MXL		-5.2217	-4.8506
61	B73HtXMo17Ht	MXL		6.9786	5.0894
62	B73HtXB84	MXL		-13.9811**	-15.8706**
63	B73HtXPa872	MXL		4.4889	2.5994
64	Mo17HtXB84	LXL	-1.8895	0.6889	-1.2006
65	Mo17HtXPa872	LXL		-1.5078	-3.3973
66	B84XPa872	LXL		3.3322	1.4427

$LSD_{0.05}(S_{ii}-S_{ij})=3.7546$, $LSD_{0.05}(S_{ii}-S_{jj})=3.2389$, $LSD_{0.05}(S_{ii}-S_{kl})=2.4957$, $LSD_{0.05}(S_{ij}-S_{ij'})=2.4292$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=11.9005$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=11.2200$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=10.7424$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=11.2927$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=10.5730$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=10.9390$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=11.6500$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=10.9539$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 122. Estimates of general combining ability effects of Stand count (# of plants/ha) in 1989, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-2.0197**	1.2858*	-0.7339
2 Cm105	"	2		2.8692**	0.8494
3 W117Ht	"	3		0.6525	-1.3672**
4 Ms74	"	4		-4.8075**	-6.8272**
5 W64A	Medium	1	0.2653	0.8975	1.1628*
6 Ms75	"	2		-0.0892	0.1761
7 A619	"	3		-2.0592**	-1.7939**
8 A632	"	4		1.2508*	1.5161**
9 B73Ht	Late	1	1.7544**	0.9850	2.7394**
10 Mo17Ht	"	2		0.0517	1.8061**
11 B84	"	3		0.0217	1.7761**
12 Pa872	"	4		-1.0583*	0.6961

$LSD_{0.05}(G_i-G_k)$=0.8336, $LSD_{0.05}(g_{ij}-g_{ij'})$=1.6670, $LSD_{0.05}(g_i-g_j)$=1.6670.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 123. Estimates of Specific Combining Ability effects of Stand count (# of plants/ha) in 1989, over three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.3515	-1.1494	-1.5009
2	A641XW117Ht	EXE		0.1006	-0.2509
3	A641XMs74	EXE		-1.5728	-1.9242
4	A641XW64A	EXM	-0.7559**	3.0750	2.3191
5	A641XMs75	EXM		-0.2383	-0.9942
6	A641XA619	EXM		2.3650	1.6091
7	A641XA632	EXM		2.1883	1.4324
8	A641XB73Ht	EXL	1.0195**	-2.6104	-1.5909
9	A641XMo17Ht	EXL		-0.0104	1.0091
10	A641XB84	EXL		-4.1804*	-3.1609
11	A641XPa872	EXL		2.0329	3.0524
12	Cm105XW117Ht	EXE		4.1506*	3.7991*
13	Cm105XMs74	EXE		2.0106	1.6591
14	Cm105XW64A	EXM		0.5583	-0.1976
15	Cm105XMs75	EXM		1.7117	0.9558
16	Cm105XA619	EXM		-1.2850	-2.0409
17	Cm105XA632	EXM		-2.1283	-2.8842
18	Cm105XB73Ht	EXL		-0.6604	0.3591
19	Cm105XMo17Ht	EXM		-1.8271	-0.8076
20	Cm105XB84	EXM		1.3363	2.3558
21	Cm105XPa872	EXL		-2.7171	-1.6976
22	W117HtXMs74	EXL		-3.5394*	-3.8909*
23	W117HtXW64A	EXL		-0.7250	-1.4809
24	W117HtXMs75	EXL		-1.8050	-2.5609
25	W117HtXA619	EXE		-0.7683	-1.5242
26	W117HtXA632	EXM		2.2550	1.4991
27	W117HtXB73Ht	EXM		-1.6104	-0.5909
28	W117HtXMo17Ht	EXM		-1.9104	-0.8909
29	W117HtXB84	EXM		1.5863	2.6058
30	W117HtXPa872	EXL		2.2663	3.2858
31	Ms74XW64A	EXL		1.8683	1.1124
32	Ms74XMs75	EXL		-2.2783	-3.0342
33	Ms74XA619	EXL		-5.7417**	-6.4976**
34	Ms74XA632	EXM		0.9483	0.1924
35	Ms74XB73Ht	EXM		0.8496	1.8691
36	Ms74XMo17Ht	EXM		1.1496	2.1691
37	Ms74XB84	EXM		4.8463**	5.8658**
38	Ms74XPa872	EXL		1.4596	2.4791
39	W64AXMs75	EXL		-6.1028**	-3.9576*
40	W64AXA619	EXL		2.0339	4.1791*
41	W64AXA632	EXL		0.5572	2.7024

Table 123. Estimates of Specific Combining Ability effects of Stand count (# of plants/ha) in 1989, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXM	2.1452**	-1.7346	-2.5876
43	W64AXMo17Ht	MXM		1.4321	0.5791
44	W64AXB84	MXM		-1.4046	-2.2576
45	W64AXPa872	MXL	-0.8530*	0.4421	-0.4109
46	Ms75XA619	MXL		4.6206**	6.7658**
47	Ms75XA632	MXL		-1.0894	1.0558
48	Ms75XB73Ht	MXL		1.7188	0.8658
49	Ms75XMo17Ht	MXM		1.8854	1.0324
50	Ms75XB84	MXM		1.6821	0.8291
51	Ms75XPa872	MXL		-0.1046	-0.9576
52	A619XA632	MXL		-0.0194	2.1258
53	A619XB73Ht	MXL		2.2888	1.4358
54	A619XMo17Ht	MXL		-0.8446	-1.6976
55	A619XB84	MXM		2.1521	1.2991
56	A619XPa872	MXL		-4.8013**	-5.6542**
57	A632XB73Ht	MXL		0.0121	-0.8409
58	A632XMo17Ht	MXL		-1.0213	-1.8742
59	A632XB84	MXL		-2.5246	-3.3776
60	A632XPa872	MXL		0.8221	-0.0309
61	B73HtXMo17Ht	MXL		-0.0089	-0.2309
62	B73HtXB84	MXL		0.9211	0.6991
63	B73HtXPa872	MXL		0.8344	0.6124
64	Mo17HtXB84	LXL	-0.2220	-1.5122	-1.7342
65	Mo17HtXPa872	LXL		2.6678	2.4458
66	B84XPa872	LXL		-2.9022	-3.1242

$LSD_{0.05}(S_{ii}-S_{ij})$=1.5778, $LSD_{0.05}(S_{ii}-S_{jj})$=1.3610, $LSD_{0.05}(S_{ii}-S_{kl})$=1.0488, $LSD_{0.05}(S_{ij}-S_{ij'})$=1.0208, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=5.0009, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=4.7150, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=4.5143, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})$=4.7456, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=4.4431, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=4.5970, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=4.8957, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})$=4.6033.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 124. Estimates of general combining ability effects of Grain yield (t/ha) in 1990, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-0.8381	0.1842	-0.6539
2 Cm105	"	2		0.1875	-0.6506
3 W117Ht	"	3		0.5242	-0.3139
4 Ms74	"	4		-0.8958	-1.7339
5 W64A	Medium	1	0.0994	0.1767	0.2761
6 Ms75	"	2		0.0133	0.1128
7 A619	"	3		-0.2100	-0.1106
8 A632	"	4		0.0200	0.1194
9 B73Ht	Late	1	0.7386	0.1908	0.9294
10 Mo17Ht	"	2		0.3108	1.0494
11 B84	"	3		0.0575	0.7961
12 Pa872	"	4		-0.5592	0.1794

$LSD_{0.05}(G_i-G_k)=0.2207$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.4414$, $LSD_{0.05}(g_i-g_j)=0.4414$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 125. Estimates of specific combining ability effects of Grain yield (t/ha) in 1990, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.6623	0.0450	-0.6173
2	A641XW117Ht	EXE		0.4083	-0.2539
3	A641XMs74	EXE		-0.7050	-1.3673
4	A641XW64A	EXM	-0.1873	0.0100	-0.1773
5	A641XMs75	EXM		0.7400	0.5527
6	A641XA619	EXM		0.0300	-0.1573
7	A641XA632	EXM		-2.0667	-2.2539
8	A641XB73Ht	EXL	0.6840	0.9854	1.6694
9	A641XMo17Ht	EXL		-0.8013	-0.1173
10	A641XB84	EXL		0.3854	1.0694
11	A641XPa872	EXL		0.9688	1.6527
12	Cm105XW117Ht	EXE		0.8050	0.1427
13	Cm105XMs74	EXE		-0.3083	-0.9706
14	Cm105XW64A	EXM		0.8733	0.6861
15	Cm105XMs75	EXM		0.6367	0.4494
16	Cm105XA619	EXM		-0.6067	-0.7939
17	Cm105XA632	EXM		-1.6033	-1.7906
18	Cm105XB73Ht	EXL		0.2488	0.9327
19	Cm105XMo17Ht	EXM		-0.4046	0.2794
20	Cm105XB84	EXM		0.8488	1.5327
21	Cm105XPa872	EXL		-0.5346	0.1494
22	W117HtXMs74	EXL		-0.2450	-0.9073
23	W117HtXW64A	EXL		-0.2300	-0.4173
24	W117HtXMs75	EXL		-0.1667	-0.3539
25	W117HtXA619	EXE		0.1233	-0.0639
26	W117HtXA632	EXM		0.7933	0.6061
27	W117HtXB73Ht	EXM		-0.6546	0.0294
28	W117HtXMo17Ht	EXM		-0.5746	0.1094
29	W117HtXB84	EXM		0.8121	1.4961
30	W117HtXPa872	EXL		-1.0712	-0.3873
31	Ms74XW64A	EXL		-0.0433	-0.2306
32	Ms74XMs75	EXL		0.7533	0.5661
33	Ms74XA619	EXL		-0.4233	-0.6106
34	Ms74XA632	EXM		1.1800	0.9927
35	Ms74XB73Ht	EXM		-0.3679	0.3161
36	Ms74XMo17Ht	EXM		-0.7113	-0.0273
37	Ms74XB84	EXM		0.6321	1.3161
38	Ms74XPa872	EXL		0.2387	0.9227
39	W64AXMs75	EXL		-1.6678	-1.6439
40	W64AXA619	EXL		-0.5444	0.5206
41	W64AXA632	EXL		1.8589	1.8827
42	W64AXB73Ht	MXM	0.0238	-0.0967	0.0727

Table 125. Estimates of specific combining ability effects of Grain yield (t/ha) in 1990, over three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
43	W64AXMo17Ht	MXM		-1.1167	-0.9473
44	W64AXB84	MXM		0.1367	0.3061
45	W64AXPa872	MXL	0.1694	0.8200	0.9894
46	Ms75XA619	MXL		-0.1811	-0.1573
47	Ms75XA632	MXL		-0.2444	-0.2206
48	Ms75XB73Ht	MXL		-0.6000	-0.4306
49	Ms75XMo17Ht	MXM		-0.1533	0.0161
50	Ms75XB84	MXM		-0.1333	0.0361
51	Ms75XPa872	MXL		1.0167	1.1861
52	A619XA632	MXL		0.7789	0.8027
53	A619XB73Ht	MXL		0.4900	0.6594
54	A619XMo17Ht	MXL		1.0033	1.1727
55	A619XB84	MXM		1.0567	1.2261
56	A619XPa872	MXL		-1.7267	-1.5573
57	A632XB73Ht	MXL		-0.9733	-0.8039
58	A632XMo17Ht	MXL		0.2400	0.4094
59	A632XB84	MXL		-0.7733	-0.6039
60	A632XPa872	MXL		0.8100	0.9794
61	B73HtXMo17Ht	MXL		1.9372	0.7994
62	B73HtXB84	MXL		-2.0094	-3.1473
63	B73HtXPa872	MXL		1.0406	-0.0973
64	Mo17HtXB84	LXL	-1.1378	0.5939	-0.5439
65	Mo17HtXPa872	LXL		-0.0128	-1.1506
66	B84XPa872	LXL		-1.5494	-2.6873

$LSD_{0.05}(S_{ii}-S_{ij})=0.4177$, $LSD_{0.05}(S_{ii}-S_{jj})=0.3602$, $LSD_{0.05}(S_{ii}-S_{kl})=0.2777$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.2703$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.3250$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.2481$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.1950$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=1.2564$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.1762$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.2170$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.2961$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.2185$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 126. Estimates of general combining ability effects of Stalk lodging (%) in 1990, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	2.8936**	-1.1392	1.7544*
2 Cm105	"	2		-2.5692**	0.3244
3 W117Ht	"	3		-1.4058*	1.4878*
4 Ms74	"	4		5.1142**	8.0078**
5 W64A	Medium	1	-0.7081*	1.6425**	0.9344
6 Ms75	"	2		-0.0075	-0.7156
7 A619	"	3		-2.1642**	-2.8722**
8 A632	"	4		0.5292	-0.1789
9 B73Ht	Late	1	-2.1856**	0.2433	-1.9422**
10 Mo17Ht	"	2		-0.7867	-2.9722**
11 B84	"	3		1.7733**	-0.4122
12 Pa872	"	4		-1.2300*	-3.4156**

$LSD_{0.05}(G_i - G_k) = 0.9922$, $LSD_{0.05}(g_{ij} - g_{ij'}) = 1.9841$, $LSD_{0.05}(g_i - g_j) = 1.9841$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 127. Estimates of Specific Combining Ability effects of Stalk lodging (%) in 1990, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	2.8188**	-0.3028	2.5161
2	A641XW117Ht	EXE		-0.2661	2.5527
3	A641XMs74	EXE		2.7806	5.5994**
4	A641XW64A	EXM	-0.1989	1.7717	1.5727
5	A641XMs75	EXM		0.1550	-0.0439
6	A641XA619	EXM		-0.7883	-0.9873
7	A641XA632	EXM		1.6517	1.4527
8	A641XB73Ht	EXL	-1.9152**	-0.1021	-2.0173
9	A641XMo17Ht	EXL		-1.2721	-3.1873
10	A641XB84	EXL		-2.4321	-4.3473*
11	A641XPa872	EXL		-1.1954	-3.1106
12	Cm105XW117Ht	EXE		-7.2361**	-4.4173*
13	Cm105XMs74	EXE		1.5439	4.3627*
14	Cm105XW64A	EXM		1.7683	1.5694
15	Cm105XMs75	EXM		-2.7817	-2.9806
16	Cm105XA619	EXM		-0.0250	-0.2239
17	Cm105XA632	EXM		0.1483	-0.0506
18	Cm105XB73Ht	EXL		-2.638	-4.5539*
19	Cm105XMo17Ht	EXM		0.3913	-1.5239
20	Cm105XB84	EXM		2.2979	0.3827
21	Cm105XPa872	EXL		6.8346**	4.9194*
22	W117HtXMs74	EXL		3.4806	6.2994**
23	W117HtXW64A	EXL		0.7383	0.5394
24	W117HtXMs75	EXL		-1.7450	-1.9439
25	W117HtXA619	EXE		4.3783*	4.1794*
26	W117HtXA632	EXM		-1.4817	-1.6806
27	W117HtXB73Ht	EXM		0.0646	-1.8506
28	W117HtXMo17Ht	EXM		0.9279	-0.9873
29	W117HtXB84	EXM		-0.3654	-2.2806
30	W117HtXPa872	EXL		1.5046	-0.4106
31	Ms74XW64A	EXL		1.2850	1.0861
32	Ms74XMs75	EXL		-3.4650	-3.6639
33	Ms74XA619	EXL		-4.9417*	-5.1406*
34	Ms74XA632	EXM		3.3317	3.1327
35	Ms74XB73Ht	EXM		-0.3221	-2.2373
36	Ms74XMo17Ht	EXM		-0.7588	-2.6739
37	Ms74XB84	EXM		-3.1521	-5.0673*
38	Ms74XPa872	EXL		0.2179	-1.6973
39	W64AXMs75	EXL		-1.4628	-1.2573
40	W64AXA619	EXL		-1.0061	-0.8006
41	W64AXA632	EXL		1.2672	1.4727
42	W64AXB73Ht	MXM	0.2055	-0.2754	-0.2306

Table 127. Estimates of Specific Combining Ability effects of Stalk lodging (%) in 1990, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		1.2546	1.2994
44	W64AXB84	MXM		-3.5054	-3.4606
45	W64AXPa872	MXL		-1.8354	-1.7906
46	Ms75XA619	MXL	0.0448	0.6772	0.8827
47	Ms75XA632	MXL		2.6506	2.8561
48	Ms75XB73Ht	MXL		0.6413	0.6861
49	Ms75XMo17Ht	MXM		2.5379	2.5827
50	Ms75XB84	MXM		3.7779	3.8227
51	Ms75XPa872	MXL		-0.9854	-0.9406
52	A619XA632	MXL		-2.1261	-1.9206
53	A619XB73Ht	MXL		-0.8021	-0.7573
54	A619XMo17Ht	MXL		2.1613	2.2061
55	A619XB84	MXM		0.5679	0.6127
56	A619XPa872	MXL		1.9046	1.9494
57	A632XB73Ht	MXL		-1.6288	-1.5839
58	A632XMo17Ht	MXL		-0.8654	-0.8206
59	A632XB84	MXL		-1.1254	-1.0806
60	A632XPa872	MXL		-1.8221	-1.7773
61	B73HtXMo17Ht	MXL		-3.4178	-0.9239
62	B73HtXB84	MXL		9.1889**	11.6827**
63	B73HtXPa872	MXL		-0.7078	1.7861
64	Mo17HtXB84	LXL	2.4938**	-1.1478	1.3461
65	Mo17HtXPa872	LXL		0.1889	2.6827
66	B84XPa872	LXL		-4.1044*	-1.6106

$LSD_{0.05}(S_{ii}-S_{ij})=0.1234$, $LSD_{0.05}(S_{ii}-S_{jj})=0.1234$, $LSD_{0.05}(S_{ii}-S_{kl})=0.1234$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=5.5923$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=5.6119$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.3729$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=5.6483$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=5.2885$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.4713$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=5.8271$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=5.4788$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 128. Estimates of general combining ability effects of Root lodging (%) in 1990, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-0.0531	0.3542**	0.3011*
2 Cm105	"	2		-0.3325*	-0.3856**
3 W117Ht	"	3		-0.1925	-0.2456
4 Ms74	"	4		0.1708	0.1178
5 W64A	Medium	1	-0.1764**	0.0242	-0.1522
6 Ms75	"	2		-0.0058	-0.1822
7 A619	"	3		-0.1392	-0.3156*
8 A632	"	4		0.1208	-0.0556
9 B73Ht	Late	1	0.2294**	-0.2983*	-0.0689
10 Mo17Ht	"	2		-0.1250	0.1044
11 B84	"	3		-0.0517	0.1778
12 Pa872	"	4		0.4750**	0.7044**

$LSD_{0.05}(G_i-G_k)=0.2150$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.4302$, $LSD_{0.05}(g_i-g_j)=0.4302$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 129. Estimates of Specific Combining Ability effects of Root lodging (%) in 1990, over three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
1	A641XCm105	EXE	0.3965**	-0.3383	0.0582
2	A641XW117Ht	EXE		-0.9450*	-0.5485
3	A641XMs74	EXE		2.6917**	3.0882**
4	A641XW64A	EXM	-0.0218	0.3467	0.3248
5	A641XMs75	EXM		-0.3233	-0.3452
6	A641XA619	EXM		-0.0567	-0.0785
7	A641XA632	EXM		0.2167	0.1948
8	A641XB73Ht	EXL	-0.2756**	-0.2496	-0.5252
9	A641XMo17Ht	EXL		-0.6229	-0.8985*
10	A641XB84	EXL		0.2704	-0.0052
11	A641XPa872	EXL		-0.9896*	-1.2652**
12	Cm105XW117Ht	EXE		-0.2583	0.1382
13	Cm105XMs74	EXE		-0.6217	-0.2252
14	Cm105XW64A	EXM		0.3000	0.2782
15	Cm105XMs75	EXM		0.0967	0.0748
16	Cm105XA619	EXM		0.2300	0.2082
17	Cm105XA632	EXM		-0.0300	-0.0518
18	Cm105XB73Ht	EXL		0.8371	0.5615
19	Cm105XMo17Ht	EXM		0.0638	-0.2118
20	Cm105XB84	EXM		-0.0096	-0.2852
21	Cm105XPa872	EXL		-0.2696	-0.5452
22	W117HtXMs74	EXL		-0.5283	-0.1318
23	W117HtXW64A	EXL		0.3600	0.3382
24	W117HtXMs75	EXL		0.1567	0.1348
25	W117HtXA619	EXE		0.0900	0.0682
26	W117HtXA632	EXM		0.2633	0.2415
27	W117HtXB73Ht	EXM		0.0971	-0.1785
28	W117HtXMo17Ht	EXM		0.3238	0.0482
29	W117HtXB84	EXM		-0.1496	-0.4252
30	W117HtXPa872	EXL		0.5904	0.3148
31	Ms74XW64A	EXL		-0.4367	-0.4585
32	Ms74XMs75	EXL		-0.4067	-0.4285
33	Ms74XA619	EXL		-0.2733	-0.2952
34	Ms74XA632	EXM		-0.5333	-0.5552
35	Ms74XB73Ht	EXM		0.0004	-0.2752
36	Ms74XMo17Ht	EXM		0.0271	-0.2485
37	Ms74XB84	EXM		-0.2463	-0.5218
38	Ms74XPa872	EXL		0.3271	0.0515
39	W64AXMs75	EXL		-0.0906	-0.1585
40	W64AXA619	EXL		0.0428	-0.0252
41	W64AXA632	EXL		-0.2172	-0.2852
42	W64AXB73Ht	MXM	-0.0679	-0.1113	-0.0385

Table 129. Estimates of specific combining ability effects of Root lodging (%) in 1990, over three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		-0.0513	0.0215
44	W64AXB84	MXM		-0.5913	-0.5185
45	W64AXPa872	MXL	0.0728	0.4488	0.5215
46	Ms75XA619	MXL		0.2728	0.2048
47	Ms75XA632	MXL		0.0128	-0.0552
48	Ms75XB73Ht	MXL		0.3521	0.4248
49	Ms75XMo17Ht	MXM		0.1454	0.2182
50	Ms75XB84	MXM		-0.1279	-0.0552
51	Ms75XPa872	MXL		-0.0879	-0.0152
52	A619XA632	MXL		-0.0206	-0.0885
53	A619XB73Ht	MXL		0.6188	0.6915
54	A619XMo17Ht	MXL		-0.3546	-0.2818
55	A619XB84	MXM		0.0054	0.0782
56	A619XPa872	MXL		-0.5546	-0.4818
57	A632XB73Ht	MXL		0.0621	0.1648
58	A632XMo17Ht	MXL		0.4854	0.5582
59	A632XB84	MXL		0.7454	0.8182
60	A632XPa872	MXL		-1.0146*	-0.9418*
61	B73HtXMo17Ht	MXL		-0.7989	-0.5285
62	B73HtXB84	MXL		-0.6056	-0.3352
63	B73HtXPa872	MXL		-0.2322	0.0382
64	Mo17HtXB84	LXL	0.2704	-0.1456	0.1248
65	Mo17HtXPa872	LXL		0.9278*	1.1982**
66	B84XPa872	LXL		0.8544*	1.1248*

$LSD_{0.05}(S_{ii}-S_{ij})=0.1234$, $LSD_{0.05}(S_{ii}-S_{jj})=0.1234$, $LSD_{0.05}(S_{ii}-S_{kl})=0.1234$,
$LSD_{0.05}(S_{ij}-S_{ij'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.2905$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.2166$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.1648$,
$LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=1.2246$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.1464$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.1862$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.2632$,
$LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=1.1878$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 130. Estimates of general combining ability effects of Moisture content (%) in 1990, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-2.5903**	-1.7008**	-4.2911**
2 Cm105	"	2		1.4992**	-1.0911**
3 W117Ht	"	3		0.3725	-2.2178**
4 Ms74	"	4		-0.1708	-2.7611**
5 W64A	Medium	1	0.2831**	-0.1242	0.1589
6 Ms75	"	2		-1.0608**	-0.7778**
7 A619	"	3		2.4958**	2.7789**
8 A632	"	4		-1.3108**	-1.0278**
9 B73Ht	Late	1	2.3072**	1.2383**	3.5456**
10 Mo17Ht	"	2		-0.4783*	1.8289**
11 B84	"	3		1.1083**	3.4156**
12 Pa872	"	4		-1.8683**	0.4389

$LSD_{0.05}(G_i-G_k)=0.3305$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.6611$, $LSD_{0.05}(g_i-g_j)=0.6611$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 131. Estimates of Specific Combining Ability effects of Moisture content (%) in 1990, over three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
1	A641XCm105	EXE	0.8452**	-1.1761	-0.3309
2	A641XW117Ht	EXE		0.4172	1.2624
3	A641XMs74	EXE		2.7939**	3.6391**
4	A641XW64A	EXM	0.2733*	1.6458*	1.9191**
5	A641XMs75	EXM		-0.1842	0.0891
6	A641XA619	EXM		-2.9075**	-2.6342**
7	A641XA632	EXM		0.7658	1.0391
8	A641XB73Ht	EXL	-0.9072**	-0.3271	-1.2342
9	A641XMo17Ht	EXL		-0.9771	-1.8842**
10	A641XB84	EXL		-1.2304	-2.1376**
11	A641XPa872	EXL		1.1796	0.2724
12	Cm105XW117Ht	EXE		-1.6494*	-0.8042
13	Cm105XMs74	EXE		-1.3728*	-0.5276
14	Cm105XW64A	EXM		-0.3208	-0.0476
15	Cm105XMs75	EXM		2.1158**	2.3891**
16	Cm105XA619	EXM		0.8925	1.1658
17	Cm105XA632	EXM		-0.3008	-0.0276
18	Cm105XB73Ht	EXL		-0.1938	-1.1009
19	Cm105XMo17Ht	EXM		1.4563*	0.5491
20	Cm105XB84	EXM		0.9363	0.0291
21	Cm105XPa872	EXL		-0.3871	-1.2942
22	W117HtXMs74	EXL		0.9872	1.8324**
23	W117HtXW64A	EXL		0.0392	0.3124
24	W117HtXMs75	EXL		0.3092	0.5824
25	W117HtXA619	EXE		0.5525	0.8258
26	W117HtXA632	EXM		-1.7075*	-1.4342*
27	W117HtXB73Ht	EXM		-0.7671	-1.6742*
28	W117HtXMo17Ht	EXM		1.5829*	0.6758
29	W117HtXB84	EXM		-0.1038	-1.0109
30	W117HtXPa872	EXL		0.3396	-0.5676
31	Ms74XW64A	EXL		-0.7175	-0.4442
32	Ms74XMs75	EXL		1.6858*	1.9591**
33	Ms74XA619	EXL		-1.0042	-0.7309
34	Ms74XA632	EXM		-0.8642	-0.5909
35	Ms74XB73Ht	EXM		-0.8238	-1.7309*
36	Ms74XMo17Ht	EXM		-0.4738	-1.3809*
37	Ms74XB84	EXM		-0.7938	-1.7009**
38	Ms74XPa872	EXL		0.5829	-0.3242
39	W64AXMs75	EXL		-0.5928	-0.9609
40	W64AXA619	EXL		1.5172*	1.1491
41	W64AXA632	EXL		-0.5761	-0.9442

Table 131. Estimates of specific combining ability effects of Moisture content (%) in 1990, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
42	W64AXB73Ht	MXM	-0.3681	-0.5204	-0.5176
43	W64AXMo17Ht	MXM		0.8629	0.8658
44	W64AXB84	MXM		-1.5571*	-1.5542*
45	W64AXPa872	MXL	0.0028	0.2196	0.2224
46	Ms75XA619	MXL		-0.8794	-1.2476
47	Ms75XA632	MXL		1.0606	0.692
48	Ms75XB73Ht	MXL		0.6829	0.685
49	Ms75XMo17Ht	MXM		-1.7671**	-1.7642
50	Ms75XB84	MXM		-2.2871**	-2.2842
51	Ms75XPa872	MXL		-0.1438	-0.1409
52	A619XA632	MXL		-0.5294	-0.8976
53	A619XB73Ht	MXL		2.4263**	2.4291
54	A619XMo17Ht	MXL		-0.9904	-0.9876
55	A619XB84	MXM		2.0229**	2.0258
56	A619XPa872	MXL		-1.1004	-1.0976
57	A632XB73Ht	MXL		0.7329	0.7358
58	A632XMo17Ht	MXL		1.4163*	1.4191
59	A632XB84	MXL		-0.1038	-0.1009
60	A632XPa872	MXL		0.1062	0.1091
61	B73HtXMo17Ht	MXL		-0.6267	0.5791
62	B73HtXB84	MXL		0.3200	1.5258
63	B73HtXPa872	MXL		-0.9033	0.3024
64	Mo17HtXB84	LXL	1.2058**	1.1033	2.3091
65	Mo17HtXPa872	LXL		-1.5867*	-0.3809
66	B84XPa872	LXL		1.6933**	2.8991

$LSD_{0.05}(S_{ii}-S_{ij})=0.1234$, $LSD_{0.05}(S_{ii}-S_{jj})=0.1234$, $LSD_{0.05}(S_{ii}-S_{kl})=0.1234$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.9831$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.8698$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.7901$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=1.8820$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.7620$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.8230$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.9414$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.8253$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 132. Estimates of general combining ability effects of Plant height (cm) in 1990, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-10.8097**	-1.1658	-11.9756**
2 Cm105	"	2		7.8642**	-2.9456*
3 W117Ht	"	3		2.5342	-8.2756**
4 Ms74	"	4		-9.2325**	-20.0422**
5 W64A	Medium	1	0.5878	-5.3033**	-4.7156**
6 Ms75	"	2		5.9100**	6.4978**
7 A619	"	3		-11.4067**	-10.8189**
8 A632	"	4		10.8000**	11.3878**
9 B73Ht	Late	1	10.2219**	0.6058	10.8278**
10 Mo17Ht	"	2		1.7892	12.0111**
11 B84	"	3		3.8658**	14.0878**
12 Pa872	"	4		-6.2608**	3.9611**

$LSD_{0.05}(G_i-G_k)=2.1727$, $LSD_{0.05}(g_{ij}-g_{ij'})=4.3453$, $LSD_{0.05}(g_i-g_j)=4.3453$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 133. Estimates of specific combining ability effects of Plant height (cm) in 1990, over three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.7790	2.7072	1.9282
2	A641XW117Ht	EXE		3.2706	2.4915
3	A641XMs74	EXE		-0.3294	-1.1085
4	A641XW64A	EXM	-1.8814*	0.4129	-1.4685
5	A641XMs75	EXM		4.1996	2.3182
6	A641XA619	EXM		-6.6176	-8.4985
7	A641XA632	EXM		-13.3571**	-15.2385**
8	A641XB73Ht	EXL	2.4657**	7.9558	10.4215*
9	A641XMo17Ht	EXL		3.8392	6.3048
10	A641XB84	EXL		-2.8042	-0.3385
11	A641XPa872	EXL		0.7225	3.1882
12	Cm105XW117Ht	EXE		2.2072	1.4282
13	Cm105XMs74	EXE		-5.6594	6.4385
14	Cm105XW64A	EXM		3.6829	1.8015
15	Cm105XMs75	EXM		-1.3971	-3.2785
16	Cm105XA619	EXM		6.0863	4.2048
17	Cm105XA632	EXM		-13.4538**	-15.3352**
18	Cm105XB73Ht	EXL		4.0592	6.5248
19	Cm105XMo17Ht	EXM		-2.1908	0.2748
20	Cm105XB84	EXM		1.3325	3.7982
21	Cm105XPa872	EXL		2.6258	5.0915
22	W117HtXMs74	EXL		-2.1961	-2.9752
23	W117HtXW64A	EXL		-4.8871	-6.7685
24	W117HtXMs75	EXL		1.3329	-0.5485
25	W117HtXA619	EXE		6.8829	5.0015
26	W117HtXA632	EXM		3.8763	1.9948
27	W117HtXB73Ht	EXM		-3.4108	-0.9452
28	W117HtXMo17Ht	EXM		-8.4275	-5.9618
29	W117HtXB84	EXM		1.8958	4.3615
30	W117HtXPa872	EXL		-0.5442	1.9215
31	Ms74XW64A	EXL		1.3129	-0.5685
32	Ms74XMs75	EXL		1.6663	-0.2152
33	Ms74XA619	EXL		3.6496	1.7682
34	Ms74XA632	EXM		6.6096	4.7282
35	Ms74XB73Ht	EXM		-5.9775	-3.5118
36	Ms74XMo17Ht	EXM		-6.8942	-4.4285
37	Ms74XB84	EXM		11.1625**	13.6282**
38	Ms74XPa872	EXL		-3.3442	-0.8785
39	W64AXMs75	EXL		-11.4844**	-12.2418**
40	W64AXA619	EXL		-1.7344	-2.4918
41	W64AXA632	EXL		10.2956*	9.5382*
42	W64AXB73Ht	MXM	-0.7574	-0.2213	2.2282

Table 133. Estimates of specific combining ability effects of Plant height (cm) in 1990, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		-4.5379	-2.0885
44	W64AXB84	MXM		0.3188	2.7682
45	W64AXPa872	MXL	2.4492**	6.8421	9.2915*
46	Ms75XA619	MXL		1.8522	1.0948
47	Ms75XA632	MXL		9.0122*	8.2548
48	Ms75XB73Ht	MXL		2.5988	5.0482
49	Ms75XMo17Ht	MXM		-11.2846*	-8.8352*
50	Ms75XB84	MXM		1.4388	3.8882
51	Ms75XPa872	MXL		2.0654	4.5148
52	A619XA632	MXL		-7.9411	-8.6985
53	A619XB73Ht	MXL		10.7154*	13.1648**
54	A619XMo17Ht	MXL		-7.5013	-5.0518
55	A619XB84	MXM		15.6221**	18.0715**
56	A619XPa872	MXL		-21.0146**	-18.5652**
57	A632XB73Ht	MXL		-10.6579*	-8.2085
58	A632XMo17Ht	MXL		14.6588**	17.1082**
59	A632XB84	MXL		-1.0846	1.3648
60	A632XPa872	MXL		2.0421	4.4915
61	B73HtXMo17Ht	MXL		11.1550**	4.6015
62	B73HtXB84	MXL		-25.3217**	-31.8752**
63	B73HtXPa872	MXL		9.1050*	2.5515
64	Mo17HtXB84	LXL	-6.5535**	3.5617	-2.9918
65	Mo17HtXPa872	LXL		7.6217	1.0682
66	B84XPa872	LXL		-6.1217	-12.6752**

$LSD_{0.05}(S_{ii}-S_{ij})=0.1234$, $LSD_{0.05}(S_{ii}-S_{jj})=0.1234$, $LSD_{0.05}(S_{ii}-S_{kl})=0.1234$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=13.0362$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=12.2908$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=11.7674$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=12.3703$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=11.5820$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=11.9829$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=12.7618$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=11.9991$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 134. Estimates of general combining ability effects of Ear heigh (cm) in 1990, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-8.0078**	1.4600	-6.5478**
2 Cm105	"	2		1.1800	-6.8278**
3 W117Ht	"	3		5.4800**	-2.5278*
4 Ms74	"	4		-8.1200**	-16.1278**
5 W64A	Medium	1	-0.7303	2.0058	1.2756
6 Ms75	"	2		5.7625**	5.0322**
7 A619	"	3		-15.3408**	-16.0711**
8 A632	"	4		7.5725**	6.8422**
9 B73Ht	Late	1	8.7381**	1.3408	10.0789**
10 Mo17Ht	"	2		4.1475**	12.8856**
11 B84	"	3		6.0275**	14.7656**
12 Pa872	"	4		-11.5158**	-2.7778*

$LSD_{0.05}(G_i-G_k)$=1.7473, $LSD_{0.05}(g_{ij}-g_{ij'})$=3.4949, $LSD_{0.05}(g_i-g_j)$=3.4949.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 135. Estimates of specific combining ability effects of Ear height (cm) in 1990, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.1656	1.5544	1.7200
2	A641XW117Ht	EXE		3.9211	4.0867
3	A641XMs74	EXE		-1.4456	-1.2800
4	A641XW64A	EXM	-0.6738	1.0571	0.3833
5	A641XMs75	EXM		1.9671	1.2933
6	A641XA619	EXM		-2.4629	-3.1367
7	A641XA632	EXM		-7.6096*	-8.2833*
8	A641XB73Ht	EXL	0.5496	8.6304*	9.1800*
9	A641XMo17Ht	EXL		-3.7096	-3.1600
10	A641XB84	EXL		-1.5229	-0.9733
11	A641XPa872	EXL		-0.3796	0.1700
12	Cm105XW117Ht	EXE		-2.1989	-2.0333
13	Cm105XMs74	EXE		-1.3656	-1.2000
14	Cm105XW64A	EXM		3.8371	3.1633
15	Cm105XMs75	EXM		-5.0196	-5.6933
16	Cm105XA619	EXM		-0.7829	-1.4567
17	Cm105XA632	EXM		-5.3296	-6.0033
18	Cm105XB73Ht	EXL		3.7771	4.3267
19	Cm105XMo17Ht	EXM		1.2704	1.8200
20	Cm105XB84	EXM		3.6571	4.2067
21	Cm105XPa872	EXL		0.6004	1.1500
22	W117HtXMs74	EXL		-0.4656	-0.3000
23	W117HtXW64A	EXL		-6.1963	-6.8700
24	W117HtXMs75	EXL		3.9138	3.2400
25	W117HtXA619	EXE		3.7504	3.0767
26	W117HtXA632	EXM		2.7371	2.0633
27	W117HtXB73Ht	EXM		-2.3896	-1.8400
28	W117HtXMo17Ht	EXM		-4.1296	-3.5800
29	W117HtXB84	EXM		-0.8096	-0.2600
30	W117HtXPa872	EXL		1.8671	2.4167
31	Ms74XW64A	EXL		3.5704	2.8967
32	Ms74XMs75	EXL		0.7804	0.1067
33	Ms74XA619	EXL		8.7504*	8.0767*
34	Ms74XA632	EXM		-2.9629	-3.6367
35	Ms74XB73Ht	EXM		-4.5563	-4.0067
36	Ms74XMo17Ht	EXM		-0.5963	-0.0467
37	Ms74XB84	EXM		2.0904	2.6400
38	Ms74XPa872	EXL		-3.7996	-3.2500
39	W64AXMs75	EXL		-6.5461	-7.0633
40	W64AXA619	EXL		-2.5094	-3.0267
41	W64AXA632	EXL		6.3106	5.7933
42	W64AXB73Ht	MXM	-0.5172	4.1950	5.2567

Table 135. Estimates of specific combining ability effects of Ear height (cm) in 1990, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		-2.6450	-1.5833
44	W64AXB84	MXM		-1.1250	-0.0633
45	W64AXPa872	MXL	1.0617	0.0517	1.1133
46	Ms75XA619	MXL		-0.9994	-1.5167
47	Ms75XA632	MXL		7.7872*	7.2700
48	Ms75XB73Ht	MXL		2.2050	3.2667
49	Ms75XMo17Ht	MXM		-6.1350	-5.0733
50	Ms75XB84	MXM		1.8850	2.9467
51	Ms75XPa872	MXL		0.1617	1.2233
52	A619XA632	MXL		-4.0428	-4.5600
53	A619XB73Ht	MXL		9.4083**	10.4700**
54	A619XMo17Ht	MXL		-7.0983*	-6.0367
55	A619XB84	MXM		6.0550	7.1167*
56	A619XPa872	MXL		-10.0683**	-9.0067*
57	A632XB73Ht	MXL		-11.0050**	-9.9433**
58	A632XMo17Ht	MXL		13.7217**	14.7833**
59	A632XB84	MXL		0.7083	1.7700
60	A632XPa872	MXL		-0.3150	0.7467
61	B73HtXMo17Ht	MXL		4.7617	2.6133
62	B73HtXB84	MXL		-18.2183**	-20.3667**
63	B73HtXPa872	MXL		3.1917	1.0433
64	Mo17HtXB84	LXL	-2.1483	1.5750	-0.5733
65	Mo17HtXPa872	LXL		2.9850	0.8367
66	B84XPa872	LXL		5.7050	3.5567

$LSD_{0.05}(S_{ii}-S_{ij})=3.3079$, $LSD_{0.05}(S_{ii}-S_{jj})=2.8536$, $LSD_{0.05}(S_{ii}-S_{kl})=2.1987$, $LSD_{0.05}(S_{ij}-S_{ij'})=2.1401$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=10.4846$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=9.8849$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=9.4641$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=9.9492$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=9.3151$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=9.6373$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=10.2637$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=9.6550$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 136. Estimates of general combining Ability effects of Stand count (# of plants/ha) in 1990, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-0.3783	-0.6583	-1.0367
2 Cm105	"	2		1.6250*	1.2467
3 W117Ht	"	3		1.1217	0.7433
4 Ms74	"	4		-2.0883**	-2.4667**
5 W64A	Medium	1	2.1075**	0.3192	2.4267**
6 Ms75	"	2		0.4158	2.5233**
7 A619	"	3		-0.4108	1.6967*
8 A632	"	4		-0.3242	1.7833*
9 B73Ht	Late	1	-1.7292**	1.1525	-0.5767
10 Mo17Ht	"	2		0.1858	-1.5433*
11 B84	"	3		-1.0242	-2.7533**
12 Pa872	"	4		-0.3142	-2.0433**

$LSD_{0.05}(G_i-G_k)=1.0666$, $LSD_{0.05}(g_{ij}-g_{ij'})=2.1335$, $LSD_{0.05}(g_i-g_j)=2.1335$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 137. Estimates of Specific Combining Ability effects of Stand count (# of plants/ha) in 1990, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.2049	1.8889	1.6839
2	A641XW117Ht	EXE		-0.4744	-0.6794
3	A641XMs74	EXE		-5.2644*	-5.4694*
4	A641XW64A	EXM	-0.2519	1.4892	1.2373
5	A641XMs75	EXM		0.1925	-0.0594
6	A641XA619	EXM		3.9858	3.7339
7	A641XA632	EXM		-5.6675**	-5.9194**
8	A641XB73Ht	EXL	0.4056	1.3017	1.7073
9	A641XMo17Ht	EXL		-3.8317	-3.4261
10	A641XB84	EXL		2.5117	2.9173
11	A641XPa872	EXL		3.8683	4.2739
12	Cm105XW117Ht	EXE		5.3756**	5.1706*
13	Cm105XMs74	EXE		-2.4811	-2.6861
14	Cm105XW64A	EXM		-2.2608	-2.5127
15	Cm105XMs75	EXM		-1.9575	-2.2094
16	Cm105XA619	EXM		0.3692	0.1173
17	Cm105XA632	EXM		-5.0842*	-5.3361*
18	Cm105XB73Ht	EXL		0.8183	1.2239
19	Cm105XMo17Ht	EXM		1.1850	1.5906
20	Cm105XB84	EXM		2.8617	3.2673
21	Cm105XPa872	EXL		-0.7150	-0.3094
22	W117HtXMs74	EXL		0.9556	0.7506
23	W117HtXW64A	EXL		-0.4775	-0.7294
24	W117HtXMs75	EXL		-2.8208	-3.0727
25	W117HtXA619	EXE		3.6392	3.3873
26	W117HtXA632	EXM		1.5525	1.3006
27	W117HtXB73Ht	EXM		-2.2450	-1.8394
28	W117HtXMo17Ht	EXM		4.2217	4.6273*
29	W117HtXB84	EXM		-3.5683	-3.1627
30	W117HtXPa872	EXL		-6.1583**	-5.7527**
31	Ms74XW64A	EXL		-0.5475	-0.7994
32	Ms74XMs75	EXL		4.6225*	4.3706*
33	Ms74XA619	EXL		-0.2175	-0.4694
34	Ms74XA632	EXM		3.1825	2.9306
35	Ms74XB73Ht	EXM		-3.7350	-3.3294
36	Ms74XMo17Ht	EXM		4.0650	4.4706*
37	Ms74XB84	EXM		-1.1917	-0.7861
38	Ms74XPa872	EXL		0.6117	1.0173
39	W64AXMs75	EXL		-1.0961	-1.6227
40	W64AXA619	EXL		1.5306	1.0039
41	W64AXA632	EXL		0.9439	0.4173

Table 137. Estimates of Specific Combining Ability effects of Stand count (# of plants/ha) in 1990, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXM	-0.5266	-1.9029	-1.2561
43	W64AXMo17Ht	MXM		0.2304	0.8773
44	W64AXB84	MXM		-1.7596	-1.1127
45	W64AXPa872	MXL	0.6469	3.8504	4.4973*
46	Ms75XA619	MXL		-4.6661*	-5.1927*
47	Ms75XA632	MXL		-1.8861	-2.4127
48	Ms75XB73Ht	MXL		0.9671	1.6139
49	Ms75XMo17Ht	MXM		-1.8663	-1.2194
50	Ms75XB84	MXM		3.6438	4.2906
51	Ms75XPa872	MXL		4.8671*	5.5139*
52	A619XA632	MXL		5.1739*	4.6473*
53	A619XB73Ht	MXL		-3.1063	-2.4594
54	A619XMo17Ht	MXL		-0.5729	0.0739
55	A619XB84	MXM		3.7371	4.3839*
56	A619XPa872	MXL		-9.8729**	-9.2261**
57	A632XB73Ht	MXL		-0.1929	0.4539
58	A632XMo17Ht	MXL		-4.2663*	-3.6194
59	A632XB84	MXL		2.7171	3.3639
60	A632XPa872	MXL		3.5271	4.1739
61	B73HtXMo17Ht	MXL		6.1172**	4.7139*
62	B73HtXB84	MXL		-0.7061	-2.1094
63	B73HtXPa872	MXL		2.6839	1.2806
64	Mo17HtXB84	LXL	-1.4033*	-5.4328**	-6.8361**
65	Mo17HtXPa872	LXL		0.1506	-1.2527
66	B84XPa872	LXL		-2.8128	-4.2161

$LSD_{0.05}(S_{ii}-S_{ij})=2.0192$ $LSD_{0.05}(S_{ii}-S_{jj})=1.7419$, $LSD_{0.05}(S_{ii}-S_{kl})=1.3422$, $LSD_{0.05}(S_{ij}-S_{ij'})=1.3063$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=6.4002$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=6.0341$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.7773$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})$ 6.0733, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=5.6864$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=5.8829$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=6.2653$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=5.8910$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 138. Estimates of general combining ability effects of Grain yield (t/ha) in 1991, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[(1)] (gij)
1 A641	Early	1	-1.0667**	-0.2633	-1.3300**
2 Cm105	"	2		0.7367**	-0.3300
3 W117Ht	"	3		-0.1067	-1.1733**
4 Ms74	"	4		-0.3667	-1.4333**
5 W64A	Medium	1	-0.1442	0.6042*	0.4600
6 Ms75	"	2		-0.6358*	-0.7800**
7 A619	"	3		-0.0125	-0.1567
8 A632	"	4		0.0442	-0.1000
9 B73Ht	Late	1	1.2108**	-0.0642	1.1467**
10 Mo17Ht	"	2		0.1625	1.3733**
11 B84	"	3		-0.5275*	0.6833*
12 Pa872	"	4		0.4292	1.6400**

$LSD_{0.05}(G_i-G_k)=0.4157$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.8314$, $LSD_{0.05}(g_i-g_j)=0.8314$.[(1)]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 139. Estimates of specific combining ability effects of Grain yield (t/ha) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.6677*	-0.7511	-1.4188
2	A641XW117Ht	EXE		0.3589	-0.3088
3	A641XMs74	EXE		0.4856	-0.1821
4	A641XW64A	EXM	0.0091	-0.1846	-0.1755
5	A641XMs75	EXM		0.8888	0.8979
6	A641XA619	EXM		0.5654	0.5745
7	A641XA632	EXM		-1.2246	-1.2155
8	A641XB73Ht	EXL	0.4916**	0.3796	0.8712
9	A641XMo17Ht	EXL		1.5529	2.0445*
10	A641XB84	EXL		-0.3571	0.1345
11	A641XPa872	EXL		-1.7138*	-1.2221
12	Cm105XW117Ht	EXE		0.3922	-0.2755
13	Cm105XMs74	EXE		-0.8478	-1.5155
14	Cm105XW64A	EXM		0.5821	0.5912
15	Cm105XMs75	EXM		0.7888	0.7979
16	Cm105XA619	EXM		-0.4346	-0.4255
17	Cm105XA632	EXM		-0.8579	-0.8488
18	Cm105XB73Ht	EXL		0.3463	0.8379
19	Cm105XMo17Ht	EXM		0.9529	1.4445
20	Cm105XB84	EXM		0.5429	1.0345
21	Cm105XPa872	EXL		-0.7138	-0.2221
22	W117HtXMs74	EXL		0.3622	-0.3055
23	W117HtXW64A	EXL		0.0254	0.0345
24	W117HtXMs75	EXL		-0.6346	-0.6255
25	W117HtXA619	EXE		0.3088	0.3179
26	W117HtXA632	EXM		0.8854	0.8954
27	W117HtXB73Ht	EXM		0.2896	0.7812
28	W117HtXMo17Ht	EXM		-2.1038*	-1.6121
29	W117HtXB84	EXM		0.5863	1.0779
30	W117HtXPa872	EXL		-0.4704	0.0212
31	Ms74XW64A	EXL		1.0521	1.0612
32	Ms74XMs75	EXL		-1.2746	-1.2655
33	Ms74XA619	EXL		-1.2313	-1.2221
34	Ms74XA632	EXM		0.7454	0.7545
35	Ms74XB73Ht	EXM		0.3496	0.8412
36	Ms74XMo17Ht	EXM		-0.4104	0.0812
37	Ms74XB84	EXM		0.2129	0.7045
38	Ms74XPa872	EXL		0.5563	1.0479*
39	W64AXMs75	EXL		-1.8183*	-1.8255*
40	W64AXA619	EXL		0.6917	0.6845
41	W64AXA632	EXL		0.3683	0.3612
42	W64AXB73Ht	MXM	-0.0071	0.2183	0.2145

Table 139. Estimates of specific combining ability effects of Grain yield (t/ha) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		-1.6750*	-1.6788
44	W64AXB84	MXM		-0.2517	-0.2555
45	W64AXPa872	MXL	-0.0038	0.9917	0.9879
46	Ms75XA619	MXL		0.1650	0.1579
47	Ms75XA632	MXL		0.3417	0.3345
48	Ms75XB73Ht	MXL		-0.3083	-0.3121
49	Ms75XMo17Ht	MXM		0.1983	0.1945
50	Ms75XB84	MXM		0.3883	0.3845
51	Ms75XPa872	MXL		1.2650	1.2612
52	A619XA632	MXL		0.2517	0.2445
53	A619XB73Ht	MXL		0.4683	0.4645
54	A619XMo17Ht	MXL		0.4083	0.4045
55	A619XB84	MXM		0.6983	0.6945
56	A619XPa872	MXL		-1.8917*	-1.8955*
57	A632XB73Ht	MXL		-0.7550	-0.7588
58	A632XMo17Ht	MXL		-0.0483	-0.0521
59	A632XB84	MXL		-0.2917	-0.2955
60	A632XPa872	MXL		0.5850	0.5812
61	B73HtXMo17Ht	MXL		0.7183	0.0679
62	B73HtXB84	MXL		-2.3583**	-3.0088**
63	B73HtXPa872	MXL		0.6517	0.0012
64	Mo17HtXB84	LXL	-0.6505*	0.2483	-0.4021
65	Mo17HtXPa872	LXL		0.1583	-0.4921
66	B84XPa872	LXL		0.5817	-0.0688

$LSD_{0.05}(S_{ii}-S_{ij})=0.7869$, $LSD_{0.05}(S_{ii}-S_{jj})=0.6789$, $LSD_{0.05}(S_{ii}-S_{kl})=0.5231$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.5092$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=2.4945$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=2.3518$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.2516$, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=2.3671$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=2.2162$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=2.2930$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=2.4420$, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=2.2961$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 140. Estimates of general combining ability effects of Stalk lodging (%) in 1991, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	3.3767**	0.8667	4.2433**
2 Cm105	"	2		-5.1233**	-1.7467*
3 W117Ht	"	3		-2.8700**	0.5067
4 Ms74	"	4		7.1267**	10.5533**
5 W64A	Medium	1	0.8458*	-0.9925	-0.1467
6 Ms75	"	2		-0.4792	0.3667
7 A619	"	3		-1.4958	-0.6500
8 A632	"	4		2.9675**	3.8133**
9 B73Ht	Late	1	-4.2225**	-1.3042	-5.5267**
10 Mo17Ht	"	2		-0.6375	-4.8600**
11 B84	"	3		3.9925**	-0.2300
12 Pa872	"	4		-2.0508**	-6.2733**

$LSD_{0.05}(G_i-G_k)=1.2254$, $LSD_{0.05}(g_{ij}-g_{ij'})=2.4508$, $LSD_{0.05}(g_i-g_j)=2.4508$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 141. Estimates of Specific Combining Ability effects of Stalk lodging (%) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	2.0674	-3.5156	-1.4482
2	A641XW117Ht	EXE		-2.7689	-0.7015
3	A641XMs74	EXE		18.3011**	20.3685**
4	A641XW64A	EXM	-0.0407	-1.1075	-1.1482
5	A641XMs75	EXM		-1.5208	-1.5615
6	A641XA619	EXM		-3.4708	-3.5115
7	A641XA632	EXM		-2.2342	-2.2748
8	A641XB73Ht	EXL	-1.5098	0.7083	-0.8015
9	A641XMo17Ht	EXL		-1.2250	-2.7348
10	A641XB84	EXL		-2.2550	-3.7648
11	A641XPa872	EXL		-0.9117	-2.4215
12	Cm105XW117Ht	EXE		-0.0122	2.0552
13	Cm105XMs74	EXE		-10.8422**	-8.7748**
14	Cm105XW64A	EXM		3.1492	3.1085
15	Cm105XMs75	EXM		-1.4975	-1.5382
16	Cm105XA619	EXM		-0.3808	-0.4215
17	Cm105XA632	EXM		3.3225	3.2818
18	Cm105XB73Ht	EXL		-0.5683	-2.0782
19	Cm105XMo17Ht	EXM		6.6317**	5.1218*
20	Cm105XB84	EXM		0.6350	-0.8748
21	Cm105XPa872	EXL		3.0783	1.5685
22	W117HtXMs74	EXL		-1.1622	0.9052
23	W117HtXW64A	EXL		0.7292	0.6885
24	W117HtXMs75	EXL		-2.2842	-2.3248
25	W117HtXA619	EXE		6.2992*	6.2585*
26	W117HtXA632	EXM		-2.8975	-2.9382
27	W117HtXB73Ht	EXM		-0.0883	-1.5982
28	W117HtXMo17Ht	EXM		-0.5883	-2.0982
29	W117HtXB84	EXM		-1.2850	-2.7948
30	W117HtXPa872	EXL		4.0583	2.5485
31	Ms74XW64A	EXL		2.2658	2.2252
32	Ms74XMs75	EXL		-1.4475	-1.4882
33	Ms74XA619	EXL		5.7358*	5.6952*
34	Ms74XA632	EXM		-4.6608	-4.7015
35	Ms74XB73Ht	EXM		-2.3517	-3.8615
36	Ms74XMo17Ht	EXM		-3.3517	-4.8615
37	Ms74XB84	EXM		1.6517	0.1418
38	Ms74XPa872	EXL		-4.1383	-5.6482*
39	W64AXMs75	EXL		-5.1450*	-6.2382*
40	W64AXA619	EXL		-2.3950	-3.4882
41	W64AXA632	EXL		5.0417*	3.9485
42	W64AXB73Ht	MXM	-1.0932	2.2946	3.1552

Table 141. Estimates of Specific Combining Ability effects of Stalk lodging (%) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		-3.3054	-2.4448
44	W64AXB84	MXM		-0.2021	0.6585
45	W64AXPa872	MXL	0.8606	-1.3254	-0.464
46	Ms75XA619	MXL		-5.6750*	-6.7682**
47	Ms75XA632	MXL		4.2283	3.1352
48	Ms75XB73Ht	MXL		-0.7188	0.1418
49	Ms75XMo17Ht	MXM		3.4146	4.2752
50	Ms75XB84	MXM		9.9846**	10.8452**
51	Ms75XPa872	MXL		0.6613	1.5218
52	A619XA632	MXL		3.9450	2.8518
53	A619XB73Ht	MXL		0.7313	1.5918
54	A619XMo17Ht	MXL		0.0979	0.9585
55	A619XB84	MXM		-3.4321	-2.5715
56	A619XPa872	MXL		-1.4554	-0.5948
57	A632XB73Ht	MXL		-3.9654	-3.1048
58	A632XMo17Ht	MXL		3.7013	4.5618
59	A632XB84	MXL		-4.0288	-3.1682
60	A632XPa872	MXL		-2.4521	-1.5915
61	B73HtXMo17Ht	MXL		-1.5972	-0.7315
62	B73HtXB84	MXL		2.6394	3.5052
63	B73HtXPa872	MXL		2.9161	3.7818
64	Mo17HtXB84	LXL	0.8657	-3.5272	-2.6615
65	Mo17HtXPa872	LXL		-0.2506	0.6152
66	B84XPa872	LXL		-0.1806	0.6852

$LSD_{0.05}(S_{ii}-S_{ij})=2.3197$, $LSD_{0.05}(S_{ii}-S_{jj})=2.0012$, $LSD_{0.05}(S_{ii}-S_{kl})=1.5419$,
$LSD_{0.05}(S_{ij}-S_{ij'})=1.5008$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=7.3525$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=6.9319$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=6.6370$,
$LSD_{0.05}(s_{ijkl}-S_{ijk'l'})=6.9770$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=6.5323$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=6.7583$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=7.1977$,
$LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})=6.7675$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 142. Estimates of general combining ability effects of Root lodging (%) in 1991, over three locations.

Parent		Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1	A641	Early	1	0.0158	-0.1708	-0.1550
2	Cm105	"	2		-0.4008**	-0.3850*
3	W117Ht	"	3		-0.4142**	-0.3983*
4	Ms74	"	4		0.9858**	1.0017**
5	W64A	Medium	1	0.0083	0.0233	0.0317
6	Ms75	"	2		0.3033*	0.3117*
7	A619	"	3		0.1000	0.1083
8	A632	"	4		-0.4267**	-0.4183**
9	B73Ht	Late	1	-0.0242	0.0258	0.0017
10	Mo17Ht	"	2		-0.0142	-0.0383
11	B84	"	3		-0.1508	-0.1750
12	Pa872	"	4		0.1392	0.1150

$LSD_{0.05}(G_i-G_k)=0.2264$, $LSD_{0.05}(g_{ij}-g_{ij'})=0.4530$, $LSD_{0.05}(g_i-g_j)=0.4530$[1].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 143. Estimates of Specific Combining Ability effects of Root lodging (%) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.1433	0.1606	0.0173
2	A641XW117Ht	EXE		0.1739	0.0306
3	A641XMs74	EXE		0.1739	0.0306
4	A641XW64A	EXM	0.0302	-0.4296	-0.3994
5	A641XMs75	EXM		-0.5096	-0.4794
6	A641XA619	EXM		-0.3063	-0.2761
7	A641XA632	EXM		0.2204	0.2506
8	A641XB73Ht	EXL	0.0773	0.0533	0.1306
9	A641XMo17Ht	EXL		0.0933	0.1706
10	A641XB84	EXL		0.0967	0.1739
11	A641XPa872	EXL		0.2733	0.3506
12	Cm105XW117Ht	EXE		0.4039	0.2606
13	Cm105XMs74	EXE		-0.8294	-0.9727*
14	Cm105XW64A	EXM		0.0004	0.0306
15	Cm105XMs75	EXM		-0.2796	-0.2494
16	Cm105XA619	EXM		-0.2763	-0.2461
17	Cm105XA632	EXM		0.2504	0.2806
18	Cm105XB73Ht	EXL		-0.2167	-0.1394
19	Cm105XMo17Ht	EXM		0.1900	0.2673
20	Cm105XB84	EXM		0.4600	0.5373
21	Cm105XPa872	EXL		0.1367	0.2139
22	W117HtXMs74	EXL		-0.0828	-0.2261
23	W117HtXW64A	EXL		-0.1863	-0.1561
24	W117HtXMs75	EXL		-0.1329	-0.1027
25	W117HtXA619	EXE		-0.2629	-0.2327
26	W117HtXA632	EXM		0.4304	0.4606
27	W117HtXB73Ht	EXM		-0.0033	0.0739
28	W117HtXMo17Ht	EXM		-0.1633	-0.0861
29	W117HtXB84	EXM		-0.0267	0.0506
30	W117HtXPa872	EXL		-0.1500	-0.0727
31	Ms74XW64A	EXL		0.0804	0.1106
32	Ms74XMs75	EXL		0.6671	0.6973
33	Ms74XA619	EXL		1.3371**	1.3673**
34	Ms74XA632	EXM		-0.6029	-0.5727
35	Ms74XB73Ht	EXM		-0.5033	-0.4261
36	Ms74XMo17Ht	EXM		-1.3967**	-1.3194**
37	Ms74XB84	EXM		-0.2267	-0.1494
38	Ms74XPa872	EXL		1.3833**	1.4606**
39	W64AXMs75	EXL		-0.4656	-0.4661
40	W64AXA619	EXL		-0.1622	-0.1627
41	W64AXA632	EXL		0.1978	0.1973
42	W64AXB73Ht	MXM	-0.0005	0.3404	0.3106

Table 143. Estimates of Specific Combining Ability effects of Root lodging (%) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		0.5471	0.5173
44	W64AXB84	MXM		-0.1496	-0.1794
45	W64AXPa872	MXL	-0.0298	0.2271	0.1973
46	Ms75XA619	MXL		0.8911*	0.8906
47	Ms75XA632	MXL		-0.4156	-0.4161
48	Ms75XB73Ht	MXL		1.3938*	1.3639**
49	Ms75XMo17Ht	MXM		-0.2663	-0.2961
50	Ms75XB84	MXM		0.0371	0.0073
51	Ms75XPa872	MXL		-0.9196*	-0.9494*
52	A619XA632	MXL		-0.0456	-0.0461
53	A619XB73Ht	MXL		-0.6029	-0.6327
54	A619XMo17Ht	MXL		-0.2296	-0.2594
55	A619XB84	MXM		0.0738	0.0439
56	A619XPa872	MXL		-0.4163	-0.4461
57	A632XB73Ht	MXL		-0.0763	-0.1061
58	A632XMo17Ht	MXL		0.1304	0.1006
59	A632XB84	MXL		0.1004	0.0706
60	A632XPa872	MXL		-0.1896	-0.2194
61	B73HtXMo17Ht	MXL		0.4772	0.4139
62	B73HtXB84	MXL		-0.2861	-0.3494
63	B73HtXPa872	MXL		-0.5761	-0.6394
64	Mo17HtXB84	LXL	-0.0633	0.1539	0.0906
65	Mo17HtXPa872	LXL		0.4639	0.4006
66	B84XPa872	LXL		-0.2328	-0.2961

$LSD_{0.05}(S_{ii}-S_{ij})$=0.4287, $LSD_{0.05}(S_{ii}-S_{jj})$=0.3699, $LSD_{0.05}(S_{ii}-S_{kl})$=0.2850, $LSD_{0.05}(S_{ij}-S_{ij'})$=0.2773, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=1.3586, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=1.2811, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=1.2264, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})$=1.2893, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=1.2072, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=1.2489, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=1.3301, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})$=1.2507.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 144. Estimates of general combining ability effects of Moisture content (%) in 1991, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[(1)] (gij)
1 A641	Early	1	-1.1958**	-0.9375**	-2.1333**
2 Cm105	"	2		0.4825**	-0.7133**
3 W117Ht	"	3		0.0158	-1.1800**
4 Ms74	"	4		0.4392**	-0.7567**
5 W64A	Medium	1	-0.0442	0.5308**	0.4867**
6 Ms75	"	2		-0.6725**	-0.7167**
7 A619	"	3		1.0608**	1.0167**
8 A632	"	4		-0.9192**	-0.9633**
9 B73Ht	Late	1	1.2400**	0.8500**	2.0900**
10 Mo17Ht	"	2		-0.5133**	0.7267**
11 B84	"	3		0.3567**	1.5967**
12 Pa872	"	4		-0.6933**	0.5467**

$LSD_{0.05}(G_i - G_k) = 0.2176$, $LSD_{0.05}(g_{ij} - g_{ij'}) = 0.4349$, $LSD_{0.05}(g_i - g_j) = 0.4349$[(1)].

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 145. Estimates of Specific Combining Ability effects of Moisture content (%) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	0.6497**	-0.3061	0.3436
2	A641XW117Ht	EXE		-0.0394	0.6103
3	A641XMs74	EXE		0.0372	0.6870
4	A641XW64A	EXM	0.0016	1.6088**	1.6103**
5	A641XMs75	EXM		0.3788	0.3803
6	A641XA619	EXM		-0.8546	-0.8530
7	A641XA632	EXM		0.6921	0.6936
8	A641XB73Ht	EXL	-0.4889**	-0.9375*	-1.4264**
9	A641XMo17Ht	EXL		-0.1408	-0.6297
10	A641XB84	EXL		-0.4108	-0.8997*
11	A641XPa872	EXL		-0.0275	-0.5164
12	Cm105XW117Ht	EXE		0.2072	0.8570
13	Cm105XMs74	EXE		-0.9494*	-0.2997
14	Cm105XW64A	EXM		-0.5446	-0.5430
15	Cm105XMs75	EXM		0.4921	0.4936
16	Cm105XA619	EXM		0.2921	0.2936
17	Cm105XA632	EXM		-0.2279	-0.2264
18	Cm105XB73Ht	EXL		-0.3242	-0.8130
19	Cm105XMo17Ht	EXM		0.6725	0.1836
20	Cm105XB84	EXM		0.4692	-0.0197
21	Cm105XPa872	EXL		0.2192	-0.2697
22	W117HtXMs74	EXL		1.0506*	1.7003**
23	W117HtXW64A	EXL		-0.2779	-0.2764
24	W117HtXMs75	EXL		-0.0413	-0.0397
25	W117HtXA619	EXE		-0.6413	-0.6397
26	W117HtXA632	EXM		-0.5279	-0.5264
27	W117HtXB73Ht	EXM		0.2425	-0.2464
28	W117HtXMo17Ht	EXM		0.6725	0.1836
29	W117HtXB84	EXM		-0.2975	-0.7864
30	W117HtXPa872	EXL		-0.3475	-0.8364
31	Ms74XW64A	EXL		-0.0013	0.0003
32	Ms74XMs75	EXL		1.2688**	1.2703**
33	Ms74XA619	EXL		-0.8313	-0.8297
34	Ms74XA632	EXM		-0.7846	-0.7830
35	Ms74XB73Ht	EXM		-0.2475	-0.7364
36	Ms74XMo17Ht	EXM		0.2158	-0.2730
37	Ms74XB84	EXM		-0.1208	-0.6097
38	Ms74XPa872	EXL		0.3625	-0.1264
39	W64AXMs75	EXL		0.1861	0.0936
40	W64AXA619	EXL		-0.2472	-0.3397
41	W64AXA632	EXL		0.1661	0.0736

Table 145. Estimates of specific combining ability effects of Moisture content (%) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [(1)] (s_{ij})
42	W64AXB73Ht	MXM	-0.0925	-0.1475	-0.0797
43	W64AXMo17Ht	MXM		-0.3175	-0.2497
44	W64AXB84	MXM		-0.6542	-0.5864
45	W64AXPa872	MXL	0.0678	0.2292	0.2970
46	Ms75XA619	MXL		-1.2439**	-1.3364**
47	Ms75XA632	MXL		0.7361	0.6436
48	Ms75XB73Ht	MXL		-1.1775**	-1.1097*
49	Ms75XMo17Ht	MXM		-0.5142	-0.4464
50	Ms75XB84	MXM		-0.4175	-0.3497
51	Ms75XPa872	MXL		0.3325	0.4003
52	A619XA632	MXL		0.4028	0.3103
53	A619XB73Ht	MXL		2.3558**	2.4236**
54	A619XMo17Ht	MXL		0.6192	0.6870
55	A619XB84	MXM		1.3158**	1.3836**
56	A619XPa872	MXL		-1.1675**	-1.0997*
57	A632XB73Ht	MXL		-0.1642	-0.0964
58	A632XMo17Ht	MXL		0.0658	0.1336
59	A632XB84	MXL		-0.3375	-0.2697
60	A632XPa872	MXL		-0.0208	0.0470
61	B73HtXMo17Ht	MXL		-0.0144	0.5470
62	B73HtXB84	MXL		0.2156	0.7770
63	B73HtXPa872	MXL		0.1989	0.7603
64	Mo17HtXB84	LXL	0.5614**	-0.6211	-0.0597
65	Mo17HtXPa872	LXL		-0.6378	-0.0764
66	B84XPa872	LXL		0.8589*	1.4203**

$LSD_{0.05}(S_{ii}-S_{ij})=0.4118$, $LSD_{0.05}(S_{ii}-S_{jj})=0.3552$, $LSD_{0.05}(S_{ii}-S_{kl})=0.2736$, $LSD_{0.05}(S_{ij}-S_{ij'})=0.2664$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=1.3050$, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=1.2305$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.1780$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=1.2383$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.1595$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=1.1995$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=1.2775$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=1.2013$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 146. Estimates of general combining ability effects of Plant height (cm) in 1991, over three locatins.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-8.6375**	-5.2375**	-13.8750**
2 Cm105	"	2		1.9825	-6.6550**
3 W117Ht	"	3		1.4892	-7.1483**
4 Ms74	"	4		1.7658	-6.8717**
5 W64A	Medium	1	-2.4642**	-0.8008	-3.2650**
6 Ms75	"	2		2.4225*	-0.0417
7 A619	"	3		-6.6608 *	-9.1250**
8 A632	"	4		5.0392**	2.5750*
9 B73Ht	Late	1	11.1017**	-1.6967	9.4050**
10 Mo17Ht	"	2		3.2900**	14.3917**
11 B84	"	3		6.7167**	17.8183**
12 Pa872	"	4		-8.3100**	2.7917*

$LSD_{0.05}(G_i-G_k)=1.8661$, $LSD_{0.05}(g_{ij}-g_{ij'})=3.7320$, $LSD_{0.05}(g_i-g_j)=3.7320$.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 147. Estimates of specific combining ability effects of Plant height (cm) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-1.3442	6.7606	5.4164
2	A641XW117Ht	EXE		3.7206	2.3764
3	A641XMs74	EXE		-1.5894	-2.9336
4	A641XW64A	EXM	-1.3641	3.9571	2.5930
5	A641XMs75	EXM		4.8004	3.4364
6	A641XA619	EXM		-7.4163*	-8.7803*
7	A641XA632	EXM		-5.4163	-6.7803
8	A641XB73Ht	EXL	2.3722**	-6.2158	-3.8437
9	A641XMo17Ht	EXL		7.4308*	9.8030*
10	A641XB84	EXL		0.6708	3.0430
11	A641XPa872	EXL		-0.7025	-4.3303
12	Cm105XW117Ht	EXE		8.4672*	7.1230
13	Cm105XMs74	EXE		-9.5428**	-10.8870**
14	Cm105XW64A	EXM		5.1704	3.8064
15	Cm105XMs75	EXM		-0.7529	-2.1170
16	Cm105XA619	EXM		-2.0696	-3.4336
17	Cm105XA632	EXM		-6.7363	-8.1003*
18	Cm105XB73Ht	EXL		1.6642	4.0364
19	Cm105XMo17Ht	EXM		-2.7558	-0.3836
20	Cm105XB84	EXM		6.1175	8.4897*
21	Cm105XPa872	EXL		-6.3225	-3.9503
22	W117HtXMs74	EXL		-7.8161*	-9.1603*
23	W117HtXW64A	EXL		-12.7029**	-14.0670**
24	W117HtXMs75	EXL		-6.3263	-7.6903*
25	W117HtXA619	EXE		7.5571*	6.1930
26	W117HtXA632	EXM		12.7571**	11.3930*
27	W117HtXB73Ht	EXM		2.5242	4.8964
28	W117HtXMo17Ht	EXM		-7.2625	-4.8903
29	W117HtXB84	EXM		-4.0225	-1.6503
30	W117HtXPa872	EXL		3.1042	5.4764
31	Ms74XW64A	EXL		1.7204	0.3564
32	Ms74XMs75	EXL		4.4971	3.1330
33	Ms74XA619	EXL		-2.6863	-4.0503
34	Ms74XA632	EXM		3.6471	2.2830
35	Ms74XB73Ht	EXM		5.0808	7.4530
36	Ms74XMo17Ht	EXM		-10.6058**	-8.2336*
37	Ms74XB84	EXM		10.5675**	12.9397**
38	Ms74XPa872	EXL		6.7275	9.0997*
39	W64AXMs75	EXL		-5.4161	-2.6736
40	W64AXA619	EXL		-0.0994	2.6430
41	W64AXA632	EXL		3.0672	5.8097
42	W64AXB73Ht	MXM	2.7425*	-0.4608	-1.1536

Table 147. Estimates of specific combining ability effects of Plant height (cm) in 1991, over three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		6.5192	5.8264
44	W64AXB84	MXM		-5.9742	-6.6670
45	W64AXPa872	MXL	-0.6928	4.2192	3.5264
46	Ms75XA619	MXL		6.2439	8.9864*
47	Ms75XA632	MXL		-1.5561	1.1864
48	Ms75XB73Ht	MXL		4.4158	3.7230
49	Ms75XMo17Ht	MXM		-11.0708**	-11.7636**
50	Ms75XB84	MXM		2.3025	1.6097
51	Ms75XPa872	MXL		2.8625	2.1697
52	A619XA632	MXL		-2.2394	0.5030
53	A619XB73Ht	MXL		0.6992	0.0064
54	A619XMo17Ht	MXL		-0.6208	-1.3136
55	A619XB84	MXM		9.4858*	8.7930*
56	A619XPa872	MXL		-8.8542*	-9.5470*
57	A632XB73Ht	MXL		-3.8675	-4.5603
58	A632XMo17Ht	MXL		7.6458*	6.9530
59	A632XB84	MXL		-5.3808	-6.0736
60	A632XPa872	MXL		-1.9208	-2.6136
61	B73HtXMo17Ht	MXL		3.5289	1.2897
62	B73HtXB84	MXL		-9.6978**	-11.9370**
63	B73HtXPa872	MXL		2.3289	0.0897
64	Mo17HtXB84	LXL	-2.2392	-0.7178	-2.9570
65	Mo17HtXPa872	LXL		7.9089*	5.6697
66	B84XPa872	LXL		-3.3511	-5.5903

$LSD_{0.05}(S_{ii}-S_{ij})$=0.1234, $LSD_{0.05}(S_{ii}-S_{jj})$=0.1234, $LSD_{0.05}(S_{ii}-S_{kl})$=0.1234,
$LSD_{0.05}(S_{ij}-S_{ij'})$=0.1234, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=11.1961,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=10.5560, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=10.1065,
$LSD_{0.05}(s_{ijkl}-S_{ijk'l'})$=10.6244, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=9.9474,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=10.2914, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=10.9605,
$LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})$=10.3055.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 148. Estimates of general combining ability effects of Ear height (cm) in 1991, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[1] (gij)
1 A641	Early	1	-6.6300**	-1.5517	-8.1817**
2 Cm105	"	2		-0.9850	-7.6150**
3 W117Ht	"	3		3.8483**	-2.7817**
4 Ms74	"	4		-1.3117	-7.9417**
5 W64A	Medium	1	-1.9125**	5.0842**	3.1717**
6 Ms75	"	2		2.7308**	0.8183
7 A619	"	3		-13.2892**	-15.2017**
8 A632	"	4		5.4742**	3.5617**
9 B73Ht	Late	1	8.5425**	-0.6742	7.8683**
10 Mo17Ht	"	2		4.3858**	12.9283**
11 B84	"	3		7.7058**	16.2483**
12 Pa872	"	4		-11.4175**	-2.8750**

$LSD_{0.05}(G_i-G_k)$=1.2797, $LSD_{0.05}(g_{ij}-g_{ij'})$=2.5594, $LSD_{0.05}(g_i-g_j)$=2.5594.[1]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 149. Estimates of specific combining ability effects of Ear height (cm) in 1991, over three locations.

	Cross	Class	Class effect (s_{ii} or s_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.9132	3.8144	2.9012
2	A641XW117Ht	EXE		1.6478	0.7345
3	A641XMs74	EXE		-3.9589	-4.8721
4	A641XW64A	EXM	0.0616	0.9529	1.0145
5	A641XMs75	EXM		3.2396	3.3012
6	A641XA619	EXM		-1.1738	-1.1121
7	A641XA632	EXM		-1.8371	-1.7755
8	A641XB73Ht	EXL	0.6233	-0.7054	-0.0821
9	A641XMo17Ht	EXL		1.1679	1.7912
10	A641XB84	EXL		0.2146	0.8379
11	A641XPa872	EXL		-3.3621	-2.7388
12	Cm105XW117Ht	EXE		5.3144*	4.4012
13	Cm105XMs74	EXE		-6.4922**	-7.4055**
14	Cm105XW64A	EXM		4.0196	4.0812
15	Cm105XMs75	EXM		0.1063	0.1679
16	Cm105XA619	EXM		-4.1738	-4.1121
17	Cm105XA632	EXM		-2.2704	-2.2088
18	Cm105XB73Ht	EXL		-1.8721	-1.2488
19	Cm105XMo17Ht	EXM		-0.7321	-0.1088
20	Cm105XB84	EXM		6.0479*	6.6712*
21	Cm105XPa872	EXL		-3.7621	-3.1388
22	W117HtXMs74	EXL		-0.3256	-1.2388
23	W117HtXW64A	EXL		-7.0138**	-6.9521**
24	W117HtXMs75	EXL		-9.1271**	-9.0655**
25	W117HtXA619	EXE		3.1263	3.1879
26	W117HtXA632	EXM		10.6296**	10.6912**
27	W117HtXB73Ht	EXM		-0.5388	0.0845
28	W117HtXMo17Ht	EXM		-0.6654	-0.0421
29	W117HtXB84	EXM		-4.7188	-4.0955
30	W117HtXPa872	EXL		1.6712	2.2945
31	Ms74XW64A	EXL		1.6129	1.6745
32	Ms74XMs75	EXL		4.4663	4.5279
33	Ms74XA619	EXL		-1.0804	-1.0188
34	Ms74XA632	EXM		-1.4771	-1.4155
35	Ms74XB73Ht	EXM		5.4546*	6.0779*
36	Ms74XMo17Ht	EXM		-4.2388	-3.6155
37	Ms74XB84	EXM		2.4079	3.0312
38	Ms74XPa872	EXL		3.6312	4.2545
39	W64AXMs75	EXL		-0.2372	1.3479
40	W64AXA619	EXL		0.8161	2.4012
41	W64AXA632	EXL		0.8861	2.4712
42	W64AXB73Ht	MXM	1.5851	-1.8850	-3.1355

Table 149. Estimates of specific combining ability effects of Ear height (cm) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
43	W64AXMo17Ht	MXM		1.2217	-0.0288
44	W64AXB84	MXM		-5.5650*	-6.8155**
45	W64AXPa872	MXL	-1.2506*	5.1917*	3.9412
46	Ms75XA619	MXL		0.7694	2.3545
47	Ms75XA632	MXL		0.7394	2.3245
48	Ms75XB73Ht	MXL		3.8683	2.6179
49	Ms75XMo17Ht	MXM		-6.5583*	-7.8088**
50	Ms75XB84	MXM		3.9550	2.7045
51	Ms75XPa872	MXL		-1.2217	-2.4721
52	A619XA632	MXL		-2.9739	-1.3888
53	A619XB73Ht	MXL		3.2217	1.9712
54	A619XMo17Ht	MXL		0.6950	-0.5555
55	A619XB84	MXM		5.4750*	4.2245
56	A619XPa872	MXL		-4.7017	-5.9521*
57	A632XB73Ht	MXL		-5.5417*	-6.7921*
58	A632XMo17Ht	MXL		6.7650**	5.5145*
59	A632XB84	MXL		-4.0550	-5.3055*
60	A632XPa872	MXL		-0.8650	-2.1155
61	B73HtXMo17Ht	MXL		-1.5617	-0.7255
62	B73HtXB84	MXL		-3.9150	-3.0788
63	B73HtXPa872	MXL		3.4750	4.3112
64	Mo17HtXB84	LXL	0.8362	2.0583	2.8945
65	Mo17HtXPa872	LXL		1.8483	2.6845
66	B84XPa872	LXL		-1.9050	-1.0688

$LSD_{0.05}(S_{ii}-S_{ij})=0.1234$, $LSD_{0.05}(S_{ii}-S_{jj})=0.1234$, $LSD_{0.05}(S_{ii}-S_{kl})=0.1234$,
$LSD_{0.05}(S_{ij}-S_{ij'})=0.1234$, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})=7.6783$,
$LSD_{0.05}(s_{ijkl}-s_{ij'kl'})=7.2391$, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=6.9310$,
$LSD_{0.05}(s_{ijkl}-s_{ijk'l'})=7.2861$, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=6.8218$,
$LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})=7.0578$, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})=7.5166$,
$LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})=7.0674$.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 150. Estimates of general combining ability effects of Stand count (# of plants/ha) in 1991, over three locations.

Parent	Class	Parent W/in Class	Class effect (Gi)	W/in class effect(gi)	GCA[(1)] (gij)
1 A641	Early	1	-1.1969**	-1.7892**	-2.9861**
2 Cm105	"	2		3.2375**	2.0406**
3 W117Ht	"	3		1.5875**	0.3906
4 Ms74	"	4		-3.0358**	-4.2328**
5 W64A	Medium	1	1.3347**	1.7258**	3.0606**
6 Ms75	"	2		1.2125*	2.5472**
7 A619	"	3		-2.2742**	-0.9394
8 A632	"	4		-0.6642	0.6706
9 B73Ht	Late	1	-0.1378	1.2217*	1.0839
10 Mo17Ht	"	2		0.3717	0.2339
11 B84	"	3		-2.0750**	-2.2128**
12 Pa872	"	4		0.4817	0.3439

$LSD_{0.05}(G_i-G_k)$=3.9200, $LSD_{0.05}(g_{ij}-g_{ij'})$=1.7199, $LSD_{0.05}(g_i-g_j)$=1.7199[(1)]

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.

Table 151. Estimates of Specific Combining Ability effects of Stand count (# of plants/ha) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
1	A641XCm105	EXE	-0.0884	-0.2928	-2.3812
2	A641XW117Ht	EXE		2.8906	2.8021
3	A641XMs74	EXE		-3.9194*	-4.0079*
4	A641XW64A	EXM	-0.1583	-1.3763	-1.5345
5	A641XMs75	EXM		-2.5629	-2.7212
6	A641XA619	EXM		1.6571	1.4988
7	A641XA632	EXM		1.0471	0.8888
8	A641XB73Ht	EXL	0.2246	-0.8158	-0.5912
9	A641XMo17Ht	EXL		9.2675**	9.4921**
10	A641XB84	EXL		-1.9192	-1.6945
11	A641XPa872	EXL		-1.9758	-1.7512
12	Cm105XW117Ht	EXE		0.9972	0.9088
13	Cm105XMs74	EXE		-0.0461	-0.1345
14	Cm105XW64A	EXM		0.0304	-0.1279
15	Cm105XMs75	EXM		-0.2229	-0.3812
16	Cm105XA619	EXM		-0.4029	-0.5612
17	Cm105XA632	EXM		-0.1796	-0.3379
18	Cm105XB73Ht	EXL		1.3908	1.6155
19	Cm105XMo17Ht	EXM		2.8075	3.0321
20	Cm105XB84	EXM		1.3208	1.5455
21	Cm105XPa872	EXL		-3.4025	-3.1779
22	W117HtXMs74	EXL		2.3706	2.2821
23	W117HtXW64A	EXL		-1.0529	-1.2112
24	W117HtXMs75	EXL		1.4271	1.2688
25	W117HtXA619	EXE		1.0138	0.8555
26	W117HtXA632	EXM		1.8038	1.6455
27	W117HtXB73Ht	EXM		-1.9592	-1.7345
28	W117HtXMo17Ht	EXM		-1.9758	-1.7512
29	W117HtXB84	EXM		-2.9958	-2.7712
30	W117HtXPa872	EXL		-2.5192	-2.2945
31	Ms74XW64A	EXL		2.9371	2.7788
32	Ms74XMs75	EXL		2.3504	2.1921
33	Ms74XA619	EXL		-10.9963**	-11.1545**
34	Ms74XA632	EXM		4.5271**	4.3688*
35	Ms74XB73Ht	EXM		1.5975	1.8221
36	Ms74XMo17Ht	EXM		-3.4525*	-3.2279
37	Ms74XB84	EXM		-1.8392	-1.6145
38	Ms74XPa872	EXL		6.4708**	6.6955**
39	W64AXMs75	EXL		-0.5717	-0.1012
40	W64AXA619	EXL		2.2817	2.7521
41	W64AXA632	EXL		-2.1617	-1.6912

Table 151. Estimates of Specific Combining Ability effects of Stand count (# of plants/ha) in 1991, over three locations.

	Cross	Class	Class effect (S_{ii} or S_{ij})	W/in class effect(s_{ijkl})	SCA [1] (s_{ij})
42	W64AXB73Ht	MXM	0.4705	-1.8100	-2.0045
43	W64AXMo17Ht	MXM		-0.0933	-0.2879
44	W64AXB84	MXM		1.6867	1.4921
45	W64AXPa872	MXL	-0.1945	0.1300	-0.0645
46	Ms75XA619	MXL		0.8283	1.2988
47	Ms75XA632	MXL		-2.4483	-1.9779
48	Ms75XB73Ht	MXL		-2.1633	-2.3579
49	Ms75XMo17Ht	MXM		-0.4867	-0.6812
50	Ms75XB84	MXM		2.2667	2.0721
51	Ms75XPa872	MXL		1.5833	1.3888
52	A619XA632	MXL		2.0717	2.5421
53	A619XB73Ht	MXL		0.1233	-0.0712
54	A619XMo17Ht	MXL		3.1733	2.9788
55	A619XB84	MXM		2.8867	2.6921
56	A619XPa872	MXL		-2.6367	-2.8312
57	A632XB73Ht	MXL		-0.6200	-0.8145
58	A632XMo17Ht	MXL		-3.0367	-3.2312
59	A632XB84	MXL		-0.1567	-0.3512
60	A632XPa872	MXL		-0.8467	-1.0412
61	B73HtXMo17Ht	MXL		0.5289	0.4888
62	B73HtXB84	MXL		2.0089	1.9688
63	B73HtXPa872	MXL		1.7189	1.6788
64	Mo17HtXB84	LXL	-0.0401	-5.7344**	-5.7745**
65	Mo17HtXPa872	LXL		-0.9978	-1.0379
66	B84XPa872	LXL		2.4756	2.4355

$LSD_{0.05}(S_{ii}-S_{ij})$=1.6280, $LSD_{0.05}(S_{ii}-S_{jj})$=1.4043, $LSD_{0.05}(S_{ii}-S_{kl})$=1.0821, $LSD_{0.05}(S_{ij}-S_{ij'})$=1.0533, $LSD_{0.05}(s_{ijkl}-s_{ijkl'})$=5.1599, $LSD_{0.05}(s_{ijkl}-s_{ij'kl'})$=4.8649, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=4.6577, $LSD_{0.05}(s_{ijkl}-S_{ijk'l'})$=4.8965, $LSD_{0.05}(s_{ijkl}-s_{ij'k'l'})$=4.5844, $LSD_{0.05}(s_{ijkl}-s_{i'jk'l'})$=4.7430, $LSD_{0.05}(s_{ijkl}-s_{ijk'l})$=5.0513, $LSD_{0.05}(s_{ijkl}-S_{ij'k'l'})$=4.7495.

(1) = Griffing's method.

*, ** = significant at p=0.05 and 0.01 respectively.