

IDENTIFICATION OF DROUGHT TOLERANT GERMPLASM IN MAIZE (*Zea mays* L.)

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1. INTRODUCTION

Maize is one of the important cereal crops occupying 144 m ha with a production of 695 mt in the world. In India, it is grown in 8.26 m ha with a production of 19.31 m t (Anonymous, 2008). The productivity of maize in India is low (2337 kg/ha) as compared the world average (4815 kg / ha). This is because nearly 79 per cent of the maize area is under rainfed situation, where the crop experiences soil moisture stress for long duration or short duration leading to decreased yield. In Karnataka, the crop is grown in 1.17 m ha with a production and productivity of 3.58 m t and 3060 kg/ha, respectively (Anonymous, 2009). About 42 per cent of the maize area is under irrigation and 58 per cent of the area is under rainfed situation in Karnataka.

Drought is the most pervasive limitation to the realization of yield potential in maize (Edmeades *et al.*, 2001). Average annual global losses due to drought in maize range from 15% in temperate zone to 17% in tropical zone as estimated by empirical methods (Edmeades *et al.*, 2000b). A precise measurement of yield losses world wide is not possible due to range of occurrences of drought from individual fields to regional in extent, range of severity from slight to catastrophic. Losses are greatest in parts of the world where soils and weather patterns are less favourable than US Corn Belt, which is named for its long term suitability for growing maize at relatively low level of risk of crop failure.

There is more subtle impact of moisture stress on yields and yield stability. Transient drought stress may limit yield, even when the visual symptoms are not evident. Within a given field of maize, variation in soil depth and texture induce stress unevenly across the field allowing portions to appear unstressed, while others suffer severe stress. Kitchen *et al.* (1999) documented a maize field where yield varied from a low of 3.4 t/ha in sandy or compacted portion of the field to a high of 11.3 t/ha in areas with deep soil or where runoff may have impounded. Since a single cultivar is normally grown, it needs to withstand a wide range of water stresses without sacrificing yield in the better areas of the field.

Keeping in view the fact that the global climatic change is under way, intensity and frequency of disturbances like *EL-Nino* effects is predicted to further increase, as realized in the past. *El-nino* is defined as a large scale shift in water currents and wind of the equatorial and tropical Pacific, resulting in extreme climatic changes characterized by excessive rains and strong winds in some areas and drought in others (Tibig, 1995). Such disturbances are certainly going to adversely affect rainfall, particularly distribution pattern that will result in poor and scanty rainfall in one area causing severe water deficit and heavy and concentrated rainfall in other, causing waterlogging coupled with heavy nutrient leaching in light soils (Zaidi *et al.*, 2007).

Breeding maize for drought tolerance is important to close the gap between rainfed and well watered yields. Water-conserving growing practices with limited or complete irrigation play a critical part, but are limited in many parts of the country due to water availability or economic reasons for non-adoption. Genetic solutions although not complete can be more easily packaged and promoted than agronomic and other input dependent practices, and are more easily adopted.

Maize is very sensitive to water stress in the period one week before flowering to two weeks after flowering (Grant *et al.*, 1989). Drought during this period results in an easily measured increase in the anthesis- silking interval (ASI) as the silk emergence is delayed (Edmeades *et al.*, 2000) and in grain abortion (Boyle *et al.*, 1991). When the drought occurs at 75 per cent silking, a yield loss to the extent of 53 per cent is noticed (Classon and Shaw, 1970).

Based on the consideration of heritability and correlation with yield under stress, Banziger *et al.* (2000b) proposed secondary traits such as barrenness, ASI, leaf senescence and leaf rolling were useful for improving maize in drought-prone environments.

In Karnataka, drought appears once in every 5-6 years. During drought years the maize grown under rainfed situations especially in Davanagere, Haveri, Shimoga, Chitradurga and Bellary districts (where about 45 per cent of *kharif* area is under rainfed conditions) suffers heavily. Hence, there is a need to identify /develop drought tolerant maize germplasm to cater to the needs of rainfed situations. Therefore, an investigation entitled "Identification of drought tolerant maize (*Zea mays* L.) germplasm" involving the maize inbred lines and populations developed/ maintained at All India Coordinated Maize Improvement Project, Agricultural Research Station, Arabhavi (University of Agricultural Sciences, Dharwad) and few inbred lines supplied by the Maize Breeder, All India Coordinated Maize Improvement Project, Agricultural Research Station, Nagenahalli (University of Agricultural Sciences, Bengaluru), has been attempted with the following objectives.

1. To evaluate inbred lines, populations and productive hybrids for drought tolerance,
2. To assess combining ability effects and variance with respect to traits related to drought tolerance and
3. To assess the relative drought tolerance of the derivatives obtained from two and more than two sources of drought tolerance.

2. REVIEW OF LITERATURE

Drought can be defined as inadequacy of availability of water including rainfall and soil moisture capacity, in quantity and distribution during the life cycle of the crop, which restricts the expression of its full genetic yield potential (Sinha, 1987). Crop experiences drought stress when the water requirements of the plants at one or more growth stages exceed the available water in the root zone, leading to substantial yield losses.

Arnon (1972) defined drought resistance as the ability to survive in drought condition without injury. To a plant breeder, drought resistance is the ability of one genotype to be more productive with a given amount of soil moisture than another (Quizenberry, 1982). However, when the drought is not a regular phenomenon, drought resistance refers to the crop plant to produce its economic yield with minimum loss in a water deficit environment, relative to water constraint-free environment. But in the absence of established correlations between field performance under drought and plant traits or mechanisms, the latter can not be directly used to characterize genotypes as drought resistant (Seetharama, 1995).

To date, the progress in improving drought resistance is slow and some times elusive. The lack of progress may be attributed to at least three major problems. First, a cultivar may utilize multiplicity of drought escape, avoidance and / or tolerance mechanisms to achieve some measure of overall drought resistance in a given climate. Because, climate in many agricultural regions exhibits substantial year- to- year variability; any single mechanism is unlikely to contribute consistently to relative success of a variety. Secondly, drought resistance is a complex trait, expression of which depends on action and interaction of different morphological, physiological and biochemical characters. Finally, with a few exceptions, technologies are not generally developed to the extent that physiological mechanisms can be routinely evaluated in plant breeding programmes dealing with large number of genotypes.

The earlier efforts to understand drought tolerance in maize is reviewed here under with following headings.

- 2.1 Drought situations
- 2.2 Approaches for genetic improvement
- 2.3 Managed stress
- 2.4 Morpho-physiological and yield traits under drought
- 2.5 Biochemical nature of drought tolerance
- 2.6 Association of traits under drought
- 2.7 Inheritance and combining ability studies
- 2.8 Heterosis
- 2.9 Stability of hybrids and inbreds
- 2.10 Variability

2.1 Drought situations

In India, quite often drought (once in 3 years) occurs in arid regions like eastern Rajasthan and once in 5-6 years in states like Karnataka and Madhya Pradesh. The chance of occurrence of drought in semi-arid region is once in four years. However, arid areas are more prone to drought because of which their share is less to total food crop production. Tropical semi-arid regions are characterized by high evapo-transpiration demand and low water holding capacity of soils rendering them more drought susceptible than semi-arid areas of temperate regions.

The type of drought situation in which a crop is grown, greatly determines the type of mechanism that should be developed and the appropriate breeding methodology to be used.

There are mainly three types of environments under which crops can be raised which may experience drought stress in their life cycle, though numerous combinations of these environments can occur.

2.1.1 Stored moisture environment

In this environment, the crop completes its entire life cycle on soil moisture that is stored in the soil during the previous season. The degree or intensity of drought is determined by the amount of water that is stored in the soil during the period. The potential for genetic improvement of drought resistance in this environment should have a high probability of success. Breeding strategies to exploit this type of environment cover a broad spectrum of traits like functional, morphological, phenological and metabolic traits.

2.1.2 Variable moisture environment

In this environment, crop is grown during the portion of the year when precipitation is expected to occur. During the crop growth, the alternate dry and wet periods of varying lengths can be expected. Plants grown in this environment must be able to take an advantage of the rainfall when it occurs and are in constant competition with atmospheric evaporation for the available soil moisture. In this environment, plants need to have high photosynthetic rates, stomatal responses sensitive to moisture deficits, dense but not necessarily deep roots, rapid osmotic adjustments and indeterminate growth habits (Turner, 1979). Probability of success of breeding efforts is less in this environment because of variability in seasonal precipitation which hinders the development of crop varieties. Maize growing regions of western and central India represent this type of environment.

2.1.3 Optimal moisture environment

The crop is grown with adequate soil moisture during most of its life cycle but occasional periods of drought may occur during the growing season. Drought in such areas is highly unpredictable. This environment is considered to be optimal for crop production. Stomata that close quickly at a relatively high water content to maintain the plant water balance during drought should be useful. Rapid osmotic adjustment to maintain cell turgor, extensive root development and indeterminate growth habits are some mechanisms of value to the plant breeder for this environment (Turner, 1979).

2.2 Approaches for genetic improvement

Various approaches have been applied for genetic improvement in maize for improved stable yields under water limited environment. The most common approaches are: 1) selection on the basis of yield through multilocation testing and 2) selection based on the secondary traits and grain yield under managed stress.

2.2.1 Selection on the basis of yield through multilocation testing

This approach relies on multilocation testing of advanced progenies in the environments representing a random selection of the variation in drought stress in the target environment (Rosielle and Hamblin, 1981) and selection is largely on the basis of grain yield. The expectation of this approach is that the germplasm with high yield potential under optimal input environment will perform better under low input environment by virtue of their high yield potential. Usually, the potential germplasm identified from the first round screening are evaluated for tolerance to various stresses, including water stress. However, since the materials are at advanced generation at the time of testing for abiotic stresses, the selection intensity is customarily low, and therefore, progress in breeding for tolerance to abiotic stresses is poor (Banziger *et al.*, 2000a). Recent study on selection of germplasm for stability across the stressed and nonstressed environment suggested that with conventional approach of selection under optimal conditions, it is possible that some of the best materials with tolerance to drought and/ or low-N stress might have been rejected, while other less desirable materials for marginal and less favourable environments are selected on the basis of their superior performance under optimal input and favourable environments (Zaidi *et al.*, 2004). Plant response to limited water condition in terms of drought adaptive traits is only expressed when they are exposed to such climate and genetic variability as can be identified.

Under multilocation testing, which is largely under optimal input conditions such traits are rarely expressed and selection on the basis of yield with an assumption that by virtue of high yield potential the selected genotypes will perform equally good under real target environment is always misleading (Zaidi *et al.*, 2007).

In general, most of the modern high yielding cultivars are usually developed under favourable environments and optimal conditions, it may not be surprising to observe their poor performance under marginal environment. Though, spillover effect with selection for high yield potential under optimal input conditions is realized under mild stress conditions. If the stress is severe enough to the extent that yield falls below 50-60 per cent, the high yield potential proved to be less important (Banziger and Lafitte, 1997) and stress adaptive genes present in the germplasm are expressed and help in saving productivity of germplasm up to some extent (Blum, 1997). Therefore, selection and improvement of germplasm only under optimal input conditions may not be suitable for those target areas that are prone to various abiotic constraints (Simmonds, 1991).

Finally, Byrne *et al.*, (1995) concluded that the desirable selection strategy for breeding maize for drought tolerance may be “selection under managed levels of drought stress at one location together with multilocation testing”.

2.2.2 Selection on the basis of secondary traits along with grain yield under managed stress

Grain yield is commonly used as a selection criterion in breeding programmes. However, inheritance of yield is complex and its heritability often declines under stress conditions. Therefore, selection on the basis of grain yield *per se* for improved performance under abiotic stresses is often misleading and inefficient. Therefore, stress breeding programmes commonly use secondary traits, whose heritability remain relatively high and genetic and phenotypic correlations between grain yield and those traits increase sharply under stress; for example, ASI and cobs per plant (Bolanos and Edmeades, 1996; Banziger and Lafitte, 1997). Use of secondary traits, in addition to grain yield, as selection criteria for tolerance to different abiotic stresses have been suggested (Banziger and Lafitte, 1997; Edmeades *et al.*, 1996). It is recognized that heritability of grain yield usually declines under drought conditions (Banziger *et al.*, 1997; Bolanos and Edmeades, 1996). Therefore, secondary traits could improve selection efficiency under stress conditions. The key secondary traits that could be used efficiently are reduced barrenness (increased cobs per plant under stress), anthesis-silking interval, stay green (reduced lower leaf senescence) and to lesser extent leaf rolling under drought (Banziger *et al.*, 2000b). Other traits such as root growth are only useful when they have been field tested but difficult to assess. Using stress adaptive secondary traits along with grain yield in maize has improved the selection gain in yield under low nitrogen stress by 20 per cent in comparison to selection for yield *per se* (Banziger and Lafitte, 1997).

2.3 Managed Stress

One challenge in selecting the basis for genotypic differences in drought tolerance is the identification and management of uniform and reproducible water deficit environments. Historically, the use of many yield test locations within a breeding programme was assumed to incorporate a percentage of these environments. In practice, this has proven challenging due to unpredictable rainfall patterns in the U.S. Corn Belt and natural bias to conduct yield trials in areas with high yield potential (Barker *et al.*, 2005).

An alternative approach to extensive sampling is to develop managed stress locations with carefully designed reproducible levels of timing, duration and intensity of water deficits. This is best accomplished by choosing locations with historically low rainfall during the maize growing season. Ideally, these locations will also possess deep, well drained soils with uniform water holding capacity in the maize root zone. These factors are critical since small differences in uniformity lead to large differences in plant water deficits under drought stress resulting in unmanageable levels of variability for yield and secondary traits of interest. A dependable high quality water source is also necessary to control pre-stress irrigation and “load” specific levels of water holding capacity and to provide adequate irrigation for irrigated control plots.

Extreme precision in irrigation application is required, necessitating the use of drip tape or overhead irrigation systems. Knowledge of evapo-transpiration rates and hybrid phenology must be combined in order to expose / “stage” plants for specific drought levels at specific developmental stages.

The flowering period in maize (a few days before silking to 25 days after silking) is most sensitive to drought stress and water deficits during this time can sharply reduce the grain number per plant (Classen and Shaw, 1970; Shaw, 1977; Herrero and Johnson, 1981; NeSmith and Ritchie, 1992). Sensitivity during this period may be greater in maize than other cereals because of its monoecious habit and its relatively synchronous development of many florets on a single ear. Data show that gains in tolerance of grain yield to flowering stress have outpaced those for stress tolerance during the latter half of grain filling (Barker *et al.*, 2005). This was accomplished by systematic reductions in anthesis-silking interval with relatively little change in stay green or in weight per kernel under grain filling and terminal stress. Thus, susceptibility to stress at flowering has kept pace with increases in yield potential, while performance under late season stress has not improved as rapidly as yield potential. Elite hybrids show considerable variation in drought susceptibility at flowering and in ASI, but the best of these show little yield loss when drought coincides with flowering (Bruce *et al.*, 2002).

2.4 Morpho-physiological and yield traits under drought

Drought resistance is a complex trait, expression of which depends on action and interaction of different morpho-physiological and biochemical reactions. When the maize plant is under drought stress, it shows the symptoms like, stunted growth, tip firing, tassel blast, leaf firing in lower leaves, both mild and extreme rolling and wilting of the leaves, silk delay, poor seed set, barrenness, reduced root system and dead plants and ultimately poor yield.

2.4.1 Plant height

Severe drought stress in early growing stage affects the length of internodes (Jurgens *et al.*, 1978). Plant height reduction had been reported when crop was subjected to drought stress (Pandey *et al.*, 1987; Fischer *et al.*, 1989; Gu *et al.*, 1989; Hemalatha Devi, 1989; Abellandsa and Cauny, 1991; Babu, 1992 and Subba Rao, 1992).

Reduction in ear height was also reported in maize when subjected to drought (Hemalatha Devi, 1989; Abellandsa and Cauny, 1991; Subba Rao, 1992; Babu, 1992 and Tej Pal, 1992).

2.4.2 Delayed silking and poor seed set

Floral development and flowering are the most drought sensitive stages of the maize life cycle. Silk delay has been found to be a primary cause of yield reduction in field condition (Jensen, 1971). Short period of water shortage at flowering stage reduces the fertilization, seed set and grain yield and ear size (Hall *et al.*, 1981). Drought stress delayed silking and anthesis-dates and reduced grain filling period but little effect on physiological maturity. Delay in silking and anthesis dates and widening of anthesis-silking interval was also reported by several workers in maize crop (Grant *et al.*, 1989, Fredrick *et al.*, 1989; Fischer *et al.*, 1989; Fussel *et al.*, 1991; Babu, 1992; Nesmith and Ritchie, 1992; Subba Rao, 1992; Tej Pal, 1992; Bolanos and Edmeades, 1993a; Ribaut *et al.*, 1996). Edmeades *et al.* (1989) suggested that reduced anthesis-silking interval in maize is caused by increased partitioning of assimilate to the development of ear rather than by changes in phenology of development rate.

Meena Kumari *et al.* (2004) reported that under severe stress, the anthesis-silking interval ranged from 3-5 in drought tolerant inbreds and 9-17 in drought sensitive inbreds.

Mwambula and Myers (1991) studied the behaviour of maize genotypes under irrigated and rainfed conditions and concluded that number of barren plants were significantly reduced under irrigated condition.

2.4.3 Root System

In general, a plant with deep root system is expected to show greater drought tolerance as compared to shallow rooted one (Sullivan and Ross, 1978; Stasovski and Peterson, 1991).

Drought commonly increases the ratio of root to shoot (Mooney, 1972 and Larcher, 1975) and there are several reports of the absolute size of the root system actually increasing during the drought (Bennett and Doss, 1960 and Scheultz, 1974).

Prior to flowering, maize roots increase extensively in length, number and dry weight, and their capacity to capture water normally reaches a maximum near flowering (Mengel and Barber, 1974). Liedgens *et al.* (2000) studied growth of maize roots by means of minirhizotrons in lysimeters. During the growing season, the root density increased to a maximum and then decreased, at all depths and positions relative to the plant row. Maximum root density did not occur at the same time as pollen shed, in contrast to maximum leaf area. At shallow depths, the maximum root density was observed at the same time as pollen shed, while at a depth of 100 cm, the maximum root density occurred 2 weeks after pollen shed. The maximum root density was observed about 10 days after pollen shed at most positions relative to the plant row. They concluded that the maximum root density and hence resource uptake capacity of the root system was reached with some delay in relation to the vegetative development of the crop.

In a two year field study on Gleyic Luvisol, Weisler and Horst (2007) reported that roots of all the cultivars penetrated to 150 cm and significant differences among the cultivars for root length densities at silking.

Excess or too little soil resistance to root growth appear to send signals, perhaps abscisic acid (ABA), that reduce top growth and directly affect yield (Passioura, 2002). Root length density (cm length cm⁻³ soil) decreases exponentially with the depth of the soil in most maize cultivars (Gregory, 1994). Intense rooting near the soil surface is of limited value to the plant under prolonged water stress, and is less necessary for nutrient capture in modern production systems because fertilizer is placed close to the plant.

Recurrent selection for eight cycles in one tropical maize population exposed to severe drought stress at flowering results in a 35 per cent root biomass reduction in upper 0.5 m of soil (Bolanos *et al.*, 1993) even though grain yield under flowering stress increased by 40 per cent (Bolanos and Edmeades, 1993a). Since measuring roots is difficult in breeding programme, several researchers have used electrical capacitance measurements for rapid root dimensions assessment. Although, electrical capacitance and total root volume are positively correlated (van Beem *et al.*, 1998). Hund *et al.* (2009) concluded from the study from rooting depth and water use efficiency of tropical maize inbred line differing for drought tolerance that a combination of high water use efficiency and sufficient water acquisition by a deep root system could increase drought tolerance.

2.4.4 Relative water content (RWC)

With increasing stress, the RWC decreased, while free proline content increased (Patil *et al.*, 1984). Popovic *et al.* (1989) reported the correlation between relative water content and water potential indicating an osmotic adjustment under mild stress conditions. Further, Chen *et al.* (1990a) interpreted that water potential and relative water content decreased under water stress condition. Chen *et al.*, (1990b) also concluded that relative water content in leaves decreased significantly in drought susceptible variety than resistant variety. Similarly, higher relative water content was observed throughout the period of water stress in drought resistant cultivar than in the drought sensitive cultivar (O'Regan *et al.*, 1993 and 1994 and Pelleschi *et al.*, 1995).

In a simulation study on responses of maize to various soil water levels, Li-Ping *et al.* (2006) observed that when compared to well-watered conditions during the silking and blister stages moderate stress did not significantly change the relative water content (RWC) but it did change significantly the relative conductivity ($P < 0.05$) of the leaves. However, severe stress did significantly decrease ($P < 0.01$) the leaf RWC.

2.4.5 Stomatal resistance, transpiration rate and photosynthetic rate

Gu *et al.* (1990) reported that maize cultivar Yuvu No. 3 was drought resistant as it reduced water loss by increased stomatal resistance and osmotic potential.

Production under water stress increases when transpiration is sustained and when water use efficiency and harvest index are improved (Blum, 1988). Subba Rao and Jana (1991) reported that drought tolerant lines maintained significantly higher transpiration efficiency, water use efficiency and plant water status than sensitive lines.

The timing and completeness of stomatal closure during water stress and reopening following water stress relief, is an important character. Preservation of water by closing of stomata is an important drought resistance mechanism as continued photosynthesis involves continuous water loss (Teare *et al.*, 1973). In plants, which have been allowed to wilt and were rewatered, the stomata remained closed for several days, even when there was a rapid recovery of the full turgidity (Hiron and Wright, 1973).

The effect of water deficit on transpiration is well known. The effect of ABA as an agent that lowered transpiration rate was first noticed by Little and Eidt (1968). Abscissic acid caused the stomata to close and thus reduced the rate of transpiration (Jones and Mansfield, 1970). Sharp reductions in photosynthesis and sharp increase in leaf diffusion resistance at specific water potentials could be the result of ABA induced stomatal closure.

Meena Kumari *et al.* (2004) observed that under stress, drought tolerant inbreds showed less leaf temperature but transpiration rate was comparatively high.

2.4.6 Chlorophyll content

Meena Kumari *et al.* (2004) reported that chlorophyll content and stability index decreased under drought stress. They observed up to 60 per cent decrease in chlorophyll content when the drought stress was applied at flowering. But when the stress was applied at grain filling period the reduction in chlorophyll content was noticed up to 50 per cent. The drought tolerant inbreds either resisted the decrease in chlorophyll content or showed very little reduction. The susceptible inbreds showed large reduction in the chlorophyll content under drought. Under drought conditions, the decrease in chlorophyll content was also reported by various workers (Gutierrez *et al.*, 1998; Abdel-Rasoul *et al.*, 1989 and Chaves *et al.*, 2003).

2.4.7 Leaf rolling

Leaf rolling is commonly observed during the vegetative period and contributes to decreased light interception. Its occurrence varies greatly among genotypes and has usually been selected against in breeding programmes that target improved drought tolerance (Bolanos and Edmeades, 1996). Rolling typically begins mid-day, a few days after first observing reduced plant height in water stressed plots. It reflects plant water status, leaf morphology and the presence of bulliform cells.

Changes in leaf angle reduced water loss by providing more shading of lower leaves and by reducing canopy temperature. Reduced tassel size, narrow leaves and leaf enlargement following drought stress were considered to be good and easy to evaluate (Jurgens *et al.*, 1978).

Bennett and Hammond (1983) reported that drought reduced leaf area by 19 per cent. Resistant lines were found to have lesser leaf area per plant under moisture stress (Morizet *et al.*, 1984). Sobrado (1990) observed reduction in leaf area under moisture stress and suggested that small leaf area, as a consequence of water deficit during vegetative development of crop, decreases the carbon source of grain yield.

2. 5 Biochemical nature of drought tolerance

One of the effects of water stress on protein synthesis relates to the blockage of amino acid at different points in their biosynthetic pathway (Younis *et al.*, 1965; Naylor, 1982). Free proline accumulates under water stress (Routley, 1966; Singh *et al.*, 1972; Waldern *et al.*, 1974). Mc Cue and Hanson (1990) proposed proline accumulation as a mechanism conferring adaptive value to plant under water deficits.

Harrigan *et al.* (2007) reported significant accumulation of free glutamine and free proline, with induction of drought in grains of at least four maize hybrids out of seven hybrids.

Betaine is another compound that accumulates under water shortage and acts like proline (Pollard and Jones, 1979; Mc Cue and Hanson, 1990). Hanson and Nelson (1978) suggested that selection against high betaine genotypes might be useful in breeding programmes.

The level of growth inhibitors in plants increase when plants are subjected to moisture stress. The major inhibitor is abscisic acid (ABA) which mainly controls stomatal closure (Aspinall, 1980), and indirectly the rate of transpiration (Milborrow, 1981). The high concentration of ABA reduces transpiration by promoting stomatal closure and therefore, may promote tolerance to drought. Pekic and Quarrie (1987) observed a positive correlation between ABA accumulation levels and drought resistance.

During moisture stress, the enzymatic action is extremely altered and variation of its activity plays a vital role in plant growth (Jurgens *et al.*, 1978). Under wilting conditions, the activities of invertase and proteases increase in both seedling and full grown plants.

In a simulation study on responses of maize to various soil water levels, Li-Ping *et al.* (2006) observed decreased activity of antioxidant enzymes in the later stages; superoxide dismutase (SOD) during tasseling and blister stages, peroxidase (POD) during milk stage, and catalase (CAT) during the tasseling, blister, and milk stages. But membrane lipid peroxidation (measured as malondialdehyde content) significantly increased ($P < 0.01$) in all stages.

Kolarovic *et al.* (2009) reported significant activation of antioxidative defense mechanisms correlated with drought-induced oxidative stress tolerance, and this phenomenon was shown to be characteristic of the drought-tolerant cv. Nova. Activities of some ROS-scavenging enzymes, superoxide dismutase (SOD), guaiacol peroxidase (POX), catalase (CAT) and ascorbate peroxidase (APX) were enhanced significantly 4 h after the start of drought exposure in the drought-tolerant cv. Nova. Furthermore, a significant increase in the ascorbate pool was observed in this cultivar. On the other hand, in the drought-sensitive cv. Ankora only SOD and POD activities and the thiol pool were increased. No changes in APX activity or the level of ascorbate were recorded in cv. Ankora. Studies of root cell viability indicated that marked oxidative damage appeared only in cv. Ankora.

2.6 Association of traits under drought

Drought resistance is a very complex phenomenon. Grain yield of plant is the net result of several genetic factors and their individual or combined interplay with environmental factors. Therefore, character association among themselves or with grain yield is of importance. Findings of various workers with respect to association of characters among themselves and with grain yield are presented below.

The leaf number was significantly correlated with plant height, silking date and grain moisture at harvest (Allen *et al.*, 1973). Plant height and cob weight exhibited positive direct effects on grain yield (Kang and Zuber, 1978).

A significant positive association was observed between grains per ear and ear length and between number of leaves and plant height (Svridov, 1979).

Grain yield was found to be significant but negatively correlated with silk delay and positively correlated with germination on osmotic solution (Martiniello and Lorenzoni, 1985).

Several workers reported the positive correlation of grain yield under drought conditions with root weight, root volume, root number and root length (Musick *et al.*, 1965; Russel, 1974 and Beck, 1986).

High positive correlation was observed between 100-grain weight and grains per cob (Satovic, 1975). Path analysis indicated that both the components directly influenced the grain yield.

Singh and Nigam (1977) reported positive correlation of grain yield with 500-grain weight, grains per cob, cob length and cob girth. They also reported the direct path effects for these characters.

The grain yield was negatively correlated with plant height and ear height under drought (Fillipov and Vishnevskii, 1981). Similarly, Fischer *et al.* (1983) reported negative association of grain yield with interval between silking and pollen shedding and plant height.

Significant positive correlation under stress was reported between yield and plant height, number of leaves, ear girth, ear length and 100-grain weight (Mahaboobali and Naidu, 1983).

Schoper (1986) reported a positive correlation of 500-grain weight with days to pollen shedding and negative correlation with interval between silking and pollen shedding and days to 75 per cent silking.

Under drought condition, grain yield was positively associated with harvest index, plant height, ear height, leaf area per plant, grains per cob and cob length Sharma (1987). Proline content, harvest index, 500-grain weight, cob length, ear height, plant height and leaf area per plant had high direct contribution to grain yield.

Hemalatha Devi (1989) observed association of grain yield per plant with plant height, ear height, ear length, ear diameter and 100 grain weight under drought. Under severe moisture stress, yield was significantly correlated with interval between male and female flowering and canopy temperature (Fischer *et al.*, 1989). Similarly, Casanas *et al.* (1989) found that days to pollen shedding and silking showed strong correlations at genotypic and environmental levels with grain yield. Jadhav *et al.* (1991) reported that grain yield was significantly and positively correlated with plant height, 100-kernel weight and leaves per plant.

Correlation coefficients indicated that grain yield of water stressed maize was significantly influenced by number of leaves, ear height, interval between pollen shedding and silking, plant height and grains per row (Biasutti and Peiretti, 1992). Dash *et al.* (1992) reported that yield was significantly but negatively correlated with maturity traits. Path coefficient analysis revealed that ear diameter, plant height, ear length and 100-grain weight were the major factors contributing to yield. The number of kernel rows per ear and number of kernels per row influenced the yield through ear diameter.

Subba Rao (1992) reported that grain yield per plant exhibited significant positive correlation with plant height, ear height and all the yield components, whereas negative association was observed with days to 50 per cent tasseling, days to 50 per cent silking and wilt ratings at seedling stage.

Path analysis indicated that number of kernels per row, days to 50 per cent silking, ear diameter, number of kernel rows per ear and 100-grain weight had high direct contribution towards grain yield. Besides these, stomatal diffusive resistance, transpiration rate and relative humidity also exhibited high positive direct effects towards grain yield (Subba Rao, 1992).

The significantly positive association of yield was observed with 100-grain weight, ear height, plant height and canopy-air temperature difference but negatively correlated with days to 50 per cent silking, days to 50 per cent tasseling and anthesis-silking interval (Arefi, 1993). Grain yield per plant was correlated with cob girth, rows per cob and grains per row, and path analysis indicated high direct effect of these traits on grain yield (Singh *et al.*, 1993).

Krishnan and Natarajan (1995) reported high positive correlation of grain yield with plant height, ear height, ear weight, number of kernels per row, dry matter production and harvest index. Path analysis revealed that selection on any trait in maize will influence the grain yield only through dry matter production.

Grain yield per plant was observed to be correlated with 1000-grain weight, grain index, harvest index, biological yield, kernels per row and leaf area per plant in individual environments and pooled over environments (Vinodkumar, 1996).

Bolanos and Edmeades (1996) observed genetic correlations between grain yield and kernels per plant of 0.86 to 0.88 under severe flowering drought stress. Similar results reported by Otegui *et al.* (1995).

Chapman and Edmeades (1999) reported that grain yield was strongly associated with grain number per square metre in both water stressed and well watered environments. Under drought, grain yield, cobs per plant and grain number per fertile ear were strongly associated with ASI. Edmeades *et al.* (1999), while reporting the improvement of drought tolerance in three late maturing tropical maize populations subjected to three cycles of S_1 recurrent selection indicated that stem biomass was negatively correlated with harvest index.

Phenotypic correlations between grain yield and male and female flowering dates were mostly negative in both inbreds and hybrids under both stress and nonstress environments (Betran *et al.*, 2003b)

Monneveux *et al.* (2006) reported in two drought tolerant populations *viz.*, DTP 1 and DTP 2 that significant yield gains in the populations were associated with a significant increase in number of cobs per plant and grains per ear and significant reductions in anthesis to silking interval, ovule number and abortion rate during grain filling. Abortion rate was positively correlated with the number of ovules at silking and anthesis-silking interval.

Monneveux *et al.* (2008) reported strong correlation between yield and that mean grain weight, previously not used within a drought selection index. Their results indicated that the traits of source organs contributed marginally to drought tolerance; they opined that variation for leaf or root traits was less important than variation in tassel parameters for increasing drought tolerance. For ensuring further progress in drought tolerance in maize, the solution might reside in the manipulation of sink organs. Therefore, they suggested that selection for even greater number of ears, bigger grains and smaller tassels may help to increase grain yield under water limited environments in the near future.

Several workers reported positive correlation of grain yield with proline content under drought conditions (Pinter *et al.*, 1978; Patil *et al.*, 1984; Kantolic and Carceller, 1985 and Sharma, 1987).

2.7 Inheritance and Combining ability studies on drought tolerance

Spargue and Tatum (1942) gave the concept of combining ability. They defined general combining ability as the average performance of a line in a series hybrid combinations and specific combining ability as denoted by the cases in which certain combinations did relatively better or worst than would be expected on the basis of the average performance of the line involved. Griffing (1956) has given the method of analysis of combining ability utilizing diallel crossing system. The estimates of general combining ability (GCA) include additive genetic variance and the portion of the additive based higher order epistatic variance and the estimates of specific combining ability (SCA) include dominance and other portion of epistatic variance. Estimation of additive and dominance genetic variance can be obtained from a diallel cross only in the absence of epistasis.

Physiological mechanisms that control response to external factors and their interactions involve multiple pathways (Barker *et al.*, 2005). At the same time, recent gene expression studies shown that there are likely many genes of unknown function associated with drought responses (Zinselmeier *et al.*, 2002). Given the suite of pathways and array of external factors and their possible interactions, understanding drought tolerance inheritance and Mendelianization of its factors is a daunting challenge. Due to increased error variation, heritability decreases for yield and secondary traits influencing drought response under stress as the level of drought stress increases (Jensen, 1971; Jensen and Cavellieri, 1983; Blum, 1988; Bolanos and Edmeades, 1996).

Most of the secondary traits associated with drought tolerance are quantitatively inherited (Leberton *et al.*, 1995; Veldbloom and Lee, 1996a, 1996b; Tuberosa *et al.*, 1998; Sanguineti *et al.*, 1999; Tuberosa *et al.*, 2002a).

However, there are few examples of simple inheritance. Gentinetta *et al.* (1986) suggested that delayed senescence (staygreen) in maize inbred line Lo 87602 may be simply inherited dominant trait. Studies on staygreen in sorghum showed small number of QTL explaining large percentage of variation, suggesting relatively simple inheritance and some overlapped with known staygreen QTL in maize (Tao *et al.*, 2000; Kebede *et al.*, 2001). In small grains, Lilley *et al.* (1996), Morgan (1999) and Kim *et al.* (2000) reported that osmotic adjustment was simply inherited. However, it is safe to conclude that inheritance of yield, yield stability and most secondary traits associated with drought tolerance is complex, involving multiple interacting pathways throughout plant life cycle (Barker *et al.*, 2005).

Williams *et al.* (1969) reported significant SCA and GCA estimates for germination percentage in mannitol solution. They also reported that inbreds which exhibit high GCA for drought tolerance produce greater number of drought tolerant hybrids. GCA was more important than SCA for days to 50 per cent silking, plant height and ear height (Dhillon and Singh, 1976; Muchena 1978). Bhalla and Khera (1977) reported the importance of both GCA and SCA for grain yield, 500 grain weight, cob length and cob girth. Muchena (1978) reported the importance of GCA effects for plant height, ear height, days to 75 per cent silking and total pollen shed under drought. He also studied drought tolerance in maize and reported that GCA effects were important for grain yield. Both GCA and SCA effects were found significant for grain yield and all the five yield components.

Qadri *et al.* (1983) observed highly significant GCA and SCA effects for ear length, ear height and grains per cob under drought condition. GCA effects were found to be more significant than SCA effects for ear length, ear height, grain yield per plant, plant height and days to 75 per cent silking and SCA effects were more important for ASI (Khamis 1983). Nawar and El-Hosary (1984) deduced significant SCA effects for the characters like plant height, ear height and days to 75 per cent silking. Both GCA and SCA effects were found to be significant for germination in osmoticum (Patil *et al.*, 1984; Trapani and Motto, 1984; Singh and Subba Rao 1993).

Tan and Fultan (1985) reported significant GCA and SCA effects for root length, root number and root weight per plant. However, high GCA effects for leaf area per plant, root number, root length, root weight and stomata number per unit leaf area were reported by Dujer and Stewart (1985), whereas Fussender (1985) reported high SCA effects for root length, root weight and root number. Herbert and Gallais (1986) found that SCA effects were important for plant height, while Zamperi *et al.*, (1986) reported significant GCA effects for ear height. Both GCA and SCA effects were found to be significant for days to silking, days to tasseling and plant height, but for ear height only GCA effects were found to be significant (Hemlatha Devi, 1986). Miscevic (1989) established significant GCA and SCA effects for plant height. Similarly, Beck *et al.* (1990) accounted significant GCA estimates for plant height while, significant SCA estimates for ear height. Debnath and Sarkar (1990) gave greater importance for GCA x environment interaction than SCA x environment interaction was revealed for ear length and ear diameter. However, only SCA x environment was important for kernel rows per ear and 1000-kernel weight. But G x E interactions were of no importance for grain yield and kernels per row.

Beck *et al.* (1991) reported highly significant GCA effects for grain yield, whereas high GCA and SCA estimates were found for early silking and plant height (Mahajan *et al.*, 1991).

Rao *et al.* (1991) reported significant GCA and SCA effects for days to 75 per cent silking, plant height and ear height in individual environments as well as pooled over environments. However, Mean squares due to GCA and SCA in pooled analysis were significant for number of leaves. The variance due to GCA x environment and SCA x environment were also found to be significant for number of leaves (Brar and Labana, 1991).

Singh and Subba Rao (1993) concluded that GCA effects were significant for germination percentage, shoot length, root/shoot ratio and plant height in both water and PEG. The SCA effects were also significant for germination percentage, root, shoot length, root/shoot ratio and plant height stress index. Both GCA and SCA effects were significant for proline content and grain yield (Sharma and Bhalla, 1993). Alika (1994) indicated the significant GCA estimates for ear length, ear diameter, ear weight per plant and 100 grain

weight while, significant SCA estimates were reported for ear diameter. Pal and Prodhan (1994) reported significant GCA effects for ear diameter, rows per ear and 100-grain weight but for ear length and grains per row, SCA mean squares were significant. The GCA estimates were significant for grain yield per plant, ear girth, ear length, 100-grain weight and days to 50 per cent silking (Mathur and Bhatnagar, 1995).

Kumar (1996) observed highly significant GCA and SCA effects for grain yield and all the five yield components in individual environments as well as pooled over environments.

Betran *et al.* (2003b) reported that under drought, additive effects were more important and the importance of additive effects increased with intensity of drought suggesting the need for drought tolerance in both parental lines to achieve acceptable hybrid performance under severe drought.

Fu *et al.* (2008) reported that dominance effect was more important than additive effect for the plant height, anthesis-silking interval (ASI), root weight, and the grain yield per plant. Whereas, they were about equal for the leaf emergence rate. The variances of special combining ability (SCA) were about double that of the general combining ability (GCA) for plant height, ASI and grain yield per plant, although they were about equal for leaf emergence rate and root weight.

2.8 Heterosis

Shull coined the term 'heterosis' in 1914 and interpreted heterosis as increase in vigour, size, fruitfulness, speed of development, resistance to diseases and pests which is manifested by crossbred organisms as compared with corresponding inbreds as the specific results of unlikeness in the constitution of uniting gametes.

Heterosis has been exploited in many cross pollinated crops, especially in maize. Various theories have been proposed to explain and understand the phenomenon of heterosis. The biochemical, physiological and genetic basis of heterosis was extensively reviewed earlier (Gowen, 1952; Frankel, 1983).

Hays and Foster (1976) suggested that heterosis may result from one or more of the following genetic situations.

1. The accumulated action of favourable dominant or semi-dominant genes dispersed amongst the two parents *i.e.* dominance.
2. Complementary interaction of additive, dominant or recessive genes at different loci *i.e.* non-allelic interaction or epistasis.
3. Favourable interaction between two alleles at the same locus *i.e.*, intra-locus or inter-allelic interaction.

Some of the salient reports on heterosis under drought and non-drought conditions are presented below:

Rosic (1965) concluded from the crosses among drought tolerant inbred lines of maize, heterosis in grain yield resulted due to simultaneous heterosis for reduced plant height, less number of stomata per unit leaf area and long branched root system with high root weight and volume. However, the greater drought resistance was associated with the heterosis for long root system with high root weight and volume (Seriverja, 1968).

Salvioli and Martin (1968) observed heterosis for grain yield in crosses involving drought resistant inbred lines. Whereas high heterosis was observed for leaf area per plant, root weight and grain yield under drought (Muresan *et al.*, 1971).

The significant heterosis for early silking was also noticed (Mukherjee *et al.*, 1971 and Crossa *et al.*, 1990).

Mukherjee *et al.* (1974) reported heterosis for ear girth, kernel number per ear and grain yield. Heterosis for grain yield in relation to parental population ranged from 6.7 to 18.6 per cent and from -7.69 to 8.31 per cent when compared to better yielding parent.

A significant heterosis was noticed for 50 per cent tasseling (8.86 to 15.57%), days to silking (-11.70 to 18.62%) and plant height (-4.26 to 59.94%) (Ramamurthy, 1978).

The heterosis for the characters viz., plant height, ear height, earliness and grain yield, was observed under drought conditions (Akhtar and Singh, 1981). Similarly, high heterosis for plant height and ear height and medium to high heterosis for days to 75 per cent silking was noticed under drought conditions (Lee, 1983). However, Gama *et al.* (1984) reported low heterosis for plant height. The canopy-air temperature of tolerant hybrids was on an average 0.5°C cooler than that of the inbreds (Kirkham *et al.*, 1984).

Debnath (1984) observed highly significant heterosis for ear length and grains per ear. He also found the heterosis for grain yield ranging from -2.69 to 95.07 per cent over better parent. However, low heterosis for 500 grain weight, grain number per cob and cob girth under drought was reported by Diem and Dolika (1985).

Crossa *et al.* (1987) observed significant heterosis for plant height. While, Debnath and Sarkar (1987) reported high heterosis for number of kernels per row and low heterosis for ear diameter and number of kernel rows per ear. Younis *et al.* (1988) inferred that heterosis for grain yield ranged from 15.2 to 36.6 per cent under drought. Debnath and Sarkar (1990) reported highly significant heterosis for grain yield.

Heterosis over better parent for yield under Mexican environment ranged from 9.9 to 14.8 per cent in the cross (Beck *et al.*, 1991). The crosses which showed high heterosis for yield also exhibited higher estimates of heterosis for one or more of the yield components (Rao *et al.*, 1991).

Significant heterobeltiosis was exhibited by 20 crosses for number of kernels per ear, 22 crosses for 100-kernel weight and maximum heterosis observed for grain yield was 58.3 per cent (Bhatnagar and Sharma, 1991). Rao and Singh (1991) reported that the heterobeltiosis among different crosses for yield ranged between -5.9 and 30.18 per cent. They also observed high heterosis for yield components.

A maximum heterosis of 50.8 per cent over better parent for grain yield was observed (Khalidi and Singh, 1991). The promising varietal crosses with regard to grain yield had high heterotic expression and high *per se* performance through yield components also.

A significant positive heterosis over better parent for yield and yield components, number of leaves per plant and stomatal diffusive resistance, was observed (Subba Rao, 1992). While, Alvarez *et al.* (1993) reported highly significant heterosis for grain yield per plant and number of kernels per row. Similarly, high heterosis for grain yield was also confirmed by Gomes-e-Gama *et al.* (1995). Vinodkumar (1996) also reported heterosis for kernels per row, 1000-grain weight and grain yield per plant.

Betran *et al.* (2003a) observed greater expression of heterosis under drought stress and smaller under low N environments than under nonstress environments.

In a nonstress environment, Lata *et al.* (2008) reported high SCA effects and high heterosis for grain yield and early maturity.

2.9 Stability of hybrids /inbred lines

Dhillon and Malhi (2006) are of the opinion that maize breeding needs to be focussed on specific adaptation, for example, development of input responsive hybrids (specifically single crosses) for favourable environments, and early maturing hybrids and composites possessing tolerance to stresses like low nutrient supply and extreme moisture and temperature regimes for other environments. The cultivars must possess high yield, stability of performance, multiple resistance / tolerance to biotic/abiotic stresses and appropriate maturity. Machado *et al.* (2008) studied the single and double crosses of maize originated from the same pool and concluded that the double-crosses were on average more stable, although some single-crosses were as stable as the double-crosses.

Olaoye *et al.* (2009) reported grain yield of maize germplasm under various water regimes at different dates of sowing. In the first set, post anthesis moisture deficit significantly reduced grain yield by 25 to 73.5% in the open pollinated varieties (OPVs) and by 20 to 64% in the hybrids. The grain yield ranged from 2.48 to 3.49, 2.82 to 3.73 and 3.58

to 4.76 tonnes/ha for 1999, 2000 and 2001 full growing seasons, respectively, and 2.03 to 2.50 tonnes/ha for 2000 late growing season. In the second set of accessions, pre and post anthesis moisture deficits reduced grain yield by 77.6 and 95.8%, respectively, of well watered condition. Grain yields in the genotypes were highest for plantings made in April and July (1.90 - 2.5 tonnes/ha), lowest for August (0.7 - 1.8 tonnes/ha) when moisture deficit coincided with reproductive phase. Yield stability exhibited under moisture deficit and on the field by 8522-2, Oba super 2 and AK9943-DMRSR in the first set as well as DT-SR-Y C0 and DT-SR-W C0 in the second set, indicated their suitability either as cultivars *per se* or as potential source of DT alleles for development of DT maize varieties for Nigeria's savanna ecologies.

Romay *et al.* (2010) while reporting the climatic and genotypic effects of grain yield under stress observed that commercial hybrids had more yield and stability than most populations. He therefore, concluded that breeding programs focusing on yield have released hybrids with high yield and stability under stress conditions. The populations with a reasonable compromise between yield and stability were Andoain and Lira. The main genotypic covariate was kernel depth, followed by ear length, although other covariates were important for each location. The main climatic covariates for yield were related to days with mean temperature over 15°C and maximum temperature in September, but they were not consistent across locations. Therefore, if yield under stress conditions is a breeding goal, several climatic variables, especially those related to high temperatures and genotypic traits such as kernel depth and ear length should be considered.

Tollenaar and Lee (2002) opined that the genetic improvement in maize yield is associated neither with yield potential *per se*, nor with heterosis *per se*, but it is associated with increased stress tolerance, which is consistent with the improvement in the genotype $\times$ management interaction. They examined the relationship between yield and yield stability. Results of the stability analyses showed that high-yielding maize hybrids could differ in yield stability, but their results did not support the contention that yield stability and high grain yield are mutually exclusive.

Dass *et al.* (2001) while screening genotypes for drought tolerance observed that hybrids were more tolerant as compared to inbreds. Hybrids 1334-3 $\times$ 645, 610-2 $\times$ 295 and 1352 $\times$ 1344 with shorter ASI could resist the moisture stress to some extent.

2.10 Variability

Variability is a prerequisite for improvement in any breeding programme. Betran *et al.* (2003b) observed that higher grain yield (GY) in lines and hybrids was associated with shorter ASI, earlier flowering, increased plant and ear height, increased EPP, increased shelling percentage, delayed senescence, and greater leaf chlorophyll concentrations. Under stress vs. nonstress conditions they noticed a higher variability for ASI and ears per plant (EPP), a higher inbred-hybrid correlation, and significant correlations between these traits and GY. Inbreds from LP appear to have high frequency of favorable dominant alleles for ASI and EPP.

Bolanos and Edmeades (1996) suggested to considering the secondary traits of adaptive value whose genetic variability increases under drought and could increase selection efficiency. They reported that genetic variances for grain yield, kernels per ear and weight per kernel decreased with increasing drought, but those of ASI and cobs per plant increased. Broad sense heritability for grain yield ranged around 0.6, but fell to values near 0.4 at very low grain yield levels. Genetic correlations between grain yield and ASI or cobs per plant were weak under well watered conditions, but approached -0.6 and 0.90, respectively under severe moisture stress. From their study they concluded that 'secondary traits are not lacking genetic variability within the elite maize populations, but their low correlation with grain yield'.

Both grain yield and ASI had similar heritabilities, and variation in ASI accounted for 70 % of the grain yield across all trials comprising of six tropical populations (Bolanos and Edmeades, 1996). Bolanos and Edmeades (1993b) also reported that ASI accounted for 76 % of the variation in Tuxpeno Sequia.

3. MATERIALS AND METHODS

The present investigation was carried out during *rabi* 2007-08, 2008-09 and 2009-10 at Agriculture College Farm, Bheemaranagudi situated at 16° 44' N Latitude, 76° 47' East longitude, with an altitude of 458 m above mean sea level. The data on climatic parameters, such as rainfall and minimum and maximum temperature recorded at Agricultural Research Station, Bheemaranagudi during the crop growth period are furnished in Appendix 1.

The weather data during total crop growth period indicated that mean minimum and maximum temperatures ranged from 30.3 to 32.3°C during 2007-08, 30.8 to 34.8°C during 2008-09 and 28.9 to 33.0°C during 2009-10, respectively. The rainfall received during the period of crop growth was 32 mm (2007-08), 23 mm (2008-09) and 29 mm (2009-10), respectively. The experiments in all the seasons conducted under *rabi* / summer irrigated conditions. The dates of sowing were 09.10.2007, 14.11.2008 and 06.11.2009, respectively. The following experiments were conducted in the present study

- 3.1 Evaluation of inbred lines, populations / composites and commercial hybrids for drought tolerance under stress and nonstress conditions.
- 3.2 Evaluation of single cross hybrids produced in diallel fashion using 12 inbred lines that show variation for drought tolerance under stress and nonstress to study the combining ability effects and variances for drought tolerance related traits.
- 3.3 Evaluation of derivatives of drought tolerant population x drought tolerant inbred lines, drought tolerant commercial hybrid x drought tolerant inbred lines and crosses obtained from drought tolerant populations for drought tolerance under stress and nonstress conditions.

3.1 Evaluation of inbred lines, populations / composites and productive hybrids for drought tolerance under stress and nonstress conditions

Sixty two inbred lines maintained / developed at All India Coordinated Research Project on Maize, Agricultural Research Station, Arabhavi and 20 inbred lines supplied by the Maize Breeder, All India Coordinated Research Project on Maize, Agricultural Research Station, Nagenahalli, seven populations (four from Arabhavi, two from Nagenahalli and one from Kolhapur) and 10 productive commercial hybrids collected from the market (Table 1) were evaluated in the field following two factorial randomized block design during *rabi* 2007-08 at College of Agriculture, Bheemaranagudi. The experiments were conducted with two replications under stress and nonstress conditions. The genotypes under nonstress received recommended cultural practices besides regular irrigation (furrow) at an interval of 10-12 days so that they did not experience any stress. The same genotypes under stress situation received recommended cultural practices but irrigation up to 40 days after sowing and no irrigation thereafter till harvest so that they experienced moisture stress during flowering and grain filling period. The irrigated and managed stress experiments were separated by a four metre buffer zone of maize crop sown along with these experiments. Each entry was grown at a spacing of 75 cm x 20 cm, in a plot size of one row of 4 m length. Two seeds were dibbled per hill and later thinned to retain one seedling per hill.

The following characters except days to 50 per cent tasseling, days to 50 per cent silking, cobs per plant, maturity and grain yield per plot, were recorded on five randomly selected competitive plants per replication per genotype in inbreds and hybrids and 10 randomly selected plants per replication per genotype in case of composites / populations. The mean of five or 10 observations were computed for all the characters.

Table 1. List of inbred lines, populations and hybrids used for screening during *rabi* /summer 2007

Sl. No.	Inbreds	Sl. No.	Inbreds	Sl. No.	Genotypes
1	Bertam 701	35	CML-364-#-NA-R-2006		Inbreds
2	CI 4	36	CML-370-#-NA-R-2006	69	KDMI 17
3	CI 5	37	CML-389-#-NA-R-2006	70	KDMI 18
4	CM 111	38	CML-415-#-NA-R-2006	71	KDMI 19
5	CM 111 Sel	39	CML-426-#-NA-R-2006	72	KDMI 20
6	CM 132	40	CML-446	73	NEI 9202B
7	CM 133	41	Hyd Sel 1	74	NEI 9208B
8	CM 135	42	Hyd Sel 2	75	NG 4
9	CM 136	43	Hyd Sel 3	76	NG 14
10	CM 136-1	44	Hyd Sel 4	77	PAC 2176
11	CM 137	45	Hyd Sel 5	78	Pop28-C6- Bulk-#-#
12	CM 137-1	46	Hyd Sel 6	79	SKV-55-X-NA-K-2006
13	CM 138	47	Hyd Sel 7	80	SKV-62-X-NA-K-2006
14	CM 138-1	48	Hyd Sel 8	81	SKV-71-X-NA-K-2006
15	CM 202	49	Hyd Sel 9	82	SKV-76-X-NA-K-2006
16	CM 202 Sel	50	Hyd Sel 10		Populations
17	CM 500	51	Hyd Sel 11	83	G-25
18	CM 501	52	Hyd Sel 12	84	G 57
19	CML 37-#-NA-R-2006	53	Hyd Sel 13	85	Karveer
20	CML-44-#-NA-R-2006	54	Hyd Sel 14	86	NAC 6002
21	CML 68 (7)-#-#-#	55	Hyd Sel 15	87	NAC 6004
22	CML-113-#-#-#	56	Hyd Sel 16	88	Parbhat
23	CML-114-#-#-#	57	Hyd Sel 17	89	Yellow Pool
24	CML-118-C332-MH2-1-2-2-B-B-#	58	Hyd Sel 18		Hybrids
25	CML-183-CB2-RMM-30-1-2-1-B-13-#	59	KDMI 4	90	30 V 92
26	CML-217*(Tropical)	60	KDMI 10	91	All-Rounder
27	CML-223 (Tropical)	61	KDMI 11	92	Bio 9681
28	CML-297-#-NA-R-2006	62	KDMI 12	93	DMH 2
29	CML-298-#-NA-R-2006	63	KDMI 13-1	94	EH 434042
30	CML-310--#-NA-R-2006	64	KDMI 13-1-13	95	NAH 2049
31	CML-321-#-NA-R-2006	65	KDMI 13-1-29	96	NK 6240
32	CML-341-#-NA-R-2006	66	KDMI 14	97	Rajkumar
33	CNL-342-#-NA-R-2006	67	KDMI 15	98	900M
34	CML-361-#-NA-R-2006	68	KDMI 16	99	Suraj

3.1.1 Morphological characteristics

3.1.1.1 Days to 50 per cent tasseling

The number of days taken from sowing to tassel emergence in 50 per cent of the population in the plot.

3.1.1.2 Days to 50 per cent silking

The number of days taken from sowing to silk emergence in 50 per cent of the population in the plot.

3.1.1.3 Anthesis-Silking Interval (ASI)

It was obtained by the difference between days to 50 per cent silking and days to 50 per cent tasseling.

3.1.1.4 Plant height (cm)

The height of the plant was recorded at maturity from the base of plant to the tip of the tassel.

3.1.1.5 Ear height (cm)

The Ear height was recorded at maturity from the base of the plant to the node bearing the uppermost cob.

3.1.2 Yield and yield related traits

3.1.2.1 Cob length (cm)

The cob length was measured from bottom to tip of the cob after harvesting the cob.

3.1.2.2 Cob girth (cm)

It was measured at maximum girth of the cob.

3.1.2.3 Cobs per plant

Cobs per plant were computed as the ratio of number cobs per plot to number of plants per plot.

3.1.2.4 Number of kernel rows per cob

The number of kernel rows in each cob was counted and mean was computed.

3.1.2.5. Number of kernels per row

The number of kernels in any one of the rows in each cob was counted and mean was computed.

3.1.2.6 Shelling percentage

The shelling percentage was computed as the ratio of kernel weight to weight of cob (grain wt + pith weight), then the value was expressed in per cent.

3.1.2.7 Hundred grain weight (g)

The weight of 100 randomly selected grains was recorded separately and expressed in grams.

3.1.2.1.8 Grain yield per plant (g)

The cobs from randomly selected five plants were dried, shelled, cleaned and weight of grains was recorded and expressed as grams per plant.

3.1.2.9 Grain yield per plot (kg)

It was recorded after drying and shelling the grains from all the plants in a plot.

3.1.2.10 Drought Susceptible Index (DSI)

Drought susceptibility index was computed as suggested by Fisher and Maurer (1978)

$$DSI = \{1 - (Y_d / Y_p)\} / D$$

Where,

Y_d = Grain yield of the genotype under moisture stress condition

Y_p = Grain yield of the genotype under irrigated condition

Mean yield of all strains under moisture stress condition

$$D = \frac{\text{Mean yield of all strains under irrigated condition}}{\text{Mean yield of all strains under irrigated condition}}$$

3.1.2.11 Maturity

The genotype was considered matured when all the cobs in the plot exhibited 75 per cent brown husk

3.1.3 Statistical analysis

3.1.3.1 Analysis of variance

Data on 82 inbreds, seven composites and 10 productive commercial hybrids grown in stress and nonstress situations were analysed for variability using two Factorial Randomized Block Design by making use of WINDOSTAT software. The first factor is stress/nonstress and the second factor is genotypes. The structure of analysis is as follows.

ANOVA

Sources of variation	d.f.	MSS
Replication	(r-1)	MSSr
Treatment	(t-1)	MSSt
Factor A	(p-1)	MSSa
Factor B	(q-1)	MSSb
Interaction (A x B)	(p-1) (q-1)	MSSi
Error	q (p-1) (r-1)	MSSe
Total	(pqr-1)	

3.1.3.2 Standard errors

To compute the standard errors (S.E.) of estimates, mean sum of squares due to error factor from two factorial RBD analysis was considered.

$$\text{S.E. (stress/nonstress)} = \sqrt{2 \text{ MSSE}/rB}$$

$$\text{S.E. (Genotypes)} = \sqrt{2 \text{ MSSE}/rA}$$

$$\text{S.E. (Interaction)} = \sqrt{2 \text{ MSSE}/r}$$

3.2 Evaluation of single cross hybrids produced in diallel fashion for drought tolerance under stress and nonstress

3.2.1 Selection of inbreds for the development of single cross hybrids

Among the 82 inbred lines evaluated, 12 inbred lines showing good yield (nearer to mean+ 1 SD) and less ASI (nearer to mean – 1 SD), cobs per plant (nearer to mean+ 1 SD) and drought susceptibility index (nearer to mean – 1 SD) were selected for the production of single crosses in half diallel fashion. The list of inbred lines selected for hybridization are: CM 111, Hyd Sel 2, Hyd Sel 7, Hyd Sel 10, KDMI 15, NEI 9208B, CI 4, CML 446, Hyd Sel 4, Hyd Sel 15, Hyd Sel 17 and NEI 9202B. A total of 66 hybrids $[n(n-1)/2]$ were produced during *kharif* 2008. The list of hybrids produced is as follows:

List of crosses produced in 12 x 12 half diallel fashion

Sr No.	Cross	Sr No.	Cross
1	CM 111 x Hyd Sel 2	17	Hyd Sel 2 x CML 446
2	CM 111 x Hyd Sel 7	18	Hyd Sel 2 x Hyd Sel 4
3	CM 111 x Hyd Sel 10	19	Hyd Sel 2 x Hyd Sel 15
4	CM 111 x KDMI 15	20	Hyd Sel 2 x Hyd Sel 17
5	CM 111 x NEI 9208B	21	Hyd Sel 2 x NEI 9202B
6	CM 111 x CI 4	22	Hyd Sel 7 x Hyd Sel 10
7	CM 111 x CML 446	23	Hyd Sel 7 x KDMI 15
8	CM 111 x Hyd Sel 4	24	Hyd Sel 7 x NEI 9208B
9	CM 111 x Hyd Sel 15	25	Hyd Sel 7 x CI 4
10	CM 111 x Hyd Sel 17	26	Hyd Sel 7 x CML 446
11	CM 111 x NEI 9202B	27	Hyd Sel 7 x Hyd Sel 4
12	Hyd Sel 2 x Hyd Sel 7	28	Hyd Sel 7 x Hyd Sel 15
13	Hyd Sel 2 x Hyd Sel 10	29	Hyd Sel 7 x Hyd Sel 17
14	Hyd Sel 2 x KDMI 15	30	Hyd Sel 7 x NEI 9202B
15	Hyd Sel 2 x NEI 9208B	31	Hyd Sel 10 x KDMI 15
16	Hyd Sel 2 x CI 4	32	Hyd Sel 10 x NEI 9208B
33	Hyd Sel 10 x CI 4	50	NEI 9208B x Hyd Sel 17

34	Hyd Sel 7 x CML 446	51	NEI 9208B x NEI 9202B
35	Hyd Sel 7 x Hyd Sel 4	52	CI 4 x CML 446
36	Hyd Sel 7 x Hyd Sel 15	53	CI 4 x Hyd Sel 4
37	Hyd Sel 7 x Hyd Sel 17	54	CI 4 x Hyd Sel 15
38	Hyd Sel 7 x NEI 9202B	55	CI 4 x Hyd Sel 17
39	KDMI 15 x NEI 9208B	56	CI 4 x NEI 9202B
40	KDMI 15 x CI 4	57	CML 446 x Hyd Sel 4
41	KDMI 15 x CML 446	58	CML 446 x Hyd Sel 15
42	KDMI 15 x Hyd Sel 4	59	CML 446 x Hyd Sel 17
43	KDMI 15 x Hyd Sel 15	60	CML 446 x NEI 9202B
44	KDMI 15 x Hyd Sel 17	61	Hyd Sel 4 x Hyd Sel 15
45	KDMI 15 x NEI 9202B	62	Hyd Sel 4 x Hyd Sel 17
46	NEI 9208B x CI 4	63	Hyd Sel 4 x NEI 9202B
47	NEI 9208B x CML 446	64	Hyd Sel 15 x Hyd Sel 17
48	NEI 9208B x Hyd Sel 4	65	Hyd Sel 15 x NEI 9202B
49	NEI 9208B x Hyd Sel 15	66	Hyd Sel 17 x NEI 9202B

3.2.2 Evaluation of single cross hybrids

Sixty six single cross hybrids along with their parents and few checks were evaluated in the field following a two factorial randomized block design during post rainy seasons of 2008-09 and 2009-10, with two replications each under stress and nonstress situations as mentioned under 3.1, to study the combining ability effects and variances for drought tolerance related traits. Each entry was grown at a spacing of 75 cm x 20 cm, in a plot size of one row of 4 m length (3m length during 2009). The irrigated and managed drought experiments were separated by a 4 m or 3 m buffer strip that was also sown along with the experiments.

The observations on morphological traits were recorded as described under 3.1.1 and 3.1.2. In addition to those traits following traits were recorded on five randomly selected plants per replication per genotype (parents and hybrids).

3.2.2.1 Relative water content (RWC)

Relative water content expresses the water in the original sample as a percentage of the water in the fully hydrated tissue. It was estimated by following the method of Barrs and Weatherly (1962) at 60 and 90 DAS. Leaf discs of the third leaf from the top were collected (from five random plants) and weighed up to three decimals. This was taken as fresh weight of the tissue sample. The weighed leaf discs were floated in petridish containing distilled water and allowed to take up water for four hours. After four hours, leaf discs were blotted gently and weighed to get a turgid weight. After recording turgid weight, the leaf discs were dried in an oven at 80° C for 48 hours to get a dry weight. Then, RWC was calculated by using the following formula:

$$\text{RWC} = \frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Turgid weight (g)} - \text{Dry weight (g)}}$$

3.2.2.2 Chlorophyll content

The chlorophyll content of the third leaf from the top was measured at 60 and 90 DAS on five random plants using chlorophyll meter (SPAD-502, Konica Minolta make). The SPAD readings were recorded as the average value of chlorophyll at lower, upper and middle portion of the leaf of sample plant. SPAD reading is equivalent to chlorophyll content mg cm^{-2} (Herre *et al.*, 2001; Teng *et al.*, 2004).

3.2.3 Statistical analysis

Statistical methods followed for evaluation of crosses for variability for combining ability are described here.

3.2.3.1 Diallel analysis

Sixty six hybrids developed by utilizing 12 maize inbred lines differing for drought tolerance were used for combining ability analysis to select the diverse single crosses with the help of WINDOSTAT 8.0 software package.

3.2.3.1.1 Analysis of variance (ANOVA)

Analysis of variance for individual characters was carried out on the basis of mean value per entry per replication as suggested by Panse and Sukhatme (1967) for randomized block design (RBD). Analysis was required to test whether the crosses differed significantly among themselves or not and further, whether the parents differed significantly with the crosses or not.

Significance of treatments was tested both at 5 and 1% levels of significance.

3.2.3.1.2 Combining ability analysis

The variation among the hybrids was partitioned into genetic components attributable to general and specific combining ability in the crosses. The detailed procedure and steps of estimating combining ability effects and variances defined for method 2, model 1 (fixed effect) of Griffing (1956) was used for diallel analysis. Sixty six hybrids and their parents were used for combining ability analysis. The mathematical model used is as follows:

$$X_{ijk} = \mu + g_i + g_j + s_{ij} + 1 / bc \sum \Sigma e_{ijkl}$$

Where,

$i, j = 1, 2, \dots, n$

$k = 1, 2, \dots, b$

$l = 1, 2, \dots, c$

μ = population mean

g_i = General combining ability (gca) effect of i^{th} parent

g_j = General combining ability (gca) effect of j^{th} parent

s_{ij} = Specific combining ability (sca) effect of $(i \times j)^{\text{th}}$ cross

e_{ijkl} = Environmental effect associated with the $ijkl^{\text{th}}$ individual observation

n = Number of parents

b = Number of replications

c = Number of individuals in each replication

The model assumes that

i) $\sum_i g_i = 0$ and $\sum_j s_{ij} + s_{ii} = 0$ (for each i)

ii) the error (e_{ijkl}) is normally and independently distributed with mean equal to zero and variance equals σ_e^2

3.2.3.1.3 Combining ability variances

The analysis of variance table for combining ability is as follows:

Source	d.f.	S.S.	MSS	EMSS
gca	(n-1)	S_g	M_g	$\sigma_e^2 + \sigma_s^2 + (n+2) \sigma_g^2$
sca	$\frac{n(n-1)}{2}$	S_s	M_s	$\sigma_e^2 + \sigma_s^2$
Error	M	S_e	M_e	σ_e^2

Where,

$$S_g = \{ \sum (X_i + X_{ij})^2 \} - \frac{1}{(n+2)} - X^2 - \frac{4}{n}$$

$$S_s = \sum_i \sum_j X_{ij}^2 - \frac{2}{(n+2)} - \sum (X_i + X_{ij})^2 + \frac{2}{(n+1)(n+2)} X^2 \dots (i \leq j)$$

X_i = Total of i^{th} row

X_{ij} = Value of i^{th} parent

X = Grand total of the diallel table

X_{ij} = Value of the cross between i^{th} and j^{th} parents

N = Number of parents

The estimation of M_e the error term in the above table was obtained as $M_e^1 = M_e/b$, where M_e is the error variance estimated in the analysis of variance of the experiment and b is the number of replications. The general and specific combining ability variances were calculated based on the mean sum of squares as follows:

Where,

$$\sigma_g^2 = \frac{(M_g - M_s)}{n + 2}$$

$$\sigma_s^2 = M_s - M_e$$

The significance was tested by the 'F' ratio against M_e^1 .

3.2.3.1.4 Estimation of combining ability effects

The general combining ability (gca) effects and specific combining ability (sca) effects were estimated as follows.

$$\text{gca effects; } g_i = 1/(p+2) [X_i + X_{ii} - 2/p \sum X_{.j}]$$

$$\text{sca effects; } S_{ij} = [X_{ij} - \frac{1}{(p+2)} (X_i + X_j + X_{ii} + X_{jj}) + \frac{2}{(p+1)(p+2)} \sum X_{..}]$$

Where,

X_j = Total of j^{th} column

X_{ij} = Value of j^{th} parent

Remaining n , X_i , X_{ii} , X are same as mentioned above.

3.2.3.1.5 Test of significance for the combining ability effects

Standard errors (SE) for different estimates were obtained from the following formulae.

$$SE(g_i) = [(n-1) \sigma_e^2 / n(n+2)]^{1/2}$$

$$SE(g_i - g_j) = [2 \sigma_e^2 (n+2)]^{1/2}$$

$$SE(S_{ij}) = [n^2 + (n+2) \sigma_e^2 / (n+1)(n+2)]^{1/2}$$

$$SE(S_{ij} - S_{kl}) = (2n \sigma_e^2 / n+2)^{1/2}$$

$$SE(S_{ij} - S_{ik}) = (2(n+1) \sigma_e^2 / n+2)^{1/2}$$

Critical difference (CD) for testing the significance of the combining ability estimated was obtained by multiplying the respective standard error with table 't' value at error degrees of freedom.

3.2.4 Combining ability analysis pooled over environment

Following ascertaining of homogeneity of errors in the two environments. Following Bartlett's, pooling of data from both locations was done for combined analysis. The pooled analysis over environment for combining ability was carried out as per the method suggested by Singh (1973) based on model 1, method 2 of Griffing (1956). The notation used by Singh (1973) are p (number of parents), v (number of genotypes), b (number of blocks), c (number of individuals in each plot), and l (number of environments). The model used is as follows:

$$X_{ijk} = \mu + g_i + g_j + s_{ij} + l_k + (gl)_{ik} + (gl)_{jk} + (sl)_{ijk} + H_i + \frac{1}{bc} \sum_m \sum_r e_{ijkmr}$$

Where,

μ = Population mean

g_i = gca effect for the i^{th} and j^{th} parents, respectively

s_{ij}	=	sca effect for the crosses between i^{th} and j^{th} parents
l_k	=	effect of the k^{th} environment
$(gl)_{ik}$ or $(gl)_{jk}$	=	Interaction between gca effect of the i^{th} or j^{th} parent with k^{th} environment
$(si)_{ijk}$	=	Interaction between sca effect of the i^{th} or j^{th} parent with k^{th} environment
H	=	0 for fixed effect model (Model I) and
e_{ijkmr}	=	environmental effect associated with the individual observations

Expectations of mean squares

ANOVA for Model I

Source	d.f.	S.S.	M.S.	Expectation of mean squares
gca	$P - 1$	SS (g)	A_g	$\sigma^2 + \frac{(p+2)}{(P-1)} \sum_i g_i^2$
sca	$\frac{p(P-1)}{2}$	SS (s)	A_s	$\sigma^2 + \frac{2l}{p(p-1)} \sum_i \sum_{sj} s_{ij}^2$
Environment (L)	$L - 1$	SS (l)	A_t	$\sigma^2 + \frac{p(p+1)}{2(l-1)} \sum_k l_k^2$
gca x L	$(p-1) (l-1)$	SS (gl)	A_{gl}	$\sigma^2 + \frac{(p+2)}{(p+1)} \sum_k \sum_i (gl)^2_{ik}$
sca x L	$P (p-1) (l-1) / 2$	SS (sl)	A_{sl}	$\sigma^2 + \frac{2l}{p(p-1)} \sum_i \sum_{sj} (s)^2_{ij}$
Error	$L (v-1) (b-1)$	M	A_e	

For testing overall differences of various effects and their interactions the following F values have been calculated:

Test	F value
gca effects	$F [p-1, 1 (v-1) (b-1)] = A_g / A_e$
sca effects	$F \left[\frac{P(P-1)}{2}, l(v-1)(b-1) \right] = A_s / A_e$
Environmental effects	$F [(l-1), l(v-1)(b-1)] = A_l / A_e$
gca and environmental interaction effects	$F [(P-1)(l-1), l(v-1)(b-1)] = A_{gl} / A_e$
sca and environmental interaction effects	$F \left[\frac{p(P-1)(l-1)}{2}, l(v-1)(b-1) \right] =$

Variances of effects and of their differences

$$\text{Var. } (\mu) = [2 / p (P + 1) I] \sigma^2$$

$$\text{Var. } (g_i) = [(p - 1) / P (P + 2) I] \sigma^2$$

$$\text{Var. } (g_i - g_j) = [2 / (P + 2) I] \sigma^2 \dots (i \neq j)$$

$$\text{Var. } (S_{ij}) = [(p2 + P + 2) / (P + 1) (P + 2) I] \sigma^2 \dots (i \neq j)$$

$$\text{Var. } (S_{ij} - S_{jk}) = [2 (P + 1) / (P + 2) I] \sigma^2 \dots (i \neq j, k; j \neq k)$$

$$\text{Var. } (S_{ij} - S_{km}) = [2p / (P + 2) I] \sigma^2 \dots (i \neq j, k, m; j \neq k, m; k \neq m)$$

Where σ^2 is the estimate of σ^2 and given by $\sigma^2 = A_e$

Standard error of an estimate = (Variance of that estimate)^{1/2}

Critical difference is obtained by multiplying the respective standard error with 't' table value at error degree of freedom.

3.2.5 Heterosis

The average F_1 values over replication were used for the estimation of heterosis expressed in percentage over mid-parent values (MP) and check.

$$\text{Mid-parent value (MP)} = \frac{P_1 + P_2}{2}$$

$$\text{Per cent } F_1 \text{ heterosis over MP} = \frac{F_1 - \text{MP}}{\text{MP}} \times 100$$

$$\text{Per cent } F_1 \text{ heterosis over check} = \frac{F_1 - \text{CC}}{\text{CC}} \times 100$$

Where, CC = Commercial check

The critical differences for testing heterosis over check and mid-parent were calculated as follows:

$$\text{C.D. for heterosis over BP} = \frac{2 \times M'e}{\sqrt{r}} \times 't' \text{ value at e.d.f}$$

$$\text{C.D. for heterosis over MP} = \frac{3 \times M'e}{\sqrt{2r}} \times 't' \text{ value at e.d.f}$$

Where $M'e$ is the error mean sum of square of design (RCBD) and r is the number of replications.

3.3 Evaluation of crosses / derivatives derived from two different drought tolerance sources under nonstress and stress

3.3.1 Selection of composites/ populations, commercial hybrids and inbred lines for hybridization

Among the 82 inbred lines evaluated, three inbred lines viz., CI 4, and CML 440 and Hyd Sel 17 showing good yield (nearer to mean + 1 SD) and less ASI (nearer to mean – 1 SD), number of cobs per plant (nearer to mean + 1 SD) and drought susceptibility index (mean – 1 SD) were selected for hybridization with the populations programme. Similarly, four populations viz., G 57, Karveer, NAC 6002 and Parbhat and four commercial hybrids were selected as per the said criteria for hybridization. The different types of crosses produced during *kharif* 2008 a) all possible combinations of crosses among the drought tolerant populations [$n(n-1)/2$] and b) the drought tolerant populations x drought tolerant inbred line crosses c) drought tolerant commercial hybrids x drought inbreds ; the inbred lines were used as male parents. A total of six population crosses (varietal hybrids), 12 population x inbred crosses (top crosses) and 12 commercial hybrids x inbred crosses (three way crosses) were produced. The list of various crosses produced is as follows:

List of crosses derived from different sources of drought tolerance

Sl. No.	Crosses	Sl. No.	Crosses
1	G 57 x Karveer	16	Parbhat x CI 4
2	G 57 x NAC 6002	17	Parbhat x CML 446
3	G 57 x Parbhat	18	Parbhat x Hyd Sel 17
4	Karveer x NAC 6002	19	All-rounder x CI 4
5	Karveer x Parbhat	20	All-rounder x CML 446
6	NAC 6002 x Parbhat	21	All-rounder x Hyd Sel 17
7	G 57 x CI 4	22	NAH 2049 x CI 4
8	G 57 x CML 446	23	NAH 2049 x CML 446
9	G 57 x Hyd Sel 17	24	NAH 2049 x Hyd Sel 17
10	Karveer x CI 4	25	NK 6240 x CI 4
11	Karveer x CML 446	26	NK 6240 x CML 446
12	Karveer x Hyd Sel 17	27	NK 6240 x Hyd Sel 17
13	NAC 6002 x CI 4	28	Rajkumar x CI 4
14	NAC 6002 x CML 446	29	Rajkumar x CML 446
15	NAC 6002 x Hyd Sel 17	30	Rajkumar x Hyd Sel 17

For the production of population crosses, bulk pollen of several plants was used to pollinate a number of cobs in female populations. In case of population x inbred crosses, bulk pollen of inbred line is used to pollinate a number of cobs in female population. For the production of three way crosses, bulk pollen of inbred line is used to pollinate a number of cobs in female parent.

3.3.2 Evaluation of derivatives of the crosses

A total of 30 crosses along with their parents and few checks were evaluated in the field following a two factorial randomized block design during *rabi*/summer 2008-09 and 2009-10, with two replications each under stress and nonstress situations as mentioned under 3.1 for drought tolerance. Each entry was grown at a spacing of 75 cm x 20 cm, in a plot size of two rows of 4 m length during 2008-09 and 3 m length during 2009-10.

During 2008-09, only yield per plot was recorded whereas during 2009-10 all the observations as described under 3.1.1 and 3.1.2 were recorded on individual plants in each cross and in each replication (about 28-30 plants) and about 55-60 plants in each cross. However, the relative water content and chlorophyll content in each cross was recorded from 14-15 plants (one row for each observation for two observations) as described in 3.2.2.1 and 3.2.2.2. The mean values of all the plants in each replication was computed and used for

- i. Line x Tester analysis to find out heterotic groups and superior parents of only those crosses that involved inbred line as one of the parents and
- ii. Evaluation of crosses derived from two or more than two sources of drought tolerance.

All plants (about 55-60) in cross from both the replication were used for computing genetic components of variation viz., mean, variance, PCV, GCV and genetic advance over mean.

3.3.3 Statistical analysis

3.3.3.1 Line x tester analysis involving different drought tolerance sources

The data of only 24 crosses without parents and one check (Rajkumar) grown in stress and nonstress situations, was subjected separately for Line x Tester analysis using WINDOSTAT 8.0 software.

3.3.3.1.1 Combining ability analysis

The variation among the hybrids was further partitioned into genetic components attributable to general combining ability (*gca*) and specific combining ability (*sca*) as suggested by Kempthorne (1957).

The analysis was based on the following mathematical model.

$$Y_{ijk} = \mu + g_i + g_j + s_{ij} + e_{ijk}$$

Where,

Y_{ijk} = Any character measured in the cross (i x j) in the k^{th} replication

μ = Population mean

g_i = *gca* effect of i^{th} parent

g_j = *gca* effect of j^{th} parent

s_{ij} = *sca* effect of (i x j)th cross

e_{ijk} = Random error effect associated with (ijk)th observation in k^{th} replication

ANOVA for combining ability

Sources of variation	d.f.	MSS	Expectations
Replication	$(r - 1)$	-	-
Hybrids	$(lt - 1)$	-	-
Lines	$(l - 1)$	M_1	$\sigma_e^2 + r \sigma^2 lt + rt \sigma^2 l$
Testers	$(t - 1)$	M_2	$\sigma_e^2 + r \sigma^2 lt + rl \sigma^2 t$
Line $\times$ Tester	$(l - 1)(t - 1)$	M_3	$\sigma_e^2 + r \sigma^2 lt$
Error	$(r - 1)(lt - 1)$	M_4	σ_e^2

The experimental material used in this study consisted of twenty four hybrids developed by crossing four productive populations/composites and four productive hybrids and three drought tolerant inbred lines in a Line $\times$ Tester fashion. This made the situation ideally suited for estimating components of variance *i.e.*, gca variance and sca variance and estimating genetic components of variance there off (additive variance and dominance variance).

3.3.3.1.2 Estimates of variances

The GCA and SCA variance were expressed in terms of covariances of full sibs (FS) and half-sibs (HS) as indicated below.

$$\begin{aligned} \text{COV (HS) lines} &= \frac{M_1 - M_3}{rt} \\ \text{COV (HS) testers} &= \frac{M_2 - M_3}{rl} \\ \text{COV (HS) = GCA variance} &= \frac{M_1 + M_2 - 2M_3}{r(1+t)} \\ \text{SCA variance} = \text{COV (FS)} - 2 \text{COV (HS)} &= \frac{M_3 - M_4}{r} = \sigma^2 lt \end{aligned}$$

3.3.3.1.3 Estimate of combining ability effects

The following effects were calculated from two way table of lines Vs testers in which each figure was a total of the two replications.

$$\mu = \frac{X \dots}{ltr}$$

$$\wedge \quad X_i \dots \quad X \dots$$

$$\begin{aligned}
g_i &= \frac{\text{tr}}{\text{tr}} - \frac{\text{ltr}}{\text{ltr}} \\
\hat{g}_j &= \frac{X_{.j}}{\text{lr}} - \frac{X_{...}}{\text{ltr}} \\
\hat{S}_{ij} &= \frac{X_{ij}}{r} - \frac{X_{i.}}{\text{tr}} - \frac{X_{.j}}{\text{lr}} + \frac{X_{...}}{\text{ltr}}
\end{aligned}$$

Where,

$X_{...}$ = Total of all hybrids

$X_{i.}$ = Total of i^{th} line over all testers and replications

$X_{.j}$ = Total of j^{th} tester over all lines and replications

X_{ij} = Total of ij^{th} cross over all the replications

3.3.3.1.4 Standard errors of the effects

The variances of the estimates were calculated by following the formula given below. The standard errors of the estimates are the square roots of their variances.

$$\text{i. S.E. (gca for line)} = \left(\frac{M_4}{rt} \right)^{1/2}$$

$$\text{ii. S.E. (gca for testers)} = \left(\frac{M_4}{rl} \right)^{1/2}$$

$$\text{iii. S.E. (sca effect)} = \left(\frac{M_4}{r} \right)^{1/2}$$

$$\text{iv. S.E. (g}_i\text{-g}_j\text{) lines} = \left(\frac{2M_4}{rt} \right)^{1/2}$$

$$\text{v. S.E. (g}_i\text{-g}_j\text{) tester} = \left(\frac{2M_4}{rl} \right)^{1/2}$$

$$\text{vi. S.E. (s}_{ij}\text{-s}_{kl}\text{) crosses} = \left(\frac{2M_4}{r} \right)^{1/2}$$

The critical differences were calculated by multiplying the standard errors with table "t" value at 5 and 1 per cent levels of probability for error degrees of freedom.

3.3.3.2 Evaluation of crosses derived from two different sources of drought tolerance under nonstress and stress situations

The data on 30 crosses with all parents except NAH 2049 and two checks (All-Rounder and 900M) grown in stress and nonstress situations were analysed for variability using two factorial randomized block design using WINDOSTAT software. The first factor was stress / nonstress and the second factor was genotypes. The structure of analysis and computation of standard errors are as given in the section 3.1.3.

3.3.3.3 Genetic components in population crosses, top crosses and three way crosses derived from drought tolerance sources

The genetic components of variance viz., phenotypic and genotypic variances were used for the estimation of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) from the data recorded on individual plants in each of 30 crosses using Microsoft EXCEL as described below:

Phenotypic variance of crosses (σ^2_{pc}) = Variance of the cross

Genotypic variance of crosses (σ^2_{gc}) = $\sigma^2_{pc} - (\sigma^2_{pp_1} + \sigma^2_{pp_2})/2$

Where, $\sigma^2_{pp_1}$ and $\sigma^2_{pp_2}$ are the phenotypic variances of parent 1 and parent 2, respectively.

3.3.3.3.1.1 Coefficient of variance (CV)

This was calculated for all the variances using the following formula:

$$CV (\%) = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

3.3.3.3.1.2 Heritability

Heritability in broad sense [$h^2_{(bs)}$] was computed as a ratio of genetic variance to the total variance (Hanson *et al.*, 1956).

$$h^2_{(bs)} = \frac{\sigma^2_g}{\sigma^2_p}$$

Where, σ^2_g and σ^2_p are genotypic and phenotypic variances, respectively.

3.3.3.3.1.3 Genetic advance

The extent of genetic advance to be expected from the superior progeny was computed using the formula given by Robinson *et al.* (1949).

$$GA = h^2 \times i \times \sigma_p$$

Where, h^2 = heritability

i = Selection differential at 5 % selection intensity (2.06)

σ_p = Phenotypic standard deviation

3.4 Stability analysis

Twenty three hybrids which performed better under stress or nonstress or both during *rabi*/summer 2008 were selected and tested at Agricultural Research Station, Hagari of University of Agricultural Sciences, Raichur under managed drought during *rabi*/summer 2009. For stability analysis, yield (kg/ha) of these 23 hybrids and checks were picked from diallel set of crosses tested under 2008 and 2009 at college of Agriculture, Bheemarayanagudi.

All the hybrids except two viz., (CM 111 x Hyd Sel 4 and Hyd Sel 2 x Hyd Sel 7) were tested at Agricultural Research Station, Arabhavi during *kharif* 2009 for yield. The grain yield (kg/ha) of nonstress (irrigated) experiments conducted during *rabi*/summer 2008 and 2009 at Bheemarayanagudi and yield obtained at Arabhavi was subjected to stability analysis.

Stability of hybrids for grain yield over three seasons was carried out as per the model suggested by Eberhart and Russell (1966). This model involves the estimation of three parameters which are defined by a mathematical formula as given below.

$$Y_{ij} = \mu_i + b_i l_j + S_{ij}$$

Where, Y_{ij} = Mean of the i^{th} variety at the j^{th} environment

μ_i = Mean of i^{th} variety over all environments

b_i = The regression coefficient that measures the response of i^{th} variety to varying environments

S_{ij} = The deviation from regression of the i^{th} variety at the j^{th} environment and

l_j = The environmental index obtained by subtracting the grand mean from the mean of all varieties at the j^{th} environment

These parameters were calculated as follows

a) Environmental index

$$l_j = \frac{\sum_i Y_{ij}}{t} - \frac{\sum_i \sum_j Y_{ij}}{t \cdot s}$$

Where, t = Number of varieties

s = Number of environments

with $\sum_j l_j = 0$

b) The regression coefficient for each variety (b_i)

$$b_i = \frac{\sum_j Y_{ij} l_j}{\sum_j l_j^2}$$

c) Deviation from regression

$$S^2 d_i = \frac{\sum_j \delta_{ij}^2}{s - 2} - \frac{S_e^2}{r}$$

Where, S_e^2/r = Mean square for (estimate of) pooled error

d) Predicted performance of the genotypes

$$Y_{ij} = \bar{X}_i + b_i l_j$$

Where, $\bar{X}_i$ is the estimate of μ_i

In this model the variance due to environments and genotype $\times$ environment are partitioned into environment (linear), genotype $\times$ environment (linear) and deviation from the regression coefficient.

3.4.1 Genotype-environment interaction

The magnitude of G $\times$ E interaction was assessed for grain yield of 12 inbred lines tested for three years, stability of selected hybrids (23) under managed drought conditions and stability of 64 hybrids under irrigated conditions was worked out as per the procedure suggested by Eberhart and Russell (1966). The analysis of variance for stability as per this model is algebraically represented as below.

Sources of variation	D.f	SS	MS	F value
Genotype (G)	(g-1)	$\Sigma_i \Sigma_j Y_{ij}^2 - CF$	MS ₁	MS ₁ /MS ₃
Environment (E)	(n-1)	$1/n \Sigma_j Y_i^2 - 1/n \Sigma_j Y_i^2$		
G $\times$ E	(g-1) (n-1)	$\Sigma_i \Sigma_j Y_{ij}^2 - 1/n \Sigma_j Y_i^2$		
Environment (linear)	1	$1/g [(\Sigma_j Y_j - l_j)^2 \Sigma_i l_j^2]$		MS ₂
Genotype $\times$ Environment (Linear)	(g-1)	$\Sigma_j [(\Sigma_i Y_{ij} l_j)^2 / \Sigma_i l_j^2] - 1/g [(\Sigma_j Y_j - l_j)^2 \Sigma_i l_j^2]$	MS ₂	
Pooled deviation	g (n-2)	$\Sigma_i \Sigma_j d^2 l_j^2$	MS ₃	MS ₃ /MS ₄
Genotype 1	(n-2)	$[\Sigma_j Y_{ij}^2 - Y_i^2/n] - [\Sigma_j Y_{ij} l_j]^2 / \Sigma_i l_j^2$		
Genotype G	(n-2)	$[\Sigma_j Y_{gj}^2 - Y_g^2/n] - [\Sigma_j Y_{gj} l_j]^2 / \Sigma_i l_j^2$		
Pooled error	n(g-1) (r-1)		MS ₄	
Total	(ng - 1)	$\Sigma_i \Sigma_j Y_{ij}^2 - CF$	TSS	

Where, n = number of environments

r = number of replications

g = number of genotypes

CF = Correction factor

a) To test the significance of pooled deviation mean square against the pooled error mean square

$$F = \frac{MS_3}{MS_4}$$

If pooled deviation mean square is found significant then it would be the appropriate denominator to test the significance of all components including genotypes, genotype $\times$ environment (linear). Other wise, pooled error mean square is appropriate denominator.

b) To test the significance of the differences among the means of genotypes

$$F = \frac{MS_1}{MS_3}$$

c) To test that the genotypes that do not differ for their regression on environmental index

$$F = \frac{MS_2}{MS_3}$$

Further, 't' test is used to test the significance of deviation of 'b_i' from unity

$$t = \frac{|1 - b_i|}{S.E. (b_i)}$$

Where,

$$SE(b_i) = \sqrt{\frac{\sum_i \delta_{ij}^2 / n - 2}{\sum_j l_j^2}}$$

Where, δ_{ij}^2 is the deviation of ith variety in jth environment from regression

d) To test individual deviation from linear regression

F = Pooled error mean square

A joint consideration of three parameters, that is

- i) The mean performance of the genotype over environments (location), $\bar{X}_i$
- ii) Regression coefficient b_i and
- iii) The deviation from linear regression $S^2 d_i$, are used to define stability of genotype.

The estimate of deviation from regression suggests the degree of reliance that should be put to linear regression in interpretation of data. If these values are significantly deviating from zero, the expected phenotype cannot be predicted satisfactorily. When deviations are non significant, the conclusions, may be drawn by joint consideration of mean yield and regression values (Finlay and Wilkinson, 1963 and Eberhart and Russell, 1966) as below.

Regression	Stability	Mean yield	Remarks
b _i = 1	Average	High	Well adapted to all the environments
b _i = 1	Average	Low	Poorly adapted to all environments
b _i > 1	Below average	High	Specifically adapted to favourable environments
b _i < 1	Above average	High	Specifically adapted to unfavourable environments

Regression value of unity is interpreted as average stability since the average slope over all varieties on the environment index will be unity.

3.5 Screening the hybrids for diseases

During *kharif* 2009, the hybrids (66) were sent for screening for turicum leaf blight and common rust at Main Agricultural Research Station (MARS), Dharwad. The hybrids were planted along with checks in randomized block design with a plot size of one row of 4 m length in 75 × 20 cm spacing and replicated twice. Four infector rows with a highly susceptible line CM 202 were planted on either side of the experiment. The inoculum of *Exserohilum turicum* multiplied on sorghum grains as suggested by Joshi *et al.* (1969) was applied (~2 g/plant per application) at 30 and 40 DAS. The inoculum was applied in the evening hours by whorl drop method (Frederiksen and Franklin, 1978) followed by water spray to create high humidity required for infection by the fungus. The recommended agronomic practices were followed to control insect pests. The observations were recorded at silk drying stage using 1-5 disease rating scale as described by Payak and Sharma (1983).

The same entries were inoculated with the inoculum of common rust (*Puccinia sorghi* Schw.). The naturally infested leaves showing large number of uredopustules were collected and macerated thoroughly between two palms of the hands dipped under a bucket of water until water was sufficiently coloured (dark pink colour). The hybrids were inoculated in the evening hours by spraying uredospores (2×10^6 spores/ml of water) with the help of knapsack sprayer. The inoculation was done at 35 and 45 DAS and the observations were recorded after 30 days of second inoculation on 1 to 5 scale as described below.

- | | | |
|---|----------------------|--|
| 1 | Highly resistant | : Very slight to slight infection one or two to few scattered pustules on lower leaves only |
| 2 | Resistant | : Moderate number of pustules on lower leaves only (light infection) |
| 3 | Moderately resistant | : Abundant pustules on lower leaves, few on middle leaves (moderate infection) |
| 4 | Susceptible | : Abundant pustules on lower and middle leaves, extending to upper leaves (heavy infection) |
| 5 | Highly susceptible | : Abundant pustules on all leaves, plant may dry pre-maturely or be killed by the disease (very heavy infection) |

4. EXPERIMENTAL RESULTS

The grain yield of maize under rainfed situation is limited by water deficit during flowering and grain filling stages of the crop growth. The present investigation, 'Identification of drought tolerant maize (*Zea mays* L.) germplasm' was designed to identify drought tolerant inbred lines and develop drought tolerant single cross hybrids, three way cross, top cross and population crosses tolerant to moisture stress especially at grain filling stage. The results of the present investigation are presented in the following headings.

1. Screening of maize inbred lines, commercial hybrids and composites/ populations for drought tolerance under nonstress and stress.
2. Diallel analysis involving 66 hybrids obtained by crossing 12 parents differing for drought tolerance under nonstress and stress.
3. Line x Tester analysis involving different drought tolerant sources under nonstress and stress.
4. Evaluation of crosses / derivatives obtained from two or more than two drought tolerance sources under nonstress and stress.

4.1 Screening of inbred lines, commercial hybrids and composites / populations for drought tolerance

The effect of stress on growth and yield manifest in varying degrees amongst the genotypes within the species. Maize is more susceptible to moisture stress at flowering (2 weeks before and after). Some genotypes of maize yield better than the others under moisture stress by reducing their anthesis to silking interval. Moisture stress affects almost all morpho-physiological and biochemical processes.

In maize, the field evaluation of genotypes under managed stress (drought) as well as under optimum moisture conditions is done to screen the genotypes for drought tolerance. A field experiment was carried out to study the performance of 82 inbred lines, 10 commercial hybrids and seven composites/populations under managed drought and optimum moisture conditions during post rainy season (October-January) of 2007-08. The results of the study are presented in Table 2 to 5.

4.1.1 Analysis of variance

The analysis of variance (Table 2) revealed that variation due to moisture stress was significant for all the traits. Similarly, variation due to genotypes was also significant for all the traits including yield. The interaction between stress and genotypes was significant for days to 50% silking, anthesis to silking interval (ASI), cob length, cobs per plant, number of kernels per row, shelling percentage, yield per plant and yield per ha.

4.1.2 Effect of moisture stress on morphological, yield and yield related traits

The expression of character under moisture stress and nonstress condition revealed that there was significant reduction in plant height, ear height, days to maturity, cob length, cob girth, cobs per plant, kernel rows per cob, number of kernels per row, test weight, shelling percentage, yield per plant and yield per ha. However, moisture stress increased significantly the days required for 50% anthesis, 50% silking and ASI (Table 3).

4.1.3 Performance of maize inbreds, commercial hybrids and composites/populations under stress and nonstress situations

The relative performance of a genotype for drought related traits and in turn grain yield will give an idea of drought tolerance ability of the genotype. The performance of 82 inbreds, 10 commercial hybrids and seven composites /populations under stress and nonstress is presented in Table 4 and 5.

Table 2. Mean sum of squares due to stress / nonstress and genotypes for morphological, yield and yield related traits in maize

Trait	MSS			
	Stress / nonstress	Genotypes	Interaction	Error
Plant height (cm)	128091.69**	1422.28**	310.75	233.63
Ear height (cm)	20063.31**	449.94**	106.66	83.46
Days to 50% anthesis	408.09**	97.84**	5.01	4.60
Days to 50% silking	4956.57**	168.90**	26.61**	10.19
ASI	2505.09**	20.13**	17.55**	2.43
Maturity	1924.57**	115.99**	14.91	11.72
Cob length (cm)	1209.25**	7.11**	2.88*	2.00
Cob girth (cm)	629.80**	3.83**	1.06	1.02
Cobs per plant	7.69**	0.08**	0.03**	0.02
Number of kernel rows/ cob	110.62**	6.53**	1.79	1.64
No. of kernels /row	8311.42**	44.70**	15.60*	10.63
100-grain wt.(g)	7679.77**	26.37**	5.43	4.54
Shelling percentage	1310.66**	58.85**	29.22**	14.97
Yield per plant (g)	355560.51**	947.18**	377.22**	125.48
Grain yield (kg/ha)	851033900.00**	2633540.00**	823169.40**	312130.00

* and ** - Significant at 0.05 and 0.01 level of probability, respectively.

Table 3. Effect of moisture stress on morphological, yield and yield related traits in maize

Trait	Nonstress	Stress	Difference	CD at 5 %
Plant height (cm)	202.66	166.69	35.97*	3.03
Ear height (cm)	86.28	72.05	14.23*	1.81
Days to 50% anthesis	59.74	61.77	- 2.02*	0.43
Days to 50% silking	62.85	69.92	- 6.27*	0.50
ASI	3.11	8.14	- 4.11*	0.31
Maturity	99.72	95.31	3.86*	0.67
Cob length (cm)	12.37	8.87	3.50*	0.28
Cob girth (cm)	12.87	10.35	2.52*	0.20
Cobs per plant	0.955	0.676	0.279*	0.026
Number of kernel rows /cob	14.07	13.01	1.09*	0.25
No. of kernels /row	27.84	18.61	9.23*	0.77
100-grain wt. (g)	26.30	17.49	8.81*	0.42
Shelling percentage	83.16	79.51	3.65*	0.77
Yield per plant (g)	94.95	35.02	59.35*	0.22
Grain yield (kg/ha)	4256.70	1324.80	2931.90*	110.73

* - Significant at 0.05 level of probability.

Under nonstress environment, the inbred lines viz., KDMI 16 (5584 kg/ha) KDMI 17 (5441 kg/ha), KDMI 19 (5361 kg/ha), KDMI 10 (5351 kg/ha), Hyd Sel 2 (5265 kg/ha) and Hyd Sel 10 (5262 kg/ha) recorded higher yields as compared to others. Among the composites / populations, Karveer (6317 kg/ha), a commercially released composite for Maharashtra recorded the highest yield. While among hybrids, NK 6240 (7460 kg/ha) and 900M (7417 kg/ha) recorded the highest yields.

Under managed drought conditions, inbred lines viz., Hyd Sel 15 (2589 kg/ha), CML 446 (2273 kg/ha), and CI 4 (2447 kg/ha), Hyd Sel 4 (2273 kg/ha) and PAC 2176 (2078 kg/ha) recorded more than population mean+ 1SD yield. Among the populations, G 57 (2581 kg/ha), NAC 6002 (2500 kg/ha), Parbhat (2167 kg/ha) and Karveer (2131 kg/ha) recorded higher yields. While among hybrids, NAH 2049 (2717 kg/ha) and NK 6240 (2568 kg/ha) recorded the highest yields.

Other two important secondary traits that contribute to yielding ability under moisture stress in maize are cobs per plant and anthesis to silking interval. The inbred lines viz., Hyd Sel 9 (0.945), KDMI 20 (0.940) and Hyd Sel 4 (0.922) recorded the highest cobs per plant. Among populations and hybrids NAC 6002 (1.000) and NK 6240 (0.974), respectively recorded the highest cobs per plant.

For anthesis to silking interval, CM 133 (3.0), Hyd Sel 9 (3.5), CML 426 (4.0), Hyd Sel 6 (4.0) Hyd Sel 1 (4.0), KDMI 16 (4.0), CI 4 (4.5) and NEI 9202B (4.5) recorded the lowest ASI values. Among the populations, Yellow pool (3.0), Parbhat (4.0), and Karveer (4.5) recorded the lowest values. Whereas, NK 6240 (4.0) and All-Rounder (5.0) recorded lower ASI values among hybrids.

4.1.4 Drought susceptibility index (DSI)

The agronomic definition of drought tolerance in crop plants involved yield as a major parameter. Drought tolerance can then be defined in terms of yield ratio between stress and nonstress conditions and in terms of calculated index of susceptibility. The drought susceptibility index (DSI) calculated for yield and yield related traits are presented in Table 5.

The results of DSI indicated that among inbreds CI 4 recorded lower DSI values for all the traits. Hyd Sel 15 (1.02) recorded lowest DSI for yield (kg/ha) and CI 4 (0.08) recorded the lowest DSI value for cobs per plant. Among composites, G 57 recorded the lower DSI values for all the traits. Whereas, Rajkumar recorded lowest DSI values for number of kernels per row, 100 grain weight and yield per plant (g) and NAH 2049 (1.47) recorded the lowest DSI value for grain yield (kg/ha) among hybrids.

4.1.5 Selection of parents for effecting various crosses

The parents were selected for hybridization based on the performance of inbreds, composites and hybrids under drought for yield per plant(g), cobs per plant, ASI, yield (kg/ha) and DSI. Six inbred lines viz., CI 4, CML 446, Hyd Sel 4, Hyd Sel 15, Hyd Sel 17 and NEI 9202B showing good yield (nearer to mean+ 1SD) and less ASI (nearer to mean – 1SD), cobs per plant (nearer to mean+ 1SD) under stress and drought susceptibility index (nearer to mean – 1SD) were selected for hybridization (Table 6). CM 111, Hyd Sel 2, Hyd Sel 7, Hyd Sel 10, KDMI 15 and NEI 9208B were selected based on same criteria as drought susceptible inbred lines for effecting crosses. Similarly, four populations\ composites (G 57, Karveer, Parbhat and NAC 6002) and four hybrids (All-Rounder, NAH 2049, NK 6240 and Rajkumar) were selected for producing three way crosses, top crosses or varietal hybrids (Table 7).

4.1.6 Stability of inbred lines under drought for grain yield

4.1.6.1 ANOVA for grain yield stability

ANOVA for stability revealed that the mean sum of squares due to varieties, environments, environment linear and variety x environment linear were significant for grain yield per ha. Variance due to pooled deviation was also significant for yield indicating the importance of both linear and non linear components for the trait (Table 8).

The year wise mean performance and stability parameters for the selected inbred lines are presented in Table 9. The grain yield (kg/ha) ranged from 1445 kg/ha (2007) to 2778 kg/ha (2009) and the population mean was 2005 kg/ha.

Table 4. Performance of maize inbred lines, populations /hybrids for important morphological, yield and yield related traits under stress and nonstress situations

Inbred lines	Plant height (cm)		Ear height (cm)		Days to 50% anthesis		Days to 50% silking	
	NS	S	NS	S	NS	S	NS	S
Bertam 701	215.20	161.00	108.00	83.30	56.50	60.00	59.50	69.00
CI 4	223.80	180.60	90.10	82.20	60.00	62.00	63.00	66.50
CI 5	218.20	187.20	88.80	76.80	55.50	59.00	60.50	65.50
CM 111	199.20	167.30	90.90	83.00	62.50	60.00	65.50	71.00
CM 111 Sel	218.70	179.10	89.10	71.10	56.50	56.00	59.00	64.50
CM 132	211.20	171.50	100.40	74.60	61.00	60.00	64.50	69.00
CM 133	169.40	154.90	77.00	76.70	57.00	59.50	60.00	62.50
CM 135	207.00	174.40	74.40	74.70	58.00	57.50	62.00	68.50
CM 136	181.30	154.20	77.00	69.40	63.50	63.50	67.00	70.00
CM 136-1	189.40	156.10	84.00	71.40	57.50	61.50	60.00	69.00
CM 137	192.90	143.40	84.90	68.70	58.00	60.50	61.00	67.50
CM 137-1	224.20	178.10	90.40	85.10	60.00	59.50	62.50	70.00
CM 138	194.30	146.80	81.20	74.00	57.50	59.00	61.50	66.50
CM 138-1	213.50	124.60	101.00	75.80	64.00	65.50	67.00	85.50
CM 202	211.60	134.90	94.90	60.30	69.00	73.50	75.00	93.50
CM 202 Sel	192.80	155.00	85.60	70.60	57.50	59.00	60.00	66.50
CM 500	207.10	176.70	84.50	73.30	56.50	57.00	60.50	62.50
CM 501	206.70	169.90	100.10	66.90	56.50	57.00	59.50	65.50
CML 37-#-NA-R-2006	183.70	114.40	99.00	59.30	72.50	76.50	75.00	96.50
CML-44-#-NA-R-2006	209.30	159.80	88.10	64.10	69.50	70.00	72.00	78.00
CML 68 (7)-#-#-#	206.70	189.70	90.00	83.70	58.50	59.50	62.00	67.00
CML-113-#-#-#	200.20	165.20	77.60	77.30	62.00	61.50	64.50	66.50
CML-114-#-#-#	211.40	159.30	97.50	78.90	58.00	61.50	61.50	70.50
CML-118-C332-MH2-1-2-2-B-B-#	195.80	169.40	78.00	69.50	59.00	54.50	61.00	61.50
CML-183-CB2-RMM-30-1-2-1-B-13-#	192.30	155.80	90.10	58.80	58.00	59.00	63.00	66.00
CML-217*(Tropical)	204.40	174.20	82.50	75.80	58.50	59.00	62.00	64.00
CML-223 (Tropical)	218.40	170.60	90.30	72.20	56.50	60.00	60.00	67.00
CML-297-#-NA-R-2006	174.50	122.30	58.60	44.20	71.00	77.50	73.00	97.50
Mean	202.66	166.69	86.28	72.05	59.74	61.77	62.85	69.92
SD	23.02	23.75	14.23	12.50	4.97	5.60	5.19	8.75

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	Plant height (cm)		Ear height (cm)		Days to 50% anthesis		Days to 50% silking	
	NS	S	NS	S	NS	S	NS	S
CML-298-#-NA-R-2006	175.40	159.50	75.30	66.70	71.50	70.00	75.00	76.50
CML-310-#-NA-R-2006	202.50	118.60	99.50	43.80	73.50	78.00	77.50	98.00
CML-321-#-NA-R-2006	177.80	130.70	59.70	51.00	73.00	73.50	76.50	93.50
CML-341-#-NA-R-2006	192.90	126.10	86.70	53.60	68.50	74.50	70.00	94.50
CNL-342-#-NA-R-2006	214.90	154.50	81.60	60.50	63.50	67.00	66.00	78.50
CML-361-#-NA-R-2006	160.90	137.80	79.00	74.20	64.00	74.50	69.50	94.50
CML-364-#-NA-R-2006	167.30	122.60	83.90	63.20	70.00	73.50	73.50	80.50
CML-370-#-NA-R-2006	212.20	162.00	83.00	69.40	64.00	66.50	66.00	73.00
CML-389-#-NA-R-2006	215.60	188.30	91.80	83.10	65.00	69.00	68.50	80.50
CML-415-#-NA-R-2006	186.50	161.00	76.70	67.10	67.00	67.00	70.50	83.50
CML-426-#-NA-R-2006	181.70	139.70	75.30	60.40	54.50	58.00	55.50	63.50
CML-446	208.70	174.00	96.10	85.40	64.00	69.00	66.00	74.50
Hyd Sel 1	207.50	175.80	95.20	83.60	56.00	56.50	57.50	60.50
Hyd Sel 2	219.30	163.80	90.00	59.00	55.00	58.00	58.00	68.50
Hyd Sel 3	218.90	154.30	91.70	79.80	59.00	61.00	64.00	67.00
Hyd Sel 4	193.60	164.00	86.30	75.40	56.00	59.50	59.00	64.50
Hyd Sel 5	233.30	183.80	104.00	93.20	58.50	59.00	62.00	65.00
Hyd Sel 6	168.90	149.50	71.30	74.80	57.00	62.00	59.50	66.00
Hyd Sel 7	207.50	169.50	85.70	70.30	55.00	58.00	57.50	69.00
Hyd Sel 8	207.90	175.60	90.90	73.30	56.50	57.00	59.00	63.00
Hyd Sel 9	203.90	173.30	90.40	81.20	57.00	58.00	60.50	61.50
Hyd Sel 10	224.00	181.90	101.90	70.85	57.00	57.00	60.00	66.50
Hyd Sel 11	189.20	162.60	88.50	67.80	53.50	55.00	55.50	64.00
Hyd Sel 12	200.00	167.00	95.10	70.70	55.00	58.50	58.00	64.50
Hyd Sel 13	197.20	189.50	84.50	82.20	58.50	59.00	62.50	64.50
Hyd Sel 14	174.40	158.90	61.00	54.10	57.00	59.50	59.00	70.50
Hyd Sel 15	212.20	174.20	87.00	74.50	58.00	60.00	61.00	65.00
Mean	202.66	166.69	86.28	72.05	59.74	61.77	62.85	69.92
SD	23.02	23.75	14.23	12.50	4.97	5.60	5.19	8.75

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	Plant height (cm)		Ear height (cm)		Days to 50% anthesis		Days to 50% silking	
	NS	S	NS	S	NS	S	NS	S
Hyd Sel 16	180.40	153.00	78.70	75.70	56.50	58.50	58.00	66.50
Hyd Sel 17	192.90	157.70	95.20	84.70	60.00	62.50	63.00	70.50
Hyd Sel 18	191.90	169.40	82.80	66.40	56.00	59.00	58.50	66.00
KDMI 4	205.20	185.90	90.20	77.10	56.50	56.50	61.50	62.50
KDMI 10	228.30	188.00	100.00	72.10	55.50	56.50	58.50	65.00
KDMI 11	216.40	181.30	110.30	88.80	60.50	61.00	63.00	66.00
KDMI 12	198.20	166.40	91.90	80.70	58.00	59.50	62.00	67.00
KDMI 13-1	207.10	159.60	92.80	63.50	57.00	57.50	60.00	62.50
KDMI 13-1-13	217.30	183.90	76.40	65.90	56.00	56.50	59.50	64.50
KDMI 13-1-29	191.70	160.00	74.60	72.10	60.00	61.50	64.00	70.50
KDMI 14	212.50	169.90	87.20	72.40	58.50	59.00	62.50	70.50
KDMI 15	198.20	148.00	76.10	73.00	57.00	59.00	61.50	70.00
KDMI 16	226.20	196.40	95.40	76.60	56.00	59.00	58.00	63.00
KDMI 17	193.30	190.70	91.90	75.40	55.50	57.00	57.50	65.00
KDMI 18	199.50	161.20	84.40	66.70	53.50	59.00	56.50	64.00
KDMI 19	187.60	156.90	81.40	65.70	63.50	65.50	66.50	70.50
KDMI 20	196.70	168.10	80.90	77.20	54.00	57.50	57.00	65.00
NEI 9202B	218.00	147.70	95.50	73.90	56.50	59.50	59.00	64.00
NEI 9208B	219.10	179.00	101.70	83.70	68.00	68.50	71.00	74.00
NG 4	187.00	165.00	68.50	72.10	57.50	59.00	61.50	68.00
NG 14	193.60	177.40	91.10	72.10	58.00	60.00	62.00	66.50
PAC 2176	187.00	186.80	77.10	73.20	55.50	57.50	56.50	63.50
Pop28-C6- Bulk-##	209.00	189.80	95.30	82.10	58.50	59.50	61.50	68.00
SKV-55-X-NA-K-2006	185.00	163.60	67.20	69.70	60.50	64.50	63.50	75.50
SKV-62-X-NA-K-2006	157.30	109.10	42.20	32.30	62.00	61.50	66.50	72.00
SKV-71-X-NA-K-2006	141.20	132.30	57.80	53.90	56.50	55.50	58.50	62.50
SKV-76-X-NA-K-2006	151.60	128.10	43.90	40.40	58.50	59.50	61.50	69.00
Mean	202.66	166.69	86.28	72.05	59.74	61.77	62.85	69.92
SD	23.02	23.75	14.23	12.50	4.97	5.60	5.19	8.75

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Populations / Hybrids	Plant height (cm)		Ear height (cm)		Days to 50% anthesis		Days to 50% silking	
	NS	S	NS	S	NS	S	NS	S
Populations								
G-25	182.70	169.20	65.80	51.50	52.50	54.50	54.50	61.00
G 57	189.10	194.00	77.00	78.80	57.50	58.50	62.00	64.50
Karveer	230.90	192.50	84.90	82.30	57.00	61.00	60.00	65.50
NAC 6002	224.10	199.75	85.90	72.60	52.50	55.50	56.50	58.50
NAC 6004	253.20	188.00	108.20	80.10	58.00	63.50	60.00	71.00
Parbhat	207.95	170.15	77.30	73.90	61.50	72.50	64.00	76.50
Yellow Pool	233.70	197.00	88.10	85.00	60.50	65.00	62.50	68.00
Hybrids								
30 V 92	245.10	205.40	95.20	78.30	61.50	64.50	64.00	71.00
All-Rounder	220.10	184.20	99.40	83.90	63.50	64.00	66.50	69.00
Bio 9681	212.40	208.50	76.00	69.90	59.50	61.00	62.00	66.50
DMH 2	230.60	172.70	94.00	68.50	60.00	61.50	64.00	66.50
EH 434042	234.40	201.30	99.80	83.00	58.50	61.00	62.00	67.00
NAH 2049	178.70	185.90	94.20	86.10	59.50	58.50	63.00	64.00
NK 6240	222.10	201.50	104.60	78.20	62.00	65.00	65.50	69.00
Rajkumar	223.10	172.70	92.10	85.10	64.50	64.50	68.00	71.00
900M	224.70	180.20	106.50	80.60	62.50	65.00	65.00	74.00
Suraj	230.80	189.10	96.60	76.80	60.00	62.50	64.00	69.00
Mean	202.66	166.69	86.28	72.05	59.74	61.77	62.85	69.92
SD	23.02	23.75	14.23	12.50	4.97	5.60	5.19	8.75

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	Anthesis to silking interval		Days to maturity		Cob length (cm)		Cob girth (cm)	
	NS	S	NS	S	NS	S	NS	S
Bertam 701	3.00	9.00	100.00	93.00	10.85	8.40	13.40	9.90
CI 4	3.00	4.50	97.50	94.00	11.30	10.75	13.30	12.05
CI 5	5.00	6.50	97.00	93.50	14.35	9.40	13.75	11.15
CM 111	3.00	11.00	102.00	102.00	9.90	8.55	11.65	9.70
CM 111 Sel	2.50	8.50	95.50	91.50	12.30	9.30	11.90	10.45
CM 132	3.50	9.00	100.50	95.50	11.80	6.80	13.90	10.60
CM 133	3.00	3.00	93.50	91.00	11.80	8.65	12.70	10.00
CM 135	4.00	11.00	102.50	94.00	11.70	8.05	13.50	10.65
CM 136	3.50	6.50	99.00	98.00	11.55	6.65	12.35	9.90
CM 136-1	2.50	7.50	100.00	94.50	13.65	9.45	12.80	10.25
CM 137	3.00	7.00	100.00	92.00	12.60	8.70	13.70	9.70
CM 137-1	2.50	10.50	101.50	93.50	11.80	8.55	13.25	10.20
CM 138	4.00	7.50	98.50	93.50	13.40	9.85	11.45	9.75
CM 138-1	3.00	20.00	101.50	100.00	9.10	9.20	13.95	12.60
CM 202	6.00	20.00	108.00	106.00	11.55	9.50	13.15	11.80
CM 202 Sel	2.50	7.50	97.00	95.00	11.35	7.35	13.00	9.30
CM 500	4.00	5.50	93.50	94.00	10.95	8.80	12.50	10.45
CM 501	3.00	8.50	96.50	91.50	11.75	8.20	13.60	10.10
CML 37-#-NA-R-2006	2.50	20.00	109.50	107.00	8.90	9.75	10.90	8.00
CML-44-#-NA-R-2006	2.50	8.00	110.00	103.00	14.65	10.50	12.50	11.25
CML 68 (7)-#-#-#	3.50	7.50	98.00	94.50	12.00	8.85	14.05	10.60
CML-113-#-#-#	2.50	5.00	100.00	97.50	11.30	10.35	13.00	11.15
CML-114-#-#-#	3.50	9.00	100.50	95.00	12.05	7.80	13.10	10.10
CML-118-C332-MH2-1-2-2-B-B-#	2.00	7.00	98.00	88.50	10.95	7.30	13.35	10.60
CML-183-CB2-RMM-30-1-2-1-B-13-#	5.00	7.00	97.00	94.00	11.80	8.55	11.80	9.75
CML-217*(Tropical)	3.50	5.00	95.50	94.50	12.20	8.65	13.70	10.75
CML-223 (Tropical)	3.50	7.00	98.00	92.50	11.55	8.85	12.60	10.40
CML-297-#-NA-R-2006	2.00	20.00	110.50	117.00	10.45	6.90	8.80	6.40
Mean	3.11	8.14	99.17	95.31	12.33	8.89	12.87	10.36
SD	1.11	4.50	5.70	6.66	1.87	1.73	1.14	1.43

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	Anthesis to silking interval		Days to maturity		Cob length (cm)		Cob girth (cm)	
	NS	S	NS	S	NS	S	NS	S
CML-298-#-NA-R-2006	3.50	6.50	107.50	106.00	13.15	9.10	12.55	10.00
CML-310-#-NA-R-2006	4.00	20.00	105.00	108.50	11.05	6.50	11.25	13.00
CML-321-#-NA-R-2006	3.50	20.00	113.50	107.50	11.25	8.15	13.40	9.45
CML-341-#-NA-R-2006	1.50	20.00	109.0	104.00	14.00	10.65	13.00	12.65
CNL-342-#-NA-R-2006	2.50	11.50	110.00	98.50	12.65	9.60	12.80	9.05
CML-361-#-NA-R-2006	5.50	20.00	105.50	108.00	9.40	8.90	11.50	8.40
CML-364-#-NA-R-2006	3.50	7.00	111.00	106.00	9.40	6.15	10.65	8.15
CML-370-#-NA-R-2006	2.00	6.50	105.00	116.00	11.75	8.15	12.50	9.90
CML-389-#-NA-R-2006	3.50	11.50	109.50	101.50	12.95	7.05	12.90	7.95
CML-415-#-NA-R-2006	3.50	16.50	109.50	110.50	10.30	8.10	10.80	10.50
CML-426-#-NA-R-2006	1.00	4.00	94.50	86.50	12.50	8.55	12.50	9.45
CML-446	2.00	5.50	106.00	98.00	14.55	11.60	14.50	12.50
Hyd Sel 1	1.50	4.00	94.50	88.50	12.50	8.15	14.05	10.20
Hyd Sel 2	3.00	10.50	99.50	89.00	13.55	7.40	12.90	9.25
Hyd Sel 3	5.00	6.00	98.00	95.00	13.05	9.05	13.30	10.15
Hyd Sel 4	3.00	5.00	95.50	91.00	12.70	10.00	12.50	11.10
Hyd Sel 5	3.50	6.00	96.00	95.00	14.00	9.05	12.75	9.40
Hyd Sel 6	2.50	4.00	99.00	90.50	14.50	8.65	11.15	9.45
Hyd Sel 7	2.50	11.00	100.00	93.00	11.95	7.15	12.90	9.05
Hyd Sel 8	2.50	6.00	96.50	91.00	10.90	8.00	13.00	11.35
Hyd Sel 9	3.50	3.50	92.50	91.50	14.00	10.00	12.45	10.05
Hyd Sel 10	3.00	9.50	99.00	94.00	12.25	8.15	13.85	9.70
Hyd Sel 11	2.00	9.00	95.00	85.50	13.15	7.70	13.40	9.60
Hyd Sel 12	3.00	6.00	95.50	89.00	11.15	8.30	12.60	9.95
Hyd Sel 13	4.00	5.50	95.50	93.50	13.30	8.55	13.00	11.35
Hyd Sel 14	2.00	11.00	101.50	94.50	10.85	6.50	12.05	9.15
Hyd Sel 15	3.00	5.00	96.00	92.00	13.90	10.05	14.35	11.30
Mean	3.11	8.14	99.17	95.31	12.33	8.89	12.87	10.36
SD	1.11	4.50	5.70	6.66	1.87	1.73	1.14	1.43

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	Anthesis to silking interval		Days to maturity		Cob length (cm)		Cob girth (cm)	
	NS	S	NS	S	NS	S	NS	S
Hyd Sel 16	1.50	8.00	99.00	89.00	12.40	8.10	12.15	11.15
Hyd Sel 17	3.00	8.00	96.00	93.00	13.40	10.65	12.90	10.10
Hyd Sel 18	2.50	7.00	96.50	91.00	11.90	7.90	13.05	10.55
KDMI 4	5.00	6.00	100.50	87.50	12.50	9.65	13.05	11.40
KDMI 10	3.00	8.50	98.00	91.00	12.40	8.05	13.40	10.15
KDMI 11	2.50	5.00	97.00	97.00	12.75	9.55	12.85	10.95
KDMI 12	4.00	7.50	98.00	94.00	12.75	9.95	12.80	9.90
KDMI 13-1	3.00	5.00	93.50	91.00	11.55	8.25	12.65	10.40
KDMI 13-1-13	3.50	8.00	95.00	91.50	12.85	9.85	12.75	9.60
KDMI 13-1-29	4.00	9.00	101.50	95.00	12.95	9.25	12.75	9.70
KDMI 14	4.00	11.50	100.50	94.50	12.80	8.40	12.65	10.25
KDMI 15	4.50	11.00	101.00	93.50	14.55	6.85	13.15	8.70
KDMI 16	2.00	4.00	91.50	89.00	13.50	9.30	13.10	10.45
KDMI 17	2.00	8.00	96.50	91.00	13.55	8.55	13.00	10.15
KDMI 18	3.00	5.00	95.00	87.50	13.05	9.20	12.60	9.35
KDMI 19	3.00	5.00	103.50	97.50	11.00	9.10	11.25	10.05
KDMI 20	3.00	7.50	96.00	88.00	12.55	9.70	12.45	10.75
NEI 9202B	2.50	4.50	95.00	91.00	12.15	9.35	13.05	11.35
NEI 9208B	3.00	5.50	105.50	111.50	15.95	8.40	12.65	8.90
NG 4	4.00	9.00	99.00	95.00	11.65	10.00	12.55	10.70
NG 14	4.00	6.50	97.50	93.00	13.30	8.95	12.65	10.85
PAC 2176	1.00	6.00	94.50	90.00	13.25	9.75	13.75	11.00
Pop28-C6- Bulk-##	3.00	8.50	99.00	92.50	13.30	9.45	12.45	9.95
SKV-55-X-NA-K-2006	3.00	11.00	106.50	99.50	11.15	8.45	12.30	10.75
SKV-62-X-NA-K-2006	4.50	10.50	103.00	99.50	9.20	5.45	12.70	8.70
SKV-71-X-NA-K-2006	2.00	7.00	89.00	92.00	7.75	7.35	12.00	9.55
SKV-76-X-NA-K-2006	3.00	9.50	103.00	93.00	8.25	3.60	9.65	6.50
Mean	3.11	8.14	99.17	95.31	12.33	8.89	12.87	10.36
SD	1.11	4.50	5.70	6.66	1.87	1.73	1.14	1.43

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Populations / Hybrids	Anthesis to silking interval		Days to maturity		Cob length (cm)		Cob girth (cm)	
	NS	S	NS	S	NS	S	NS	S
Populations								
G-25	2.00	6.50	92.00	85.50	13.55	9.65	12.10	10.40
G 57	4.50	6.00	96.00	93.50	11.40	10.50	12.60	11.20
Karveer	3.00	4.50	96.50	91.00	15.55	9.10	14.10	11.00
NAC 6002	4.00	4.00	89.50	87.50	11.10	10.70	12.95	12.15
NAC 6004	2.00	7.50	102.00	92.00	12.75	9.60	14.75	11.80
Parbhat	2.50	4.00	107.50	97.50	10.45	8.80	13.45	11.45
Yellow Pool	2.00	3.00	98.00	93.50	16.45	15.00	13.75	13.00
Hybrids								
30 V 92	2.50	6.50	102.00	95.00	15.15	9.85	13.90	10.50
All-Rounder	3.00	5.00	100.00	97.50	14.40	10.25	14.35	11.15
Bio 9681	2.50	5.50	97.50	93.50	14.45	9.65	14.60	11.85
DMH 2	4.00	5.00	97.50	95.00	14.70	9.35	14.00	11.60
EH 434042	3.50	6.00	98.00	93.00	13.25	10.00	13.75	12.20
NAH 2049	3.50	5.50	95.00	94.00	12.45	11.25	14.20	11.80
NK 6240	3.50	4.00	100.00	100.00	14.30	10.25	14.00	11.70
Rajkumar	3.50	6.50	102.00	97.50	14.25	9.10	13.00	10.80
900M	2.50	9.00	106.50	97.00	13.45	9.40	14.40	9.75
Suraj	4.00	6.50	100.00	94.50	12.15	8.95	14.05	11.00
Mean	3.11	8.14	99.17	95.31	12.33	8.89	12.87	10.36
SD	1.11	4.50	5.70	6.66	1.87	1.73	1.14	1.43

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	Kernel rows/cob		Kernels per row		Cobs per plant		Shelling percentage	
	NS	S	NS	S	NS	S	NS	S
Bertam 701	15.20	11.80	31.30	14.90	0.837	0.389	79.69	72.65
CI 4	12.80	14.10	26.30	23.00	0.934	0.879	84.50	83.27
CI 5	14.80	14.20	33.50	22.20	1.111	0.837	83.89	77.43
CM 111	14.70	12.40	27.00	17.90	1.008	0.570	78.89	77.51
CM 111 Sel	12.40	12.80	28.00	19.00	0.950	0.798	77.82	83.25
CM 132	14.20	11.80	26.50	14.00	0.892	0.445	84.78	79.96
CM 133	13.00	12.40	25.30	19.00	0.962	0.862	79.91	80.79
CM 135	17.60	14.90	24.90	16.10	0.943	0.655	83.34	80.83
CM 136	13.80	13.10	27.60	15.80	1.034	0.613	83.20	78.88
CM 136-1	14.60	12.00	29.40	20.50	0.928	0.536	83.52	83.34
CM 137	15.00	13.60	30.15	19.80	0.948	0.825	83.26	80.66
CM 137-1	14.80	14.60	26.30	20.60	0.917	0.557	84.50	82.14
CM 138	12.60	12.70	30.20	23.90	1.011	0.661	83.96	82.54
CM 138-1	16.60	17.30	22.90	19.35	0.892	0.344	80.21	81.44
CM 202	15.60	16.00	21.00	19.00	0.778	0.250	79.44	85.15
CM 202 Sel	17.00	13.60	27.00	17.20	0.950	0.679	83.85	88.17
CM 500	15.20	13.10	24.80	17.70	0.862	0.829	81.60	79.75
CM 501	14.20	12.20	26.30	18.20	0.925	0.837	83.20	73.36
CML 37-#-NA-R-2006	13.60	9.35	22.00	5.35	0.777	0.165	74.52	46.78
CML-44-#-NA-R-2006	13.20	14.20	27.40	23.90	0.875	0.434	80.59	77.20
CML 68 (7)-#-#-#	16.60	14.80	24.30	16.20	1.058	0.790	85.07	83.19
CML-113-#-#-#	13.80	13.20	27.50	26.80	0.967	0.764	83.24	79.72
CML-114-#-#-#	13.40	11.60	27.60	15.00	0.882	0.789	77.20	74.47
CML-118-C332-MH2-1-2-2-B-B-#	13.60	13.00	23.10	16.20	0.950	0.915	83.67	80.78
CML-183-CB2-RMM-30-1-2-1-B-13-#	14.40	14.20	27.50	21.40	0.919	0.862	83.22	80.30
CML-217*(Tropical)	15.60	13.80	28.00	18.30	0.974	0.775	83.41	84.44
CML-223 (Tropical)	14.60	14.40	26.20	20.00	0.980	0.691	85.26	80.66
CML-297-#-NA-R-2006	10.80	9.70	27.45	8.85	0.867	0.230	84.64	57.51
Mean	14.07	13.01	27.84	18.61	0.955	0.676	83.16	79.51
SD	1.52	1.87	5.20	4.72	0.15	0.23	3.08	6.96

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	Kernel rows/cob		Kernels per row		Cobs per plant		Shelling percentage	
	NS	S	NS	S	NS	S	NS	S
CML-298-#-NA-R-2006	15.40	14.80	30.20	21.10	0.999	0.691	85.29	79.35
CML-310-#-NA-R-2006	14.20	10.00	19.70	10.70	0.834	0.189	79.66	80.92
CML-321-#-NA-R-2006	15.00	12.95	23.60	10.70	1.050	0.785	78.99	62.17
CML-341-#-NA-R-2006	12.20	12.00	23.10	16.50	0.986	0.071	84.52	81.91
CNL-342-#-NA-R-2006	14.00	9.30	26.10	15.50	0.881	0.548	81.30	73.50
CML-361-#-NA-R-2006	11.80	10.00	24.90	16.50	0.795	0.059	79.55	51.48
CML-364-#-NA-R-2006	12.00	12.10	19.00	10.30	0.871	0.347	75.70	77.36
CML-370-#-NA-R-2006	13.60	12.20	33.20	18.50	1.082	0.570	87.54	81.29
CML-389-#-NA-R-2006	14.20	9.40	28.90	14.05	0.768	0.255	86.08	85.80
CML-415-#-NA-R-2006	12.25	13.60	23.40	18.65	0.559	0.211	80.82	81.82
CML-426-#-NA-R-2006	13.00	12.60	29.30	19.40	0.921	0.702	83.43	75.68
CML-446	13.45	15.20	32.00	23.90	1.084	0.649	82.31	79.61
Hyd Sel 1	13.80	11.60	30.00	17.70	1.028	0.764	86.43	83.39
Hyd Sel 2	14.00	11.80	30.80	15.30	0.950	0.754	84.14	79.48
Hyd Sel 3	14.60	12.80	29.40	18.60	0.920	0.515	86.31	81.61
Hyd Sel 4	12.80	12.60	29.70	22.10	1.047	0.922	84.13	78.31
Hyd Sel 5	13.60	12.80	28.60	17.70	0.896	0.864	82.90	76.79
Hyd Sel 6	10.60	11.00	30.00	18.50	0.857	0.555	85.76	81.70
Hyd Sel 7	15.60	13.00	30.90	17.80	0.917	0.482	84.78	82.50
Hyd Sel 8	13.10	14.20	26.50	19.30	0.993	0.915	83.86	80.62
Hyd Sel 9	13.20	12.80	32.00	24.00	1.058	0.945	85.16	83.76
Hyd Sel 10	14.40	12.20	26.70	15.70	0.972	0.631	84.46	82.27
Hyd Sel 11	14.20	11.40	32.10	20.80	0.876	0.617	92.13	82.63
Hyd Sel 12	13.30	12.10	23.10	17.50	0.867	0.670	82.72	79.32
Hyd Sel 13	13.50	13.00	28.30	19.30	1.136	0.862	87.75	81.85
Hyd Sel 14	13.80	11.80	14.00	14.50	0.815	0.548	80.78	79.86
Hyd Sel 15	15.40	15.30	26.50	18.80	1.034	0.731	86.41	85.24
Mean	14.07	13.01	27.84	18.61	0.955	0.676	83.16	79.51
SD	1.52	1.87	5.20	4.72	0.15	0.23	3.08	6.96

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	Kernel rows/cob		Kernels per row		Cobs per plant		Shelling percentage	
	NS	S	NS	S	NS	S	NS	S
Hyd Sel 16	14.60	14.80	28.30	18.70	0.972	0.548	84.28	81.47
Hyd Sel 17	13.60	12.80	27.50	23.90	0.892	0.664	79.97	81.18
Hyd Sel 18	13.60	13.20	26.90	18.70	0.912	0.728	87.50	80.36
KDMI 4	14.60	13.60	27.90	20.10	1.318	0.800	86.65	81.96
KDMI 10	14.00	13.00	27.30	18.10	1.049	0.683	84.00	82.84
KDMI 11	16.00	14.40	28.00	21.30	1.088	0.659	84.44	82.52
KDMI 12	13.00	12.60	26.80	22.50	0.914	0.725	87.26	84.37
KDMI 13-1	14.80	13.40	25.50	16.80	0.939	0.734	85.66	84.09
KDMI 13-1-13	12.60	11.50	26.50	16.60	0.898	0.694	81.52	77.81
KDMI 13-1-29	15.20	13.40	30.50	20.80	0.842	0.561	83.42	80.58
KDMI 14	13.40	12.60	30.00	17.50	1.258	0.784	82.57	78.56
KDMI 15	13.00	10.60	32.90	12.50	1.111	0.617	85.43	81.95
KDMI 16	13.20	13.00	31.80	22.20	0.955	0.787	82.66	80.59
KDMI 17	13.80	13.20	30.90	17.10	0.972	0.873	84.38	81.29
KDMI 18	11.80	12.20	29.90	20.20	1.027	0.697	85.54	84.73
KDMI 19	12.60	12.40	24.90	20.10	0.967	0.725	84.88	78.60
KDMI 20	14.00	14.40	30.50	21.70	1.000	0.940	80.81	81.80
NEI 9202B	13.40	12.80	28.80	21.50	0.976	0.892	83.79	79.44
NEI 9208B	12.80	11.60	36.30	17.60	0.967	0.487	84.59	76.95
NG 4	14.80	14.00	26.30	22.10	0.950	0.846	80.09	77.45
NG 14	14.20	12.80	28.70	20.50	0.922	0.711	85.20	8379.00
PAC 2176	13.80	14.20	28.80	18.80	0.972	0.871	82.46	76.35
Pop28-C6- Bulk-##	15.40	13.80	30.10	20.90	1.033	0.759	80.59	78.71
SKV-55-X-NA-K-2006	14.20	12.60	27.40	18.50	0.883	0.407	84.15	79.00
SKV-62-X-NA-K-2006	18.00	15.20	20.90	11.00	0.963	0.727	81.84	73.78
SKV-71-X-NA-K-2006	12.80	11.40	17.70	13.50	0.966	0.755	82.27	80.07
SKV-76-X-NA-K-2006	11.80	7.70	17.50	11.15	0.709	0.338	76.61	81.11
Mean	14.07	13.01	27.84	18.61	0.955	0.676	83.16	79.51
SD	1.52	1.87	5.20	4.72	0.15	0.23	3.08	6.96

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Populations / Hybrids	Kernel rows/cob		Kernels per row		Cobs per plant		Shelling percentage	
	NS	S	NS	S	NS	S	NS	S
Populations								
G-25	13.40	13.20	29.60	23.10	0.972	0.801	85.83	79.17
G 57	14.80	13.40	25.40	22.70	0.950	0.875	84.11	79.81
Karveer	13.80	13.40	32.60	22.50	1.000	0.799	83.23	78.15
NAC 6002	13.00	13.00	29.50	22.30	1.084	1.000	82.40	80.73
NAC 6004	15.00	13.25	27.90	21.30	0.886	0.862	80.53	79.96
Parbhat	14.10	13.40	30.65	18.90	0.838	0.709	83.33	82.26
Yellow Pool	13.80	14.00	36.10	16.00	1.143	0.700	80.60	78.26
Hybrids								
30 V 92	14.60	14.60	35.60	20.90	1.032	0.911	85.60	84.93
All-Rounder	15.20	15.80	36.15	24.60	0.912	0.775	84.39	78.19
Bio 9681	14.80	14.80	33.00	19.70	1.000	0.758	82.85	81.06
DMH 2	14.40	13.10	35.30	21.20	1.009	0.900	82.58	74.70
EH 434042	15.80	13.40	31.60	20.50	0.921	0.782	83.06	74.46
NAH 2049	15.40	14.80	28.30	23.80	0.969	0.875	81.47	81.38
NK 6240	15.40	15.40	26.40	19.60	1.179	0.974	82.08	81.76
Rajkumar	13.80	13.40	30.20	23.90	0.945	0.808	85.12	84.43
900M	14.80	12.60	30.70	20.10	0.909	0.773	85.12	84.78
Suraj	14.60	15.60	27.40	20.40	1.000	0.783	85.37	84.38
Mean	14.07	13.01	27.84	18.61	0.955	0.676	83.16	79.51
SD	1.52	1.87	5.20	4.72	0.15	0.23	3.08	6.96

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	100-grain weight (g)		Yield per plant (g)		Yield (kg/ha)	
	NS	S	NS	S	NS	S
Bertam 701	23.80	17.85	86.60	24.95	3483.00	696.34
CI 4	27.50	21.20	91.10	64.25	4845.83	2447.00
CI 5	25.80	16.00	114.10	36.85	5521.33	1707.67
CM 111	22.15	13.60	77.95	27.25	2183.00	683.83
CM 111 Sel	26.35	17.85	81.10	38.00	4249.50	1671.67
CM 132	28.65	18.90	101.05	28.40	3853.50	846.67
CM 133	25.90	15.00	81.25	30.45	3314.83	1220.50
CM 135	22.90	16.65	89.80	31.30	3678.83	921.16
CM 136	24.70	14.30	79.50	26.15	3779.50	794.17
CM 136-1	25.60	16.90	102.65	35.05	4710.99	964.17
CM 137	29.35	18.40	111.70	41.70	4541.83	1570.00
CM 137-1	28.40	16.40	85.40	36.55	3638.83	1103.67
CM 138	23.95	15.50	82.40	37.50	3948.00	1199.33
CM 138-1	25.65	16.20	73.45	32.50	3027.66	1012.17
CM 202	27.60	19.50	84.40	18.30	2270.00	366.50
CM 202 Sel	18.20	13.70	71.70	25.15	3358.50	1071.17
CM 500	23.50	16.45	67.40	35.25	3001.50	1438.67
CM 501	26.30	18.25	94.05	45.15	3885.33	1740.67
CML 37-#-NA-R-2006	21.80	9.75	47.80	3.65	2033.33	95.00
CML-44-#-NA-R-2006	29.75	17.60	111.90	52.15	5166.66	1337.00
CML 68 (7)-#-#-#	27.75	20.20	118.30	39.10	4685.50	1262.50
CML-113-#-#-#	26.80	15.40	87.25	49.95	3451.50	1700.00
CML-114-#-#-#	26.00	20.60	87.95	30.20	3322.33	1027.50
CML-118-C332-MH2-1-2-2-B-B-#	30.45	19.00	79.70	31.50	4495.00	1291.50
CML-183-CB2-RMM-30-1-2-1-B-13-#	22.25	12.95	76.15	35.15	3736.00	1910.00
CML-217*(Tropical)	24.45	17.70	95.90	38.30	4876.33	1545.17
CML-223 (Tropical)	26.25	19.70	89.75	45.00	4730.33	1356.50
CML-297-#-NA-R-2006	23.15	14.00	65.15	12.85	3048.00	213.83
Mean	26.30	17.49	94.95	35.02	4256.70	1324.80
SD	3.32	3.03	23.75	13.50	1258.81	666.64

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	100-grain weight (g)		Yield per plant (g)		Yield (kg/ha)	
	NS	S	NS	S	NS	S
CML-298-#-NA-R-2006	24.35	13.70	89.20	27.35	3539.50	1043.50
CML-310-#-NA-R-2006	25.10	15.10	51.45	14.60	1817.33	231.00
CML-321-#-NA-R-2006	27.90	15.80	93.55	15.80	4326.66	833.00
CML-341-#-NA-R-2006	27.20	22.25	72.00	18.00	3489.66	150.00
CNL-342-#-NA-R-2006	25.60	21.75	80.90	26.25	3395.00	702.00
CML-361-#-NA-R-2006	24.10	18.75	59.95	1.85	2975.67	45.00
CML-364-#-NA-R-2006	22.40	13.40	40.85	9.70	2031.83	183.67
CML-370-#-NA-R-2006	24.30	16.85	99.10	28.00	3866.66	870.83
CML-389-#-NA-R-2006	24.25	17.30	94.80	36.60	3871.83	704.00
CML-415-#-NA-R-2006	25.55	18.75	90.40	32.05	2551.66	588.33
CML-426-#-NA-R-2006	23.65	14.15	78.45	28.40	3896.67	930.84
CML-446	28.35	22.30	119.15	58.10	4993.83	2272.50
Hyd Sel 1	28.60	16.60	110.25	28.30	4911.16	1381.50
Hyd Sel 2	27.80	16.40	110.10	26.55	5264.66	975.50
Hyd Sel 3	25.75	17.00	95.10	35.00	3563.17	934.50
Hyd Sel 4	29.05	18.50	96.65	47.55	4877.66	2273.00
Hyd Sel 5	28.15	20.15	101.60	36.85	4378.16	1675.66
Hyd Sel 6	28.85	16.95	90.00	30.55	3117.33	1141.67
Hyd Sel 7	21.35	14.40	90.05	23.75	4472.66	626.50
Hyd Sel 8	25.45	18.70	92.70	44.25	4488.67	1799.50
Hyd Sel 9	25.55	15.00	107.60	42.35	4700.33	1592.50
Hyd Sel 10	29.00	18.60	102.15	28.60	5261.66	915.67
Hyd Sel 11	24.00	15.65	101.25	31.30	4450.50	1253.16
Hyd Sel 12	28.55	17.95	73.90	28.20	2611.83	1245.67
Hyd Sel 13	27.50	18.65	95.05	45.25	4620.50	1767.00
Hyd Sel 14	21.30	15.00	61.50	19.80	2400.33	510.00
Hyd Sel 15	31.55	22.00	122.95	47.75	3882.16	2588.50
Mean	26.30	17.49	94.95	35.02	4256.70	1324.80
SD	3.32	3.03	23.75	13.50	1258.81	666.64

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Inbred lines	100-grain weight (g)		Yield per plant (g)		Yield (kg/ha)	
	NS	S	NS	S	NS	S
Hyd Sel 16	23.50	15.20	96.35	35.20	3870.67	969.66
Hyd Sel 17	28.35	17.75	92.10	46.55	3795.49	1519.16
Hyd Sel 18	26.15	17.05	100.90	34.95	4060.83	1172.67
KDMI 4	25.60	18.50	95.05	44.85	3895.16	1592.00
KDMI 10	28.45	18.20	118.55	30.75	5350.66	1117.33
KDMI 11	23.50	17.70	108.75	43.90	5200.00	1611.50
KDMI 12	25.30	17.25	96.85	42.15	4870.00	1393.50
KDMI 16	26.10	15.25	99.45	38.15	5584.33	1407.17
KDMI 17	28.45	17.25	112.35	33.20	5440.99	1470.33
KDMI 18	28.55	18.10	95.40	36.75	5103.66	1390.33
KDMI 19	28.10	16.90	77.40	34.30	5361.16	1043.17
KDMI 20	23.45	16.75	88.35	46.30	4717.49	1912.66
NEI 9202B	27.40	19.05	102.10	47.20	4858.49	1930.83
NEI 9208B	26.60	11.50	117.00	21.40	4993.00	536.83
NG 4	22.50	15.05	75.75	37.10	3319.83	1855.33
NG 14	22.50	18.45	95.85	44.75	3919.00	1549.00
PAC 2176	27.10	16.95	101.55	41.80	3819.83	2077.83
Pop28-C6- Bulk-##	19.40	15.15	86.05	33.65	4155.00	1438.67
SKV-55-X-NA-K-2006	25.30	20.50	83.95	44.05	3207.83	965.00
SKV-62-X-NA-K-2006	19.60	9.70	60.40	14.45	2208.66	440.67
SKV-71-X-NA-K-2006	27.20	20.70	56.50	30.65	2937.83	1408.67
SKV-76-X-NA-K-2006	28.50	18.10	35.60	6.40	1516.17	150.17
Mean	26.30	17.49	94.95	35.02	4256.70	1324.80
SD	3.32	3.03	23.75	13.50	1258.81	666.64

NS = Nonstress; S = Stress

Contd.....

Table 4 contd.....

Populations / Hybrids	100-grain weight (g)		Yield per plant (g)		Yield (kg/ha)	
	NS	S	NS	S	NS	S
Populations						
G-25	23.90	14.55	92.05	37.70	4658.00	1300.00
G 57	25.40	20.60	84.00	50.25	4678.00	2580.83
Karveer	32.45	18.10	137.30	44.65	6316.99	2131.17
NAC 6002	29.45	21.25	88.00	52.30	4476.50	2499.50
NAC 6004	31.35	20.75	126.40	50.45	5232.16	1771.66
Parbhat	27.10	21.55	90.35	52.05	5250.00	2166.50
Yellow Pool	30.45	22.05	140.65	19.90	5266.66	1583.00
Hybrids						
30 V 92	28.40	17.95	156.75	46.00	6256.16	2001.50
All-Rounder	28.90	17.45	128.75	53.50	5263.99	1981.00
Bio 9681	29.50	20.45	136.25	40.65	6685.66	2061.50
DMH 2	30.80	20.45	147.00	31.00	5891.50	1471.84
EH 434042	30.25	22.35	124.70	36.25	5783.33	1703.83
NAH 2049	26.25	16.30	108.65	52.95	5055.00	2717.00
NK 6240	32.05	20.40	145.80	51.20	7460.33	2567.66
Rajkumar	29.65	20.10	108.00	50.95	5833.33	2066.50
900M	30.30	20.85	148.45	47.75	7416.66	2101.17
Suraj	27.65	15.20	113.55	43.25	5354.16	1499.33
Mean	26.30	17.49	94.95	35.02	4256.70	1324.80
SD	3.32	3.03	23.75	13.50	1258.81	666.64

NS = Nonstress; S = Stress

Table 5. Drought susceptibility index of inbreds, hybrids and populations for yield and related traits

Inbred lines	Cobs per plant	Kernels per row	100-grain weight (g)	Yield per plant (g)	Yield (kg/ha)
Bertam 701	0.75	0.75	0.34	1.94	2.57
CI 4	0.08	0.18	0.31	0.79	1.50
CI 5	0.33	0.49	0.62	1.81	2.22
CM 111	0.57	0.48	0.61	1.77	2.16
CM 111 Sel	0.21	0.47	0.35	1.45	1.97
CM 132	0.70	0.68	0.53	1.94	2.49
CM 133	0.15	0.36	0.69	1.71	1.99
CM 135	0.42	0.52	0.41	1.78	2.41
CM 136	0.57	0.62	0.63	1.81	2.53
CM 136-1	0.58	0.45	0.59	1.79	2.56
CM 137	0.18	0.50	0.66	1.71	2.11
CM 137-1	0.54	0.32	0.71	1.56	2.24
CM 138	0.50	0.30	0.72	1.48	2.24
CM 138-1	0.88	0.38	0.51	1.40	2.05
CM 202	0.92	0.14	0.48	2.13	2.67
CM 202 Sel	0.38	0.52	0.47	1.75	2.18
CM 500	0.06	0.41	0.38	1.27	1.61
CM 501	0.13	0.45	0.52	1.41	1.82
CML 37-#-NA-R-2006	1.11	1.10	0.74	2.52	3.07
CML-44-#-NA-R-2006	0.70	0.19	0.54	1.37	2.38
CML 68 (7)-#-#-#	0.36	0.48	0.38	1.82	2.30
CML-113-#-#-#	0.30	0.04	0.69	1.16	1.62
CML-114-#-#-#	0.15	0.67	0.23	1.77	2.20
CML-118-C332-MH2-1-2-2-B-B-#	0.06	0.44	0.50	1.64	2.25
CML-183-CB2-RMM-30-1-2-1-B-13-#	0.09	0.29	0.54	1.41	1.57
CML-217*(Tropical)	0.29	0.51	0.53	1.64	2.18
CML-223 (Tropical)	0.45	0.34	0.44	1.36	2.30
CML-297-#-NA-R-2006	1.03	0.99	0.74	2.19	2.99
Mean	0.42	0.48	0.54	1.71	2.22
CD at 5%	0.38	0.40	0.02	0.60	0.70
CV (%)	45.63	42.11	1.56	17.60	15.90

Contd.....

Table 5 contd.....

Inbred lines	Cobs per plant	Kernels per row	100-grain weight (g)	Yield per plant (g)	Yield (kg/ha)
CML-298-#-NA-R-2006	0.45	0.44	0.69	1.89	2.25
CML-310-#-NA-R-2006	1.08	0.65	0.60	1.94	2.79
CML-321-#-NA-R-2006	0.36	0.80	0.63	2.26	2.59
CML-341-#-NA-R-2006	1.31	0.42	0.38	2.04	3.08
CNL-342-#-NA-R-2006	0.53	0.56	0.11	1.79	2.44
CML-361-#-NA-R-2006	1.30	0.49	0.27	2.65	3.17
CML-364-#-NA-R-2006	0.85	0.65	0.57	2.08	2.93
CML-370-#-NA-R-2006	0.67	0.64	0.53	1.96	2.50
CML-389-#-NA-R-2006	0.94	0.75	0.44	1.68	2.63
CML-415-#-NA-R-2006	0.79	0.30	0.35	1.77	2.47
CML-426-#-NA-R-2006	0.33	0.49	0.69	1.74	2.42
CML-446	0.57	0.37	0.40	1.40	1.74
Hyd Sel 1	0.36	0.60	0.72	2.01	2.31
Hyd Sel 2	0.30	0.74	0.64	2.07	2.61
Hyd Sel 3	0.62	0.53	0.50	1.72	2.38
Hyd Sel 4	0.16	0.38	0.62	1.35	1.63
Hyd Sel 5	0.06	0.56	0.52	1.76	2.01
Hyd Sel 6	0.51	0.57	0.63	1.80	2.02
Hyd Sel 7	0.68	0.62	0.53	2.01	2.76
Hyd Sel 8	0.10	0.40	0.40	1.43	1.94
Hyd Sel 9	0.16	0.36	0.69	1.65	2.11
Hyd Sel 10	0.48	0.60	0.63	1.97	2.64
Hyd Sel 11	0.42	0.52	0.67	1.88	2.30
Hyd Sel 12	0.33	0.36	0.72	1.69	1.26
Hyd Sel 13	0.34	0.47	0.56	1.46	2.01
Hyd Sel 14	0.49	0.38	0.43	1.83	2.53
Hyd Sel 15	0.42	0.42	0.49	1.63	1.02
Mean	0.42	0.48	0.54	1.71	2.22
CD at 5%	0.38	0.40	0.02	0.60	0.70
CV (%)	45.63	42.11	1.56	17.60	15.90

Contd.....

Table 5 contd.....

Inbred lines	Cobs per plant	Kernels per row	100-grain weight (g)	Yield per plant (g)	Yield (kg/ha)
Hyd Sel 16	0.60	0.47	0.55	1.71	2.42
Hyd Sel 17	0.35	0.19	0.62	1.34	1.87
Hyd Sel 18	0.28	0.45	0.69	1.83	2.30
KDMI 4	0.48	0.41	0.30	1.44	1.89
KDMI 10	0.47	0.50	0.82	2.02	2.54
KDMI 11	0.54	0.35	0.56	1.58	2.20
KDMI 12	0.30	0.25	0.47	1.57	2.31
KDMI 13-1	0.31	0.51	0.49	1.63	2.02
KDMI 13-1-13	0.32	0.54	0.47	1.74	2.25
KDMI 13-1-29	0.48	0.46	0.47	1.54	2.15
KDMI 14	0.53	0.61	0.49	1.88	2.55
KDMI 15	0.64	0.91	0.35	2.28	2.83
KDMI 16	0.23	0.44	0.70	1.69	2.41
KDMI 17	0.15	0.65	0.70	1.93	2.36
KDMI 18	0.45	0.47	0.75	1.69	2.37
KDMI 19	0.35	0.29	0.51	1.52	2.58
KDMI 20	0.09	0.42	0.40	1.28	1.86
NEI 9202B	0.12	0.37	0.60	1.47	1.92
NEI 9208B	0.70	0.75	0.93	2.23	2.87
NG 4	0.16	0.23	0.60	1.37	1.15
NG 14	0.33	0.42	0.43	1.46	1.95
PAC 2176	0.15	0.51	0.48	1.61	1.44
Pop28-C6- Bulk-#-#	0.37	0.44	0.26	1.63	2.10
SKV-55-X-NA-K-2006	0.75	0.48	0.42	1.29	2.26
SKV-62-X-NA-K-2006	0.34	0.69	0.63	2.07	2.57
SKV-71-X-NA-K-2006	0.31	0.40	0.36	1.26	1.68
SKV-76-X-NA-K-2006	0.70	0.56	0.61	2.24	2.90
Mean	0.42	0.48	0.54	1.71	2.22
CD at 5%	0.38	0.40	0.02	0.60	0.70
CV (%)	45.63	42.11	1.56	17.60	15.90

Contd.....

Table 5 contd.....

Populations / hybrids	Cobs per plant	Kernels per row	100-grain weight (g)	Yield per plant (g)	Yield (kg/ha)
Populations					
G-25	0.21	0.32	0.74	1.60	2.32
G 57	0.12	0.16	0.35	1.10	1.43
Karveer	0.29	0.45	0.72	1.68	2.13
NAC 6002	0.10	0.35	0.40	1.11	1.41
NAC 6004	0.04	0.32	0.70	1.65	2.09
Parbhat	0.22	0.55	0.29	1.14	1.89
Yellow Pool	0.53	0.82	0.39	2.33	2.24
Hybrids					
30 V 92	0.17	0.56	0.65	1.94	2.19
All-Rounder	0.22	0.46	0.68	1.62	2.04
Bio 9681	0.33	0.59	0.56	1.92	2.23
DMH 2	0.15	0.56	0.74	2.16	2.41
EH 434042	0.19	0.50	0.50	1.93	2.28
NAH 2049	0.19	0.23	0.55	1.39	1.47
NK 6240	0.25	0.36	0.62	1.77	2.11
Rajkumar	0.19	0.31	0.46	1.44	2.08
900M	0.21	0.51	0.51	1.85	2.31
Suraj	0.31	0.38	0.65	1.70	2.34
Mean	0.42	0.48	0.54	1.71	2.22
CD at 5%	0.38	0.40	0.02	0.60	0.70
CV (%)	45.63	42.11	1.56	17.60	15.90

Table 6. Performance of parents selected for production of single cross hybrids under stress and nonstress situations during *rabi* 2007 at College of Agriculture, Bheemarayanagudi (selected characters)

Sl. No.	Inbred lines	Yield per plant (g)		Cobs per plant		Anthesis to silking interval		Yield (kg/ha)		Drought susceptibility index
		NS	S	NS	S	NS	S	NS	S	
	Susceptible									
1	CM 111	77.95	27.25	1.008	0.570	3.00	11.00	2183.00	683.00	1.77
2	Hyd Sel 2	110.10	26.55	0.950	0.754	3.00	10.50	5264.66	975.50	2.07
3	Hyd Sel 7	90.05	23.75	0.917	0.482	2.50	11.00	4472.66	626.50	2.01
4	Hyd Sel 10	102.15	28.60	0.972	0.631	3.00	9.50	5261.66	915.67	1.97
5	KDMI 15	119.10	19.90	1.111	0.617	4.50	11.00	4683.33	572.83	2.28
6	NEI 9208B	117.00	21.40	0.967	0.487	3.00	5.50	4993.00	536.83	2.23
	Tolerant									
1	CI 4	91.10	64.25	0.934	0.879	3.00	4.50	4845.83	2447.00	0.79
2	CML 446	119.15	58.10	1.084	0.649	2.00	5.50	4993.83	2272.50	1.40
3	Hyd Sel 4	96.65	47.55	1.047	0.922	3.00	5.00	4877.66	2273.00	1.35
4	Hyd Sel 15	122.95	47.75	0.955	0.676	3.00	5.00	3882.16	2588.50	1.63
5	Hyd Sel 17	92.10	46.55	0.892	0.664	3.00	8.00	3795.49	1519.20	1.34
6	NEI 9202B	102.10	47.20	0.976	0.892	2.50	4.50	4858.49	1930.83	1.47
	Mean	94.95	35.02	0.955	0.676	3.11	8.14	4256.70	1324.80	1.71
	SD	23.75	13.50	0.15	0.270	1.11	4.50	1258.81	666.64	0.40

NS = Nonstress; S = Stress

Table 7. Performance of parents selected for production of three way /top crosses, varietal hybrids under stress and nonstress situations during rabi 2007 at College of Agriculture, Bheemarayanagudi (selected characters)

Sl. No.	Populations / Hybrids/inbreds	Yield per plant (g)		Cobs per plant		Anthesis to silking interval		Yield (kg/ha)		Drought susceptibility index
		NS	S	NS	S	NS	S	NS	S	
	Populations									
1	G 57	84.00	50.25	0.950	0.875	4.50	6.00	4678.00	2580.33	1.10
2	Karveer	137.30	44.65	1.000	0.799	3.00	4.50	6316.99	2131.17	1.68
3	Parbhat	88.00	52.30	1.084	1.000	4.00	4.00	4476.50	2499.50	1.14
4	NAC 6002	90.35	50.05	0.938	0.709	2.50	4.00	5250.00	2166.50	1.11
	Hybrids									
1	All-Rounder	128.75	53.50	0.912	0.775	3.00	5.00	5263.99	1981.00	1.62
2	NAH 2049	108.65	52.95	0.969	0.875	3.50	5.50	5055.00	2717.00	1.39
3	NK 6240	145.80	51.20	1.179	0.974	3.50	4.00	7460.33	2567.66	1.77
4	Rajkumar	108.00	50.95	0.945	0.808	3.50	6.50	5833.33	2066.50	1.44
	Inbreds									
1	CI 4	91.10	64.25	0.934	0.879	3.00	4.50	4845.83	2447.00	0.79
2	CML 446	119.15	58.10	1.084	0.649	2.00	5.50	4993.83	2272.50	1.40
3	HS 17	92.10	46.55	0.892	0.664	3.00	8.00	3795.49	1519.20	1.34
	Mean	94.95	35.02	0.955	0.676	3.11	8.14	4256.70	1324.80	1.71
	SD	23.75	13.50	0.15	0.270	1.11	4.50	1258.81	666.64	0.40

NS = Nonstress; S = Stress

Table 8. Pooled ANOVA for stability with respect to yield (kg/ha) of selected inbred lines tested under managed drought conditions at College of Agriculture, Bheemarayanagudi

Sourcess of variation	df	Mean sum of squares
Rep within Env.	3	118476.80
Varieties	11	546694.70*
Env.+ (Var.* Env.)	24	842786.00**
Environments	2	5734384.00**
Var.* Env.	22	398095.30
Environments (Lin.)	1	11468770.00**
Var.* Env.(Lin.)	11	579010.80*
Pooled Deviation	12	199081.60*
Pooled Error	33	79185.55
Total	35	749728.80

* & ** - Significant at 0.05 and 0.01 level of probability, respectively

Table 9. Stability parameters of selected maize inbred lines tested under managed drought conditions at College of Agriculture, Bheemarayanagudi

Inbreds	2007	2008	2009	Mean	bi	S ² Di
CI 4	2447.00	2265.00	3649.68	2787.23	1.01	69191.8
CM 111	683.84	1265.00	2786.10	1578.31	1.57	-81734
CML 446	2272.50	1668.33	1958.04	1966.29	-0.12	86488
Hyd Sel 2	975.50	1641.34	2877.12	1831.32	1.39	-64334.2
Hyd Sel 4	2273.00	2341.66	3250.08	2621.58	0.78	-61143.6
Hyd Sel 7	626.50	1060.00	2235.54	1307.35	1.20	-82322.5
Hyd Sel 10	915.67	1385.00	2373.18	1557.95	1.07	-77429.4
Hyd Sel 15	2588.50	1845.00	2084.58	2172.69	-0.24	149754.2
Hyd Sel 17	1519.17	2286.33	2251.08	2018.86	0.42	123500.3
KDMI 15	572.84	2385.00	3183.48	2047.10	1.71	712308.1**
NEI 9202B	1930.83	1201.00	2564.07	1898.63	0.68	413053.4*
NEI 9208B	536.84	2158.33	4118.10	2271.09	2.53	212129.5
Environmental Index	-559.69	-213.04	772.72			
Mean	1445.18	1791.83	2777.59	2004.90		
C. V.	24.52	21.06	16.38			
SE of Difference	354.41	377.38	455.07			
CD at 5 %	780.05	830.61	1001.60			
CD at 1 %	1100.73	1172.07	1413.35			

* & ** - Significant at 0.05 and 0.01 level of probability, respectively;

During 2007, Hyd sel. 15 (2589 kg/ha) followed by CI 4 (2447 kg/ha), CML 446 (2273 kg/ha) and Hyd Sel 4 (2273 kg/ha) recorded good yields. During 2008, KDMI 15 (2385 kg/ha) followed by Hyd Sel 4 (2342 kg/ha) and CI 4 (2265 kg/ha) recorded the higher yields. During 2009, CI 4 (3650 kg/ha) followed by Hyd Sel 4 (3250 kg/ha) recorded the highest yields.

The pooled grain yield of all the genotypes for three years indicated that CI 4 (2787 kg/ha) and Hyd Sel 4 (2622 kg/ha) recorded the highest yield. CI 4 with higher mean value than the population mean (2005 kg/ha) with bi value near unity (1.01) and non significant S^2Di , emerged as the stable drought tolerant inbred line.

4.2 Diallel analysis involving 12 parents differing for drought tolerance under stress and nonstress situations

Six drought tolerant and six drought susceptible parents were identified based on the performance of inbreds lines during *rabi*/summer 2007. Single crosses (excluding reciprocals) were produced during *kharif* 2008 in 12 x 12 diallel fashion and the resulting 66 hybrids, their parents and few checks were evaluated under nonstress and stress situations during *rabi*/summer 2008-09 and 2009-10. The pooled analysis of data was carried out for stress and nonstress separately. The results of these studies are presented in the following headings.

4.2.1 Analysis of variance

The ANOVA in respect of all the characters studied on parents and hybrids under nonstress and stress situations are presented in Table 10.

It was observed from the Table 10 that the differences among genotypes (treatments) were significant for all the traits except RWC1 in both the situations and RWC2 (under nonstress). Further, the mean sum of squares for parents were significant for all the traits except DSI, RWC1 and CHL2 (under stress) and RWC1 and RWC2 (under nonstress) in both the situations. Hybrids recorded significant mean sum of square for most of the traits in both the situations, indicating considerable differences among the hybrids. Mean sum of squares due to interaction of parents vs hybrids were significant for all the traits except ASI, days to maturity, DSI and RWC1 (under stress); ASI, number of kernel rows per cob, cobs per plant, 100 grain weight, RWC1, RWC2, CHL1 and CHL2 (under nonstress) in both the situations. The mean sum of squares due to interaction of parents vs hybrids vs environments were significant for plant height, ear height, days to 50% anthesis, days to 50% silking, ASI and CHL1 under stress and no significant interactions were noticed under nonstress situation.

4.2.2 *Per se* performance and heterosis of hybrids

Per se performance and heterosis values of the hybrids over mid parent and commercial check for various quantitative traits obtained for 66 hybrids are presented in Table 11 to 20. The results are as follows.

4.2.2.1 Plant height (cm)

Among the hybrids, mean value for the trait ranged between 233.80 (Hyd Sel 2 x Hyd Sel 15) and 278.50 cm (CML 446 x NEI 9202B) with an overall mean of 255.48 cm under nonstress. Under stress, CM 111 x Hyd Sel 17 (199.0 cm) recorded the lowest and Hyd Sel 10 x CML 446 (256.0 cm) recorded the maximum mean value for plant height with an overall mean of 237.0 cm. The magnitude of heterosis over mid parent for the trait under nonstress ranged between -2.74 and 15.55% whereas under stress, it ranged from -3.41 to 27.12%. Thirteen hybrids expressed significant positive heterosis over mid parent under nonstress whereas under stress, 19 hybrids expressed significant positive heterosis for the traits. Many hybrids (26) exhibited significant negative heterosis over commercial check under nonstress, but only two hybrids *viz.*, CM 111 x Hyd Sel 17 and Hyd Sel 2 x Hyd Sel 4 expressed significant negative heterosis over check, under stress.

4.2.2.2 Ear height (cm)

Variation for this trait ranged from 88.25 (Hyd Sel 2 x Hyd Sel 15) to 138.75 cm (CML 446 x NEI 9202B) with an overall mean of 117.24 cm under nonstress. Under stress, it ranged from 85.5 (Hyd Sel 2 x Hyd Sel 15) to 148.5 cm (CM 111 x NEI 9202B) with an overall mean of 110.7 cm.

Table 10. Pooled ANOVA for different quantitative traits in 12 x 12 half diallel set of crosses under nonstress and stress situations

Sources of variation	df	Plant height (cm)		Ear height (cm)		Day to 50% anthesis	
		Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
Environments	1	245.04	24581.97**	283.20	427.47	5.65	71.16**
Blocks within Environments	2	1094.54**	2404.77**	824.92**	1269.96**	12.78*	12.32**
Treatments	77	508.13*	639.00**	491.97**	553.22**	31.07**	26.50**
Parents	11	676.98*	1005.08**	536.37**	380.47**	45.10**	28.98**
Hybrids	65	396.20**	365.14**	454.76**	526.48**	27.82**	24.97**
Parents vs. Hybrids	1	5926.41**	14413.01**	2422.09**	4191.49**	88.41**	98.92**
Treatment* Environments	77	139.97	177.41	91.73	121.90	3.64	3.89**
Parent* Environments	11	179.37	42.83	79.81	29.72	1.87	3.71
Hybrids* Environments	65	135.43	183.97	95.12	130.53	3.96	3.67*
Parent vs. Hybrids* Env.	1	1.76	1231.66**	2.55	574.74*	2.20	20.60**
Error	154	118.15	157.19	89.36	123.96	3.29	2.45
Total	311	226.79	374.48	194.98	238.08	10.32	9.05

* and ** - Significant at 0.05 and 0.01 level of probability, respectively.

Contd.....

Table 10 contd.....

Sources of variation	df	Days to 50% silking		Anthesis to silking interval		Days to maturity	
		Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
Environments	1	26.54**	94.82**	6.21**	1.85	98.16**	9.70
Blocks within Environments	2	9.25	11.42*	0.84	0.11	85.66**	8.97
Treatments	77	23.21**	23.45**	2.86**	4.35**	8.73**	7.88**
Parents	11	40.25**	34.02**	3.501**	3.57**	14.48**	6.80*
Hybrids	65	19.30**	20.13**	2.79**	4.53**	7.38**	8.09**
Parents vs. Hybrids	1	89.55**	122.51**	0.02	1.21	33.15**	6.30
Treatment* Environments	77	4.10	6.67**	0.87**	3.37**	4.87	3.50
Parent* Environments	11	3.22	3.157	1.02*	4.57**	4.34	1.22
Hybrids* Environments	65	4.22	6.36**	0.84**	3.02**	5.01	3.93
Parent vs. Hybrids* Env.	1	6.30	65.20**	0.82	12.68**	1.61	1.03
Error	154	3.34	3.18	0.52	1.23	4.09	3.22
Total	311	8.56	9.41	1.20	2.53	6.26	4.50

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

Contd.....

Table 10 contd.....

Sources of variation	df	Cob length (cm)		Cob girth (cm)		No. of kernel rows /Cob	
		Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
Environments	1	213.68**	15.75**	64.36**	0.38	30.53**	1.30
Blocks within Environments	2	0.29	2.12	2.20**	0.32	2.04	0.93
Treatments	77	2.59**	2.82**	1.73**	1.30**	3.86**	3.11**
Parents	11	3.46**	2.65*	3.64**	1.99**	6.20**	4.33**
Hybrids	65	2.29**	2.50**	1.32**	1.15**	3.50**	2.85**
Parents vs. Hybrids	1	12.35**	25.47**	7.67**	3.25*	1.20	6.68**
Treatment* Environments	77	1.67	1.82	0.50*	0.79**	1.16**	1.05
Parent* Environments	11	2.04	1.95	0.57	0.50	2.42**	0.77
Hybrids* Environments	65	1.63	1.82	0.49	0.84**	0.96	1.09
Parent vs. Hybrids* Env.	1	0.53	0.460	0.52	0.50	0.88	1.21
Error	154	1.38	1.40	0.35	0.50	0.70	0.90
Total	311	2.42	1.89	0.95	0.77	1.70	1.49

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

Contd.....

Table 10 contd.....

Sources of variation	df	Kernels /row		Cobs/plant		Shelling percentage	
		Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
Environments	1	2.85	530.93**	0.360**	0.12**	143.08**	406.18**
Blocks within Environments	2	19.59	65.40**	0.062**	0.23**	2.47	6.84
Treatments	77	29.56**	28.40**	0.013**	0.03**	8.65**	17.59**
Parents	11	22.31*	19.51**	0.038**	0.04**	10.06**	17.96**
Hybrids	65	29.43**	28.20**	0.009	0.03**	7.87**	17.34**
Parents vs. Hybrids	1	118.14**	138.95**	0.000	0.11**	43.89**	29.93*
Treatment* Environments	77	10.57	10.75*	0.009	0.02	2.82	8.16*
Parent* Environments	11	13.06	14.06	.026**	0.02	3.76	6.26
Hybrids* Environments	65	10.30	10.22	0.007	0.02	2.68	8.60*
Parent vs. Hybrids* Env.	1	0.70	8.72	0.012	0.01	1.59	0.19
Error	154	9.46	7.78	0.009	0.02	2.63	5.76
Total	311	14.76	15.67	0.011	0.02	4.62	10.58

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

Contd.....

Table 10 contd.....

Sources of variation	df	100-grain weight (g)		Yield/plant (g)		Yield (kg/ha)	
		Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
Environments	1	479.48**	153.20**	55.51	5341.68**	10277910.00**	64149120.00**
Blocks within Environments	2	36.414**	15.24*	734.27	502.48*	12396170.00**	1300999.00*
Treatments	77	26.264**	16.78**	563.44**	219.62**	4589460.00**	1272204.00**
Parents	11	48.630**	19.584**	1143.17**	259.38**	4661016.00**	1024124.00**
Hybrids	65	22.807**	16.49**	417.94*	187.56**	4085425.00**	1045176.00**
Parents vs. Hybrids	1	4.987	4.57	3644.23**	1866.28**	36564610.00**	18757920.00**
Treatment* Environments	77	6.494	6.32**	426.81*	211.87**	1473344.00**	688580.50**
Parent* Environments	11	9.322	6.93	388.44	153.47	1523459.00	341882.80
Hybrids* Environments	65	6.106	6.30*	437.17**	224.796**	1472708.00**	756487.20**
Parent vs. Hybrids* Env.	1	0.571	0.87	175.58	14.37	963388.40	88319.23
Error	154	5.548	3.96	273.58	108.22	906761.10	274711.70
Total	311	12.634	8.27	385.55	180.83	2062853.00	836132.30

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

Contd.....

Table 10 contd.....

Sources of variation	df	RWC1		RWC2		CHL1		CHL2		Drought susceptibility index
		Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	
Environments	1	0.136**	0.364**	0.009	0.079**	548.44**	917.05**	054.67**	4078.23**	6.26**
Blocks within Environments	2	0.026**	0.014*	0.014**	0.001	8.25	18.71	32.80	42.65	0.10
Treatments	77	0.002	0.006*	0.005**	0.015**	22.80**	47.05**	26.57**	36.26**	0.07*
Parents	11	0.003	0.005	0.002	0.023**	28.73**	59.87**	28.46**	10.34	0.04
Hybrids	65	0.002	0.006	0.005**	0.013**	21.66*	40.45**	26.39**	29.526**	0.07*
Parents vs. Hybrids	1	0.000	0.015	0.010	0.041**	32.13	335.00**	17.27	758.90**	0.09
Treatment* Environments	77	0.002	0.004	0.003	0.013**	7.47	18.24	8.88	22.60	0.08**
Parent* Environments	11	0.003	0.006	0.005*	0.016**	9.62	29.07*	7.64	24.20	0.03
Hybrids* Environments	65	0.002	0.003	0.003	0.012**	7.18	14.30	9.22	22.36	0.09**
Parent vs. Hybrids* Env.	1	0.002	0.00	0.001	0.003	2.30	154.86**	0.06	20.39	0.004
Error	154	0.003	0.004	0.003	0.006	9.62	14.73	11.67	16.93	0.05
Total	311	0.003	0.006	0.003	0.010	14.08	26.53	21.37	36.34	0.08

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

RWC1 - Relative water content at 60 DAS

RWC2 - Relative water content at 90 DAS

CHL1 – Chlorophyll content at 60 DAS

CHL2 – Chlorophyll content at 90 DAS

Table 11. Per se performance and heterosis for different traits in 12 x 12 half diallel set of hybrids under nonstress and stress situations for plant height (cm) and Ear height (cm)

Hybrids	Plant height (cm)						Ear height (cm)					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
CM 111 x HS 2	247.0	5.44	-9.69*	233	10.97*	-5.77	99.75	-5.87	-20.68**	106.00	9.48	-11.85
CM 111 x HS 7	248.8	5.55	-9.02*	229	9.07	-7.49	111.08	1.93	-11.67	107.25	11.72	-10.81
CM 111 x HS 10	263.8	9.38*	-3.56	233	7.74	-5.57	131.05	14.63*	4.21	118.00	11.19	-1.87
CM 111 x KDMI 15	258.3	5.46	-5.58	242	11.94*	-2.23	117.35	3.21	-6.68	112.50	10.97	-6.44
CM 111 x NEI 9208B	252.3	0.45	-7.77	254	13.68**	2.63	114.00	-8.85	-9.34	129.75	14.82	7.9
CM 111 x CI 4	250.5	4.00	-8.41*	237	12.72*	-4.05	122.75	6.72	-2.39	121.25	19.31*	0.83
CM 111 x CML 446	259.8	2.06	-5.03	239	9.21	-3.14	127.15	4.91	1.11	114.50	11.71	-4.78
CM 111 x HS 4	248.8	3.48	-9.05*	230	9.68	-7.09	113.65	-1.63	-9.62	112.75	12.33	-6.24
CM 111 x HS 15	245.3	2.13	-10.33*	237	10.44*	-4.09	105.50	-1.52	-16.10*	105.50	7.38	-12.27
CM 111 x HS 17	243.0	1.57	-11.15**	199	-3.41	-19.64**	113.25	-4.31	-9.94	102.25	-0.61	-14.97
CM 111 x NEI 9202B	267.3	15.26**	-2.29	246	27.12**	-0.61	121.75	9.12	-3.18	148.50	56.11**	23.49*
HS 2 x HS 7	244.5	5.73	-10.60**	233	7.64	-5.87	102.55	7.95	-18.45*	97.05	4.83	-19.29*
HS 2 x HS 10	254.5	7.55	-6.95	239	6.95	-3.44	114.75	14.35	-8.75	101.00	-1.66	-16.01
HS 2 x KDMI 15	243.0	1.09	-11.15**	231	3.71	-6.68	97.75	-1.98	-22.27**	101.00	3.11	-16.01
HS 2 x NEI 9208B	259.5	5.22	-5.12	241	4.79	-2.63	122.85	10.58	-2.31	110.50	0.84	-8.11
HS 2 x CI 4	246.8	4.39	-9.78*	229	5.42	-7.49	103.10	2.03	-18.01*	102.05	3.92	-15.14
HS 2 x CML 446	256.0	2.40	-6.4	228	0.85	-7.89	112.90	5.29	-10.22	102.50	3.46	-14.76
HS 2 x HS 4	235.8	-0.05	-13.80**	222	2.78	-10.22*	97.45	-4.05	-22.50**	97.50	0.57	-18.92*
HS 2 x HS 15	233.8	-0.80	-14.53**	225	1.92	-8.81	88.25	-5.26	-29.82**	85.50	-9.83	-28.90**
HS 2 x HS 17	243.3	3.62	-11.06**	222	4.83	-10.02	105.25	0.84	-16.30*	97.00	-2.46	-19.33*
HS 2 x NEI 9202B	250.0	9.95*	-8.59*	243	21.73**	-1.62	117.85	20.75*	-6.28	116.25	26.77*	-3.33
HS 7 x HS 10	253.3	6.35	-7.4	228	2.13	-7.89	115.80	12.05	-7.91	99.50	-2.33	-17.26
Rajkumar (check)	273.5			247.0			125.75			120.25		
Mean	255.48	5.02	-6.50	237.0	8.85	-3.98	117.24	7.16	-6.77	110.7	9.41	-6.61
Range	233.80- 278.50	-2.74- 15.55	-14.53- 1.83	199- 256	-3.41- 27.12	-19.64- 3.54	88.25- 138.75	-8.85- 27.56	-29.82- 10.34	85- 148.5	-9.83- 56.11	-28.9- 23.49
SEd	10.87	9.41	10.87	12.54	10.86	12.54	9.45	8.19	9.45	11.13	9.64	11.13
CD at 5%	21.47	18.60	21.47	24.79	21.45	24.79	18.67	16.17	18.67	21.99	19.05	21.99
CD at 1%	28.35	24.55	28.35	32.70	28.32	32.70	24.65	21.35	24.65	29.04	25.15	29.04

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 11 contd....

Hybrids	Plant height (cm)						Ear height (cm)					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
HS 7 x KDMI 15	255.8	5.74	-6.49	234	5.29	-5.36	115.50	12.44	-8.15	105.00	8.11	-12.68
HS 7 x NEI 9208B	254.0	2.37	-7.13	237	3.27	-4.15	121.80	6.75	-3.14	111.50	2.53	-7.28
HS 7 x CI 4	256.3	7.72	-6.31	233	7.74	-5.57	114.65	10.19	-8.83	109.50	12.45	-8.94
HS 7 x CML 446	263.3	4.67	-3.75	242	7.18	-2.23	117.60	6.69	-6.48	106.25	8.14	-11.64
HS 7 x HS 4	254.3	7.11	-7.04	236	9.7	-4.29	108.80	4.05	-13.48	103.75	7.93	-13.72
HS 7 x HS 15	245.0	3.32	-10.42**	232	4.98	-6.17	98.85	2.81	-21.39**	98.75	5.05	-17.88
HS 7 x HS 17	258.0	9.21*	-5.67	236	11.45*	-4.45	118.05	9.94	-6.12	116.00	17.62	-3.53
HS 7 x NEI 9202B	241.5	5.52	-11.70**	238	19.57**	-3.48	116.13	15.43	-7.65	108.25	19.12	-9.98
HS 10 x KDMI 15	257.0	3.94	-6.03	233	1.64	-5.77	114.00	5.48	-9.34	102.75	-4.2	-14.55
HS 10 x NEI 9208B	261.8	3.25	-4.3	243	2.86	-1.62	132.25	10.72	5.17	129.25	8.73	7.48
HS 10 x CI 4	260.3	6.99	-4.84	237	6.15	-3.95	127.00	16.09*	0.99	114.25	6.28	-4.99
HS 10 x CML 446	263.5	2.58	-3.66	256	9.98*	3.44	126.85	9.76	0.87	128.25	18.34*	6.65
HS 10 x HS 4	247.5	1.96	-9.51*	235	5.39	-5.06	108.10	-1.65	-14.04	98.75	-7.06	-17.88
HS 10 x HS 15	250.5	3.30	-8.41*	237	4.17	-3.95	118.90	17.14*	-5.45	109.55	5.21	-8.9
HS 10 x HS 17	254.5	5.33	-6.95	238	8.91	-3.54	125.30	11.16	-0.36	124.00	14.02	3.12
HS 10 x NEI 9202B	269.8	15.15**	-1.37	249	20.41**	0.61	135.15	27.56**	7.48	126.00	24.75*	4.78
KDMI 15 x NEI 9208B	260.3	1.17	-4.84	249	5.73	0.81	115.60	-2.71	-8.07	119.50	4.71	-0.62
KDMI 15 x CI 4	250.8	1.52	-8.32*	242	8.75	-1.92	105.55	-2.96	-16.06*	114.00	10.95	-5.2
KDMI 15 x CML 446	267.3	2.54	-2.29	251	8.24	1.48	121.90	6.05	-3.06	113.00	9.05	-6.03
KDMI 15 x HS 4	239.8	-2.74	-12.34**	222	0.23	-10.02	104.30	-4.56	-17.06*	98.75	-2.71	-17.88
KDMI 15 x HS 15	250.8	1.83	-8.32*	236	3.85	-4.55	112.70	11.72	-10.38	103.50	4.15	-13.93
KDMI 15 x HS 17	250.8	2.19	-8.32*	224	2.89	-9.19	111.50	-0.54	-11.33	105.25	1.2	-12.47
Rajkumar (check)	273.5			247.0			125.75			120.25		
Mean	255.48	5.02	-6.50	237.0	8.85	-3.98	117.24	7.16	-6.77	110.7	9.41	-6.61
Range	233.80- 278.50	-2.74- 15.55	-14.53- 1.83	199-256	-3.41- 27.12	-19.64- 3.54	88.25- 138.75	-8.85- 27.56	-29.82- 10.34	85-148.5	-9.83- 56.11	-28.9- 23.49
SEd	10.87	9.41	10.87	12.54	10.86	12.54	9.45	8.19	9.45	11.13	9.64	11.13
CD at 5%	21.47	18.60	21.47	24.79	21.45	24.79	18.67	16.17	18.67	21.99	19.05	21.99
CD at 1%	28.35	24.55	28.35	32.70	28.32	32.70	24.65	21.35	24.65	29.04	25.15	29.04

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 11 contd....

	Plant height (cm)						Ear height (cm)					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
KDMI 15 x NEI 9202B	275.0	15.55**	0.55	246	19.85**	-0.22	130.90	24.28**	4.10	125.50	30.39**	4.37
NEI 9208B x CI 4	264.3	4.34	-3.38	244	6.09	-1.21	124.85	3.91	-0.72	124.50	8.85	3.53
NEI 9208B x CML 446	278.5	4.36	1.83	253	5.73	2.23	134.60	6.55	7.04	131.50	14.1	9.36
NEI 9208B x HS 4	271.5	7.42*	-0.73	241	5.31	-2.37	132.25	9.60	5.17	124.50	10.06	3.53
NEI 9208B x HS 15	273.0	8.12*	-0.18	253	8.18	2.59	128.80	14.74*	2.43	118.75	6.98	-1.25
NEI 9208B x HS 17	250.9	-0.31	-8.28*	238	5.55	-3.74	120.80	-2.17	-3.94	120.00	3.78	-0.21
NEI 9208B x NEI 9202B	263.3	7.78*	-3.75	243	14.15**	-1.62	123.80	6.08	-1.55	119.00	10.31	-1.04
CI 4 x CML 446	257.5	0.34	-5.85	239	5.83	-3.14	125.25	7.72	-0.40	110.50	6.38	-8.11
CI 4 x HS 4	247.7	2.12	-9.45*	232	7.47	-5.91	111.45	0.76	-11.37	116.40	14.4	-3.20
CI 4 x HS 15	254.5	5.06	-6.95	233	5.19	-5.67	111.20	8.81	-11.57	97.50	-2.13	-18.92*
CI 4 x HS 17	253.0	4.82	-7.5	238	11.88*	-3.74	123.50	8.88	-1.79	118.60	13.76	-1.37
CI 4 x NEI 9202B	265.0	13.25**	-3.11	243	21.17**	-1.82	131.45	23.25**	4.53	121.50	25.91*	1.04
CML 446 x HS 4	262.7	2.55	-3.97	242	7.52	-2.02	120.20	2.92	-4.41	115.50	12.55	-3.95
CML 446 x HS 15	256.6	0.28	-6.18	243	5.39	-1.72	117.85	8.74	-6.28	115.75	15.17	-3.74
CML 446 x HS 17	271.4	6.41	-0.79	240	8.39	-2.87	131.85	10.24	4.85	121.60	15.67	1.12
CML 446 x NEI 9202B	278.3	12.37**	1.74	252	20.41**	1.86	138.75	22.98**	10.34	129.00	32.48**	7.28
HS 4 x HS 15	243.0	0.50	-11.17**	227	2.74	-8.28	100.21	-2.43	-20.31**	91.00	-7.50	-24.32**
HS 4 x HS 17	253.5	5.24	-7.31	231	9.34	-6.38	122.45	7.47	-2.62	110.00	6.80	-8.52
HS 4 x NEI 9202B	264.8	13.38**	-3.2	250	25.47**	1.15	126.65	18.19*	0.72	126.25	32.55**	4.99
HS 15 x HS 17	245.8	2.13	-10.15*	226	4.31	-8.46	108.75	3.06	-13.52	100.25	-0.62	-16.63
HS 15 x NEI 9202B	264.0	13.18**	-3.47	249	21.69**	0.69	120.50	22.03**	-4.17	122.05	31.06**	1.50
HS 17 x NEI 9202B	250.5	7.80	-8.41*	238	21.82**	-3.64	125.60	14.21	-0.12	118.00	20.72*	-1.87
Rajkumar (check)	273.5			247.0			125.75			120.25		
Mean	255.48	5.02	-6.50	237.0	8.85	-3.98	117.24	7.16	-6.77	110.7	9.41	-6.61
Range	233.80- 278.50	-2.74- 15.55	-14.53- 1.83	199- 256	-3.41- 27.12	-19.64- 3.54	88.25- 138.75	-8.85- 27.56	-29.82- 10.34	85- 148.5	-9.83- 56.11	-28.9- 23.49
SEd	10.87	9.41	10.87	12.54	10.86	12.54	9.45	8.19	9.45	11.13	9.64	11.13
CD at 5%	21.47	18.60	21.47	24.79	21.45	24.79	18.67	16.17	18.67	21.99	19.05	21.99
CD at 1%	28.35	24.55	28.35	32.70	28.32	32.70	24.65	21.35	24.65	29.04	25.15	29.04

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

The mean heterosis over mid parent for the trait under nonstress and stress was 7.16 and 9.41 %, respectively. Eleven hybrids exhibited significant positive heterosis over mid parent under stress and 12 hybrids expressed significant negative heterosis over check under nonstress.

4.2.2.3 Days to 50% anthesis

The mean values of the trait among hybrids ranged between 56.75 (Hyd Sel 2 x Hyd Sel 7) and 67.25 (NEI 9208B x NEI 9202B) with an overall mean of 61.84 under nonstress. Under stress, the corresponding values were 56.80 (Hyd Sel 2 x Hyd Sel 7), 68.00 (CML 446 x NEI 9202B) and 62.81, respectively.

The mean heterosis over commercial check was -5.94 and -3.36% under nonstress and stress, respectively. Eight hybrids and 34 hybrids exhibited significant negative heterosis over mid parent and check, respectively under nonstress. Under stress, 12 and 24 hybrids exhibited significant negative heterosis over mid parent and check, respectively.

4.2.2.4 Days to 50% silking

Among the 66 hybrids evaluated, KDMI 15 x Hyd Sel 4 (60.00) recorded minimum and CI 4 x NEI 9202B (69.25) recorded maximum number of days required for 50% silking under nonstress. The overall mean of hybrids was 64.14. Under stress, the mean number of days required for 50% silking increased to 65.9. Hyd Sel 2 x Hyd Sel 7 (61.5) and NEI 9208 x CML 446 (71.0) recorded minimum and maximum days for the trait. The mean heterosis over mid parent and check for the trait under nonstress was -2.25 and -5.33%, respectively. The corresponding values under stress were -2.60 and 1.00 %, respectively. Many hybrids (32) expressed significant negative heterosis over check under nonstress. Under stress, 10 hybrids exhibited significant negative heterosis over check.

4.2.2.5 Anthesis to silking interval (ASI)

The range for this trait among 66 hybrids was from 0.50 (Hyd Sel 17 x NEI 9202B) to 4.75 (CM 111 x Hyd Sel 17) with an overall mean of 2.29 under nonstress. Under stress, the range was from 1.25 (Hyd Sel 4 x NEI 9202B) to 6.75 (Hyd Sel 7 x Hyd Sel 10) with an overall mean of 3.06.

The mean heterosis over mid parent and check was -0.89 and 14.58%, respectively under nonstress and -4.54 and 103.79 %, respectively under stress. Hyd Sel 15 x 9202B and Hyd Sel 17 x NEI 9202B recorded significant negative heterosis over mid parent and check, respectively under nonstress. Under stress conditions, none of the hybrids recorded significant negative heterosis over check. However, one hybrid (NEI 9208B x NEI 9202B) recorded significant negative heterosis (desirable) over mid parent for the trait under stress.

4.2.2.6 Days to maturity

Among the 66 hybrids, Hyd Sel 2 x Hyd Sel 4 (104.0) was early and Hyd Sel 7 x Hyd Sel 15 (109.75) was late, with an overall mean of 106.74 under nonstress. Under stress, Hyd Sel 2 x KDMI 15 (98.00) was early and CM 111 x Hyd Sel 7 and NEI 9208B x CML 446 (both 103.50 d) were late with an overall mean of the hybrids 100.70 days.

The mean heterosis for the trait over mid parent and check was -0.83 and 0.24% under nonstress and 0.40 and -2.20% under stress, respectively. None of the hybrids except NEI 9208B x NEI 9202B (significant negative over mid parent) recorded significant heterosis over mid parent or check under nonstress. However, 10 hybrids recorded significant negative heterosis over check, under stress condition.

4.2.2.7 Cob length (cm)

Among the hybrids studied over two seasons, Hyd Sel 7 x Hyd Sel 17 (13.60 cm) and CML 446 x NEI 9202B (17.60 cm) recorded lowest and highest cob length, respectively with an overall mean of 15.82 cm under nonstress. Under stress, it ranged from 11.30 (CM 111 x Hyd Sel 10) to 15.50 cm (Hyd Sel 7 x NEI 9202B) with an overall mean of 13.60 cm.

Table 12. Per se performance and heterosis for different traits in 12 x 12 half diallel set of hybrids under nonstress and stress situations for days to 50 % anthesis and days to 50 % silking

Hybrids	Days to 50 % anthesis						Days to 50 % silking					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
CM 111 x HS 2	61.50	-1.40	-6.46*	63.0	-0.59	-3.08	64.00	-2.29	-5.54*	66.3	-0.56	-0.38
CM 111 x HS 7	61.50	-2.96	-6.46*	61.0	-4.13	-6.15*	66.25	-1.49	-2.21	66.8	-1.66	0.38
CM 111 x HS 10	61.25	-4.11	-6.84*	62.8	-2.14	-3.46	64.75	-3.18	-4.43	68.0	0.00	2.26
CM 111 x KDMI 15	59.75	-3.43	-9.13**	63.0	-0.40	-3.08	63.75	-0.97	-5.90*	66.5	0.57	0.00
CM 111 x NEI 9208B	62.50	-5.48*	-4.94	62.8	-5.10*	-3.46	65.00	-5.28*	-4.06	66.0	-5.55*	-0.75
CM 111 x CI 4	62.50	-3.10	-4.94	64.0	-1.54	-1.54	64.75	-3.18	-4.43	66.8	-1.48	0.38
CM 111 x CML 446	65.00	-2.07	-1.14	66.8	-0.37	2.69	67.50	-1.82	-0.37	70.3	-0.53	5.64*
CM 111 x HS 4	63.00	-1.18	-4.18	64.0	-0.78	-1.54	65.75	-1.13	-2.95	67.0	-0.74	0.75
CM 111 x HS 15	62.75	-2.33	-4.56	63.5	-1.93	-2.31	64.75	-3.54	-4.43	67.5	-1.1	1.5
CM 111 x HS 17	60.25	-4.93*	-8.37**	61.0	-5.61**	-6.15*	62.75	-4.56	-7.38**	63.5	-5.75*	-4.51
CM 111 x NEI 9202B	62.50	-7.41**	-4.94	66.5	-1.3	2.31	64.25	-8.05**	-5.17	68.8	-2.65	3.38
HS 2 x HS 7	56.75	-5.81*	-13.69**	56.8	-7.72**	-12.69**	60.50	-5.47*	-10.70**	61.5	-6.11*	-7.52**
HS 2 x HS 10	58.00	-4.53	-11.79**	58.5	-5.65*	-10.00**	61.50	-3.34	-9.23**	63.0	-4	-5.26
HS 2 x KDMI 15	58.00	-1.28	-11.79**	59.0	-3.48	-9.23**	60.25	-1.43	-11.07**	61.8	-3.14	-7.14**
HS 2 x NEI 9208B	60.25	-4.37	-8.37**	62.3	-2.73	-4.23	63.25	-3.25	-6.64*	66.0	-2.22	-0.75
HS 2 x CI 4	59.00	-3.87	-10.27**	62.0	-1.39	-4.62	61.75	-2.95	-8.86**	66.0	0.96	-0.75
HS 2 x CML 446	62.50	-1.19	-4.94	63.8	-1.73	-1.92	64.50	-1.53	-4.80	66.0	-3.3	-0.75
HS 2 x HS 4	57.75	-4.74	-12.17**	59.0	-5.41*	-9.23**	60.50	-4.35	-10.70**	62.5	-4.03	-6.02*
HS 2 x HS 15	58.00	-5.11*	-11.79**	62.8	0.20	-3.46	61.50	-3.72	-9.23**	66.5	0.95	0.00
HS 2 x HS 17	59.50	-1.24	-9.51**	61.3	-2.00	-5.77*	61.75	-1.20	-8.86**	65.8	1.15	-1.13
HS 2 x NEI 9202B	62.00	-3.69	-5.70*	62.3	-4.60*	-4.23	63.50	-4.69	-6.27*	63.8	-6.59**	-4.14
HS 7 x HS 10	58.75	-4.86	-10.65**	60.5	-2.81	-6.92**	63.75	-2.49	-5.90*	67.3	0.56	1.13
Rajkumar (check)	65.75			65.00			67.75			66.50		
Mean	61.84	-2.34	-5.95	62.81	-2.45	-3.36	64.14	-2.25	-5.33	65.9	-2.60	1.00
Range	56.75- 67.25	-7.41- 1.80	-13.69- 2.28	56.8- 68.0	-7.72	-12.69- 4.62	60.00- 69.25	-8.05- 1.84	-11.44- 2.21	61.50- 71.00	-674- 1.15	-7.52- 6.77
SEd	1.81	1.57	1.81	1.57	1.36	1.57	1.83	1.58	1.83	1.55	1.78	1.55
CD at 5%	3.58	3.10	3.58	3.09	2.68	3.09	3.61	3.12	3.61	3.05	3.52	3.05
CD at 1%	4.73	4.10	4.73	4.09	3.54	4.09	4.77	4.13	4.77	4.03	4.65	4.03

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 12 contd....

Hybrids	Days to 50 % anthesis						Days to 50 % silking					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
HS 7 x KDMI 15	57.50	-3.77	-12.55**	59.3	-3.46	-8.85**	60.75	-3.38	-10.33**	64.0	-1.54	-3.76
HS 7 x NEI 9208B	62.00	-3.13	-5.70*	63.0	-1.95	-3.08	64.50	-3.91	-4.80	65.8	-4.36	-1.13
HS 7 x CI 4	63.50	1.80	-3.42	61.3	-2.97	-5.77*	66.25	1.34	-2.21	64.8	-2.81	-2.63
HS 7 x CML 446	62.75	-2.33	-4.56	64.0	-1.73	-1.54	65.00	-3.35	-4.06	67.8	-2.52	1.88
HS 7 x HS 4	58.50	-5.07*	-11.03**	61.3	-2.20	-5.77*	61.50	-5.38*	-9.23**	65.5	-1.32	-1.5
HS 7 x HS 15	61.50	-1.01	-6.46*	62.5	-0.60	-3.85	64.75	-1.33	-4.43	65.5	-2.42	-1.5
HS 7 x HS 17	60.75	-0.82	-7.60**	60.0	-4.38*	-7.69**	63.00	-1.95	-7.01*	63.8	-3.77	-4.14
HS 7 x NEI 9202B	65.25	-0.19	-0.76	63.5	-3.05	-2.31	67.25	-1.65	-0.74	66.0	-5.04*	-0.75
HS 10 x KDMI 15	59.75	-0.83	-9.13**	59.0	-4.65*	-9.23**	63.50	1.60	-6.27*	62.8	-3.65	-5.64*
HS 10 x NEI 9208B	63.75	-1.16	-3.04	64.3	-0.77	-1.15	65.50	-1.87	-3.32	67.0	-2.72	0.75
HS 10 x CI 4	63.50	0.99	-3.42	61.8	-2.95	-5.00*	65.75	1.15	-2.95	65.5	-1.87	-1.5
HS 10 x CML 446	64.25	-0.77	-2.28	64.3	-2.1	-1.15	66.25	-0.93	-2.21	68.3	-1.97	2.63
HS 10 x HS 4	59.75	-3.82	-9.13**	61.0	-3.37	-6.15*	62.75	-2.90	-7.38**	64.8	-2.63	-2.63
HS 10 x HS 15	60.25	-3.79	-8.37**	61.3	-3.35	-5.77*	63.00	-3.45	-7.01*	64.3	-4.46	-3.38
HS 10 x HS 17	59.75	-3.24	-9.13**	62.0	-1.98	-4.62	63.00	-1.37	-7.01*	65.3	-1.69	-1.88
HS 10 x NEI 9202B	64.75	-1.71	-1.52	65.3	-1.14	0.38	66.50	-2.21	-1.85	68.0	-2.33	2.26
KDMI 15 x NEI 9208B	62.50	0.00	-4.94	64.3	0.59	-1.15	64.00	-0.39	-5.54*	67.0	0.00	0.75
KDMI 15 x CI 4	60.25	-1.03	-8.37**	61.8	-1.59	-5.00*	62.75	0.40	-7.38**	63.5	-2.12	-4.51
KDMI 15 x CML 446	62.25	-0.80	-5.32	63.8	-1.54	-1.92	64.75	0.58	-4.43	66.0	-2.58	-0.75
KDMI 15 x HS 4	58.00	-3.53	-11.79**	59.8	-4.02	-8.08**	60.00	-3.42	-11.44**	61.5	-4.84*	-7.52**
KDMI 15 x HS 15	59.75	-1.44	-9.13**	61.0	-2.4	-6.15*	61.75	-1.59	-8.86**	63.0	-3.63	-5.26
KDMI 15 x HS 17	58.50	-2.09	-11.03**	57.8	-7.41**	-11.15**	61.00	-0.61	-9.96**	61.8	-4.26	-7.14**
Rajkumar (check)	65.75			65.00			67.75			66.50		
Mean	61.84	-2.34	-5.95	62.81	-2.45	-3.36	64.14	-2.25	-5.33	65.9	-2.60	1.00
Range	56.75- 67.25	-7.41- 1.80	-13.69- 2.28	56.8- 68.0	-7.72	-12.69- 4.62	60.00- 69.25	-8.05- 1.84	-11.44- 2.21	61.50- 71.00	-674- 1.15	-7.52- 6.77
SEd	1.81	1.57	1.81	1.57	1.36	1.57	1.83	1.58	1.83	1.55	1.78	1.55
CD at 5%	3.58	3.10	3.58	3.09	2.68	3.09	3.61	3.12	3.61	3.05	3.52	3.05
CD at 1%	4.73	4.10	4.73	4.09	3.54	4.09	4.77	4.13	4.77	4.03	4.65	4.03

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 12 contd....

	Days to 50 % anthesis						Days to 50 % silking					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
KDMI 15 x NEI 9202B	62.00	-2.94	-5.70*	64.3	-1.34	-1.15	63.50	-3.05	-6.27*	65.8	-2.95	-1.13
NEI 9208B x CI 4	65.50	0.58	-0.38	66.5	1.33	2.31	67.00	0.37	-1.11	69.3	0.91	4.14
NEI 9208B x CML 446	66.00	-1.49	0.38	68.0	0.55	4.62	67.75	-1.28	0.00	71.0	-0.7	6.77*
NEI 9208B x HS 4	62.25	-3.30	-5.32	64.0	-1.73	-1.54	64.25	-3.20	-5.17	66.5	-2.74	0.00
NEI 9208B x HS 15	64.50	-0.58	-1.90	64.5	-1.34	-0.77	66.00	-1.49	-2.58	66.5	-3.8	0.00
NEI 9208B x HS 17	65.00	1.56	-1.14	63.3	-3.07	-2.69	66.00	0.57	-2.58	65.0	-4.76*	-2.26
NEI 9208B x NEI 9202B	67.25	-1.28	2.28	68.0	0.00	4.62	68.00	-2.51	0.37	69.5	-2.8	4.51
CI 4 x CML 446	64.75	-0.96	-1.52	65.5	-1.5	0.77	65.75	-1.68	-2.95	67.8	-2.34	1.88
CI 4 x HS 4	59.25	-5.58*	-9.89**	62.8	-1.95	-3.46	61.25	-5.22*	-9.59**	65.0	-1.89	-2.26
CI 4 x HS 15	61.25	-3.16	-6.84*	62.5	-2.72	-3.85	63.50	-2.68	-6.27*	65.5	-2.24	-1.5
CI 4 x HS 17	61.50	-1.40	-6.46*	61.8	-3.7	-5.00*	63.00	-1.37	-7.01*	64.3	-2.84	-3.38
CI 4 x NEI 9202B	67.00	0.75	1.90	66.3	-0.93	1.92	69.25	1.84	2.21	68.5	-1.26	3.01
CML 446 x HS 4	64.00	-0.97	-2.66	64.8	-1.89	-0.38	66.00	-0.75	-2.58	67.8	-1.99	1.88
CML 446 x HS 15	64.25	-1.34	-2.28	65.5	-1.13	0.77	66.25	-1.30	-2.21	68.8	-1.61	3.38
CML 446 x HS 17	63.50	-1.17	-3.42	64.8	-2.08	-0.38	64.75	-1.52	-4.43	67.5	-2.17	1.5
CML 446 x NEI 9202B	66.50	-2.74	1.14	68.0	-1.27	4.62	67.75	-3.04	0.00	70.3	-2.77	5.64*
HS 4 x HS 15	58.25	-6.80**	-11.41**	59.8	-6.27**	-8.08**	60.25	-7.13**	-11.07**	62.3	-6.74**	-6.39*
HS 4 x HS 17	60.00	-2.64	-8.75**	61.5	-3.34	-5.38*	62.25	-1.97	-8.12**	64.3	-2.47	-3.38
HS 4 x NEI 9202B	64.50	-1.90	-1.90	64.8	-2.45	-0.38	66.00	-2.40	-2.58	66.0	-4.52*	-0.75
HS 15 x HS 17	62.00	-0.20	-5.70*	61.0	-4.50*	-6.15*	63.50	-0.97	-6.27*	63.0	-5.44*	-5.26
HS 15 x NEI 9202B	64.00	-3.40	-2.66	63.8	-4.32*	-1.92	64.75	-5.13*	-4.43	65.8	-5.90**	-1.13
HS 17 x NEI 9202B	66.25	1.34	0.76	66.8	0.38	2.69	66.75	-0.19	-1.48	68.5	-0.72	3.01
Rajkumar (check)	65.75			65.00			67.75			66.50		
Mean	61.84	-2.34	-5.95	62.81	-2.45	-3.36	64.14	-2.25	-5.33	65.9	-2.60	1.00
Range	56.75- 67.25	-7.41- 1.80	-13.69- 2.28	56.8- 68.0	-7.72	-12.69- 4.62	60.00- 69.25	-8.05- 1.84	-11.44- 2.21	61.50- 71.00	-674- 1.15	-7.52- 6.77
SEd	1.81	1.57	1.81	1.57	1.36	1.57	1.83	1.58	1.83	1.55	1.78	1.55
CD at 5%	3.58	3.10	3.58	3.09	2.68	3.09	3.61	3.12	3.61	3.05	3.52	3.05
CD at 1%	4.73	4.10	4.73	4.09	3.54	4.09	4.77	4.13	4.77	4.03	4.65	4.03

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Table 13. *Per se* performance and heterosis for different traits in 12 x 12 half diallel set of hybrids under nonstress and stress situations for anthesis to silking interval and days to maturity

Hybrids	Anthesis to silking interval						Days to maturity					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
CM 111 x HS 2	2.50	-20.00	25.00	3.25	0.00	116.67	108.75	2.11	1.64	102.0	1.75	-0.97
CM 111 x HS 7	4.75	22.58	137.50**	5.75	35.29	283.33**	108.75	-0.34	1.64	103.5	2.48	0.49
CM 111 x HS 10	3.50	16.67	75.00*	5.25	35.48	250.00**	109.00	0.93	1.87	102.0	0.87	-0.97
CM 111 x KDMI 15	4.00	60.00*	100.00**	3.50	21.74	133.33	107.75	1.41	0.70	101.0	0.75	-1.94
CM 111 x NEI 9208B	2.50	0.00	25.00	3.25	-13.33	116.67	105.75	-2.98	-1.17	101.0	-0.62	-1.94
CM 111 x CI 4	2.25	-5.26	12.50	2.75	0.00	83.33	106.75	-0.81	-0.23	102.8	1.11	-0.24
CM 111 x CML 446	2.50	5.26	25.00	3.50	-3.45	133.33	107.50	-1.04	0.47	102.5	-0.12	-0.49
CM 111 x HS 4	2.75	0.00	37.50	3.00	0.00	100.00	107.25	-0.12	0.23	100.0	-1.36	-2.91
CM 111 x HS 15	2.00	-30.43	0.00	4.00	14.29	166.67*	106.50	-1.05	-0.47	102.5	1.23	-0.49
CM 111 x HS 17	2.50	5.26	25.00	2.50	-9.09	66.67	104.75	-2.90	-2.10	99.0	-2.22	-3.88*
CM 111 x NEI 9202B	1.75	-26.32	-12.50	2.25	-30.77	50.00	107.75	-1.26	0.70	102.8	0.86	-0.24
HS 2 x HS 7	3.75	0.00	87.50*	4.75	18.75	216.67**	106.00	-1.28	-0.93	99.8	0.00	-3.16
HS 2 x HS 10	3.50	21.74	75.00*	4.50	24.14	200.00**	105.25	-0.94	-1.64	99.0	-0.88	-3.88*
HS 2 x KDMI 15	2.25	-5.26	12.50	2.75	4.76	83.33	104.25	-0.24	-2.57	98.0	-1.01	-4.85**
HS 2 x NEI 9208B	3.00	26.32	50.00	3.75	7.14	150.00*	106.50	-0.70	-0.47	100.8	0.37	-2.18
HS 2 x CI 4	2.75	22.22	37.50	4.00	60.00	166.67*	106.25	0.35	-0.70	100.8	0.37	-2.18
HS 2 x CML 446	2.00	-11.11	0.00	2.25	-33.33	50.00	106.75	-0.12	-0.23	100.3	-1.11	-2.67
HS 2 x HS 4	2.75	4.76	37.50	3.50	27.27	133.33	104.00	-1.54	-2.80	98.5	-1.62	-4.37*
HS 2 x HS 15	3.25	18.18	62.50	3.75	15.38	150.00*	106.50	0.59	-0.47	100.5	0.50	-2.43
HS 2 x HS 17	2.25	0.00	12.50	4.50	80.00*	200.00**	105.00	-1.06	-1.87	100.0	0.00	-2.91
HS 2 x NEI 9202B	1.50	-33.33	-25.00	1.50	-50.00	0.00	106.50	-0.81	-0.47	98.0	-2.61	-4.85**
HS 7 x HS 10	4.00	10.34	100.00**	6.75	45.95*	350.00**	107.25	-1.49	0.23	100.8	0.12	-2.18
Rajkumar (check)	2.00			1.50			107.00			103.00		
Mean	2.29	-0.89	14.58	3.06	-4.54	103.79	106.74	-0.83	-0.24	100.7	0.40	-2.20
Range	0.50-4.75	-66.67-66.67	-75.00-137.50	1.25-6.75	-57.14-88.25	-16.67-350.0	104.00-109.75	-3.30-2.49	-2.80-2.57	98.0-103.5	-2.84-2.48	-4.85-0.49
SEd	0.72	0.62	0.72	1.11	0.96	1.11	2.02	1.75	2.02	1.79	1.55	1.79
CD at 5%	1.42	1.23	1.42	2.19	1.90	2.19	4.00	3.46	4.00	3.54	3.07	3.54
CD at 1%	1.88	1.63	1.88	2.9	2.05	2.9	5.28	4.57	5.28	4.68	4.05	4.68

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 13 contd....

Hybrids	Anthesis to silking interval						Days to maturity					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
HS 7 x KDMI 15	3.25	4.00	62.50	4.75	31.03	216.67**	105.50	-1.52	-1.40	99.5	-0.25	-3.40
HS 7 x NEI 9208B	2.50	-20.00	25.00	2.75	-38.89	83.33	108.75	-1.02	1.64	101.8	0.62	-1.21
HS 7 x CI 4	2.75	-8.33	37.50	3.50	0.00	133.33	106.50	-1.84	-0.47	100.3	-0.87	-2.67
HS 7 x CML 446	2.25	-25.00	12.50	3.75	-14.29	150.00*	107.75	-1.60	0.70	102.0	-0.12	-0.97
HS 7 x HS 4	3.00	-11.11	50.00	4.25	13.33	183.33*	105.00	-3.00	-1.87	100.0	-0.87	-2.91
HS 7 x HS 15	3.25	-7.14	62.50	3.00	-29.41	100.00	109.75	1.15	2.57	100.3	-0.50	-2.67
HS 7 x HS 17	2.25	-25.00	12.50	3.75	7.14	150.00*	105.75	-2.76	-1.17	98.5	-2.23	-4.37*
HS 7 x NEI 9202B	2.00	-33.33	0.00	2.50	-37.50	66.67	109.50	-0.45	2.34	99.5	-1.85	-3.40
HS 10 x KDMI 15	3.75	66.67*	87.50*	3.75	15.38	150.00*	107.75	1.65	0.70	100.0	0.13	-2.91
HS 10 x NEI 9208B	1.75	-22.22	-12.50	2.75	-33.33	83.33	108.00	-0.69	0.93	103.3	1.98	0.24
HS 10 x CI 4	2.25	5.88	12.50	3.75	20.00	150.00*	108.00	0.58	0.93	99.8	-1.48	-3.16
HS 10 x CML 446	2.00	-5.88	0.00	4.00	0.00	166.67*	107.75	-0.58	0.70	101.0	-1.22	-1.94
HS 10 x HS 4	3.00	20.00	50.00	3.75	11.11	150.00*	107.00	-0.12	0.00	100.5	-0.50	-2.43
HS 10 x HS 15	2.75	4.76	37.50	3.00	-22.58	100.00	107.25	-0.12	0.23	100.8	-0.12	-2.18
HS 10 x HS 17	3.25	52.94	62.50	3.25	4.00	116.67	106.75	-0.81	-0.23	100.3	-0.62	-2.67
HS 10 x NEI 9202B	1.75	-17.65	-12.50	2.75	-24.14	83.33	106.00	-2.64	-0.93	101.5	0.00	-1.46
KDMI 15 x NEI 9208B	1.75	0.00	-12.50	3.00	-4.00	100.00	104.25	-2.57	-2.57	99.0	-1.37	-3.88*
KDMI 15 x CI 4	2.50	53.85	25.00	1.75	-17.65	16.67	108.25	2.49	1.17	100.0	-0.37	-2.91
KDMI 15 x CML 446	2.50	53.85	25.00	2.25	-25.00	50.00	107.25	0.59	0.23	100.0	-1.36	-2.91
KDMI 15 x HS 4	2.00	0.00	0.00	1.75	-26.32	16.67	105.50	0.12	-1.40	100.0	-0.12	-2.91
KDMI 15 x HS 15	2.00	-5.88	0.00	2.00	-30.43	33.33	106.00	0.36	-0.93	99.0	-1.00	-3.88*
KDMI 15 x HS 17	2.50	53.85	25.00	4.00	88.24	166.67*	105.50	-0.35	-1.40	99.5	-0.50	-3.40
Rajkumar (check)	2.00			1.50			107.00			103.00		
Mean	2.29	-0.89	14.58	3.06	-4.54	103.79	106.74	-0.83	-0.24	100.7	0.40	-2.20
Range	0.50-4.75	-66.67-66.67	-75.00-137.50	1.25-6.75	-57.14-88.25	-16.67-350.0	104.00-109.75	-3.30-2.49	-2.80-2.57	98.0-103.5	-2.84-2.48	-4.85-0.49
SEd	0.72	0.62	0.72	1.11	0.96	1.11	2.02	1.75	2.02	1.79	1.55	1.79
CD at 5%	1.42	1.23	1.42	2.19	1.90	2.19	4.00	3.46	4.00	3.54	3.07	3.54
CD at 1%	1.88	1.63	1.88	2.9	2.05	2.9	5.28	4.57	5.28	4.68	4.05	4.68

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 13 contd....

Hybrids	Anthesis to silking interval						Days to maturity					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
KDMI 15 x NEI 9202B	1.50	-7.69	-25.00	1.50	-42.86	0.00	105.50	-1.52	-1.40	100.0	-0.62	-2.91
NEI 9208B x CI 4	1.50	-7.69	-25.00	2.75	-8.33	83.33	108.00	-0.35	0.93	101.0	-0.74	-1.94
NEI 9208B x CML 446	1.75	7.69	-12.50	3.00	-22.58	100	108.25	-1.03	1.17	103.5	0.73	0.49
NEI 9208B x HS 4	2.00	0.00	0.00	2.50	-23.08	66.67	108.50	0.35	1.40	102.5	0.99	-0.49
NEI 9208B x HS 15	1.50	-29.41	-25.00	2.00	-46.67	33.33	107.75	-0.58	0.70	101.8	0.37	-1.21
NEI 9208B x HS 17	1.25	-23.08	-37.50	1.75	-41.67	16.67	107.25	-1.27	0.23	101.0	-0.37	-1.94
NEI 9208B x NEI 9202B	0.75	-53.85	-62.50	1.50	-57.14*	0.00	106.25	-3.30*	-0.70	103.0	0.98	0.00
CI 4 x CML 446	1.00	-33.33	-50.00	2.25	-21.74	50.00	107.75	-0.23	0.70	101.0	-1.70	-1.94
CI 4 x HS 4	2.00	6.67	0.00	2.25	0.00	50.00	104.50	-2.11	-2.34	100.3	-1.23	-2.67
CI 4 x HS 15	2.25	12.50	12.50	3.00	9.09	100.00	106.75	-0.23	-0.23	101.0	-0.37	-1.94
CI 4 x HS 17	1.50	0.00	-25.00	2.50	25.00	66.67	105.75	-1.40	-1.17	98.5	-2.84	-4.37*
CI 4 x NEI 9202B	2.25	50.00	12.50	2.25	-10.00	50.00	107.50	-0.92	0.47	102.5	0.49	-0.49
CML 446 x HS 4	2.00	6.67	0.00	3.00	-4.00	100.00	106.25	-1.39	-0.70	102.3	-0.24	-0.73
CML 446 x HS 15	2.00	0.00	0.00	3.25	-10.34	116.67	108.00	0.00	0.93	102.8	0.37	-0.24
CML 446 x HS 17	1.25	-16.67	-37.50	2.75	-4.35	83.33	105.25	-2.77	-1.64	99.8	-2.56	-3.16
CML 446 x NEI 9202B	1.25	-16.67	-37.50	2.25	-33.33	50.00	106.75	-2.51	-0.23	103.0	0.00	0.00
HS 4 x HS 15	2.00	-15.79	0.00	2.50	-16.67	66.67	105.00	-1.64	-1.87	98.8	-2.35	-4.13*
HS 4 x HS 17	2.25	20.00	12.50	2.75	22.22	83.33	104.00	-2.80	-2.80	100.8	-0.37	-2.18
HS 4 x NEI 9202B	1.50	-20.00	-25.00	1.25	-54.55	-16.67	107.50	-0.69	0.47	101.0	-0.74	-1.94
HS 15 x HS 17	1.50	-25.00	-25.00	2.00	-27.27	33.33	106.75	-0.47	-0.23	99.8	-1.24	-3.16
HS 15 x NEI 9202B	0.75	-62.50*	-62.50	2.00	-38.46	33.33	106.50	-1.84	-0.47	100.0	-1.60	-2.91
HS 17 x NEI 9202B	0.50	-66.67	-75.00*	1.75	-30.00	16.67	106.75	-1.84	-0.23	102.8	1.11	-0.24
Rajkumar (check)	2.00			1.50			107.00			103.00		
Mean	2.29	-0.89	14.58	3.06	-4.54	103.79	106.74	-0.83	-0.24	100.7	0.40	-2.20
Range	0.50-4.75	-66.67-66.67	-75.00-137.50	1.25-6.75	-57.14-88.25	-16.67-350.0	104.00-109.75	-3.30-2.49	-2.80-2.57	98.0-103.5	-2.84-2.48	-4.85-0.49
SEd	0.72	0.62	0.72	1.11	0.96	1.11	2.02	1.75	2.02	1.79	1.55	1.79
CD at 5%	1.42	1.23	1.42	2.19	1.90	2.19	4.00	3.46	4.00	3.54	3.07	3.54
CD at 1%	1.88	1.63	1.88	2.9	2.05	2.9	5.28	4.57	5.28	4.68	4.05	4.68

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Table 14. Per se performance and heterosis for different traits in 12 x 12 half diallel set of hybrids under nonstress and stress situations for cob length (cm) and Cob girth (cm)

Hybrids	Cob length (cm)						Cob girth (cm)					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
CM 111 x HS 2	16.60	13.50	0.61	13.6	8.37	-7.64	13.93	1.00	-3.30	12.7	8.22	-1.55
CM 111 x HS 7	15.10	7.19	-8.48	14.0	17.40*	-4.92	13.80	5.85	-4.17	13.0	12.19*	0.97
CM 111 x HS 10	15.88	13.90	-3.79	11.3	-5.44	-23.26**	14.60	2.37	1.39	11.6	-2.83	-9.9
CM 111 x KDMI 15	15.95	6.60	-3.33	14.1	11.95	-4.58	14.58	5.14	1.22	12.6	6.12	-2.33
CM 111 x NEI 9208B	15.55	4.63	-5.76	13.4	1.23	-9.34	14.18	5.00	-1.56	12.3	4.23	-4.27
CM 111 x CI 4	15.43	4.75	-6.52	14.1	8.27	-4.41	14.45	2.48	0.35	13.0	6.46	0.78
CM 111 x CML 446	14.93	-2.29	-9.55	12.9	2.89	-12.39	14.58	3.92	1.22	12.6	2.44	-2.33
CM 111 x HS 4	15.48	2.40	-6.21	12.8	0.00	-13.07	14.30	0.53	-0.69	12.3	0.82	-4.85
CM 111 x HS 15	15.73	9.68	-4.70	13.8	12.45	-6.45	15.18	5.84	5.38	13.0	4.52	0.97
CM 111 x HS 17	15.78	8.61	-4.39	14.1	8.05	-4.24	14.33	5.14	-0.52	12.0	2.35	-6.99
CM 111 x NEI 9202B	17.08	19.51**	3.48	14.6	16.22*	-0.85	14.05	9.44*	-2.43	12.2	9.09	-5.63
HS 2 x HS 7	15.75	5.79	-4.55	14.5	18.69*	-1.87	13.80	3.95	-4.17	12.0	3.45	-6.8
HS 2 x HS 10	14.95	1.44	-9.39	13.0	6.56	-11.71	14.93	2.93	3.65	12.4	3.35	-4.08
HS 2 x KDMI 15	16.20	2.78	-1.82	14.5	13.48	-1.36	14.03	-0.53	-2.60	12.8	7.48	-0.97
HS 2 x NEI 9208B	16.65	6.30	0.91	13.1	-2.51	-11.04	13.73	-0.09	-4.69	11.4	-3.91	-11.65*
HS 2 x CI 4	14.68	-5.48	-11.06	13.1	-1.32	-11.21	13.90	-3.05	-3.47	12.1	-1.23	-6.41
HS 2 x CML 446	16.55	2.95	0.30	13.2	2.83	-10.70	14.25	-0.09	-1.04	12.0	-2.75	-7.18
HS 2 x HS 4	15.18	-4.63	-8.03	12.9	-1.15	-12.39	13.83	-4.41	-3.99	11.9	-2.16	-7.57
HS 2 x HS 15	14.73	-2.73	-10.76	14.1	12.80	-4.24	15.35	5.32	6.60	12.7	1.61	-1.75
HS 2 x HS 17	16.43	7.18	-0.45	12.7	-4.51	-13.75	14.05	1.35	-2.43	11.1	-5.23	-13.79*
HS 2 x NEI 9202B	16.43	8.86	-0.45	15.3	19.02*	3.57	13.90	6.31	-3.47	12.3	10.09	-4.66
HS 7 x HS 10	14.95	5.28	-9.39	12.7	9.94	-13.58	14.30	4.00	-0.69	12.1	1.90	-6.41
Rajkumar (check)	16.50			14.72			14.40			12.88		
Mean	15.82	3.75	-4.12	13.60	6.40	-7.60	14.41	3.18	0.07	12.33	2.40	-4.20
Range	13.60- 17.60	-8.03- 19.51	-17.58- 6.67	11.30- 15.50	-11.23- 27.38	-23.26- 5.43	13.18- 15.90	-5.24- 10.84	-8.51- 10.42	11.10- 13.90	-7.91- 12.51	-13.98- 7.96
SEd	1.17	1.02	1.17	1.16	1.01	1.16	0.59	0.52	0.59	0.71	0.61	0.71
CD at 5%	2.32	2.01	2.32	2.30	1.99	2.30	1.17	1.02	1.17	1.40	1.21	1.40
CD at 1%	3.06	2.65	3.06	3.04	2.63	3.04	1.55	1.34	1.55	1.85	1.60	1.85

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 14 contd....

Hybrids	Cob length (cm)						Cob girth (cm)					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
HS 7 x KDMI 15	15.88	4.27	-3.79	13.5	11.09	-8.15	13.95	4.49	-3.13	12.4	5.22	-4.08
HS 7 x NEI 9208B	14.90	-1.49	-9.70	13.9	8.49	-5.60	13.28	2.21	-7.81	11.8	0.32	-8.74
HS 7 x CI 4	15.50	3.42	-6.06	14.1	11.29	-4.58	13.80	1.56	-4.17	12.3	1.86	-4.47
HS 7 x CML 446	15.63	0.56	-5.30	13.7	12.23	-7.30	13.55	0.28	-5.90	11.2	-7.91	-13.01*
HS 7 x HS 4	16.03	4.23	-2.88	13.7	10.06	-7.13	14.20	3.56	-1.39	12.5	4.05	-2.72
HS 7 x HS 15	16.00	9.59	-3.03	13.9	16.63	-5.94	14.93	7.96*	3.65	12.9	4.26	-0.19
HS 7 x HS 17	13.60	-8.03	-17.58*	13.7	8.28	-6.79	13.30	1.43	-7.64	11.8	1.83	-8.35
HS 7 x NEI 9202B	17.23	18.38**	4.39	15.5	27.38**	5.43	13.38	8.52*	-7.12	11.8	7.26	-8.16
HS 10 x KDMI 15	15.35	1.82	-6.97	12.0	-1.43	-18.34*	14.83	1.72	2.95	12.4	2.17	-4.08
HS 10 x NEI 9208B	15.55	3.84	-5.76	12.9	0.10	-12.73	14.63	2.90	1.56	12.4	2.59	-3.88
HS 10 x CI 4	16.05	8.17	-2.73	13.8	9.09	-6.28	14.90	0.59	3.47	12.9	4.02	0.39
HS 10 x CML 446	14.63	-4.96	-11.36	13.6	11.38	-7.81	14.85	0.76	3.13	12.8	2.50	-0.39
HS 10 x HS 4	16.75	10.02	1.52	13.8	10.64	-6.45	14.80	-0.92	2.78	12.2	-1.92	-5.63
HS 10 x HS 15	16.18	11.94	-1.97	13.1	10.29	-10.87	15.90	5.65	10.42*	13.9	9.66*	7.96
HS 10 x HS 17	15.18	3.67	-8.03	13.5	6.50	-8.15	14.73	2.70	2.26	12.6	5.76	-1.94
HS 10 x NEI 9202B	16.48	14.41*	-0.15	13.0	6.24	-11.88	14.58	7.56*	1.22	12.1	6.59	-5.83
KDMI 15 x NEI 9208B	15.70	-1.88	-4.85	12.9	-4.00	-12.39	14.70	6.43	2.08	11.9	-1.04	-7.96
KDMI 15 x CI 4	15.60	-1.65	-5.45	13.9	4.91	-5.60	14.08	-2.34	-2.26	12.3	-0.51	-4.66
KDMI 15 x CML 446	16.43	0.08	-0.45	14.2	10.65	-3.90	14.88	3.75	3.30	12.4	-0.20	-3.69
KDMI 15 x HS 4	15.40	-5.23	-6.67	13.9	6.32	-5.77	13.78	-5.25	-4.34	12.2	-0.81	-5.24
KDMI 15 x HS 15	15.23	-1.62	-7.73	14.4	15.40	-2.04	14.65	0.00	1.74	12.4	-1.29	-3.5
KDMI 15 x HS 17	15.35	-2.00	-6.97	12.2	-8.65	-17.49*	14.28	2.42	-0.87	12.0	1.48	-6.6
Rajkumar (check)	16.50			14.72			14.40			12.88		
Mean	15.82	3.75	-4.12	13.60	6.40	-7.60	14.41	3.18	0.07	12.33	2.40	-4.20
Range	13.60- 17.60	-8.03- 19.51	-17.58- 6.67	11.30- 15.50	-11.23- 27.38	-23.26- 5.43	13.18- 15.90	-5.24- 10.84	-8.51- 10.42	11.10- 13.90	-7.91- 12.51	-13.98- 7.96
SEd	1.17	1.02	1.17	1.16	1.01	1.16	0.59	0.52	0.59	0.71	0.61	0.71
CD at 5%	2.32	2.01	2.32	2.30	1.99	2.30	1.17	1.02	1.17	1.40	1.21	1.40
CD at 1%	3.06	2.65	3.06	3.04	2.63	3.04	1.55	1.34	1.55	1.85	1.60	1.85

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 14 contd....

Hybrids	Cob length (cm)						Cob girth (cm)					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
KDMI 15 x NEI 9202B	16.30	5.67	-1.21	14.2	10.83	-3.57	14.58	10.84**	1.22	12.7	12.51*	-1.36
NEI 9208B x CI 4	16.83	6.74	1.97	14.2	1.89	-3.90	14.60	3.91	1.39	12.7	2.94	-1.55
NEI 9208B x CML 446	17.58	7.74	6.52	12.9	-3.72	-12.22	14.13	1.07	-1.91	11.8	-5.24	-8.74
NEI 9208B x HS 4	15.80	-2.17	-4.24	12.2	-11.23	-17.49*	15.15	6.88	5.21	11.7	-4.68	-9.13
NEI 9208B x HS 15	15.63	1.63	-5.30	15.3	16.08*	3.57	15.28	6.91	6.08	13.4	6.47	3.88
NEI 9208B x HS 17	16.03	2.97	-2.88	13.2	-5.47	-10.53	14.15	4.24	-1.74	12.0	1.48	-6.8
NEI 9208B x NEI 9202B	15.83	3.26	-4.09	13.7	1.67	-7.13	13.18	3.03	-8.51*	11.1	-1.66	-13.98*
CI 4 x CML 446	15.98	-1.24	-3.18	14.2	7.27	-3.57	15.18	4.12	5.38	12.8	0.49	-0.39
CI 4 x HS 4	16.05	0.23	-2.73	13.5	-0.37	-8.66	14.80	0.17	2.78	12.6	-0.30	-2.14
CI 4 x HS 15	16.25	6.64	-1.52	13.9	7.53	-5.43	15.68	5.29	8.85*	13.2	2.13	2.52
CI 4 x HS 17	15.75	2.11	-4.55	13.2	-3.82	-10.19	14.15	-0.18	-1.74	12.0	-1.33	-6.6
CI 4 x NEI 9202B	16.83	10.78	1.97	14.6	9.90	-1.02	14.35	7.19	-0.35	12.2	5.16	-5.05
CML 446 x HS 4	15.55	-6.11	-5.76	12.8	-1.63	-12.90	15.08	2.55	4.69	12.4	-2.55	-3.69
CML 446 x HS 15	15.43	-2.30	-6.52	12.9	3.10	-12.56	14.80	-0.08	2.78	12.5	-3.94	-2.91
CML 446 x HS 17	16.33	2.19	-1.06	12.9	-2.92	-12.39	14.43	2.30	0.17	12.8	3.87	-0.97
CML 446 x NEI 9202B	17.60	11.83	6.67	14.4	12.70	-2.04	14.35	7.79*	-0.35	12.3	4.80	-4.66
HS 4 x HS 15	14.55	-6.88	-11.82	13.4	4.71	-9.34	15.33	2.08	6.42	13.1	1.45	1.55
HS 4 x HS 17	15.85	0.24	-3.94	13.9	2.58	-5.60	14.53	1.57	0.87	12.2	0.62	-5.05
HS 4 x NEI 9202B	16.33	4.82	-1.06	15.2	16.56*	3.40	14.25	5.46	-1.04	12.3	6.15	-4.47
HS 15 x HS 17	14.38	-4.41	-12.88	13.5	4.04	-8.15	14.98	3.90	3.99	13.2	6.13	2.52
HS 15 x NEI 9202B	16.60	12.16	0.61	13.9	11.09	-5.60	14.28	4.77	-0.87	12.8	8.00	-0.39
HS 17 x NEI 9202B	16.15	7.76	-2.12	13.5	1.03	-8.66	13.90	7.65	-3.47	11.7	4.83	-9.32
Rajkumar (check)	16.50			14.72			14.40			12.88		
Mean	15.82	3.75	-4.12	13.60	6.40	-7.60	14.41	3.18	0.07	12.33	2.40	-4.20
Range	13.60- 17.60	-8.03- 19.51	-17.58- 6.67	11.30- 15.50	-11.23- 27.38	-23.26- 5.43	13.18- 15.90	-5.24- 10.84	-8.51- 10.42	11.10- 13.90	-7.91- 12.51	-13.98- 7.96
SEd	1.17	1.02	1.17	1.16	1.01	1.16	0.59	0.52	0.59	0.71	0.61	0.71
CD at 5%	2.32	2.01	2.32	2.30	1.99	2.30	1.17	1.02	1.17	1.40	1.21	1.40
CD at 1%	3.06	2.65	3.06	3.04	2.63	3.04	1.55	1.34	1.55	1.85	1.60	1.85

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

The mean heterosis for the trait over mid parent and check was 3.75 and -4.12% under nonstress and 6.4 and -7.60% under stress, respectively. None of the hybrids recorded significant positive heterosis over check in either of the environments.

4.2.2.8 Cob girth (cm)

The variation for this trait ranged from 13.18 (NEI 9208B x NEI 9202B) to 15.90 cm (Hyd Sel 10 x Hyd Sel 15) with an overall mean of 14.41 under nonstress. Under stress, Hyd Sel 2 x Hyd Sel 17 (11.10 cm) recorded the lowest and Hyd Sel 10 x Hyd Sel 15 (13.80 cm) recorded the highest cob girth with an overall mean of 12.33 cm.

The average heterosis over mid parent and check was -4.12 and 14.41% under nonstress and 12.33 and 2.40% under stress, respectively. Two hybrids viz., Hyd Sel 10 x Hyd Sel 15 and CI 4 x Hyd Sel 15 recorded significant positive standard heterosis under nonstress conditions. But none of the hybrids showed significant positive standard heterosis under stress.

4.2.2.9 Number of kernel rows per cob

The mean value of the hybrids averaged over two seasons ranged from 12.93 (Hyd Sel 7 x NEI 9208B) to 17.30 (Hyd Sel 2 x Hyd Sel 15) with an overall mean of 14.71 under nonstress. Under stress, it ranged from 12.95 (Hyd Sel 4 x NEI 92.02 B) to 16.40 (Hyd Sel 10 x Hyd Sel 15) with an overall mean of 14.50.

The mean heterosis over mid parent and check was 1.22 and 5.82% under nonstress and 2.90 and 1.75% under stress, respectively. Eleven hybrids showed significant positive heterosis over check under nonstress and four hybrids exhibited significant positive standard heterosis under stress.

4.2.2.10 Number of kernels per row

The range for this trait among the hybrids was from 25.95 (Hyd Sel 4 x Hyd Sel 15) to 39.10 (CM 111 x NEI 9202B) with an overall mean of 31.57 under nonstress. Under stress, the corresponding values were 22.10 (CM 111 x Hyd Sel 10), 34.60 (CM 111 x NEI 9202B) and 28.07, respectively.

The average heterosis over mid parent and check was 5.70 and 3.51% under nonstress and 7.12 and -3.21% under stress, respectively. Three hybrids viz., CM 111 x NEI 9202B (28.20%), Hyd Sel 7 x NEI 9202B (25.90%) and KDMI 15 x NEI 9202B (20.98%) recorded significant positive standard heterosis under nonstress. One of the above hybrids (CM 111 x NEI 9202B) also recorded significant positive standard heterosis for the trait under stress also.

4.2.2.11 Cobs per Plant

Among the 66 hybrids evaluated, CM 111 x CI 4 (0.87) and Hyd Sel 7 x NEI 9202B (1.07) recorded lowest and highest number of cobs per plant with an overall mean of 0.98 under nonstress. The corresponding figures under stress were 0.59 (CM 111 x Hyd Sel 10), 0.98 (NEI 9208B x Hyd Sel 15) and 0.84, respectively.

The average heterosis over mid parent and check was 0.26 and -8.66% under nonstress conditions and 6.81 and -7.78% under stress, respectively. CM 111 x Hyd Sel 10 under nonstress, CM 111 x CML 446 and Hyd Sel 7 x Hyd Sel 17 both under stress recorded significant positive heterosis over mid parent. None of the hybrids showed significant standard heterosis.

4.2.2.12 Shelling percentage

The range for this trait among the hybrids was 80.86 (Hyd Sel 10 x KDMI 15) to 86.24% (Hyd Sel 15 x Hyd Sel 17) with an overall mean of 83.47% under nonstress. Under stress, the respective values were 73.31 (CM 111 x CI 4), 87.99% (Hyd Sel 2 x NEI 9202B) and 81.42, respectively.

The average heterosis over mid parent and check was 1.26 and -2.26% under nonstress and 1.07 and -3.69% under stress, respectively. None of the hybrids recorded significant standard heterosis in either of the environments.

Table 15. Per se performance and heterosis for different traits in 12 x 12 half diallel set of hybrids under nonstress and stress situations for number of kernel rows per cob and number of kernels per row

Hybrids	Number of kernel rows per cob						Number of kernels per row					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
CM 111 x HS 2	14.70	-4.70	5.76	14.95	4	4.91	32.50	9.01	6.56	27.45	7.7	-5.34
CM 111 x HS 7	15.18	2.88	9.17	15.40	6.94	8.07	30.88	1.48	1.23	31.95	18.77*	10.17
CM 111 x HS 10	15.30	-0.33	10.07	15.05	0.84	5.61	32.75	8.62	7.38	22.1	-14.05	-23.79*
CM 111 x KDMI 15	15.10	3.07	8.63	15.20	7.04	6.67	32.45	5.10	6.39	29.5	16.08	1.72
CM 111 x NEI 9208B	13.70	-1.08	-1.44	15.10	9.03	5.96	34.20	3.56	12.13	28.45	0.57	-1.9
CM 111 x CI 4	14.60	1.39	5.04	15.70	10.37	10.18	32.45	2.53	6.39	31.35	15.52	8.1
CM 111 x CML 446	15.10	1.17	8.63	15.20	4.29	6.67	32.50	0.23	6.56	27.75	6.37	-4.31
CM 111 x HS 4	14.80	-1.33	6.47	15.35	8.87	7.72	32.70	8.91	7.21	28.45	8.48	-1.9
CM 111 x HS 15	17.00	7.26	22.30**	16.30	5.16	14.39*	30.95	6.36	1.48	27.45	15.09	-5.34
CM 111 x HS 17	14.50	2.29	4.32	15.05	8.86	5.61	31.30	2.96	2.62	30.2	13.59	4.14
CM 111 x NEI 9202B	13.50	-2.53	-2.88	13.60	0.09	-4.56	39.10	23.93**	28.20**	34.6	28.09**	19.31*
HS 2 x HS 7	14.80	-2.47	6.47	14.40	1.59	1.05	33.50	18.85*	9.84	32.1	22.93*	10.69
HS 2 x HS 10	16.10	2.06	15.83**	14.80	0.68	3.86	29.70	6.40	-2.62	26.95	8.12	-7.07
HS 2 x KDMI 15	15.40	2.16	10.79	14.00	0.18	-1.75	31.65	10.52	3.77	27.8	12.89	-4.14
HS 2 x NEI 9208B	14.40	0.88	3.60	13.80	1.28	-3.16	29.50	-4.18	-3.28	25.85	-6	-10.86
HS 2 x CI 4	14.05	-5.23	1.08	14.25	1.79	0.00	30.20	2.68	-0.98	25.85	-1.9	-10.86
HS 2 x CML 446	14.40	-6.19	3.60	13.60	-5.23	-4.56	32.55	7.83	6.72	26.25	3.75	-9.48
HS 2 x HS 4	13.60	-11.83*	-2.16	13.60	-1.98	-4.56	26.00	-6.43	-14.75	24.85	-2.31	-14.31
HS 2 x HS 15	17.30	6.30	24.46**	15.80	3.44	10.88	26.30	-2.09	-13.77	25.6	11	-11.72
HS 2 x HS 17	14.70	0.68	5.76	13.63	0.18	-4.39	31.50	11.85	3.28	25.1	-2.71	-13.45
HS 2 x NEI 9202B	13.20	-7.53	-5.04	13.90	4.02	-2.46	33.58	14.54	10.08	31.05	18.40*	7.07
HS 7 x HS 10	16.10	6.62	15.83**	15.30	3.9	7.37	32.45	13.76	6.39	26.15	-0.71	-9.83
Rajkumar (check)	13.90			14.25			30.50			29.00		
Mean	14.71	1.22	5.82	14.50	2.90	1.75	31.57	5.70	3.51	28.07	7.12	-3.21
Range	12.93-17.30	-11.83-9.63	-7.01-24.46	12.95-16.40	-6.16-11.56	-9.12-15.10	25.95-39.10	-6.43-28.32	-14.92-28.20	22.10-34.63	-14.05-31.93	-23.79-19.31
SEd	0.83	0.72	0.83	0.95	0.82	0.95	3.08	2.66	3.08	2.79	2.42	2.79
CD at 5%	1.65	1.43	1.65	1.88	1.63	1.88	6.08	5.26	6.08	5.51	4.77	5.51
CD at 1%	2.18	1.88	2.18	2.48	2.15	2.48	8.02	6.95	8.02	7.27	6.30	7.27

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 15 contd....

Hybrids	Number of kernel rows per cob						Number of kernels per row					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
HS 7 x KDMI 15	14.80	2.78	6.47	15.40	10	8.07	30.45	4.10	-0.16	27.2	4.46	-6.21
HS 7 x NEI 9208B	12.93	-4.96	-7.01	13.25	-2.93	-7.02	35.15	11.94	15.25	32.6	12.75	12.41
HS 7 x CI 4	14.70	3.89	5.76	14.40	2.67	1.05	31.95	6.41	4.75	29.9	7.7	3.1
HS 7 x CML 446	15.70	6.98	12.95*	14.73	2.43	3.33	35.55	15.42	16.56	27.25	2.01	-6.03
HS 7 x HS 4	15.20	3.05	9.35	14.35	3.24	0.70	30.85	8.63	1.15	28.85	7.45	-0.52
HS 7 x HS 15	16.90	8.33	21.58**	16.15	5.56	13.33*	30.85	12.28	1.15	28.85	17.88	-0.52
HS 7 x HS 17	14.05	0.90	1.08	13.50	-0.92	-5.26	29.20	1.48	-4.26	27.35	0.51	-5.69
HS 7 x NEI 9202B	14.00	2.94	0.72	13.40	0.09	-5.96	38.40	28.32**	25.90*	30.9	11.8	6.55
HS 10 x KDMI 15	14.90	-0.67	7.19	14.35	-1.2	0.70	29.35	1.29	-3.77	25.5	2.62	-12.07
HS 10 x NEI 9208B	14.50	2.11	4.32	13.50	-4.76	-5.26	31.90	2.49	4.59	28.15	1.53	-2.93
HS 10 x CI 4	14.63	-0.85	5.22	15.40	5.84	8.07	31.75	6.72	4.10	27.5	3.48	-5.17
HS 10 x CML 446	14.90	-2.45	7.19	14.20	-4.7	-0.35	29.40	-3.69	-3.61	29.45	15.38	1.55
HS 10 x HS 4	14.60	-4.89	5.04	14.30	-0.87	0.35	28.60	1.69	-6.23	25.6	-0.24	-11.72
HS 10 x HS 15	16.50	1.85	18.71**	16.40	3.63	15.09*	30.20	11.03	-0.98	25.3	8.64	-12.76
HS 10 x HS 17	15.00	3.27	7.91	15.75	11.31	10.53	29.10	2.11	-4.59	28.05	7.78	-3.28
HS 10 x NEI 9202B	14.75	3.87	6.12	14.20	2.07	-0.35	35.10	18.38*	15.08	30.4	14.93	4.83
KDMI 15 x NEI 9208B	14.80	9.63	6.47	13.80	2.6	-3.16	33.28	4.47	9.10	29.75	8.48	2.59
KDMI 15 x CI 4	14.05	0.00	1.08	14.40	4.16	1.05	31.80	4.35	4.26	26.95	2.57	-7.07
KDMI 15 x CML 446	15.30	4.97	10.07	14.25	0.53	0.00	31.20	-0.16	2.30	29.3	16.15	1.03
KDMI 15 x HS 4	14.50	-1.02	4.32	14.25	4.01	0.00	28.35	-1.73	-7.05	26	2.51	-10.34
KDMI 15 x HS 15	15.23	-1.77	9.53	15.20	0.66	6.67	28.45	1.88	-6.72	27.85	21.15*	-3.97
KDMI 15 x HS 17	14.90	7.78	7.19	14.15	5.4	-0.70	28.45	-2.65	-6.72	23.9	-7.09	-17.59
Rajkumar (check)	13.90			14.25			30.50			29.00		
Mean	14.71	1.22	5.82	14.50	2.90	1.75	31.57	5.70	3.51	28.07	7.12	-3.21
Range	12.93- 17.30	-11.83- 9.63	-7.01- 24.46	12.95- 16.40	-6.16- 11.56	-9.12- 15.10	25.95- 39.10	-6.43- 28.32	-14.92- 28.20	22.10- 34.63	-14.05- 31.93	-23.79- 19.31
SEd	0.83	0.72	0.83	0.95	0.82	0.95	3.08	2.66	3.08	2.79	2.42	2.79
CD at 5%	1.65	1.43	1.65	1.88	1.63	1.88	6.08	5.26	6.08	5.51	4.77	5.51
CD at 1%	2.18	1.88	2.18	2.48	2.15	2.48	8.02	6.95	8.02	7.27	6.30	7.27

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 15 contd....

Hybrids	Number of kernel rows per cob						Number of kernels per row					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
KDMI 15 x NEI 9202B	14.00	3.70	0.72	13.60	3.13	-4.56	36.90	21.48*	20.98*	34.5	31.93**	18.97
NEI 9208B x CI 4	14.20	7.17	2.16	14.20	5.38	-0.35	33.40	2.38	9.51	30.45	4.46	5
NEI 9208B x CML 446	13.60	-1.27	-2.16	13.70	-0.9	-3.86	35.40	5.99	16.07	29.05	3.38	0.17
NEI 9208B x HS 4	13.90	0.36	0.00	14.30	7.12	0.35	31.90	2.90	4.59	25.4	-10.05	-12.41
NEI 9208B x HS 15	15.90	8.16	14.39*	14.95	1.36	4.91	30.45	1.25	-0.16	31.5	21.80*	8.62
NEI 9208B x HS 17	14.00	7.49	0.72	13.90	6.31	-2.46	31.10	-0.88	1.97	29.5	3.15	1.72
NEI 9208B x NEI 9202B	13.00	2.36	-6.47	13.20	2.82	-7.37	35.15	8.07	15.25	32.3	11.28	11.38
CI 4 x CML 446	15.10	5.41	8.63	14.40	1.41	1.05	31.85	-0.55	4.43	28.2	4.64	-2.76
CI 4 x HS 4	14.30	-0.69	2.88	14.40	4.92	1.05	29.00	-2.11	-4.92	26.2	-3.28	-9.66
CI 4 x HS 15	16.15	5.90	16.19**	16.40	8.43	15.09*	30.90	7.67	1.31	23.58	-4.6	-18.71
CI 4 x HS 17	14.10	3.87	1.44	13.80	2.6	-3.16	31.00	3.33	1.64	28.15	2.55	-2.93
CI 4 x NEI 9202B	13.80	4.15	-0.72	14.20	7.47	-0.35	34.40	10.43	12.79	30.1	7.98	3.79
CML 446 x HS 4	14.50	-2.85	4.32	14.65	4.09	2.81	32.25	6.09	5.74	27	3.7	-6.9
CML 446 x HS 15	15.65	-0.79	12.59*	15.35	-0.81	7.72	29.55	0.25	-3.11	25.08	5.97	-13.53
CML 446 x HS 17	13.70	-2.84	-1.44	12.95	-6.16	-9.12	28.90	-6.09	-5.25	24.65	-6.63	-15
CML 446 x NEI 9202B	13.80	0.18	-0.72	13.85	2.12	-2.81	35.35	10.73	15.90	30.9	15.19	6.55
HS 4 x HS 15	15.95	0.63	14.75*	14.95	-0.33	4.91	25.95	-4.16	-14.92	23.28	-2.21	-19.74*
HS 4 x HS 17	14.20	0.18	2.16	13.30	-0.19	-6.67	28.90	1.85	-5.25	26.33	-0.8	-9.22
HS 4 x NEI 9202B	14.30	3.25	2.88	14.60	11.56	2.46	32.80	11.09	7.54	31.45	16.64	8.45
HS 15 x HS 17	14.80	-1.50	6.47	15.10	2.55	5.96	26.00	-5.28	-14.75	25.9	7.19	-10.69
HS 15 x NEI 9202B	14.30	-2.72	2.88	14.65	1.12	2.81	32.05	12.06	5.08	28.45	15.71	-1.9
HS 17 x NEI 9202B	13.20	1.34	-5.04	13.20	3.02	-7.37	32.40	8.36	6.23	27.3	-0.09	-5.86
Rajkumar (check)	13.90			14.25			30.50			29.00		
Mean	14.71	1.22	5.82	14.50	2.90	1.75	31.57	5.70	3.51	28.07	7.12	-3.21
Range	12.93- 17.30	-11.83- 9.63	-7.01- 24.46	12.95- 16.40	-6.16- 11.56	-9.12- 15.10	25.95- 39.10	-6.43- 28.32	-14.92- 28.20	22.10- 34.63	-14.05- 31.93	-23.79- 19.31
SEd	0.83	0.72	0.83	0.95	0.82	0.95	3.08	2.66	3.08	2.79	2.42	2.79
CD at 5%	1.65	1.43	1.65	1.88	1.63	1.88	6.08	5.26	6.08	5.51	4.77	5.51
CD at 1%	2.18	1.88	2.18	2.48	2.15	2.48	8.02	6.95	8.02	7.27	6.30	7.27

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Table 16. Per se performance and heterosis for different traits in 12 x 12 half diallel set of hybrids under nonstress and stress situations for cobs per plant and shelling percentage

Hybrids	Cobs per plant						Shelling percentage					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
CM 111 x HS 2	0.95	4.41	-11.86	0.88	11.04	-3.56	81.24	-0.14	-4.87*	79.97	1.33	-5.41
CM 111 x HS 7	0.87	4.65	-18.84*	0.68	2.25	-25.21	81.74	0.06	-4.28*	81.52	1.06	-3.58
CM 111 x HS 10	1.03	18.73*	-4.19	0.59	-19.73	-35.89**	80.91	0.22	-5.26**	81.57	2.16	-3.51
CM 111 x KDMI 15	0.93	-1.06	-13.49	0.95	22.58	4.11	82.16	2.76	-3.80*	75.99	-1.44	-10.11**
CM 111 x NEI 9208B	1.03	6.72	-3.95	0.88	16.12	-3.29	83.77	2.94	-1.91	81.75	2.37	-3.3
CM 111 x CI 4	0.87	0.72	-18.84*	0.86	14.10	-5.75	82.69	1.76	-3.17	73.31	-8.17**	-13.29**
CM 111 x CML 446	1.00	4.56	-6.74	0.88	35.26*	-3.84	82.21	1.50	-3.74	77.07	-1.53	-8.84**
CM 111 x HS 4	0.89	-4.03	-16.98*	0.78	-3.73	-15.07	82.24	1.12	-3.70	80.11	1.32	-5.24
CM 111 x HS 15	0.96	6.11	-11.16	0.84	11.04	-7.67	83.45	0.76	-2.29	80.94	0.82	-4.26
CM 111 x HS 17	0.90	3.31	-16.51	0.85	14.72	-7.12	82.85	2.40	-2.98	81.33	3.26	-3.8
CM 111 x NEI 9202B	1.07	16.51	-0.70	0.84	9.80	-7.95	83.88	3.67*	-1.78	78.86	-0.52	-6.72*
HS 2 x HS 7	0.93	-0.13	-13.72	0.91	17.86	-0.55	84.54	1.47	-1.01	80.66	-1.50	-4.6
HS 2 x HS 10	0.93	-3.38	-13.49	0.93	11.28	1.37	82.16	-0.21	-3.79*	82.26	1.48	-2.7
HS 2 x KDMI 15	0.98	-5.56	-9.07	0.88	0.57	-3.29	82.41	1.03	-3.51	78.62	0.38	-7.01*
HS 2 x NEI 9208B	1.04	-2.35	-3.49	0.8	-7.54	-12.60	82.97	-0.02	-2.85	80.66	-0.51	-4.59
HS 2 x CI 4	1.00	4.03	-6.98	0.93	8.61	1.92	83.35	0.57	-2.41	79.61	-1.77	-5.83*
HS 2 x CML 446	0.97	-7.95	-9.77	0.93	23.79	1.92	82.52	-0.10	-3.37	79.21	-0.34	-6.31*
HS 2 x HS 4	1.04	1.71	-3.02	0.87	-4.41	-4.93	82.78	-0.19	-3.07	81.62	1.66	-3.46
HS 2 x HS 15	0.97	-3.02	-10.23	0.82	-4.50	-9.86	85.22	0.93	-0.21	81.93	0.53	-3.08
HS 2 x HS 17	0.99	2.98	-7.67	0.77	-9.06	-16.16	82.72	0.23	-3.14	80.76	0.98	-4.47
HS 2 x NEI 9202B	0.99	-2.60	-8.37	0.9	3.17	-1.92	85.11	3.13	-0.35	87.99	9.33**	4.08
HS 7 x HS 10	1.02	14.21	-5.58	0.65	-7.61	-28.49*	83.71	1.24	-1.98	83.84	1.25	-0.83
Rajkumar (check)	1.07			0.91			85.40			84.54		
Mean	0.98	0.26	-8.66	0.84	6.81	-7.78	83.47	1.26	-2.26	81.42	1.07	-3.69
Range	0.87-1.07	-12.80-18.73	-11.86-(-2.79)	0.59-0.98	-19.73-35.26	-35.89-7.32	80.66-86.24	-1.79-4.87	-5.32-0.98	73.30-87.99	-8.17-9.33	-13.29-4.08
SEd	0.092	0.080	0.092	0.123	0.107	0.123	1.621	1.40	1.621	2.40	2.08	2.40
CD at 5%	0.182	0.158	0.182	0.243	0.21	0.243	3.20	2.77	3.20	4.74	4.01	4.74
CD at 1%	0.241	0.208	0.241	0.321	0.28	0.321	4.23	3.66	4.23	6.26	5.42	6.26

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

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Table 16 contd...

Hybrids	Cobs per plant						Shelling percentage					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
HS 7 x KDMI 15	0.95	-1.69	-12.09	0.88	16.28	-4.11	83.79	2.30	-1.89	80.98	1.14	-4.21
HS 7 x NEI 9208B	0.95	-4.17	-11.86	0.88	18.64	-4.11	84.75	1.71	-0.76	83.55	0.88	-1.17
HS 7 x CI 4	0.95	7.04	-11.63	0.8	8.72	-12.88	84.66	1.73	-0.87	80.67	-2.56	-4.57
HS 7 x CML 446	0.96	-1.79	-10.47	0.69	9.78	-24.66	85.54	3.13	0.17	82.58	1.67	-2.32
HS 7 x HS 4	0.97	1.97	-9.77	0.92	17.57	0.82	85.57	2.75	0.19	82.95	1.12	-1.88
HS 7 x HS 15	1.02	10.18	-5.58	0.82	10.70	-10.68	85.03	0.30	-0.44	83.33	0.09	-1.43
HS 7 x HS 17	0.92	2.81	-14.88	0.94	30.89*	2.74	85.69	3.42*	0.34	82.6	1.07	-2.29
HS 7 x NEI 9202B	1.07	14.13	-0.47	0.83	11.45	-9.32	85.62	3.32	0.25	82.26	0.03	-2.7
HS 10 x KDMI 15	0.97	-3.02	-10.23	0.88	8.14	-3.56	80.86	-0.09	-5.32**	79.17	-0.09	-6.35*
HS 10 x NEI 9208B	0.96	-6.36	-10.93	0.74	-7.98	-19.45	82.05	-0.38	-3.93*	82.11	0.13	-2.87
HS 10 x CI 4	0.99	6.92	-8.37	0.76	-4.10	-16.71	83.93	2.04	-1.72	80.59	-1.69	-4.67
HS 10 x CML 446	1.00	-1.36	-6.98	0.84	22.18	-7.95	83.09	1.36	-2.70	80.81	0.49	-4.42
HS 10 x HS 4	0.97	-1.78	-10.00	0.86	1.93	-5.75	81.14	-1.42	-4.99**	80.96	-0.31	-4.23
HS 10 x HS 15	1.00	4.97	-6.74	0.84	5.33	-7.95	85.22	1.69	-0.22	82.64	0.25	-2.25
HS 10 x HS 17	0.97	4.47	-10.23	0.79	1.93	-13.15	83.43	1.87	-2.31	81.73	1.02	-3.32
HS 10 x NEI 9202B	0.97	-0.13	-9.77	0.85	5.75	-6.85	82.26	0.44	-3.68	81.85	0.53	-3.19
KDMI 15 x NEI 9208B	1.02	-6.62	-4.88	0.77	-9.17	-15.89	83.52	2.37	-2.21	80.66	1.77	-4.59
KDMI 15 x CI 4	0.97	-2.89	-10.23	0.86	1.94	-6.30	82.33	1.05	-3.60	81.28	2.59	-3.86
KDMI 15 x CML 446	1.04	-4.49	-3.49	0.69	-6.64	-24.93	83.40	2.71	-2.34	80.66	3.85	-4.59
KDMI 15 x HS 4	0.94	-10.87	-12.33	0.9	1.12	-1.37	82.57	1.26	-3.32	80.16	2.16	-5.18
KDMI 15 x HS 15	0.95	-7.54	-11.63	0.91	7.85	-0.27	83.16	0.16	-2.63	79.17	-0.65	-6.35*
KDMI 15 x HS 17	1.03	3.39	-4.19	0.78	-5.61	-14.79	83.07	2.40	-2.73	83.43	6.73*	-1.32
Rajkumar (check)	1.07			0.91			85.40			84.54		
Mean	0.98	0.26	-8.66	0.84	6.81	-7.78	83.47	1.26	-2.26	81.42	1.07	-3.69
Range	0.87- 1.07	-12.80- 18.73	-11.86- (-2.79)	0.59- 0.98	-19.73- 35.26	-35.89- 7.32	80.66- 86.24	-1.79- 4.87	-5.32- 0.98	73.30- 87.99	-8.17- 9.33	-13.29- 4.08
SEd	0.092	0.080	0.092	0.123	0.107	0.123	1.621	1.40	1.621	2.40	2.08	2.40
CD at 5%	0.182	0.158	0.182	0.243	0.21	0.243	3.20	2.77	3.20	4.74	4.01	4.74
CD at 1%	0.241	0.208	0.241	0.321	0.28	0.321	4.23	3.66	4.23	6.26	5.42	6.26

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 16 contd...

Hybrids	Cobs per plant						Shelling percentage					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
KDMI 15 x NEI 9202B	1.03	-1.32	-4.19	0.93	9.12	1.64	85.07	4.87**	-0.38	80.78	2.68	-4.45
NEI 9208B x CI 4	0.99	-3.06	-7.91	0.85	3.19	-6.85	82.66	-0.28	-3.21	83.16	1.43	-1.63
NEI 9208B x CML 446	1.05	-6.17	-2.79	0.71	-0.87	-21.92	82.98	0.43	-2.84	80.75	0.41	-4.48
NEI 9208B x HS 4	0.96	-11.52	-10.70	0.94	7.14	2.74	82.76	-0.24	-3.09	81.72	0.60	-3.34
NEI 9208B x HS 15	0.92	-12.80	-14.42	0.98	17.95	7.12	85.07	0.73	-0.39	82.72	0.33	-2.15
NEI 9208B x HS 17	1.07	4.76	-0.23	0.84	4.17	-7.67	82.00	-0.66	-3.99*	82.85	2.38	-2
NEI 9208B x NEI 9202B	1.05	-2.22	-2.56	0.81	-2.99	-11.23	84.51	2.38	-1.04	83.66	2.74	-1.04
CI 4 x CML 446	0.97	-4.69	-10.23	0.9	26.67	-1.10	83.40	1.08	-2.34	82.8	3.00	-2.06
CI 4 x HS 4	0.98	-0.13	-8.60	0.83	-4.75	-9.32	83.79	1.14	-1.89	83.17	2.43	-1.62
CI 4 x HS 15	1.00	4.85	-6.98	0.91	10.64	-0.27	86.08	2.06	0.80	82.75	0.40	-2.12
CI 4 x HS 17	1.04	13.01	-3.02	0.84	4.98	-7.67	81.93	-0.61	-4.07*	80.3	-0.73	-5.02
CI 4 x NEI 9202B	1.01	3.87	-6.28	0.85	2.56	-6.85	83.25	0.98	-2.52	82.09	0.85	-2.9
CML 446 x HS 4	0.97	-9.87	-9.77	0.93	21.77	1.92	81.10	-1.79	-5.04**	78.53	-1.38	-7.11*
CML 446 x HS 15	1.06	1.08	-1.63	0.86	20.21	-5.48	85.04	1.15	-0.43	83.52	3.29	-1.21
CML 446 x HS 17	0.92	-9.11	-14.19	0.73	4.66	-20.00	83.35	1.44	-2.41	82.09	3.48	-2.9
CML 446 x NEI 9202B	1.02	-3.76	-4.88	0.78	8.12	-14.25	84.02	2.25	-1.62	82.32	3.12	-2.62
HS 4 x HS 15	0.94	-7.37	-12.33	0.9	2.43	-1.92	85.74	1.58	0.39	83.23	1.93	-1.55
HS 4 x HS 17	1.00	1.39	-6.98	0.83	-3.07	-9.32	81.96	-0.65	-4.03*	81.43	1.63	-3.68
HS 4 x NEI 9202B	1.02	-1.33	-5.12	0.85	-3.13	-6.58	84.04	1.87	-1.59	82.1	1.81	-2.89
HS 15 x HS 17	0.90	-5.88	-16.28	0.94	16.10	2.74	86.24	2.68	0.98	84.73	4.16	0.23
HS 15 x NEI 9202B	0.99	-1.87	-8.37	0.91	8.85	-0.55	86.10	2.51	0.81	83.41	1.89	-1.34
HS 17 x NEI 9202B	1.05	7.46	-2.79	0.84	3.23	-7.95	83.04	1.17	-2.76	81.85	1.89	-3.18
Rajkumar (check)	1.07			0.91			85.40			84.54		
Mean	0.98	0.26	-8.66	0.84	6.81	-7.78	83.47	1.26	-2.26	81.42	1.07	-3.69
Range	0.87-1.07	-12.80-18.73	-11.86-(-2.79)	0.59-0.98	-19.73-35.26	-35.89-7.32	80.66-86.24	-1.79-4.87	-5.32-0.98	73.30-87.99	-8.17-9.33	-13.29-4.08
SEd	0.092	0.080	0.092	0.123	0.107	0.123	1.621	1.40	1.621	2.40	2.08	2.40
CD at 5%	0.182	0.158	0.182	0.243	0.21	0.243	3.20	2.77	3.20	4.74	4.01	4.74
CD at 1%	0.241	0.208	0.241	0.321	0.28	0.321	4.23	3.66	4.23	6.26	5.42	6.26

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

However, CM 111 x NEI 9202B, Hyd Sel 7 x Hyd Sel 17 and KDMI 15 x NEI 9202B under nonstress and Hyd Sel 2 x NEI 9202B and KDMI 15 x Hyd Sel 17 under stress recorded significant positive heterosis over mid parent.

4.2.2.13 Hundred grain weight (g)

Mean values for the trait varied from 22.71 (Hyd Sel 7 x NEI 9202B) to 33.71 g (Hyd Sel 4 x Hyd Sel 15) with an overall mean of 27.66 g under nonstress. Under stress, it ranged from 14.37 (Hyd Sel 2 x Hyd Sel 17) to 24.31 g (Hyd Sel 15 x Hyd Sel 17) with an overall mean of 17.82 g.

The mean heterosis over mid parent and check was 1.46 and -7.86% under nonstress and 2.01 and -16.83% under stress, respectively. None of the hybrids exhibited significant positive standard heterosis in either of the environments. However, CM 111 x Hyd Sel 15 (under nonstress) and Hyd Sel 7 x Hyd Sel 17 (under stress) expressed significant positive heterosis over mid parent.

4.2.2.14. Yield per plant (g)

Among the hybrids, yield per plant ranged from 95.05 (Hyd Sel 7 x Hyd Sel 17) to 142.15 g (Hyd Sel 10 x Hyd Sel 15) with an overall mean of 120.83 g under nonstress. The corresponding figures in stress conditions were observed in CM 111 x Hyd Sel 10 (37.92 g) and NEI 9208B x Hyd Sel 15 (77.03 g). The overall mean was 59.52 g.

The mean heterosis over mid parent and check was 9.46 and 4.84% under nonstress and 14.00 and -12.80% under stress, respectively. None of the hybrids showed significant positive standard heterosis in either of the environments. However, seven hybrids in each environment showed significant positive heterosis over mid parent. CM 111 x 9202B, Hyd Sel 2 x NEI 9202B, Hyd Sel 7 x NEI 9202B and KDMI 15 x NEI 9202B recorded significant positive heterosis over mid parent under both the environments.

4.2.2.15 Grain yield (kg/ha)

Among the 66 hybrids tested and over two seasons, CM 111 x Hyd Sel 7 (4178.68 kg/ha) and CM 111 x NEI 9202B (8876.75 kg/ha) recorded the lowest and highest grain yield, respectively with an overall mean of 6897.09 (kg/ha) under nonstress. Under stress, Hyd Sel 7 x Hyd Sel 10 (1765.90 kg/ha) and Hyd Sel 15 x Hyd Sel 17 (4179.10 kg/ha) recorded lowest and highest grain yields. The overall mean of hybrids was 2964.3 kg (about 57% less yield under stress).

The average heterosis over midparent and check was 17.08 and -15.18% under nonstress and 31.76 and -27.65% under stress, respectively. None of the hybrids showed significant positive standard heterosis for grain yield in either of the environments. However, 15 hybrids under nonstress and 21 hybrids under stress recorded significant positive heterosis over mid parent. Ten hybrids viz., CM 111 x CI 4, CM 111 x NEI 9202B, Hyd Sel 2 x NEI 9202B, Hyd Sel 7 x Hyd Sel 15, Hyd Sel 7 x NEI 9202B, Hyd Sel 10 x Hyd Sel 15, Hyd Sel 10 x NEI 9202B, KDMI 15 x NEI 9202B, Hyd Sel 4 x NEI 9202B and Hyd Sel 15 x NEI 9202B expressed significant positive heterosis over mid parent under both the situations indicating their drought tolerance as well as ability to respond to high input management simultaneously.

4.2.2.16 Relative water content (RWC) at 60 DAS (RWC1) and 90 DAS (RWC2)

The mean value of the hybrids ranged from 0.820 (Hyd Sel 7 x Hyd Sel 17) to 1.03 (Hyd Sel 4 x Hyd Sel 17) with an overall mean of 0.93 under nonstress at 60 DAS. At 90 DAS, it ranged from 0.65 to 1.05 with an overall mean of 0.87 under nonstress. Under stress, the range was 0.79 (Hyd Sel 4 x CI 4) to 1.13 (CM 111 x Hyd Sel 10) at 60 DAS. Whereas, at 90 DAS, it was between 0.55 and 0.87. The mean relative water content of hybrids under stress was 0.91 and 0.71 at 60 DAS and 90 DAS, respectively.

The average heterosis over midparent and check was -0.30 and 2.45% at 60 DAS and -0.79 and -2.14% at 90 DAS, respectively under nonstress. Under stress, the average heterosis over mid parent and check was 2.30 and -0.22% and 5.22 and 1.14% at 60 DAS and 90 DAS, respectively. Hyd Sel 4 x Hyd Sel 17 at 60 DAS recorded significant positive heterosis under nonstress.

Table 17. Per se performance and heterosis for different traits in 12 × 12 half diallel set of hybrids under nonstress and stress situations for 100-grain weight (g) and yield per plant (g)

Hybrids	100-grain weight (g)						Yield per plant (g)					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
CM 111 x HS 2	26.70	9.72	-11.04	16.96	0.34	-20.87*	122.65	22.13	6.42	55.88	18.12	-18.14
CM 111 x HS 7	24.54	10.90	-18.26*	15.41	5.83	-28.11**	95.85	5.79	-16.83	60.81	40.59	-10.93
CM 111 x HS 10	26.00	5.63	-13.40	14.75	-1.16	-31.16**	126.20	21.08	9.50	37.92	-15.21	-44.45**
CM 111 x KDMI 15	25.22	-0.06	-15.98*	16.68	3.95	-22.14*	111.00	8.42	-3.69	56.67	23.47	-16.98
CM 111 x NEI 9208B	26.91	11.94	-10.34	17.07	7.95	-20.34*	117.55	12.81	2.00	65.79	25.61	-3.63
CM 111 x CI 4	25.62	0.38	-14.64	17.73	1.44	-17.26	118.45	6.62	2.78	54.50	1.73	-20.16
CM 111 x CML 446	24.14	-0.35	-19.57*	15.13	-3.68	-29.41**	113.50	-1.15	-1.52	55.05	13.63	-19.36
CM 111 x HS 4	24.08	-14.48*	-19.77*	15.41	-9.83	-28.07**	113.70	-0.61	-1.34	54.02	4.19	-20.87
CM 111 x HS 15	29.74	15.77*	-0.93	16.70	-4.29	-22.09*	137.70	29.72*	19.48	60.13	28.90	-11.92
CM 111 x HS 17	25.50	-1.76	-15.07	16.99	2.42	-20.73*	113.90	10.21	-1.17	68.41	45.96*	0.21
CM 111 x NEI 9202B	26.46	14.46	-11.87	15.91	6.86	-25.77**	133.45	50.41**	15.79	66.84	59.85**	-2.09
HS 2 x HS 7	24.47	-0.63	-18.47*	14.91	-12.04	-30.42**	115.65	19.75	0.35	58.43	18.49	-14.41
HS 2 x HS 10	29.06	7.16	-3.21	18.21	5.13	-15.03	122.90	11.52	6.64	57.24	12.72	-16.15
HS 2 x KDMI 15	27.60	-0.51	-8.06	18.39	-0.29	-14.18	125.00	15.37	8.46	64.00	23.17	-6.25
HS 2 x NEI 9208B	29.93	12.74	-0.31	15.98	-12.22	-25.41**	113.35	2.88	-1.65	50.70	-13.24	-25.74
HS 2 x CI 4	26.39	-5.83	-12.08	17.99	-9.50	-16.07	103.20	-11.85	-10.46	52.94	-11.22	-22.45
HS 2 x CML 446	28.37	6.13	-5.50	18.00	-0.57	-16.02	124.95	3.44	8.42	56.03	2.79	-17.93
HS 2 x HS 4	30.29	-1.23	0.89	18.41	-5.52	-14.07	100.95	-16.14	-12.41	53.51	-7.59	-21.61
HS 2 x HS 15	27.51	-2.43	-8.37	16.66	-16.01	-22.24*	118.45	5.64	2.78	58.18	10.38	-14.78
HS 2 x HS 17	27.90	-1.94	-7.05	14.37	-24.30**	-32.95**	124.35	13.74	7.90	46.38	-12.36	-32.06*
HS 2 x NEI 9202B	29.03	13.31	-3.31	19.67	13.82	-8.21	124.90	31.89*	8.37	74.88	56.41**	9.69
HS 7 x HS 10	22.74	-8.69	-24.26**	15.21	1.55	-29.02**	113.70	13.28	-1.34	49.52	5.99	-27.46
Rajkumar (check)	30.02			21.43			115.25			68.26		
Mean	27.66	1.46	-7.86	17.82	2.01	-16.83	120.83	9.46	4.84	59.52	14.00	-12.80
Range	22.74-	-14.48-	-24.26-	14.37-	-24.30-	-32.95-	95.05-	-16.14-	-17.53-	37.92-	-24.65-	-44.45-
	33.71	15.77	12.28	24.31	24.48	13.43	142.15	50.41	23.34	77.03	59.85	12.84
SEd	2.36	2.04	2.36	1.99	1.72	1.99	16.54	14.32	16.54	10.40	9.01	10.40
CD at 5%	4.65	4.03	4.65	3.92	3.41	3.92	32.68	28.30	32.68	20.55	17.80	20.55
CD at 1%	6.14	5.32	6.14	5.19	4.50	5.19	43.14	37.36	43.14	27.13	23.50	27.13

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 17 contd....

Hybrids	100-grain weight (g)						Yield per plant (g)					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
HS 7 x KDMI 15	25.93	1.59	-13.61	16.58	2.98	-22.61*	110.75	12.41	-3.90	58.96	23.09	-13.63
HS 7 x NEI 9208B	24.59	1.06	-18.08*	16.22	2.21	-24.31**	109.55	9.17	-4.95	63.21	16.26	-7.40
HS 7 x CI 4	25.26	-2.17	-15.87*	18.19	3.73	-15.13	117.70	9.74	2.13	62.56	12.57	-8.36
HS 7 x CML 446	22.92	-6.50	-23.64**	14.81	-6.02	-30.89**	121.05	9.08	5.03	50.40	-0.10	-26.18
HS 7 x HS 4	26.65	-6.33	-11.22	18.54	8.13	-13.48	118.80	7.46	3.08	64.75	20.25	-5.15
HS 7 x HS 15	26.67	2.68	-11.14	16.39	-6.34	-23.52*	129.85	26.93	12.67	61.60	26.63	-9.76
HS 7 x HS 17	24.51	-6.59	-18.34*	20.63	23.98*	-3.73	95.05	-4.47	-17.53	62.03	26.95	-9.13
HS 7 x NEI 9202B	22.74	-2.84	-24.24**	15.45	3.41	-27.91**	125.10	47.39**	8.55	68.46	56.24**	0.28
HS 10 x KDMI 15	27.64	-1.33	-7.93	18.31	11.14	-14.57	120.30	7.27	4.38	51.73	4.77	-24.23
HS 10 x NEI 9208B	27.32	1.88	-8.99	18.37	13.14	-14.28	118.95	4.36	3.21	58.61	4.95	-14.15
HS 10 x CI 4	29.38	3.80	-2.14	18.92	5.71	-11.7	132.20	9.37	14.71	55.77	-2.24	-18.31
HS 10 x CML 446	29.33	8.61	-2.31	17.64	9.40	-17.68	122.15	-1.97	5.99	60.73	16.98	-11.03
HS 10 x HS 4	31.57	2.06	5.18	19.65	12.20	-8.3	127.95	3.04	11.02	56.53	2.19	-17.19
HS 10 x HS 15	30.26	6.31	0.80	18.97	6.16	-11.49	142.15	22.62	23.34	57.32	14.36	-16.04
HS 10 x HS 17	28.73	0.01	-4.29	15.92	-6.40	-25.71**	118.25	4.53	2.60	60.74	20.68	-11.02
HS 10 x NEI 9202B	27.32	5.52	-8.99	15.23	-0.51	-28.93**	135.95	38.02**	17.96	56.45	24.65	-17.31
KDMI 15 x NEI 9208B	28.64	4.36	-4.59	18.03	3.85	-15.87	131.60	17.37	14.19	59.03	3.51	-13.54
KDMI 15 x CI 4	27.84	-3.76	-7.26	20.06	5.45	-6.38	119.55	0.44	3.73	64.39	10.59	-5.68
KDMI 15 x CML 446	27.81	0.66	-7.35	18.68	8.28	-12.83	128.90	5.01	11.84	60.08	13.15	-11.99
KDMI 15 x HS 4	27.20	-13.82*	-9.39	19.64	5.36	-8.35	104.30	-14.74	-9.50	60.70	7.43	-11.09
KDMI 15 x HS 15	27.82	-4.36	-7.32	18.41	-3.05	-14.08	114.35	0.24	-0.78	68.38	33.30	0.16
KDMI 15 x HS 17	28.56	-2.70	-4.86	20.50	13.07	-4.33	108.80	-2.22	-5.60	57.36	11.34	-15.98
Rajkumar (check)	30.02			21.43			115.25			68.26		
Mean	27.66	1.46	-7.86	17.82	2.01	-16.83	120.83	9.46	4.84	59.52	14.00	-12.80
Range	22.74-33.71	-14.48-15.77	-24.26-12.28	14.37-24.31	-24.30-24.48	-32.95-13.43	95.05-142.15	-16.14-50.41	-17.53-23.34	37.92-77.03	-24.65-59.85	-44.45-12.84
SEd	2.36	2.04	2.36	1.99	1.72	1.99	16.54	14.32	16.54	10.40	9.01	10.40
CD at 5%	4.65	4.03	4.65	3.92	3.41	3.92	32.68	28.30	32.68	20.55	17.80	20.55
CD at 1%	6.14	5.32	6.14	5.19	4.50	5.19	43.14	37.36	43.14	27.13	23.50	27.13

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 17 contd....

Hybrids	100-grain weight (g)						Yield per plant (g)					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
KDMI 15 x NEI 9202B	26.66	0.53	-11.20	16.56	0.81	-22.70*	135.25	39.94**	17.35	69.31	49.17*	1.53
NEI 9208B x CI 4	28.58	3.06	-4.79	17.91	-4.67	-16.42	129.95	7.53	12.75	67.35	4.10	-1.35
NEI 9208B x CML 446	27.23	3.00	-9.30	16.44	-3.39	-23.30*	130.00	4.35	12.80	53.05	-10.95	-22.29
NEI 9208B x HS 4	30.11	-0.85	0.30	16.50	-10.37	-23.02*	129.95	4.67	12.75	47.45	-24.65	-30.50*
NEI 9208B x HS 15	30.35	8.81	1.12	20.68	10.24	-3.51	135.35	16.78	17.44	77.03	33.34*	12.84
NEI 9208B x HS 17	28.10	-0.20	-6.39	18.45	3.09	-13.91	112.75	-0.31	-2.17	58.07	0.13	-14.94
NEI 9208B x NEI 9202B	23.40	-7.58	-22.05**	15.50	-4.28	-27.66**	109.60	11.30	-4.90	55.22	4.32	-19.11
CI 4 x CML 446	29.12	4.30	-3.00	19.04	1.94	-11.14	129.10	-1.81	12.02	69.96	15.12	2.49
CI 4 x HS 4	32.39	1.69	7.90	22.84	13.79	6.57	128.00	-2.33	11.06	64.17	0.00	-6.00
CI 4 x HS 15	28.97	-1.40	-3.51	19.23	-5.85	-10.28	140.45	14.37	21.87	62.81	6.51	-7.99
CI 4 x HS 17	27.32	-7.85	-9.00	18.59	-4.97	-13.25	119.55	-0.38	3.73	55.14	-6.83	-19.22
CI 4 x NEI 9202B	28.87	7.70	-3.83	16.81	-5.87	-21.55*	123.85	17.53	7.46	63.52	17.33	-6.95
CML 446 x HS 4	27.57	-9.77	-8.17	18.00	-1.63	-16.02	120.85	-10.33	4.86	52.07	-11.81	-23.72
CML 446 x HS 15	29.59	5.37	-1.43	18.25	-2.11	-14.83	125.65	-0.69	9.02	52.99	-1.60	-22.38
CML 446 x HS 17	30.29	6.88	0.92	20.59	15.75	-3.93	117.80	-4.79	2.21	57.48	6.32	-15.80
CML 446 x NEI 9202B	28.20	10.56	-6.06	17.44	8.42	-18.62*	132.40	21.36	14.88	65.08	32.77	-4.67
HS 4 x HS 15	33.71	5.29	12.28	22.58	12.68	5.36	109.50	-13.16	-4.99	65.09	13.70	-4.66
HS 4 x HS 17	31.96	-1.00	6.45	20.88	8.87	-2.58	116.05	-5.88	0.69	60.84	5.87	-10.88
HS 4 x NEI 9202B	28.61	-2.83	-4.71	18.25	4.43	-14.84	122.15	12.40	5.99	69.08	31.80	1.19
HS 15 x HS 17	32.15	7.88	7.11	24.31	24.48**	13.43	123.05	6.95	6.77	62.96	20.47	-7.77
HS 15 x NEI 9202B	26.67	-1.12	-11.17	18.50	3.79	-13.66	131.25	30.69*	13.88	66.08	39.96*	-3.21
HS 17 x NEI 9202B	28.71	5.44	-4.35	17.24	1.62	-19.54*	107.45	10.06	-6.77	56.57	19.27	-17.13
Rajkumar (check)	30.02			21.43			115.25			68.26		
Mean	27.66	1.46	-7.86	17.82	2.01	-16.83	120.83	9.46	4.84	59.52	14.00	-12.80
Range	22.74- 33.71	-14.48- 15.77	-24.26- 12.28	14.37- 24.31	-24.30- 24.48	-32.95- 13.43	95.05- 142.15	-16.14- 50.41	-17.53- 23.34	37.92- 77.03	-24.65- 59.85	-44.45- 12.84
SEd	2.36	2.04	2.36	1.99	1.72	1.99	16.54	14.32	16.54	10.40	9.01	10.40
CD at 5%	4.65	4.03	4.65	3.92	3.41	3.92	32.68	28.30	32.68	20.55	17.80	20.55
CD at 1%	6.14	5.32	6.14	5.19	4.50	5.19	43.14	37.36	43.14	27.13	23.50	27.13

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Table 18. Per se performance and heterosis for different traits in 12 x 12 half diallel set of hybrids under nonstress and stress situations for yield (kg/ha) and relative water content at 60 days

Hybrids	Yield (kg/ha)						Relative water content at 60 days					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
CM 111 x HS 2	6243.75	31.80	-23.21*	2539.6	18.54	-38.02**	0.92	-0.94	1.65	0.89	3.78	-2.19
CM 111 x HS 7	4178.68	1.80	-48.61**	2859.0	55.67*	-30.22*	0.98	5.69	7.44	0.92	9.33	1.10
CM 111 x HS 10	5723.68	23.49	-29.61*	1960.1	0.39	-52.16**	0.91	-0.82	-0.28	1.13	35.74**	23.84**
CM 111 x KDMI 15	5489.40	6.81	-32.49**	2936.4	22.10	-28.33*	0.93	1.22	2.75	0.90	7.65	-1.64
CM 111 x NEI 9208B	6551.43	25.63	-19.43	3702.5	43.41*	-9.63	0.94	2.59	3.58	0.92	8.08	0.82
CM 111 x CI 4	7561.93	49.17**	-7.00	3958.5	58.88**	-3.39	0.93	-3.62	2.75	0.94	9.04	2.47
CM 111 x CML 446	6522.25	17.03	-19.79	2608.8	35.92	-36.33**	0.93	0.00	2.48	0.92	7.27	1.10
CM 111 x HS 4	5178.83	0.88	-36.31**	2718.2	12.76	-33.66**	0.94	1.22	3.03	0.92	7.47	0.55
CM 111 x HS 15	7797.58	55.54**	-4.10	2853.6	43.03	-30.35*	0.94	1.08	3.31	0.87	1.75	-4.38
CM 111 x HS 17	5731.58	20.97	-29.51*	3376.7	57.27**	-17.59	0.94	2.46	3.31	0.90	5.87	-1.10
CM 111 x NEI 9202B	8876.75	102.08**	9.17	3238.3	65.71**	-20.97	0.93	0.27	2.75	0.92	10.68	0.82
HS 2 x HS 7	6263.35	19.77	-22.97	3060.0	56.64*	-25.32*	0.92	-1.74	1.10	0.92	1.79	1.10
HS 2 x HS 10	5825.50	1.14	-28.36*	2899.5	40.13	-29.23*	0.92	-0.41	1.38	0.91	1.68	-0.27
HS 2 x KDMI 15	7457.00	19.04	-8.29	2990.4	18.58	-27.02*	0.93	0.00	2.75	0.93	3.21	1.37
HS 2 x NEI 9208B	6939.50	9.46	-14.65	2247.8	-16.71	-45.14**	0.95	1.89	4.13	0.88	-3.69	-3.56
HS 2 x CI 4	6174.43	-0.32	-24.06*	2539.9	-2.63	-38.01**	0.94	-4.47	3.03	0.91	-1.63	-0.82
HS 2 x CML 446	6807.08	1.63	-16.28	2708.0	33.00	-33.91**	0.96	1.99	5.79	0.92	-0.27	0.82
HS 2 x HS 4	5607.33	-10.40	-31.04**	2507.8	-0.78	-38.79**	0.93	-0.27	2.75	0.93	1.50	1.92
HS 2 x HS 15	6562.58	6.92	-19.29	2699.1	27.80	-34.12**	0.93	-1.46	1.93	0.92	-0.54	0.27
HS 2 x HS 17	7811.15	33.23*	-3.93	2035.8	-10.08	-50.31**	0.93	0.40	2.48	0.90	-2.19	-1.92
HS 2 x NEI 9202B	7267.50	31.71*	-10.62	3766.0	81.85**	-8.08	0.94	-0.40	3.31	0.92	3.22	1.10
HS 7 x HS 10	5995.18	16.93	-26.27*	1765.9	0.14	-56.90**	0.94	2.19	3.03	0.87	-1.00	-4.66
Rajkumar (check)	8131.10			4097.25			0.91		0.91			
Mean	6897.09	17.08	-15.18	2964.3	31.76	-27.65	0.93	-0.30	2.45	0.91	2.30	-0.22
Range	4178.68-8876.75	-18.30-102.08	-48.61-9.17	1765.9-4179.1	-16.71-97.43	-56.96-2.00	0.82-1.03	-10.90-12.38	-9.92-13.77	0.79-1.13	-13.35-35.74	-13.42-23.84
SEd	952.24	824.66	952.24	524.1	453.91	524.1	0.058	0.050	0.058	0.066	0.057	0.066
CD at 5%	1881.13	1629.11	1881.13	1035.4	896.69	1035.4	0.114	0.099	0.114	0.130	0.113	0.130
CD at 1%	2483.58	2150.84	2483.58	1367.0	1183.86	1367.0	0.151	0.130	0.151	0.172	0.149	0.172

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 18 contd....

Hybrids	Yield (kg/ha)						Relative water content at 60 days					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
HS 7 x KDMI 15	5732.25	1.78	-29.50*	2879.8	29.96	-29.71*	0.91	-1.22	0.55	0.89	1.42	-2.19
HS 7 x NEI 9208B	6204.43	8.71	-23.69*	3010.0	25.79	-26.54*	0.93	0.68	1.93	0.91	0.84	-0.82
HS 7 x CI 4	7004.00	25.93	-13.86	2713.2	17.83	-33.78**	0.91	-6.19	0.28	0.91	0.14	-0.82
HS 7 x CML 446	6945.50	14.51	-14.58	2200.2	27.14	-46.30**	0.95	1.34	4.13	0.93	2.07	1.37
HS 7 x HS 4	7328.33	30.26*	-9.87	3064.8	37.94	-25.2	0.95	2.02	4.13	0.89	-0.83	-2.19
HS 7 x HS 15	7424.50	34.86*	-8.69	3183.4	76.24**	-22.3	0.95	1.88	4.41	0.92	1.52	0.55
HS 7 x HS 17	5325.93	1.82	-34.50**	3024.2	54.44*	-26.19*	0.82	-10.90*	-9.92	0.90	-0.42	-1.92
HS 7 x NEI 9202B	7427.85	52.05**	-8.65	3308.2	87.41**	-19.26	0.95	1.34	4.13	0.92	4.56	0.55
HS 10 x KDMI 15	6952.25	12.82	-14.50	2873.0	23.21	-29.88*	0.94	2.87	3.58	0.93	7.05	1.92
HS 10 x NEI 9208B	8130.43	30.35*	-0.01	2535.8	1.08	-38.11**	0.92	0.69	0.83	0.90	0.99	-1.92
HS 10 x CI 4	7421.25	21.82	-8.73	2505.7	3.61	-38.84**	0.93	-3.13	2.48	0.79	-11.48	-13.42
HS 10 x CML 446	6860.50	4.02	-15.63	2788.8	51.05*	-31.94*	0.91	-1.08	0.55	0.91	1.68	-0.27
HS 10 x HS 4	6453.68	4.83	-20.63	2945.2	25.99	-28.12*	0.93	1.77	2.75	0.88	-1.55	-4.11
HS 10 x HS 15	8113.68	34.43*	-0.21	3005.1	56.35*	-26.66*	0.94	2.45	3.86	0.91	1.96	-0.27
HS 10 x HS 17	6666.58	15.72	-18.01	2335.9	12.63	-42.99**	0.93	2.75	2.75	0.91	2.82	0.00
HS 10 x NEI 9202B	8248.65	52.32**	1.45	2981.8	58.52*	-27.23*	0.93	0.81	2.48	0.91	5.05	-0.27
KDMI 15 x NEI 9208B	8207.83	21.74	0.94	2657.8	-10.25	-35.13**	0.93	0.82	1.93	0.90	1.41	-1.37
KDMI 15 x CI 4	6913.58	4.81	-14.97	3418.4	19.07	-16.57	0.93	-4.26	2.20	0.96	7.41	5.21
KDMI 15 x CML 446	7145.50	0.64	-12.12	2792.3	21.47	-31.85*	0.94	0.67	3.31	0.93	3.49	1.64
KDMI 15 x HS 4	5441.83	-18.30	-33.07**	3183.8	14.11	-22.3	0.93	0.00	1.93	0.90	0.56	-1.92
KDMI 15 x HS 15	5842.85	-10.66	-28.14*	3879.5	63.38**	-5.31	0.92	-1.21	1.10	0.92	3.22	1.10
KDMI 15 x HS 17	5376.25	-14.19	-33.88**	2495.7	-1.22	-39.09**	0.92	0.41	1.38	0.91	2.11	-0.55
Rajkumar (check)	8131.10			4097.25			0.91		0.91			
Mean	6897.09	17.08	-15.18	2964.3	31.76	-27.65	0.93	-0.30	2.45	0.91	2.30	-0.22
Range	4178.68- 8876.75	-18.30- 102.08	-48.61- 9.17	1765.9- 4179.1	-16.71- 97.43	-56.96- 2.00	0.82- 1.03	-10.90- 12.38	-9.92- 13.77	0.79- 1.13	-13.35- 35.74	-13.42- 23.84
SEd	952.24	824.66	952.24	524.1	453.91	524.1	0.058	0.050	0.058	0.066	0.057	0.066
CD at 5%	1881.13	1629.11	1881.13	1035.4	896.69	1035.4	0.114	0.099	0.114	0.130	0.113	0.130
CD at 1%	2483.58	2150.84	2483.58	1367.0	1183.86	1367.0	0.151	0.130	0.151	0.172	0.149	0.172

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 18 contd....

Hybrids	Yield (kg/ha)						Relative water content at 60 days					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
KDMI 15 x NEI 9202B	8858.83	49.64**	8.95	4013.6	72.00**	-2.04	0.93	-0.40	2.20	0.93	6.92	1.64
NEI 9208B x CI 4	7924.68	18.78	-2.54	3376.6	10.79	-17.59	0.95	-1.95	4.13	0.92	1.23	1.10
NEI 9208B x CML 446	7786.93	8.52	-4.23	2351.3	-5.02	-42.61**	0.94	1.75	3.86	0.92	0.96	1.10
NEI 9208B x HS 4	7491.50	11.21	-7.87	2591.7	-12.65	-36.75**	0.94	2.17	3.58	0.87	-4.41	-4.93
NEI 9208B x HS 15	8092.43	22.32	-0.48	3961.7	55.27**	-3.31	0.93	0.41	2.20	0.92	0.96	0.82
NEI 9208B x HS 17	6680.68	5.36	-17.84	3406.0	25.99	-16.87	0.92	0.96	1.38	0.89	-1.79	-2.47
NEI 9208B x NEI 9202B	5603.00	-6.54	-31.09**	2754.7	9.73	-32.77*	0.94	0.94	3.03	0.92	3.67	0.55
CI 4 x CML 446	8627.40	22.72	6.10	3547.7	48.73*	-13.41	0.94	-3.84	3.58	0.93	0.82	1.64
CI 4 x HS 4	7100.68	7.74	-12.67	3721.8	29.38	-9.16	0.92	-5.02	1.65	0.91	-0.96	-0.82
CI 4 x HS 15	7316.08	13.08	-10.02	2931.5	19.11	-28.45*	0.93	-4.36	2.75	0.80	-13.35*	-12.88
CI 4 x HS 17	6540.43	5.57	-19.56	2981.0	14.08	-27.24*	0.93	-3.64	2.20	0.92	0.55	0.55
CI 4 x NEI 9202B	7691.00	31.47*	-5.41	2934.4	21.25	-28.38*	0.95	-3.32	4.13	0.94	5.47	3.01
CML 446 x HS 4	6926.25	-2.37	-14.82	2914.5	26.47	-28.87*	0.92	-2.01	0.83	0.90	-2.05	-1.64
CML 446 x HS 15	7370.00	5.68	-9.36	2977.8	57.64*	-27.32*	0.93	-1.07	2.20	0.90	-2.17	-1.37
CML 446 x HS 17	5937.08	-11.37	-26.98*	2691.5	31.88	-34.31**	0.88	-5.14	-3.31	0.90	-1.37	-1.10
CML 446 x NEI 9202B	8645.68	36.08**	6.33	2686.6	45.38	-34.43**	0.93	-1.06	2.48	0.91	1.82	-0.27
HS 4 x HS 15	7042.25	7.77	-13.39	3400.0	42.84*	-17.02	0.91	-2.01	0.55	0.91	-0.14	0.00
HS 4 x HS 17	6633.83	5.98	-18.41	2876.2	13.58	-29.80*	1.03	12.38*	13.77*	0.89	-2.06	-2.47
HS 4 x NEI 9202B	8625.93	45.85**	6.09	3741.0	59.92**	-8.69	0.93	-0.40	2.48	0.96	7.61	4.66
HS 15 x HS 17	6159.18	0.33	-24.25*	4179.1	97.43**	2.00	0.91	-1.90	-0.28	0.90	-1.92	-1.92
HS 15 x NEI 9202B	7747.50	33.72*	-4.72	3339.8	73.61**	-18.49	0.92	-1.87	1.38	0.95	6.31	3.84
HS 17 x NEI 9202B	6672.50	20.91	-17.94	2512.9	21.06	-38.67**	0.93	0.00	1.93	0.91	2.68	-0.27
Rajkumar (check)	8131.10			4097.25			0.91		0.91			
Mean	6897.09	17.08	-15.18	2964.3	31.76	-27.65	0.93	-0.30	2.45	0.91	2.30	-0.22
Range	4178.68- 8876.75	-18.30- 102.08	-48.61- 9.17	1765.9- 4179.1	-16.71- 97.43	-56.96- 2.00	0.82- 1.03	-10.90- 12.38	-9.92- 13.77	0.79- 1.13	-13.35- 35.74	-13.42- 23.84
SEd	952.24	824.66	952.24	524.1	453.91	524.1	0.058	0.050	0.058	0.066	0.057	0.066
CD at 5%	1881.13	1629.11	1881.13	1035.4	896.69	1035.4	0.114	0.099	0.114	0.130	0.113	0.130
CD at 1%	2483.58	2150.84	2483.58	1367.0	1183.86	1367.0	0.151	0.130	0.151	0.172	0.149	0.172

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Whereas, at 90 DAS, none of the hybrids showed significant positive standard heterosis. Under stress, CM 111 x Hyd Sel 10 (at 60 DAS) and NEI 9208B x NEI 9202B (at 90 DAS) recorded significant positive standard heterosis.

4.2.2.17 Chlorophyll content (mg/cm²) at 60 DAS (CHL1) and 90 DAS (CHL2)

The mean chlorophyll content among hybrids ranged from 42.20 (CML 446 x Hyd Sel 2) to 53.98 (Hyd Sel 2 x KDMI 15) at 60 DAS and 37.33 (Hyd Sel 10 x Hyd Sel 4) to 51.90 (NEI 9208B x Hyd Sel 4) at 90 DAS, respectively under nonstress. The overall mean of hybrids at 60 DAS and 90 DAS was 49.53 and 47.00, respectively.

Under stress, Hyd Sel 10 x NEI 9202B (36.55) and CM 111 x Hyd Sel 17 (50.60) at 60 DAS and Hyd Sel 2 x Hyd Sel 15 (23.47) and Hyd Sel 4 x Hyd Sel 15 (37.00) at 90 DAS recorded lowest and highest chlorophyll values, respectively. The mean chlorophyll content of hybrids was 43.93 and 30.06 at 60 DAS and 90 DAS, respectively.

Hyd Sel 2 x Hyd Sel 15 recorded significant positive heterosis over check at both the stages under nonstress. But it recorded lowest chlorophyll content at 90 DAS under stress. Hyd Sel 4 x NEI 9202B recorded significant positive heterosis over mid parent at both the stages under nonstress, while Hyd Sel 4 x Hyd Sel 15 recorded significant positive standard heterosis at 90 DAS.

4.2.2.18 Drought susceptibility Index (DSI)

The mean DSI values among hybrids ranged from 0.74 (Hyd Sel 7 x Hyd Sel 17) to 1.44 (CM 111 x Hyd Sel 10) with an overall mean of 1.03. The mean heterosis over mid parent and check was -4.31 and 24.39, respectively. None of the hybrids showed significant negative (desirable) heterosis over mid parent or check.

4.2.3 Combining ability analysis

ANOVA for combining ability of 12 x 12 half diallel set of hybrids evaluated over two seasons under stress and nonstress environments is presented in Table 21.

From Table 21, it is evident that the variance due to GCA and SCA were significant for all the traits except days to maturity (nonsignificant SCA), kernels per row (nonsignificant SCA), cobs per plant (nonsignificant SCA), RWC1 (both GCA and SCA were nonsignificant) and CHL1 (nonsignificant SCA) under nonstress, indicating the importance of both additive and nonadditive gene action in controlling the traits. Whereas, they were nonsignificant for days to maturity (nonsignificant SCA), number of kernel rows per cob (nonsignificant SCA), RWC1 (nonsignificant GCA), CHL2 (nonsignificant GCA) and DSI (nonsignificant SCA) under stress. Variance due to GCA alone was significant for days to maturity under both the situations indicating the importance of additive gene action in controlling the trait.

The magnitude of GCA variance was greater than SCA variance for all the traits under both the situations except RWC1 and CHL2 under stress indicating predominance of additive variance in controlling the expression of these traits. The magnitude of SCA variance was greater than GCA for RWC1 and CHL2 under stress indicating predominance of nonadditive (dominance) variance in controlling the expression of these two traits. For RWC1 under nonstress, GCA and SCA variances were equally important for its expression.

4.2.4. Combining ability effects

4.2.4.1 General Combining Ability (gca) effects

The general combining ability (gca) effect were estimated for 12 parents under stress and nonstress conditions and the results are presented in Table 22.

4.2.4.1.1 Plant height (cm)

Among the 12 parents, five parents recorded significant negative gca effects and three parents viz., NEI 9208B, CML 446 and NEI 9202B recorded significant positive gca effects for the trait under nonstress. Under stress also, CML 446 and NEI 9208B recorded significant positive gca effects for plant height indicating their good combining ability for the trait.

Table 19. *Per se* performance and heterosis for different traits in 12 × 12 half diallel set of hybrids under nonstress and stress situations for relative water content at 90 days and chlorophyll content at 60 days

Hybrids	Relative water content at 90 days						Chlorophyll content at 60 days					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
CM 111 x HS 2	0.86	-3.11	4.57	0.76	28.45*	7.69	51.11	-0.42	8.17	45.08	1.52	1.35
CM 111 x HS 7	0.82	-7.12	-0.61	0.72	14.8	2.42	48.98	-3.28	3.65	48.75	10.95	9.61
CM 111 x HS 10	0.85	-4.37	3.35	0.76	14.09	8.12	47.78	-2.40	1.11	39.55	-4.27	-11.07
CM 111 x KDMI 15	0.83	-4.73	1.22	0.69	-3.45	-1.82	51.33	0.07	8.62	45.45	5.42	2.19
CM 111 x NEI 9208B	0.87	-2.12	5.79	0.65	-4.08	-7.97	51.70	4.89	9.42	47.10	18.12*	5.90
CM 111 x CI 4	0.86	-3.93	4.27	0.78	21.50*	11.46	48.25	-4.48	2.12	46.68	10.87	4.95
CM 111 x CML 446	0.91	1.54	10.37	0.71	2.56	1.42	45.58	-7.88	-3.54	39.73	0.47	-10.68
CM 111 x HS 4	0.82	-5.19	0.30	0.61	-6.97	-12.85	47.85	-7.36	1.27	46.20	5.72	3.88
CM 111 x HS 15	0.87	-1.56	5.49	0.74	2.34	5.80	49.60	-1.95	4.97	44.05	8.60	-0.96
CM 111 x HS 17	0.90	-0.14	10.06	0.68	-0.17	-3.45	50.20	1.67	6.24	50.60	23.26**	13.77
CM 111 x NEI 9202B	0.87	-2.25	6.10	0.72	4.17	2.31	50.58	8.01	7.04	46.05	20.67*	3.54
HS 2 x HS 7	0.90	1.99	9.45	0.73	31.27**	4.17	48.98	-6.69	3.65	46.50	0.95	4.55
HS 2 x HS 10	0.86	-3.52	4.57	0.64	7.92	-8.37	52.48	3.30	11.06	44.05	1.41	-0.96
HS 2 x KDMI 15	0.82	-6.72	-0.61	0.63	-1.61	-9.65	53.98	1.58	14.23*	45.93	1.52	3.26
HS 2 x NEI 9208B	0.88	-1.27	7.01	0.66	9.26	-5.95	53.23	4.08	12.65	44.65	6.31	0.39
HS 2 x CI 4	0.88	-1.12	7.62	0.71	22.61*	0.39	49.50	-5.47	4.76	44.03	-0.45	-1.01
HS 2 x CML 446	0.85	-5.45	3.05	0.75	19.23	6.16	51.18	-0.29	8.31	44.68	7.23	0.45
HS 2 x HS 4	0.88	0.86	7.01	0.72	21.98	2.24	50.75	-5.14	7.41	48.93	6.76	10.01
HS 2 x HS 15	0.84	-4.68	2.44	0.62	-5.06	-11.21	53.60	2.22	13.44*	50.33	17.89*	13.15
HS 2 x HS 17	0.83	-8.14	1.52	0.78	28.10**	11.25	51.25	0.05	8.47	44.00	1.91	-1.07
HS 2 x NEI 9202B	0.89	-0.56	8.23	0.57	-8.54	-19.19	51.53	5.86	9.05	45.65	13.31	2.64
HS 7 x HS 10	0.83	-1.72	-7.30	0.63	-0.95	-10.57	46.35	-1.60	-11.47*	43.58	1.40	-2.02
Rajkumar (check)	0.82			0.70			47.25			44.48		
Mean	0.87	-0.79	-2.14	0.71	5.22	1.14	49.53	0.51	-3.82	43.93	7.12	-1.22
Range	0.65-1.05	-15.70-10.67	-21.62-10.37	0.55-0.87	-20.59-31.27	-21.54-23.18	42.20-53.98	-9.23-17.77	-18.30-14.23	36.55-50.60	-6.74-23.26	-17.82-13.77
SEd	0.051	0.044	0.051	0.076	0.066	0.076	3.10	2.69	3.10	3.838	3.324	3.838
CD at 5%	0.100	0.087	0.100	0.150	0.129	0.150	6.13	5.31	6.13	7.582	6.566	7.582
CD at 1%	0.132	0.115	0.132	0.197	0.171	0.197	8.09	7.01	8.09	10.01	8.669	10.01

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS Hyd Sel

Contd.....

Table 19 contd....

Hybrids	Relative water content at 90 days						Chlorophyll content at 60 days					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
HS 7 x KDMI 15	0.84	0.00	-7.03	0.69	1.56	-1.28	49.60	-2.56	-6.22	46.90	4.75	5.45
HS 7 x NEI 9208B	0.86	-1.72	-7.30	0.69	7.2	-1.96	46.65	0.15	-8.64	40.48	-2.56	-8.99
HS 7 x CI 4	0.89	-0.29	-5.95	0.71	16.16	1.35	47.35	-6.55	-10.50	43.50	-0.60	-2.19
HS 7 x CML 446	0.83	-4.01	-9.46	0.76	14.03	7.65	46.85	-1.01	-9.01	38.43	-6.74	-13.60
HS 7 x HS 4	0.82	-3.23	-10.81	0.55	-12.03	-21.54*	49.15	-1.83	-5.53	44.13	-2.73	-0.79
HS 7 x HS 15	0.87	-3.72	-9.19	0.71	2.2	1.07	50.50	-0.63	-4.55	45.78	8.41	2.92
HS 7 x HS 17	0.93	-0.29	-5.95	0.72	10.91	2.28	48.35	-2.18	-10.45	42.28	-1.02	-4.95
HS 7 x NEI 9202B	0.83	-2.01	-7.57	0.68	2.96	-3.49	45.50	8.32	-11.10	45.58	14.44	2.47
HS 10 x KDMI 15	0.65	-15.70**	-21.62**	0.72	-0.05	2.71	47.00	2.53	-7.76	42.88	1.72	-3.60
HS 10 x NEI 9208B	0.90	-2.81	-6.49	0.70	2.79	-0.28	48.15	-1.29	-11.19	37.10	-4.66	-16.58
HS 10 x CI 4	0.83	-5.06	-8.65	0.78	19.26	10.68	46.10	-3.36	-13.05*	43.73	6.29	-1.69
HS 10 x CML 446	0.89	-0.28	-4.05	0.74	4.74	4.70	44.15	-3.20	-12.91*	39.40	2.14	-11.41
HS 10 x HS 4	0.81	-1.17	-8.92	0.75	12.72	6.80	44.85	0.88	-9.24	45.20	5.76	1.63
HS 10 x HS 15	0.92	0.86	-4.59	0.72	-1.19	3.20	48.45	2.94	-7.39	44.15	11.49	-0.73
HS 10 x HS 17	0.88	-2.81	-6.49	0.71	3.88	1.57	46.00	-0.10	-10.13	42.23	5.33	-5.06
HS 10 x NEI 9202B	0.76	-8.99	-12.43*	0.72	3.55	2.81	42.85	-0.45	-18.30**	36.55	-1.75	-17.82*
KDMI 15 x NEI 9208B	0.78	-4.65	-11.35*	0.69	-4.81	-1.07	50.90	3.97	-5.16	45.05	10.65	1.29
KDMI 15 x CI 4	0.82	-2.03	-8.92	0.71	1.55	1.28	50.50	2.33	-2.00	45.90	6.90	3.20
KDMI 15 x CML 446	0.89	4.36	-2.97	0.69	-7.71	-1.35	50.70	-0.96	-8.96	43.20	7.00	-2.87
KDMI 15 x HS 4	0.89	4.11	-4.05	0.70	-2.63	-1.00	51.65	1.55	0.19	46.95	5.42	5.56
KDMI 15 x HS 15	0.82	-1.45	-8.38	0.63	-19.00*	-9.79	49.10	-3.24	-7.06	49.25	18.96*	10.74
KDMI 15 x HS 17	0.88	3.49	-3.78	0.64	-13.16	-9.08	50.25	4.77	-4.09	47.55	13.52	6.91
Rajkumar (check)	0.82			0.70			47.25			44.48		
Mean	0.87	-0.79	-2.14	0.71	5.22	1.14	49.53	0.51	-3.82	43.93	7.12	-1.22
Range	0.65-1.05	-15.70-10.67	-21.62-10.37	0.55-0.87	-20.59-31.27	-21.54-23.18	42.20-53.98	-9.23-17.77	-18.30-14.23	36.55-50.60	-6.74-23.26	-17.82-13.77
SEd	0.051	0.044	0.051	0.076	0.066	0.076	3.10	2.69	3.10	3.838	3.324	3.838
CD at 5%	0.100	0.087	0.100	0.150	0.129	0.150	6.13	5.31	6.13	7.582	6.566	7.582
CD at 1%	0.132	0.115	0.132	0.197	0.171	0.197	8.09	7.01	8.09	10.01	8.669	10.01

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 19 contd....

Hybrids	Relative water content at 90 days						Chlorophyll content at 60 days					
	Nonstress			Stress			Nonstress			Stress		
	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc	Mean	Hmp	Hcc
KDMI 15 x NEI 9202B	0.89	5.81	-1.62	0.66	-11.28	-5.77	46.00	3.57	-15.00*	42.40	8.72	-4.67
NEI 9208B x CI 4	0.85	-2.25	-5.95	0.77	17.05	10.00	48.65	0.00	-8.78	41.50	4.53	-6.69
NEI 9208B x CML 446	0.90	1.12	-2.70	0.74	3.73	4.91	46.75	-0.66	-9.38	40.45	8.92	-9.05
NEI 9208B x HS 4	0.90	5.87	-2.43	0.65	-3.88	-7.80	49.85	7.28	-2.14	43.43	5.15	-2.36
NEI 9208B x HS 15	0.86	0.29	-5.14	0.74	-0.44	5.16	45.55	-3.72	-12.17*	46.93	22.96**	5.51
NEI 9208B x HS 17	0.95	5.62	1.62	0.78	12.72	11.53	49.40	2.44	-6.55	44.48	15.07	0.00
NEI 9208B x NEI 9202B	1.05	10.67	6.49	0.87	22.61*	23.18*	44.55	4.58	-14.17*	41.65	16.46	-6.35
CI 4 x CML 446	0.90	0.00	-2.97	0.75	10.58	7.19	47.50	1.21	-6.97	42.85	8.86	-3.65
CI 4 x HS 4	0.87	2.93	-5.14	0.75	16.75	7.08	51.64	1.40	-2.89	46.75	7.41	5.12
CI 4 x HS 15	0.89	2.29	-3.24	0.75	5.79	7.30	51.61	-0.04	-4.26	44.88	11.11	0.90
CI 4 x HS 17	0.87	-1.95	-4.86	0.73	9	3.28	47.20	-2.28	-10.54	45.20	10.58	1.63
CI 4 x NEI 9202B	0.87	-0.56	-3.51	0.69	1.52	-2.28	46.70	5.94	-13.05*	39.73	4.57	-10.68
CML 446 x HS 4	0.86	3.52	-4.59	0.80	14.78	13.49	42.20	-4.24	-11.98*	42.95	4.85	-3.43
CML 446 x HS 15	0.91	5.71	0.00	0.61	-20.59*	-13.78	46.55	-3.08	-10.92	42.48	12.29	-4.50
CML 446 x HS 17	0.91	0.00	-2.70	0.75	4.94	6.94	45.35	-9.23	-16.91**	38.33	0.03	-13.83
CML 446 x NEI 9202B	0.88	0.28	-2.70	0.74	1.45	4.91	43.90	4.75	-14.03*	38.00	7.27	-14.56
HS 4 x HS 15	0.91	6.16	-2.16	0.73	0.71	4.09	53.45	4.74	0.60	48.10	14.56	8.15
HS 4 x HS 17	0.92	7.33	-1.08	0.76	11.86	8.15	51.75	3.40	-5.34	44.45	4.65	-0.06
HS 4 x NEI 9202B	0.88	1.47	-6.49	0.70	0.89	-0.93	50.00	17.77*	-3.34	44.43	12.22	-0.11
HS 15 x HS 17	0.92	1.43	-4.05	0.76	1.89	8.40	46.45	0.00	-8.45	41.83	6.32	-5.96
HS 15 x NEI 9202B	0.93	4.57	-1.08	0.72	-5.05	2.46	46.75	8.94	-10.59	43.68	19.82*	-1.80
HS 17 x NEI 9202B	0.90	-1.67	-4.59	0.77	8.81	10.15	45.60	5.94	-13.05*	37.53	1.59	-15.63
Rajkumar (check)	0.82			0.70			47.25			44.48		
Mean	0.87	-0.79	-2.14	0.71	5.22	1.14	49.53	0.51	-3.82	43.93	7.12	-1.22
Range	0.65-1.05	-15.70-10.67	-21.62-10.37	0.55-0.87	-20.59-31.27	-21.54-23.18	42.20-53.98	-9.23-17.77	-18.30-14.23	36.55-50.60	-6.74-23.26	-17.82-13.77
SEd	0.051	0.044	0.051	0.076	0.066	0.076	3.10	2.69	3.10	3.838	3.324	3.838
CD at 5%	0.100	0.087	0.100	0.150	0.129	0.150	6.13	5.31	6.13	7.582	6.566	7.582
CD at 1%	0.132	0.115	0.132	0.197	0.171	0.197	8.09	7.01	8.09	10.01	8.669	10.01

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Table 20. Per se performance and heterosis for different traits in 12 x 12 half diallel set of hybrids under nonstress and situations for chlorophyll content at 90 days and Drought susceptibility index (yield per plant)

Hybrids	Chlorophyll content at 90 days						Drought susceptibility index		
	Nonstress			Stress			Mean	Hmp	Hcc
	Mean	Hmp	Hcc	Mean	Hmp	Hcc			
CM 111 x HS 2	49.79	2.71	13.57	33.96	33.89*	21.50	1.10	-0.68	32.93
CM 111 x HS 7	48.30	2.94	10.17	35.60	49.11**	27.37	0.81	-25.09	-2.11
CM 111 x HS 10	47.19	0.78	7.63	28.17	17.36	0.79	1.44	21.86	74.32**
CM 111 x KDMI 15	49.74	4.64	13.45	31.82	23.08	13.85	0.99	-13.82	19.64
CM 111 x NEI 9208B	50.82	8.34	15.92*	35.55	42.79**	27.17	0.88	-16.15	6.65
CM 111 x CI 4	48.56	5.09	10.77	30.94	20.31	10.70	1.14	3.87	37.76
CM 111 x CML 446	43.64	-6.88	-0.45	31.53	24.21	12.79	1.06	-11.32	27.79
CM 111 x HS 4	46.19	-4.33	5.36	28.08	8.38	0.47	1.08	-5.79	30.21
CM 111 x HS 15	46.06	-4.83	5.05	31.53	30.99*	12.81	1.16	-0.43	40.18
CM 111 x HS 17	48.58	4.93	10.80	29.45	16.31	5.37	0.80	-29.8	-3.93
CM 111 x NEI 9202B	47.09	8.05	7.41	32.47	24.36	16.17	1.02	-5.66	23.26
HS 2 x HS 7	46.37	-6.01	5.76	28.18	13.45	0.81	1.00	-0.12	21.15
HS 2 x HS 10	50.16	1.89	14.42	34.95	40.01**	25.04	1.10	-0.56	32.93
HS 2 x KDMI 15	49.39	-1.10	12.66	27.48	2.47	-1.70	0.98	-8.75	18.13
HS 2 x NEI 9208B	49.08	-0.49	11.94	28.10	8.69	0.54	1.11	13.59	33.84
HS 2 x CI 4	47.76	-1.77	8.93	28.28	5.99	1.16	0.99	-3.43	19.03
HS 2 x CML 446	46.14	-6.36	5.25	31.53	19.68	12.79	1.12	0	34.74
HS 2 x HS 4	46.82	-7.63	6.80	30.75	14.42	10.00	0.89	-16.53	7.55
HS 2 x HS 15	51.12	0.63	16.61*	23.47	-6.23	-16.03	0.98	-10.11	18.13
HS 2 x HS 17	48.03	-1.39	9.55	26.22	-0.25	-6.21	1.25	18.48	51.06
HS 2 x NEI 9202B	48.45	5.34	10.50	31.05	14.69	11.08	0.81	-19.05	-1.81
HS 7 x HS 10	42.66	-6.29	-12.39	30.12	28.3	7.75	1.13	4.63	36.56
Rajkumar (check)	43.84			27.95			0.83		
Mean	47.00	0.85	-2.80	30.06	17.05	7.58	1.03	-4.31	24.39
Range	37.33-51.90	-8.28-18.46	-19.64-16.61	23.47-37.00	-8.05-49.11	-16.03-32.38	0.74-1.44	-29.80-27.32	-10.57-74.32
SEd	3.42	2.96	3.42	4.115	3.564	4.115	0.215	0.186	0.215
CD at 5%	6.75	5.85	6.75	8.129	7.040	8.129	0.425	0.368	0.425
CD at 1%	8.91	7.72	8.91	10.732	9.294	10.732	0.561	0.485	0.561

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 20 contd....

Hybrids	Chlorophyll content at 90 days						Drought susceptibility index		
	Nonstress			Stress			Mean	Hmp	Hcc
	Mean	Hmp	Hcc	Mean	Hmp	Hcc			
HS 7 x KDMI 15	47.68	1.55	-4.66	28.21	11.38	0.91	0.94	-10.53	12.99
HS 7 x NEI 9208B	45.64	0.62	-5.58	28.47	16.84	1.84	0.89	-6.46	7.25
HS 7 x CI 4	40.09	-5.18	-13.64*	28.60	13.55	2.33	0.98	-1.64	18.13
HS 7 x CML 446	43.38	-3.99	-10.06	28.42	14.37	1.68	1.21	10.91	45.92
HS 7 x HS 4	41.25	-2.98	-8.91	29.83	17.53	6.73	0.90	-13.46	8.76
HS 7 x HS 15	47.56	3.84	-2.52	34.11	44.90**	22.04	1.07	1.06	29.61
HS 7 x HS 17	42.99	-2.84	-11.18	31.45	26.85	12.50	0.74	-28.07	-10.57
HS 7 x NEI 9202B	39.72	7.96	-12.82	28.95	13.17	3.58	0.93	-4.86	12.39
HS 10 x KDMI 15	47.30	1.48	-5.13	27.60	8.45	-1.25	1.15	0.44	39.27
HS 10 x NEI 9208B	42.11	-8.28	-14.26*	25.16	2.72	-10.00	1.04	-0.83	25.98
HS 10 x CI 4	45.32	-0.78	-9.63	31.69	25.18	13.38	1.21	10.15	45.92
HS 10 x CML 446	39.32	-7.33	-13.36*	25.84	3.43	-7.57	0.97	-18.36	17.52
HS 10 x HS 4	37.33	-6.00	-12.13	31.18	22.22	11.54	1.16	1.09	39.58
HS 10 x HS 15	43.76	-0.82	-7.28	30.89	30.50*	10.50	1.23	5.91	48.94
HS 10 x HS 17	42.80	-1.05	-9.55	31.42	26.1	12.42	1.01	-10.94	21.75
HS 10 x NEI 9202B	37.63	-0.49	-19.64**	30.26	17.71	8.26	1.20	10.88	44.71
KDMI 15 x NEI 9208B	43.30	-2.88	-8.86	30.69	16.5	9.79	1.13	10.7	35.95
KDMI 15 x CI 4	46.10	9.13	-0.61	32.39	19.23	15.89	0.96	-9.31	16.31
KDMI 15 x CML 446	46.25	-2.60	-8.76	31.20	16.28	11.61	1.14	-1.41	37.76
KDMI 15 x HS 4	47.73	3.01	-0.83	30.01	9.7	7.37	0.84	-24.38	1.21
KDMI 15 x HS 15	49.04	1.18	-2.58	26.81	5.07	-4.08	0.84	-26.02	0.91
KDMI 15 x HS 17	44.02	2.25	-6.53	33.53	25.25	19.95	0.96	-12.66	15.71
Rajkumar (check)	43.84			27.95			0.83		
Mean	47.00	0.85	-2.80	30.06	17.05	7.58	1.03	-4.31	24.39
Range	37.33-51.90	-8.28-18.46	-19.64-16.61	23.47-37.00	-8.05-49.11	-16.03-32.38	0.74-1.44	-29.80-27.32	-10.57-74.32
SEd	3.42	2.96	3.42	4.115	3.564	4.115	0.215	0.186	0.215
CD at 5%	6.75	5.85	6.75	8.129	7.040	8.129	0.425	0.368	0.425
CD at 1%	8.91	7.72	8.91	10.732	9.294	10.732	0.561	0.485	0.561

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 20 contd....

Hybrids	Chlorophyll content at 90 days						Drought susceptibility index		
	Nonstress			Stress			Mean	Hmp	Hcc
	Mean	Hmp	Hcc	Mean	Hmp	Hcc			
KDMI 15 x NEI 9202B	39.87	0.41	-18.92**	25.34	-8.05	-9.34	0.99	-5.26	19.64
NEI 9208B x CI 4	40.12	-3.64	-12.23	32.28	23.17	15.48	0.99	2.85	19.94
NEI 9208B x CML 446	41.91	-3.12	-9.25	30.57	18.16	9.36	1.22	14.62	46.83
NEI 9208B x HS 4	51.91	12.16	5.25	31.68	20.01	13.35	1.29	27.32	55.59*
NEI 9208B x HS 15	41.65	-6.60	-12.35	33.32	35.68*	19.21	0.90	-13.32	8.16
NEI 9208B x HS 17	45.74	2.91	-5.93	27.67	7.22	-1.00	0.99	-1.25	19.34
NEI 9208B x NEI 9202B	39.22	4.98	-15.23*	28.16	5.87	0.75	1.05	10.14	26.28
CI 4 x CML 446	42.66	2.99	-6.20	30.64	14.78	9.62	0.93	-15.61	12.69
CI 4 x HS 4	46.06	8.81	-0.89	30.49	12	9.09	1.04	-1.78	25.38
CI 4 x HS 15	48.42	5.53	-3.88	29.21	15.06	4.49	1.10	1.62	32.33
CI 4 x HS 17	43.10	-0.69	-9.55	28.20	5.87	0.88	1.06	1.67	28.40
CI 4 x NEI 9202B	39.42	2.48	-17.24*	28.05	2.27	0.34	0.99	-0.63	19.34
CML 446 x HS 4	44.18	0.79	-5.59	34.41	27.97*	23.09	1.16	0.33	39.58
CML 446 x HS 15	42.60	-3.55	-9.65	30.20	20.58	8.05	1.19	1.28	43.50
CML 446 x HS 17	44.19	-7.19	-15.16*	28.87	9.79	3.29	1.06	-7.02	28.10
CML 446 x NEI 9202B	40.40	8.06	-12.74	32.08	18.44	14.78	1.05	-3.56	26.89
HS 4 x HS 15	51.30	3.04	2.24	37.00	44.67**	32.38*	0.82	-26.81	-0.60
HS 4 x HS 17	47.31	3.96	-4.97	27.37	2.01	-2.09	0.97	-11.34	16.92
HS 4 x NEI 9202B	46.85	18.46*	-4.34	28.33	2.59	1.36	0.89	-14.9	6.95
HS 15 x HS 17	41.94	-1.28	-9.76	29.51	18.09	5.56	0.98	-11.69	18.73
HS 15 x NEI 9202B	43.31	10.87	-10.47	29.97	16.26	7.21	1.02	-3.65	23.56
HS 17 x NEI 9202B	44.99	12.55	-9.12	25.32	-6.33	-9.43	0.98	-4.74	18.43
Rajkumar (check)	43.84			27.95			0.83		
Mean	47.00	0.85	-2.80	30.06	17.05	7.58	1.03	-4.31	24.39
Range	37.33-51.90	-8.28-18.46	-19.64-16.61	23.47-37.00	-8.05-49.11	-16.03-32.38	0.74-1.44	-29.80-27.32	-10.57-74.32
SEd	3.42	2.96	3.42	4.115	3.564	4.115	0.215	0.186	0.215
CD at 5%	6.75	5.85	6.75	8.129	7.040	8.129	0.425	0.368	0.425
CD at 1%	8.91	7.72	8.91	10.732	9.294	10.732	0.561	0.485	0.561

Hmp = Heterosis over mid-parent, Hcc = Heterosis over commercial check.* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Table 21. ANOVA for combining ability for different quantitative traits in 12 x 12 half diallel set of crosses under nonstress and stress situations

Sources of variation	df	Plant height (cm)		Ear height (cm)		Day to 50% anthesis		Days to 50% silking		Anthesis to silking interval		Days to maturity	
		Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
GCA	11	883.88**	705.26**	1125.51**	1032.26**	90.00**	75.22**	62.59**	59.56**	7.39**	9.10**	13.77**	15.01**
SCA	66	149.10**	255.21**	99.40**	150.67**	3.13**	2.92**	3.11**	3.75**	0.44**	1.02**	2.80	2.09
Environments	1	122.52	12290.99**	141.60	213.74	2.83	35.58**	13.27**	47.41**	3.10**	0.92	49.08**	4.85
GCA*Environments	11	142.26**	105.60	97.63*	66.28	3.48*	3.57**	4.02**	5.42**	0.59*	2.49**	3.071	2.08
SCA* Environments	66	57.94	85.89	37.24	60.06	1.54	1.68	1.72	2.98**	0.41*	1.55**	2.33	1.70
Error	154	59.07	78.59	44.68	61.98	1.64	1.23	1.67	1.59	0.26	0.62	2.05	1.61
GCA/SCA		5.92	2.76	11.32	6.85	28.75	25.76	20.12	15.88	16.79	8.92	4.91	7.18

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

Contd.....

Table 21 contd....

Sources of variation	df	Cob length (cm)		Cob girth (cm)		No. of kernel rows /Cob		Kernels /row		Cobs per plant		Shelling percentage	
		Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
GCA	11	2.54**	2.46**	4.29**	2.39**	10.11**	7.96**	68.14**	47.88**	0.018**	0.03**	18.69**	30.12**
SCA	66	1.09*	1.23**	0.30**	0.37*	0.57**	0.49	5.89	8.59**	0.005	0.01*	1.93*	5.24**
Environments	1	106.84**	7.87**	32.18**	0.19	15.27**	0.65	1.42	265.46**	0.182**	0.060**	71.54**	203.09**
GCA*Environments	11	1.49*	1.12	0.39*	0.32	1.12**	0.49	3.66	5.30	0.004	0.02*	1.90	1.50
SCA* Environments	66	0.73	0.87	0.23	0.41**	0.49*	0.53	5.56	5.39	0.005	0.01	1.33	4.51*
Error	154	0.69	0.68	0.18	0.25	0.35	0.45	4.73	3.89	0.004	0.01	1.31	2.88
GCA/SCA		2.33	2.00	14.30	6.46	17.73	16.24	11.56	5.57	3.60	3.00	9.68	5.75

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

Contd.....

Table 21 contd....

Sources of variation	df	100-grain weight (g)		Yield/plant (g)		Yield (kg/ha)		RWC1		RWC2	
		Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
GCA	11	65.24**	33.48**	647.67**	155.50**	5722042.00**	1143330.00**	0.001	0.001	0.006**	0.011**
SCA	66	4.45**	4.21**	220.73**	102.20**	1723511.00**	551564.30**	0.001	0.003*	0.002*	0.007**
Environments	1	239.74**	76.60**	27.75	2670.84**	5138955.00**	32074560.00**	0.068**	0.182**	0.005	0.040**
GCA*Environments	11	3.49	4.38*	284.26*	94.73	1341159.00**	532007.900**	0.001	0.002	0.003*	0.004
SCA* Environments	66	3.21	2.96*	201.60*	107.81**	635924.10*	313004.00**	0.001	0.002	0.001	0.007**
Error	154	2.77	1.98	136.79	54.12	453380.50	137355.80	0.002	0.002	0.001	0.003
GCA/SCA		14.66	7.95	2.93	1.52	3.32	2.07	1.00	0.33	3.00	1.57

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

RWC1 - Relative water content at 60 DAS

RWC2 - Relative water content at 90 DAS

Contd.....

Table 21 contd....

Sources of variation	df	CHL1		CHL2		Drought susceptibility index
		Nonstress	Stress	Nonstress	Stress	
GCA	11	47.74**	90.85**	45.95**	9.04	0.068**
SCA	66	5.35	12.30**	7.84	19.64**	0.027
Environments	1	274.22**	458.52**	1027.34**	2039.11**	3.131**
GCA*Environments	11	4.73	4.19	3.41	17.05*	0.032
SCA* Environments	66	3.57	9.94	4.61	10.34	0.044**
Error	154	4.81	7.37	5.84	8.47	0.023
GCA/SCA		8.92	7.39	5.86	0.46	2.52

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

CHL1 – Chlorophyll content at 60 DAS

CHL2 – Chlorophyll content at 90 DAS

4.2.4.1.2. Ear height (cm)

Under nonstress, four parents viz., NEI 9208B, CML 446, NEI 9202B and Hyd Sel 10 recorded significant positive gca effects for the trait. Under stress also, the same parents except Hyd Sel 10 recorded significant positive gca effects for the trait revealing their good combining ability. While Hyd Sel 2, Hyd Sel 7, KDMI 15, Hyd Sel 4, Hyd Sel 15 proved to be poor combiners for ear height under stress as they recorded significant negative gca effects.

4.2.4.1.3 Days to 50% anthesis

Among the 12 parents, Hyd Sel 2, KDMI 15, Hyd Sel 4 and Hyd Sel 17 recorded significant negative gca effects under both the situations indicating that they were good combiners for days to 50% anthesis.

4.2.4.1.4 Days to 50% silking

Four parents viz., Hyd Sel 2, KDMI 15, Hyd Sel 4 and Hyd Sel 17 recorded significant negative gca effects under both the situations indicating that they were good combiners for days to 50% silking.

4.2.4.1.5 Anthesis to silking interval

For anthesis to silking interval, CI 4, Hyd Sel 17 and NEI 9202B recorded significant negative gca effects under both the situations indicating their good combining ability.

4.2.4.1.6 Days to maturity

Among 12 parents, CM 111, NEI 9208B, and CML 446 proved to be good general combiners as they recorded significant positive gca effects under both the situations. Hyd Sel 7 and NEI 9202B recorded significant positive gca effects for the trait under nonstress and stress, respectively indicating their good combining ability only under specific environment.

4.2.4.1.7 Cob length (cm)

For cob length, NEI 9202B recorded significant positive gca effects in both the environments. Whereas, CML 446 and CI 4 recorded significant positive gca effects under nonstress and stress, respectively indicating their good combining ability only in specific environment.

4.2.4.1.8 Cob girth (cm)

Two parents viz., CI 4 and Hyd Sel 15 were good combiners for the trait under both the environments as indicated by their significant positive gca effects. Hyd Sel 10, CML 446 and Hyd Sel 4 recorded significant positive gca effects under nonstress indicating their good combining ability for the trait under nonstress.

4.2.4.1.9. Number of kernel rows per cob

For this trait, two parents viz., Hyd Sel 15 and Hyd Sel 10 proved to be good general combiners under both the situations as they recorded significant positive gca effects in both the situations. Hyd Sel 2 and CM 111 were also good combiners for the trait under nonstress and stress, respectively.

4.2.4.1.10. Number of kernels per row

Among 12 parents, three parents viz., CM 111, NEI 9208B and NEI 9202B were considered to be good general combiners as they recorded significant positive gca effects under both the situations.

4.2.4.1.11 Cobs per plant

There were no common general combiners for both the situations for this trait. NEI 9208B, CML 446 and NEI 9202B were good combiners under nonstress. Whereas, Hyd Sel 2, Hyd Sel 4 and Hyd Sel 15 were good combiners under stress as indicated by their significant positive gca effects.

4.2.1.12 Shelling percentage

Among the 12 parents, Hyd Sel 7, Hyd Sel 15 and NEI 9202B recorded significant positive gca effects under both the environments indicating their good combining ability for both the situations. NEI 9208B was another good combiner for the trait under stress as indicated by significant positive gca effects.

4.2.4.1.12. Hundred grain weight (g)

Four parents viz., CI 4, Hyd sel. 4, Hyd Sel 15 and Hyd Sel 17 proved to be good general combiners for 100 grain weight under both the environments as indicated by their significant positive gca effects.

4.2.4.1.14 Yield per plant (g)

Only one parent (CI 4) was a good general combiner for both the environments, while CML 446 and Hyd Sel 15 were good combiners under nonstress as they recorded significant positive gca effects.

4.2.4.1.15 Grain yield (kg/ha)

Among the 12 parents, CI 4, Hyd Sel 15 and NEI 9202B recorded significant positive gca effects under both the environments indicating their good combining ability for yield under both the situations. NEI 9208B and CML 446 were good combiners for yield under nonstress, whereas KDMI 15 and Hyd Sel 4 were good combiners for yield under stress as revealed by their significant positive gca effects.

4.2.4.16. Relative water content at 60 DAS and 90 DAS

Among the 12 parents, none of the parents recorded significant positive gca effects at 60 DAS under both the situations. While at 90 DAS CML 446 and Hyd Sel 17 recorded significant positive gca effects under both the environments indicating their good combining ability for the trait. NEI 9208B and NEI 9202B were good combiners for the trait under nonstress as indicated by their significant positive gca effects.

4.2.4.1.17 Chlorophyll content at 60 DAS and 90 DAS

Three parents viz., Hyd Sel 2, Hyd Sel 4 and KDMI 15 were good combiners for chlorophyll content at 60 DAS (CHL1) under nonstress and stress situations as they recorded significant positive gca effects under both the situations. CM 111 and Hyd Sel 15 were also good combiners for the trait at 60 DAS under nonstress. At 90 DAS, CM 111 was good combiner for the trait under stress, whereas Hyd Sel 2, KDMI 15, Hyd Sel 4 and Hyd Sel 15 proved to be good general combiners under nonstress.

4.2.4.1.18 Drought susceptibility index (DSI)

Among the 12 parents, Hyd Sel 7 recorded significant negative gca effects and proved to be a good general combiner for DSI.

4.2.4.2. Specific combining ability (sca) effects

Specific combining ability effects were estimated for all the 66 hybrids, tested for two seasons under stress and nonstress separately and the results are presented in Table 23.

4.2.4.2.1 Plant height (cm)

Among the 66 crosses, CM 111 x NEI 9202B, Hyd Sel 7 x Hyd Sel 17, Hyd Sel 4 x NEI 9202B and Hyd Sel 15 x NEI 9202B recorded significant positive sca effects under nonstress as well as stress situations. Whereas, CM 111 x NEI 9208B and Hyd Sel 2 x NEI 9202B recorded significant positive sca effects under stress. CM 111 x KDMI 15, Hyd Sel 10 x NEI 9202B, KDMI 15 x NEI 9202B, NEI 9208B x Hyd Sel 4, NEI 9208B x Hyd Sel 15 and CML 446 x NEI 9202B recorded significant positive sca effects under nonstress indicating their good specific combining ability for the trait.

4.2.4.2.2. Ear height (cm)

There were no common hybrids that exhibited good specific combining ability for the trait under both the situations.

Table 22. Estimates of gca effects of parents for different traits in 12 × 12 half diallel set of hybrids under nonstress and stress situations

Parents	Plant height (cm)		Ear height (cm)		Days to 50% anthesis		Days to 50% silking		Anthesis to silking interval		Days to maturity	
	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S
CM 111	-2.50	-4.48**	0.61	2.80	0.48*	0.68**	1.02**	1.10**	0.55**	0.42**	0.54*	0.86**
HS 2	-8.82**	-4.99**	-11.59**	-9.74**	-2.51**	-1.90**	-2.09**	-1.58**	0.41**	0.35*	-1.02**	-1.07**
HS 7	-4.07**	-2.68	-5.14**	-6.66**	-1.11**	-1.65**	-0.13	-0.55*	0.93**	1.11**	0.79**	-0.23
HS 10	1.87	2.87	4.13**	2.55	-0.61**	-0.97**	-0.04	-0.12	0.52**	0.81**	0.43	-0.003
KDMI 15	0.96	1.44	-3.34*	-2.41	-2.29**	-1.78**	-2.20**	-2.12**	0.12	-0.37*	-0.96**	-1.14**
NEI 9208 B	8.51**	9.61**	8.81**	10.76**	2.01**	1.75**	1.53**	1.51**	-0.44**	-0.22	0.66*	0.86**
CI 4	-0.33	-0.27	0.88	1.18	0.58*	0.37	0.31	0.00	-0.27**	-0.31**	0.04	0.08
CML 446	11.29**	7.62**	7.94**	4.16**	2.39**	2.59**	1.93**	2.571**	-0.45**	-0.04	0.56*	1.08**
HS 4	-3.14*	-3.38*	-2.92*	-3.09*	-1.26**	-0.72**	-1.21**	-1.054**	-0.01	-0.37*	-0.85**	-0.25
HS 15	-3.71**	0.24	-7.76**	-7.06**	-0.31	-0.26	-0.44	-0.446	-0.11	-0.15	0.09	-0.02
HS 17	-3.08*	-7.13**	2.22	0.31	-0.52*	-0.80**	-0.97**	-1.125**	-0.42*	-0.37*	-0.78**	-0.60**
NEI 9202B	3.02*	1.14	6.16**	7.19**	3.16**	2.71**	2.34**	1.821**	-0.81**	-0.89**	0.50	0.56*
Mean	243.39	218.33	109.52	102.14	63.21	64.38	65.63	67.60	2.31	3.23	107.64	101.13
CD (gi) @ 5%	2.75	3.16	2.39	2.80	0.46	0.40	0.46	0.45	0.18	0.28	0.51	0.45
CD (gi-gj) @ 5%	4.06	4.68	3.53	4.16	0.68	0.58	0.68	0.67	0.27	0.41	0.76	0.67

* and ** - Significant at 0.05 and 0.01 level of probability, respectively.

HS – Hyd. Sel; NS = Nonstress; S = Stress

Contd.....

Table 22 contd....

Parents	Cob length (cm)		Cob girth (cm)		No. kernel rows /Cob		No. kernels/row		Ears per plant		Shelling percentage	
	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S
CM 111	-0.25	-0.15	-0.10	0.05	0.19	0.60**	1.35**	0.75*	-0.046**	-0.031	-1.18**	-2.06**
HS 2	0.03	0.02	-0.20*	-0.23*	0.25*	-0.19	-1.06**	-0.92*	0.001	0.040*	-0.15	-0.22
HS 7	-0.38*	0.07	-0.65**	-0.22*	0.18	0.07	0.70	1.21**	-0.033**	-0.041*	1.06**	1.10**
HS 10	-0.32*	-0.67**	0.47**	0.13	0.56**	0.43**	-0.73	-1.12**	-0.009	-0.042**	-0.78**	0.34
KDMI 15	0.07	0.01	0.01	0.01	0.05	-0.10	-0.38	-0.27	0.012	0.021	-0.75**	-1.63**
NEI 9208 B	0.23	0.04	-0.18*	-0.25**	-0.75**	-0.55**	1.60**	1.59**	0.037**	0.001	-0.004	0.77*
CI 4	0.12	0.37*	0.19*	0.26**	-0.26*	0.11	0.30	0.21	-0.012	0.013	0.04	-0.21
CML 446	0.39**	-0.11	0.19*	0.09	0.04	-0.12	0.94*	-0.32	0.029*	-0.049**	-0.14	-0.62*
HS 4	0.09	-0.01	0.24**	0.054	-0.07	-0.17	-1.69**	-1.10**	0.001	0.043**	-0.26	0.01
HS 15	-0.30*	0.09	0.72**	0.68**	1.30**	1.16**	-2.36**	-1.82**	-0.007	0.038*	1.79**	1.24**
HS 17	-0.24	-0.01	-0.16*	-0.21*	-0.50**	-0.51**	-1.55**	-0.78*	-0.009	-0.009	-0.19	0.42
NEI 9202B	0.56**	0.56**	-0.53**	-0.36**	-0.97**	-0.72**	2.88**	2.58**	0.037**	0.016	0.57*	0.86**
Mean	15.27	12.81	13.98	12.05	14.54	14.09	29.86	26.22	0.98	0.790	82.43	80.56
CD (gi) @ 5%	0.30	0.29	0.15	0.18	0.21	0.24	0.78	0.71	0.021	0.032	0.41	0.61
CD (gi-gj) @ 5%	0.44	0.44	0.22	0.26	0.31	0.35	1.15	1.04	0.034	0.046	0.61	0.90

* and ** - Significant at 0.05 and 0.01 level of probability, respectively.

HS – Hyd. Sel; NS = Nonstress; S = Stress

Contd.....

Table 22 contd....

Parents	100-grain weight (g)		Yield per plant (g)		Yield (kg/ha)		RWC1		RWC2	
	NS	S	NS	S	NS	S	NS	S	NS	S
CM 111	-2.16**	-1.66**	-4.21*	-2.98*	-763.16**	-26.74	0.002	0.002	-0.01	-0.003
HS 2	0.15	-0.20	-3.05	-1.81	-220.08	-190.35**	0.004	0.005	-0.007	-0.040**
HS 7	-3.07**	-1.38**	-8.95**	-0.65	-624.32**	-200.91**	-0.005	-0.004	-0.015*	-0.028**
HS 10	0.38	-0.65*	4.06	-4.38**	-4.14	-344.41**	-0.006	-0.001	-0.020**	0.004
KDMI 15	-0.05	0.43	-1.53	0.81	-72.40	179.43**	-0.004	0.002	-0.021**	-0.012
NEI 9208 B	-0.09	-0.40	1.05	1.58	391.65**	121.08	-0.001	-0.003	0.014*	0.01
CI 4	0.67*	1.22**	4.69*	3.18*	397.39**	240.47**	0.013	-0.004	0.004	0.016
CML 446	-0.08	-0.22	6.07**	-1.15	491.23**	-234.51**	0	0.008	0.017*	0.022*
HS 4	2.45**	1.36**	0.65	0.91	-44.60	148.54*	0.006	-0.003	-0.003	-0.01
HS 15	1.69**	1.45**	6.55**	2.59	323.71**	225.92**	-0.002	-0.004	0.006	0.012
HS 17	1.07**	1.05**	-5.02*	-0.67	-464.37**	-51.76	-0.011	-0.005	0.019**	0.022*
NEI 9202B	-0.96**	-0.99**	-0.32	2.56	589.10**	133.25*	0.003	0.008	0.016*	0.007
Mean	27.31	17.49	111.35	52.74	5948.26	2284.73	0.932	0.890	0.886	0.680
CD (gi) @ 5%	0.59	0.50	4.18	2.63	240.61	132.44	0.014	0.016	0.012	0.020
CD (gi-gj) @ 5%	0.88	0.74	6.17	3.88	355.50	195.67	0.022	0.025	0.019	0.028

* and ** - Significant at 0.05 and 0.01 level of probability, respectively; HS – Hyd. Sel; NS = Nonstress; S = Stress
RWC1 - Relative water content at 60 DAS RWC2 - Relative water content at 90 DAS

Contd.....

Table 22 contd....

Parents	CHL1		CHL2		Drought susceptibility index
	NS	S	NS	S	
CM 111	-0.27	1.312**	0.41	1.119*	0.026
HS 2	2.01**	2.246**	1.61**	-0.403	-0.007
HS 7	-0.10	0.834	-0.41	-0.259	-0.066*
HS 10	-1.34**	-1.879**	-1.04*	-0.556	0.109**
KDMI 15	1.43**	1.710**	0.99*	-0.184	-0.025
NEI 9208 B	-0.02	-1.261*	0.08	0.011	-0.012
CI 4	0.06	0.226	-0.21	0.184	-0.005
CML 446	-1.43**	-2.952**	-1.10*	0.41	0.073**
HS 4	1.69**	1.882**	1.73**	0.836	-0.018
HS 15	0.75	0.980*	1.12*	0.088	0.007
HS 17	-0.52	-0.522	-0.45	-0.771	-0.038
NEI 9202B	-2.25**	-2.577**	-2.71**	-0.474	-0.043
Mean	50.42	41.06	47.65	25.74	1.07
CD (gi) @ 5%	0.78	0.97	0.86	1.04	0.055
CD (gi-gj) @ 5%	0.16	1.43	1.28	1.54	0.080

* and ** - Significant at 0.05 and 0.01 level of probability, respectively;
CHL1 – Chlorophyll content at 60 DAS

HS – Hyd. Sel; NS = Nonstress; S = Stress
CHL2 – Chlorophyll content at 90 DAS

However, CM 111 x Hyd Sel 10, Hyd Sel 2 x NEI 9208B, Hyd Sel 10 x Hyd Sel 17, KDMI 15 x Hyd Sel 17, NEI 9208B x CML 446 and NEI 9208B x Hyd Sel 4 recorded good specific combining ability under nonstress as indicated by their significant positive sca effects. Whereas, CM 111 x NEI 9202B, Hyd Sel 7 x Hyd Sel 17, Hyd Sel 10 x CML 446, Hyd Sel 10 x Hyd Sel 17, Hyd Sel 4 x NEI 9202B and Hyd Sel 15 x NEI 9202B recorded significant positive sca effects for the trait under stress.

4.2.4.2.3. Days to 50% anthesis

Among the hybrids, CM 111 x NEI 9208B, CM 111 x Hyd Sel 17, Hyd Sel 2 x Hyd Sel 7 and Hyd Sel 4 x Hyd Sel 15 exhibited good specific combining ability for the trait under both the situations by recording significant negative sca effects.

4.2.4.2.4 Days to 50% silking

Among the hybrids, CM 111 x NEI 9208B recorded significant negative sca effects under both the environments indicating its specific combining ability under both the situations. Whereas, CM 111 x NEI 9202B, CI 4 x Hyd Sel 4 and Hyd Sel 4 x Hyd Sel 15 under nonstress and CM 111 x Hyd Sel 17, Hyd Sel 2 x Hyd Sel 7, Hyd Sel 2 x NEI 9202B and Hyd Sel 4 x Hyd Sel 15 under stress recorded significant negative effects, respectively indicating their good combining ability for the trait under specific environments.

4.2.4.2.5 Anthesis to silking interval (ASI)

None of the hybrids recorded good specific combining ability effects for the trait under both the environments. However, CM 111 x Hyd Sel 2 and CM 111 x Hyd Sel 15 under nonstress and Hyd Sel 2 x CML 446 and Hyd Sel 7 x NEI 9208B under stress recorded significant negative sca effects, respectively indicating their good specific combining ability.

4.2.4.2.6. Days to maturity

Among the hybrids, CM 111 x NEI 9202B and KDMI 15 x NEI 9208B under nonstress and CM 111 x Hyd Sel 17, Hyd Sel 2 x NEI 9202B, CI 4 x Hyd Sel 17 and Hyd Sel 4 x Hyd Sel 15 under stress were good specific combiners, respectively for the trait as revealed by their significant negative sca effects.

4.2.4.2.7 Cob length (cm)

Among the hybrids, Hyd Sel 7 x NEI 9202B was a good specific combiner for the trait under both the situations as revealed by its significant positive sca effects. Whereas, CM 111 x Hyd Sel 2, Hyd Sel 10 x Hyd Sel 4 and NEI 9208B x CML 446 under nonstress and Hyd Sel 2 x NEI 9202B, NEI 9208B x Hyd Sel 15 and Hyd Sel 4 x NEI 9202B under stress were good specific combiners, respectively for the trait.

4.2.4.2.8 Cob girth (cm)

KDMI 15 x NEI 9202B was the only hybrid that showed good specific combining ability under both the situations by recording significant positive sca effects. Whereas, NEI 9208B, x Hyd Sel 4 under nonstress and CM 111 x Hyd Sel 7, Hyd Sel 2 x KDMI 15, Hyd Sel 10 x Hyd Sel 15 and NEI 9208B x Hyd Sel 15 under stress recorded significant positive sca effects, respectively indicating their good specific combining ability for the trait under specific environment.

4.2.4.2.9 Number of kernel rows per cob

Four hybrids viz., CM 111 x Hyd Sel 15, Hyd Sel 2 x Hyd Sel 15, Hyd Sel 7 x CML 446, KDMI 15 x NEI 9208B recorded significant positive sca effects under nonstress. Three hybrids viz., Hyd Sel 7 x KDMI 15, Hyd Sel 10 x Hyd Sel 17 and Hyd Sel 4 x NEI 9202B recorded significant positive sca effects for the trait indicating their good specific combining ability.

4.2.4.2.10 Number of kernels per row

CM 111 x NEI 9202B recorded significant positive sca effects under both the situations indicating its good specific combining ability for the trait.

Whereas, Hyd Sel 7 x NEI 9202B under nonstress and CM 111 x CI 4, Hyd Sel 2 x Hyd Sel 7, Hyd Sel 10 x CML 446, KDMI 15 x NEI 9202B and NEI 9208B x Hyd Sel 15 under stress recorded significant positive sca effects, respectively.

4.2.4.2.11 Cobs per plant

Among the hybrids, CM 111 x NEI 9202B and Hyd Sel 7 x NEI 9202B under nonstress and CM 111 x KDMI 15, CM 111 x CML 446, Hyd Sel 2 x CML 446, Hyd Sel 7 x Hyd Sel 17, NEI 9208B x Hyd Sel 15 and CI 4 x CML 446 under stress recorded significant positive sca effects, respectively indicating their good specific combining ability for the trait.

4.2.4.2.12 Shelling percentage

For shelling percentage, CM 111 x NEI 9208B, Hyd Sel 7 x Hyd Sel 17 and KDMI 15 x NEI 9202B under nonstress and Hyd Sel 2 x NEI 9202B, KDMI 15 x Hyd Sel 17 and CI 4 x CML 446 under stress exhibited significant positive sca effects, respectively there by proving that they were good specific combiners for the trait.

4.2.4.2.13 Hundred grain weight (g)

Among the hybrids, Hyd Sel 2 x NEI 9202B proved to be good specific combiner under both the situations by recording significant positive sca effects for the trait. Whereas, CM 111 x Hyd Sel 7, CM 111 x Hyd Sel 15 and Hyd Sel 2 x NEI 9208B under nonstress and Hyd Sel 7 x Hyd Sel 17, NEI 9208B x Hyd Sel 15, CI 4 x Hyd Sel 4 and Hyd Sel 15 x Hyd Sel 17 under stress recorded significant positive sca effects, respectively.

4.2.4.2.14 Yield per plant (g)

Three hybrids viz., CM 111 x Hyd Sel 15, CM 111 x NEI 9202B and KDMI 15 x NEI 9202B recorded significant positive sca effects indicating their good specific combining ability under nonstress. Similarly, three hybrids viz., CM 111 x Hyd Sel 17 Hyd Sel 2 x NEI 9202B and NEI 9208B x Hyd Sel 15 proved to be good specific combiners for the trait under stress as indicated by their significant positive sca effects.

4.2.4.2.15 Grain yield (kg/ha)

Among the 66 hybrids tested, CM 111 x CI 4, KDMI 15 x NEI 9202B, CI 4 x CML 446 and Hyd Sel 4 x NEI 9202B showed good specific combining ability for grain yield (kg/ha) under both the situations by recording significant positive sca effects. Whereas, CM 111 x Hyd Sel 15, CM 111 x NEI 9202B, Hyd Sel 2 x KDMI 15, Hyd Sel 2 x Hyd Sel 17, Hyd Sel 7 x Hyd Sel 4, Hyd Sel 7 x Hyd Sel 17, Hyd Sel 10 x NEI 9208B, Hyd Sel 10 x Hyd Sel 15, Hyd Sel 10 x NEI 9202B and KDMI 15 x NEI 9208B under nonstress recorded significant positive sca effects. Under stress, CM 111 x NEI 9208B, CM 111 x Hyd Sel 17, Hyd Sel 2 x Hyd Sel 7, Hyd Sel 2 x Hyd Sel 10 and Hyd Sel 15 x Hyd Sel 17 were good specific combiners for grain yield under stress as revealed by their significant positive sca effects.

4.2.4.2.16 Relative water content at 60 DAS (RWC1) and 90 DAS (RWC2)

None of the hybrids except CM 111 x Hyd Sel 10 (under stress) recorded significant positive sca effects at 60 DAS (RWC1) in both the environments. However, Hyd Sel 2 x Hyd Sel 7 and NEI 9208B x NEI 9202B proved to be good specific combiners for RWC at 90 DAS under both the situations by recording significant positive sca effects. CML 446 x Hyd Sel 4 and Hyd Sel 2 x Hyd Sel 17 also recorded significant sca effects under drought at 90 DAS.

4.2.4.2.17 Chlorophyll content at 60 DAS (CHL1) and 90 DAS (CHL2)

Among the hybrids, CM 111 x NEI 9202B recorded significant positive sca effects for chlorophyll content at 60 DAS under both the environments, indicating its good specific combining ability for the trait. Other hybrids viz., Hyd Sel 4 x NEI 9202B (under nonstress) and CM 111 x NEI 9208B CM 111 x Hyd Sel 17, Hyd Sel 2 x Hyd Sel 15, Hyd Sel 7 x NEI 9202B, KDMI 15 x Hyd Sel 17 and NEI 9208BX Hyd Sel 15 (under stress) also proved to be good specific combiners as they recorded significant positive sca effects.

At 90 DAS, CM 111 x NEI 9208B recorded significant positive sca effects under both the environments. Under stress, two hybrids viz., CM 111 x NEI 9208B and NEI 9208B x Hyd Sel 15 proved to be good specific combiners for chlorophyll content at both the stages by recording significant positive sca effects for the trait.

Table 23. Estimates of sca effects for different traits in 12 × 12 half diallel set of hybrids under nonstress and stress situations

Hybrids	Plant height (cm)		Ear height (cm)		Days to 50% anthesis		Days to 50% silking		Anthesis to silking interval		Days to maturity	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
CM 111 x HS 2	4.70	7.97	-5.32	2.21	1.47	1.17	0.71	0.60	-0.75*	-0.57	2.35*	1.43
CM 111 x HS 7	1.77	1.41	-0.45	0.38	0.07	-1.08	1.00	0.06	0.99*	1.14*	0.54	2.13*
CM 111 x HS 10	10.76*	0.59	10.26*	1.91	-0.68	-0.01	-0.60	0.88	0.15	0.89	1.15	0.38
CM 111 x KDMI 15	6.17	10.28	4.03	1.38	-0.50	1.05	0.57	1.38	1.04**	0.32	1.29	0.54
CM 111 x NEI 9208B	-7.38	14.11*	-11.47*	5.45	-2.05*	-2.74**	-1.92*	-2.76**	0.09	-0.04	-2.33*	-1.46
CM 111 x CI 4	-0.29	7.49	5.22	6.54	-0.62	-0.11	-0.93	-0.49	-0.32	-0.38	-0.71	1.05
CM 111 x CML 446	-2.66	1.85	2.55	-3.20	0.07	0.42	0.19	0.44	0.11	0.02	-0.48	-0.21
CM 111 x HS 4	0.77	3.10	-0.09	2.31	1.72*	0.99	1.64	0.81	-0.09	-0.18	0.68	-1.39
CM 111 x HS 15	-2.16	6.87	-3.40	-0.97	0.52	0.03	-0.22	0.71	-0.73*	0.68	-1.01	0.96
CM 111 x HS 17	-5.04	-24.15**	-5.63	-11.60*	-1.77*	-1.94*	-1.67	-2.62**	0.07	-0.68	-1.89	-2.02*
CM 111 x NEI 9202B	13.11*	14.57*	-1.07	27.77**	-3.20**	0.05	-3.47*	-0.31	-0.28	-0.36	-0.17	0.54
HS 2 x HS 7	3.77	5.92	3.22	2.72	-1.70*	-2.74**	-1.65	-2.49**	0.13	0.25	-0.66	0.27
HS 2 x HS 10	7.83	6.35	6.15	-2.55	-0.95	-1.67*	-0.74	-1.42	0.29	0.25	-1.05	-0.73
HS 2 x KDMI 15	-2.76	-0.21	-3.38	2.42	0.73	-0.36	0.17	-0.67	-0.57	-0.32	-0.66	-0.57
HS 2 x NEI 9208B	6.20	1.62	9.58*	-1.26	-1.32	-0.65	-0.56	-0.06	0.74*	0.57	-0.03	0.18
HS 2 x CI 4	2.29	-0.50	-2.24	-0.12	-1.14	0.48	-0.83	1.46	0.32	0.98	0.35	0.95
HS 2 x CML 446	-0.09	-9.40	0.50	-2.66	0.56	0.01	0.30	-1.12	-0.25	-1.13*	0.33	-0.57
HS 2 x HS 4	-5.90	-4.14	-4.09	-0.39	-0.55	-1.42	-0.51	-0.99	0.06	0.43	-1.01	-1.00
HS 2 x HS 15	-7.33	-4.27	-8.46	-8.43	-1.25	1.87*	-0.36	2.40**	0.66*	0.54	0.54	0.86
HS 2 x HS 17	1.53	0.12	-1.44	-4.31	0.47	0.90	0.44	2.33**	-0.03	1.43*	-0.08	0.88
HS 2 x NEI 9202B	2.19	12.58*	7.23	8.06	-0.71	-1.61*	-1.11	-2.62**	-0.39	-1.00	0.13	-2.32**
HS 7 x HS 10	1.83	-6.96	0.75	-7.13	-1.59	0.08	-0.45	1.79	0.27	1.71**	-0.85	0.21
Mean	255.48	237.00	117.24	110.70	61.84	62.81	64.17	65.90	2.29	3.06	106.74	100.70
CD (Sij) @ 5%	9.99	11.53	8.69	10.24	1.67	1.44	1.68	1.98	0.66	1.02	1.86	1.65
CD (Sij-Skl) @ 5%	14.06	16.21	12.22	14.40	2.35	2.03	2.36	2.31	0.93	1.44	2.62	2.32

* and ** - Significant at 0.05 and 0.01 level of probability, respectively;

HS = Hyd Sel

Contd.....

Table 23 contd....

Hybrids	Plant height (cm)		Ear height (cm)		Days to 50% anthesis		Days to 50% silking		Anthesis to silking interval		Days to maturity	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
HS 7 x KDMI 15	5.24	0.73	7.92	3.34	-1.16	-0.36	-1.29	0.54	-0.09	0.89	-1.21	0.13
HS 7 x NEI 9208B	-4.06	-4.44	2.07	-3.34	-0.96	-0.15	-1.27	-1.35	-0.28	-1.21*	0.42	0.38
HS 7 x CI 4	7.03	1.95	2.86	4.25	1.97	-0.53	1.71	-0.83	-0.19	-0.30	-1.21	-0.36
HS 7 x CML 446	2.41	2.30	-1.26	-1.99	-0.59	0.01	-1.17	-0.40	-0.52	-0.41	-0.48	0.38
HS 7 x HS 4	7.85	8.21	0.81	2.78	-1.20	0.58	-1.47	0.97	-0.21	0.39	-1.82	-0.30
HS 7 x HS 15	-0.84	-0.07	-4.31	1.74	0.86	1.37	0.92	0.37	0.15	-1.00	1.99*	-0.20
HS 7 x HS 17	11.53*	11.56*	4.91	11.61*	0.32	-0.60	-0.27	-0.71	-0.55	-0.11	-1.14	-1.43
HS 7 x NEI 9202B	-11.07*	5.68	-0.95	-3.02	1.14	-0.61	0.67	-1.40	-0.41	-0.79	1.33	-1.63
HS 10 x KDMI 15	0.55	-5.84	-2.85	-8.13	0.59	-1.29	1.37	-1.14	0.82*	0.14	1.40	0.38
HS 10 x NEI 9208B	-2.25	-3.76	3.26	5.20	0.29	0.42	-0.36	-0.53	-0.62	-0.96	0.02	1.63
HS 10 x CI 4	5.09	0.38	5.94	-0.22	1.47	-0.70	1.12	-0.51	-0.28	0.20	0.65	-1.11
HS 10 x CML 446	-3.28	10.73	-1.27	10.80*	0.41	-0.42	-0.01	-0.33	-0.35	0.09	-0.12	-0.88
HS 10 x HS 4	-4.85	0.74	-9.16*	-11.44*	-0.45	-0.35	-0.31	-0.21	0.20	0.14	0.54	-0.05
HS 10 x HS 15	-1.28	-0.14	6.47	3.33	-0.89	-0.56	-0.92	-1.31	0.06	-0.75	-0.16	0.05
HS 10 x HS 17	2.09	8.24	2.89	10.40*	-1.18	0.73	-0.36	0.37	0.86*	-0.36	0.22	0.07
HS 10 x NEI 9202B	11.24*	10.21	8.80*	5.51	0.14	0.46	-0.17	0.17	-0.25	-0.29	-1.82	0.13
KDMI 15 x NEI 9208B	-2.84	3.68	-5.92	0.41	0.72	1.23	0.30	1.47	-0.23	0.46	-2.33*	-1.46
KDMI 15 x CI 4	-3.50	6.81	-8.04	4.50	-0.11	0.10	0.28	-0.51	0.36	-0.63	2.29*	0.30
KDMI 15 x CML 446	1.38	7.32	1.25	0.51	0.09	-0.11	0.66	-0.58	0.54	-0.48	0.77	-0.71
KDMI 15 x HS 4	-11.69*	-10.08	-5.49	-6.47	-0.52	-0.79	-0.90	-1.46	-0.41	-0.68	0.43	0.61
KDMI 15 x HS 15	-0.12	-0.21	7.74	2.25	0.29	-0.01	-0.01	-0.56	-0.30	-0.57	-0.01	-0.54
KDMI 15 x HS 17	-0.75	-4.27	-3.44	-3.39	-0.75	-2.72**	-0.20	-1.14	0.50	1.57*	0.36	0.48
Mean	255.48	237.00	117.24	110.70	61.84	62.81	64.17	65.90	2.29	3.06	106.74	100.70
CD (Sij) @ 5%	9.99	11.53	8.69	10.24	1.67	1.44	1.68	1.98	0.66	1.02	1.86	1.65
CD (Sij-Skl) @ 5%	14.06	16.21	12.22	14.40	2.35	2.03	2.36	2.31	0.93	1.44	2.62	2.32

* and ** - Significant at 0.05 and 0.01 level of probability, respectively;

HS = Hyd Sel

Contd.....

Table 23 contd....

Hybrids	Plant height (cm)		Ear height (cm)		Days to 50% anthesis		Days to 50% silking		Anthesis to silking interval		Days to maturity	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
KDMI 15 x NEI 9202B	17.40**	9.60	12.03*	9.98	-0.93	0.26	-1.01	-0.08	-0.10	-0.36	-0.92	-0.21
NEI 9208B x CI 4	2.46	0.39	-0.89	1.82	0.84	1.32	0.80	1.60	-0.09	0.27	0.42	-0.70
NEI 9208B x CML 446	5.09	1.00	1.80	5.84	-0.46	0.60	-0.08	0.78	0.34	0.16	0.15	0.79
NEI 9208B x HS 4	12.52*	0.65	10.31*	6.10	-0.57	-0.08	-0.38	-0.10	0.15	-0.04	1.81	1.11
NEI 9208B x HS 15	14.59**	9.27	11.70*	4.32	0.73	-0.04	0.51	-0.71	-0.25	-0.68	0.11	0.21
NEI 9208B x HS 17	-8.20	1.01	-6.28	-1.81	1.45	-0.76	1.07	-1.53	-0.19	-0.79	0.49	-0.02
NEI 9208B x NEI 9202B	-1.89	-2.03	-7.22	-9.70	0.02	0.48	-0.24	0.03	-0.30	-0.46	-1.80	0.79
CI 4 x CML 446	-7.08	-2.37	0.39	-5.58	-0.28	-0.53	-0.85	-0.96	-0.57	-0.43	0.27	-0.95
CI 4 x HS 4	-2.49	1.79	-2.56	7.59	-2.14*	0.05	-2.15*	-0.08	-0.02	-0.13	-1.57	-0.38
CI 4 x HS 15	4.93	-1.24	2.03	-7.35	-1.09	-0.67	-0.76	-0.19	0.34	0.48	-0.26	0.23
CI 4 x HS 17	2.79	10.89	4.35	6.37	-0.62	-0.88	-0.70	-0.76	-0.10	0.13	-0.39	-1.75*
CI 4 x NEI 9202B	8.70	7.36	8.36	2.39	1.20	0.10	2.25*	0.54	1.04**	0.45	0.08	1.05
CML 446 x HS 4	0.89	3.49	-0.87	3.70	0.81	-0.17	0.98	0.10	0.16	0.27	-0.33	0.61
CML 446 x HS 15	-4.60	0.61	1.62	7.92	0.11	0.12	0.37	0.49	0.27	0.38	0.47	0.96
CML 446 x HS 17	9.52	5.15	5.64	6.39	-0.43	-0.10	-0.58	-0.08	-0.18	0.02	-1.41	-1.52
CML 446 x NEI 9202B	10.33*	8.56	8.60	6.90	-1.11	-0.36	-0.88	-0.28	0.22	0.09	-1.19	0.54
HS 4 x HS 15	-3.81	-4.58	-5.16	-9.57	-2.25*	-2.31**	-2.43**	-2.39*	-0.18	-0.07	-1.12	-1.71*
HS 4 x HS 17	6.10	7.50	7.10	2.05	-0.28	-0.03	0.12	0.29	0.38	0.32	-1.25	0.80
HS 4 x NEI 9202B	11.26*	17.82*	7.36	11.42*	0.54	-0.29	0.57	-0.90	0.02	-0.61	0.97	-0.14
HS 15 x HS 17	-1.08	-1.28	-1.77	-3.73	0.77	-0.99	0.51	-1.56	-0.27	-0.57	0.56	-0.34
HS 15 x NEI 9202B	11.08*	13.04*	6.04	11.19*	-0.91	-1.76*	-1.54	-1.76	-0.62	0.00	-0.98	-1.29
HS 17 x NEI 9202B	-3.06	9.72	1.17	-0.25	1.56	1.78*	1.01	1.67	-0.57	-0.11	0.15	1.98*
Mean	255.48	237.00	117.24	110.70	61.84	62.81	64.17	65.90	2.29	3.06	106.74	100.70
CD (Sij) @ 5%	9.99	11.53	8.69	10.24	1.67	1.44	1.68	1.98	0.66	1.02	1.86	1.65
CD (Sij-Skl) @ 5%	14.06	16.21	12.22	14.40	2.35	2.03	2.36	2.31	0.93	1.44	2.62	2.32

* & ** - Significant at 0.05 and 0.01 level of probability, respectively;

HS = Hyd Sel

Contd.....

Table 23 contd....

Hybrids	Cob length (cm)		Cob girth (cm)		No. kernel rows /Cob		No. kernels/row		Ears per plant		Shelling percentage	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
CM 111 x HS 2	1.08*	0.26	-0.12	0.56	-0.42	0.10	0.91	-0.17	0.010	0.04	-0.74	0.97
CM 111 x HS 7	-0.01	0.60	0.21	0.88*	0.13	0.29	-2.48	2.20	-0.030	-0.08	-1.45	1.19
CM 111 x HS 10	0.71	-1.36*	-0.11	-0.88*	-0.13	-0.42	0.82	-5.32**	0.103	-0.18**	-0.45	2.01
CM 111 x KDMI 15	0.39	0.71	0.32	0.22	0.18	0.27	0.17	1.23	-0.018	0.13*	0.77	-1.60
CM 111 x NEI 9208B	-0.17	0.00	0.12	0.24	-0.42	0.62	-0.06	-1.69	0.060	0.08	1.63*	1.75
CM 111 x CI 4	-0.18	0.42	0.01	0.37	-0.01	0.55	-0.51	2.59*	-0.052	0.05	0.52	-5.69**
CM 111 x CML 446	-0.96	-0.28	0.15	0.13	0.19	0.28	-1.09	-0.47	0.038	0.12*	0.21	-1.53
CM 111 x HS 4	-0.10	-0.48	-0.18	-0.15	0.01	0.49	1.74	1.01	-0.045	-0.07	0.36	0.88
CM 111 x HS 15	0.53	0.36	0.21	-0.03	0.83*	0.09	0.66	0.73	0.026	0.00	-0.48	0.48
CM 111 x HS 17	0.52	0.86	0.24	-0.16	0.13	0.53	0.19	2.44	-0.029	0.05	0.91	1.68
CM 111 x NEI 9202B	1.03	0.68	0.34	0.18	-0.40	-0.72	3.56*	3.47*	0.094*	0.02	1.18	-1.23
HS 2 x HS 7	0.36	0.89	0.30	0.17	-0.31	0.08	2.55	4.03**	-0.022	0.08	0.32	-1.51
HS 2 x HS 10	-0.49	0.17	0.31	0.16	0.61	0.12	0.18	1.22	-0.044	0.09	-0.22	0.86
HS 2 x KDMI 15	0.36	1.02	-0.14	0.68*	0.42	-0.14	1.78	1.22	-0.017	-0.01	-0.01	-0.81
HS 2 x NEI 9208B	0.65	-0.42	-0.24	-0.43	0.22	0.11	-2.35	-2.61*	0.018	-0.08	-0.19	-1.18
HS 2 x CI 4	-1.21*	-0.75	-0.44	-0.27	-0.62	-0.11	-0.35	-1.23	0.029	0.04	0.15	-1.23
HS 2 x CML 446	0.39	-0.19	-0.08	-0.21	-0.57	-0.53	1.37	-0.29	-0.042	0.11*	-0.50	-1.23
HS 2 x HS 4	-0.68	-0.54	-0.56*	-0.21	-1.26**	-0.47	-2.55	-0.91	0.058	-0.05	-0.12	0.55
HS 2 x HS 15	-0.74	0.52	0.48	-0.09	1.07*	0.38	-1.58	0.57	-0.011	-0.09	0.27	-0.37
HS 2 x HS 17	0.90	-0.70	0.06	-0.75*	0.27	-0.10	2.80	-0.98	0.019	-0.10	-0.25	-0.73
HS 2 x NEI 9202B	0.11	1.17*	0.28	0.59	-0.76	0.38	0.45	1.60	-0.035	0.01	1.38	6.07**
HS 7 x HS 10	-0.08	-0.15	0.14	-0.15	0.68	0.36	1.17	-1.72	0.076	-0.10	0.11	1.11
Mean	15.82	13.60	14.41	12.33	14.71	14.50	31.57	28.07	0.98	0.840	83.47	81.42
CD (Sij) @ 5%	1.08	1.07	0.55	0.65	0.77	0.87	2.83	2.57	0.084	0.113	1.49	2.21
CD (Sij-Skl) @ 5%	1.52	1.51	0.77	0.92	1.09	1.23	3.98	3.61	0.119	0.159	2.10	3.10

* and ** - Significant at 0.05 and 0.01 level of probability, respectively;

HS = Hyd Sel

Contd.....

Table 23 contd....

Hybrids	Cob length (cm)		Cob girth (cm)		No. kernel rows /Cob		No. kernels/row		Ears per plant		Shelling percentage	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
HS 7 x KDMI 15	0.45	-0.03	0.25	0.28	-0.11	1.00*	-1.18	-1.52	-0.015	0.06	0.16	0.22
HS 7 x NEI 9208B	-0.69	0.33	-0.23	-0.06	-1.18*	-0.70	1.54	2.01	-0.038	0.08	0.38	0.38
HS 7 x CI 4	0.03	0.18	-0.09	-0.03	0.10	-0.22	-0.36	0.69	0.013	-0.01	0.25	-1.50
HS 7 x CML 446	-0.12	0.26	-0.33	-0.96**	0.80*	0.34	2.61	-1.42	-0.015	-0.06	1.31	0.82
HS 7 x HS 4	0.58	0.18	0.27	0.41	0.41	0.02	0.53	0.96	0.020	0.09	1.45	0.55
HS 7 x HS 15	0.94	0.21	0.51	0.10	0.74	0.47	1.20	1.68	0.073	-0.02	-1.13	-0.31
HS 7 x HS 17	-1.52**	0.27	-0.23	-0.05	-0.31	-0.49	-1.26	-0.86	-0.024	0.15*	1.51*	-0.22
HS 7 x NEI 9202B	1.31*	1.39*	0.22	0.13	0.11	-0.38	3.51*	-0.68	0.084*	0.02	0.68	-1.00
HS 10 x KDMI 15	-0.13	-0.79	0.00	-0.08	-0.39	-0.42	-0.85	-0.88	-0.019	0.07	-0.93	-0.83
HS 10 x NEI 9208B	-0.10	0.02	0.00	0.21	0.01	-0.82	-0.28	-0.11	-0.052	-0.06	-0.48	-0.30
HS 10 x CI 4	0.52	0.66	-0.10	0.24	-0.36	0.42	0.87	0.63	0.024	-0.05	1.36	-0.82
HS 10 x CML 446	-1.18*	0.92	-0.14	0.30	-0.38	-0.55	-2.12	3.12*	-0.001	0.10	0.70	-0.20
HS 10 x HS 4	1.25*	1.02	-0.25	-0.33	-0.57	-0.40	-0.29	0.05	-0.006	0.03	-1.14	-0.67
HS 10 x HS 15	1.06	0.22	0.37	0.79*	-0.04	0.36	1.98	0.47	0.037	0.01	0.90	-0.23
HS 10 x HS 17	0.00	0.81	0.08	0.41	0.26	1.40**	0.07	2.18	0.002	0.01	1.08	-0.33
HS 10 x NEI 9202B	0.51	-0.42	0.30	0.07	0.48	0.05	1.64	1.15	-0.040	0.04	-0.85	-0.65
KDMI 15 x NEI 9208B	-0.34	-0.61	0.53	-0.19	0.82*	0.02	0.74	0.64	-0.008	-0.09	0.95	0.23
KDMI 15 x CI 4	-0.32	0.09	-0.48	-0.29	-0.43	-0.04	0.57	-0.78	-0.017	-0.01	-0.28	1.84
KDMI 15 x CML 446	0.23	0.82	0.33	0.00	0.53	0.04	-0.67	2.12	0.015	-0.12*	0.98	1.63
KDMI 15 x HS 4	-0.49	0.44	-0.82*	-0.15	-0.16	0.09	-0.89	-0.41	-0.053	0.00	0.26	0.50
KDMI 15 x HS 15	-0.28	0.85	-0.43	-0.56	-0.81*	-0.30	-0.12	2.17	-0.037	0.02	-1.20	-1.73
KDMI 15 x HS 17	-0.22	-1.25*	0.08	-0.06	0.67	0.34	-0.93	-2.83*	0.046	-0.07	0.69	3.34**
Mean	15.82	13.60	14.41	12.33	14.71	14.50	31.57	28.07	0.98	0.840	83.47	81.42
CD (Sij) @ 5%	1.08	1.07	0.55	0.65	0.77	0.87	2.83	2.57	0.084	0.113	1.49	2.21
CD (Sij-Skl) @ 5%	1.52	1.51	0.77	0.92	1.09	1.23	3.98	3.61	0.119	0.159	2.10	3.10

* and ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 23 contd....

Hybrids	Cob length (cm)		Cob girth (cm)		No. kernel rows /Cob		No. kernels/row		Ears per plant		Shelling percentage	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
KDMI 15 x NEI 9202B	-0.06	0.13	0.75*	0.77*	0.24	-0.01	3.09	4.40**	-0.001	0.06	1.94*	0.26
NEI 9208B x CI 4	0.74	0.32	0.25	0.38	0.53	0.21	0.19	0.85	-0.017	0.00	-0.69	1.31
NEI 9208B x CML 446	1.21*	-0.43	-0.22	-0.38	-0.37	-0.06	1.56	-0.01	-0.002	-0.07	-0.19	-0.69
NEI 9208B x HS 4	-0.25	-1.30*	0.75*	-0.39	0.04	0.59	0.68	-2.88*	-0.060	0.06	-0.29	-0.36
NEI 9208B x HS 15	-0.05	1.66**	0.39	0.66*	0.67	-0.10	-0.10	3.94**	-0.092*	0.11*	-0.03	-0.59
NEI 9208B x HS 17	0.29	-0.24	0.15	0.18	0.57	0.54	-0.26	0.90	0.063	0.02	-1.12	0.35
NEI 9208B x NEI 9202B	-0.70	-0.42	-0.45	-0.59	0.04	0.04	-0.64	0.33	-0.009	-0.04	0.63	0.73
CI 4 x CML 446	-0.27	0.54	0.45	0.18	0.63	-0.03	-0.69	0.52	-0.034	0.11*	0.19	2.36*
CI 4 x HS 4	0.11	-0.31	0.02	-0.01	-0.05	0.02	-0.92	-0.70	0.011	-0.06	0.69	2.10
CI 4 x HS 15	0.70	0.03	0.42	-0.04	0.42	0.68	1.65	-2.60*	0.037	0.03	0.94	0.44
CI 4 x HS 17	0.14	-0.49	-0.23	-0.31	0.18	-0.23	0.94	0.93	0.082	0.01	-1.24	-1.20
CI 4 x NEI 9202B	0.42	0.18	0.34	0.04	0.35	0.37	-0.09	-0.49	0.000	-0.01	-0.68	0.16
CML 446 x HS 4	-0.66	-0.45	0.31	-0.04	-0.15	0.51	1.70	0.64	-0.042	0.10	-1.82*	-2.14
CML 446 x HS 15	-0.40	-0.54	-0.45	-0.57	-0.37	-0.13	-0.33	-0.56	0.054	0.04	0.07	1.61
CML 446 x HS 17	0.43	-0.34	0.06	0.57	-0.52	-0.85	-1.80	-2.03	-0.079	-0.05	0.36	1.00
CML 446 x NEI 9202B	0.92	0.51	0.35	0.26	0.05	0.26	0.23	0.85	-0.025	-0.02	0.27	0.80
HS 4 x HS 15	-0.97	-0.17	0.02	0.05	0.04	-0.48	-1.30	-1.58	-0.034	-0.02	0.89	0.69
HS 4 x HS 17	0.27	0.56	0.10	0.09	0.09	-0.45	0.83	0.43	0.026	-0.04	-0.91	-0.30
HS 4 x NEI 9202B	-0.05	1.21*	0.20	0.33	0.66	1.06*	0.31	2.18	-0.001	-0.04	0.41	-0.06
HS 15 x HS 17	-0.83	0.05	0.07	0.44	-0.68	0.01	-1.40	0.72	-0.065	0.07	1.33	1.78
HS 15 x NEI 9202B	0.61	-0.26	-0.26	0.22	-0.71	-0.23	0.22	-0.10	-0.027	0.02	0.43	0.01
HS 17 x NEI 9202B	0.10	-0.53	0.25	-0.03	-0.01	0.01	-0.24	-2.29	0.035	0.00	-0.65	-0.73
Mean	15.82	13.60	14.41	12.33	14.71	14.50	31.57	28.07	0.98	0.840	83.47	81.42
CD (Sij) @ 5%	1.08	1.07	0.55	0.65	0.77	0.87	2.83	2.57	0.084	0.113	1.49	2.21
CD (Sij-Skl) @ 5%	1.52	1.51	0.77	0.92	1.09	1.23	3.98	3.61	0.119	0.159	2.10	3.10

* & ** - Significant at 0.05 and 0.01 level of probability, respectively;

HS = Hyd Sel

Contd.....

Table 23 contd...

Hybrids	100-grain weight (g)		Yield per plant (g)		Yield (kg/ha)		RWC1		RWC2	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
CM 111 x HS 2	1.11	1.05	10.54	2.20	475.87	-103.10	-0.013	-0.022	0.002	0.094
CM 111 x HS 7	2.17*	0.69	-10.36	5.96	-1184.96*	226.89	0.048	0.017	-0.032	0.045
CM 111 x HS 10	0.18	-0.70	6.98	-13.20*	-260.14	-528.53*	-0.021	0.222**	0.005	0.053
CM 111 x KDMI 15	-0.17	0.15	-2.63	0.36	-426.16	-76.04	0.004	-0.014	-0.011	-0.002
CM 111 x NEI 9208B	1.56	1.37	1.34	8.70	171.81	748.40**	0.008	0.014	-0.009	-0.067
CM 111 x CI 4	-0.48	0.40	-1.40	-4.18	1176.58*	885.01**	-0.013	0.030	-0.012	0.064
CM 111 x CML 446	-1.22	-0.75	-7.73	0.70	43.06	10.32	-0.002	0.005	0.026	-0.013
CM 111 x HS 4	-3.81**	-2.05*	-2.11	-2.39	-764.53	-263.39	-0.003	0.011	-0.037	-0.080*
CM 111 x HS 15	2.61*	-0.87	16.00*	2.03	1485.90**	-205.38	0.007	-0.033	-0.004	0.029
CM 111 x HS 17	-1.02	-0.18	3.76	13.58**	207.99	595.42*	0.016	-0.002	0.021	-0.047
CM 111 x NEI 9202B	1.97	0.79	18.61*	8.77	2299.69**	271.97	-0.003	0.003	-0.008	0.009
HS 2 x HS 7	-0.21	-1.26	8.27	2.41	356.64	591.50*	-0.011	0.014	0.047*	0.095*
HS 2 x HS 10	0.93	1.30	2.51	4.96	-701.39	574.50*	-0.007	-0.001	0.012	-0.025
HS 2 x KDMI 15	-0.11	0.40	10.21	6.51	998.37*	141.50	0.002	0.011	-0.029	-0.019
HS 2 x NEI 9208B	2.26*	-1.18	-4.02	-7.56	16.82	-542.74*	0.012	-0.029	-0.002	-0.015
HS 2 x CI 4	-2.02	-0.81	-17.82*	-6.91	-754.00	-370.03	-0.012	-0.003	0.013	0.024
HS 2 x CML 446	0.69	0.66	2.56	0.51	-215.18	273.11	0.026	0.000	-0.037	0.058
HS 2 x HS 4	0.09	-0.51	-16.02*	-4.07	-879.11*	-310.20	-0.007	0.021	0.015	0.063
HS 2 x HS 15	-1.94	-2.36*	-4.42	-1.09	-292.17	-196.27	-0.007	0.007	-0.032	-0.053
HS 2 x HS 17	-0.92	-4.25**	13.05	-9.62*	1744.49**	-581.83*	0.007	-0.012	-0.052	0.094*
HS 2 x NEI 9202B	2.23*	3.10**	8.90	15.64**	147.37	963.33*	0.001	0.003	0.006	-0.105**
HS 7 x HS 10	-2.17*	-0.52	-0.79	-3.93	-127.48	-548.51	0.016	-0.032	0.020	-0.053
Mean	27.66	17.82	120.83	59.52	6897.09	2964.30	0.93	0.910	0.87	0.710
CD (Sij) @ 5%	2.17	1.83	15.22	9.57	876.11	482.25	0.053	0.061	0.047	0.069
CD (Sij-Skl) @ 5%	3.05	2.57	21.39	13.45	1231.48	677.83	0.075	0.085	0.066	0.098

* and ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 23 contd...

Hybrids	100-grain weight (g)		Yield per plant (g)		Yield (kg/ha)		RWC1		RWC2	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
HS 7 x KDMI 15	1.45	-0.23	1.86	0.31	-322.14	41.53	-0.009	-0.013	0.024	0.028
HS 7 x NEI 9208B	0.14	0.24	-1.92	3.79	-314.02	230.07	0.000	0.005	-0.014	0.001
HS 7 x CI 4	0.06	0.58	2.58	1.54	479.82	-186.15	-0.029	0.006	0.009	0.019
HS 7 x CML 446	-1.54	-1.34	4.56	-6.29	327.48	-224.16	0.019	0.013	-0.036	0.056
HS 7 x HS 4	-0.33	0.80	7.73	6.00	1246.14**	257.43	0.014	-0.008	-0.030	-0.116**
HS 7 x HS 15	0.45	-1.45	12.88	1.17	974.00*	298.64	0.024	0.018	-0.023	0.021
HS 7 x HS 17	-1.09	3.19**	-10.35	4.87	-336.50	417.08	-0.097*	-0.004	-0.007	0.019
HS 7 x NEI 9202B	-0.83	0.06	15.00	8.05	711.96	516.07*	0.016	0.006	-0.018	-0.006
HS 10 x KDMI 15	-0.29	0.76	-1.61	-3.19	277.68	178.21	0.020	0.022	-0.106**	0.024
HS 10 x NEI 9208B	-0.57	1.65	-5.53	2.92	991.80*	-100.61	-0.008	-0.008	-0.002	-0.019
HS 10 x CI 4	0.73	0.58	4.07	-1.52	276.89	-250.14	-0.007	-0.112	-0.012	0.052
HS 10 x CML 446	1.42	0.75	-7.35	7.78	-377.70	507.92*	-0.012	-0.004	0.018	0.004
HS 10 x HS 4	1.15	1.17	3.87	1.52	-248.70	281.26	0.003	-0.028	-0.008	0.051
HS 10 x HS 15	0.59	0.39	12.17	0.62	1042.99*	263.80	0.021	0.008	0.024	0.004
HS 10 x HS 17	-0.32	-2.25*	-0.16	7.31	383.97	-127.69	0.019	0.011	-0.007	-0.018
HS 10 x NEI 9202B	0.30	-0.89	12.83	-0.22	912.58*	333.15	0.003	-0.004	-0.059*	0.006
KDMI 15 x NEI 9208B	1.17	0.23	12.71	-1.86	1137.46*	-502.46*	-0.001	-0.006	-0.045	-0.009
KDMI 15 x CI 4	-0.38	0.63	-2.98	1.91	-162.53	138.75	-0.012	0.055	-0.013	0.002
KDMI 15 x CML 446	0.33	0.71	4.99	1.93	-24.44	-12.44	0.011	0.010	0.030	-0.023
KDMI 15 x HS 4	-2.80*	0.08	-14.19	0.49	-1192.29*	-3.99	-0.008	-0.012	0.039	0.012
KDMI 15 x HS 15	-1.43	-1.25	-10.04	6.48	-1159.58*	614.37*	-0.007	0.017	-0.010	-0.072*
KDMI 15 x HS 17	-0.07	1.25	-4.02	-1.27	-838.10	-491.77	0.004	0.003	0.019	-0.078*
Mean	27.66	17.82	120.83	59.52	6897.09	2964.30	0.93	0.910	0.87	0.710
CD (Sij) @ 5%	2.17	1.83	15.22	9.57	876.11	482.25	0.053	0.061	0.047	0.069
CD (Sij-Skl) @ 5%	3.05	2.57	21.39	13.45	1231.48	677.83	0.075	0.085	0.066	0.098

* and ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 23 contd...

Hybrids	100-grain weight (g)		Yield per plant (g)		Yield (kg/ha)		RWC1		RWC2	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
KDMI 15 x NEI 9202B	0.06	-0.64	17.73*	7.45	1591.01**	841.12**	-0.002	0.010	0.043	-0.039
NEI 9208B x CI 4	0.40	-0.69	4.84	4.09	384.52	155.26	0.002	0.023	-0.021	0.041
NEI 9208B x CML 446	-0.22	-0.70	3.51	-5.87	152.93	-395.00	0.013	0.010	-0.003	-0.001
NEI 9208B x HS 4	0.14	-2.23*	8.88	-13.54**	393.34	-537.71*	0.004	-0.034	0.018	-0.058
NEI 9208B x HS 15	1.14	1.85*	8.38	14.37**	625.95	754.88**	0.000	0.020	-0.015	0.011
NEI 9208B x HS 17	-0.49	0.03	-2.65	-1.33	2.28	476.92	0.001	-0.009	0.034	0.045
NEI 9208B x NEI 9202B	-3.16**	-0.87	-10.50	-7.41	-2128.86**	-359.43	0.002	0.006	0.082*	0.142**
CI 4 x CML 446	0.93	0.27	-1.03	9.44	987.67*	681.96*	-0.004	0.016	0.004	0.009
CI 4 x HS 4	1.67	2.48*	3.29	1.59	-3.23	473.05	-0.027	0.005	0.003	0.041
CI 4 x HS 15	-0.99	-1.23	9.84	-1.45	-156.14	-394.66	-0.009	-0.104*	0.012	0.021
CI 4 x HS 17	-2.03	-1.47	0.51	-5.86	-143.71	-67.47	-0.005	0.019	-0.016	-0.018
CI 4 x NEI 9202B	1.56	-1.19	0.11	-0.72	-46.60	-299.14	-0.002	0.029	0.000	-0.042
CML 446 x HS 4	-2.41**	-0.91	-5.24	-6.18	-271.49	140.71	-0.022	-0.015	-0.004	0.080*
CML 446 x HS 15	0.37	-0.75	-6.33	-6.94	-196.05	126.65	-0.001	-0.012	0.030	-0.134**
CML 446 x HS 17	1.69	1.99	-2.62	0.82	-840.90	118.02	-0.042	-0.008	-0.009	0.001
CML 446 x NEI 9202B	1.63	0.89	7.28	5.18	814.24	-71.93	-0.004	-0.013	-0.005	0.002
HS 4 x HS 15	1.97	1.99	-17.07*	3.09	12.03	165.77	-0.022	0.012	0.029	0.024
HS 4 x HS 17	0.83	0.69	1.05	2.11	391.68	-80.37	0.107	-0.010	0.026	0.042
HS 4 x NEI 9202B	-0.49	0.11	2.45	7.12	1330.31**	599.44*	-0.009	0.043	-0.021	-0.006
HS 15 x HS 17	1.79	4.02*	2.16	2.55	-451.28	1145.15**	-0.013	-0.004	-0.011	0.022
HS 15 x NEI 9202B	-1.67	0.27	5.65	2.43	83.58	120.80	-0.011	0.036	0.020	-0.004
HS 17 x NEI 9202B	0.99	-0.59	-6.58	-3.81	-203.34	-428.33	0.002	-0.001	-0.025	0.039
Mean	27.66	17.82	120.83	59.52	6897.09	2964.30	0.93	0.910	0.87	0.710
CD (Sij) @ 5%	2.17	1.83	15.22	9.57	876.11	482.25	0.053	0.061	0.047	0.069
CD (Sij-Skl) @ 5%	3.05	2.57	21.39	13.45	1231.48	677.83	0.075	0.085	0.066	0.098

* & ** - Significant at 0.05 and 0.01 level of probability, respectively;
RWC1 – Relative water content at 60 DAS

HS = Hyd Sel
RWC2 – Relative water content at 90 DAS

Contd.....

Table 23 contd...

Hybrids	CHL1		CHL2		Drought susceptibility index
	Nonstress	Stress	Nonstress	Stress	
CM 111 x HS 2	-0.30	-1.976	0.67	3.842*	0.044
CM 111 x HS 7	-0.32	3.112	1.20	5.338**	-0.187
CM 111 x HS 10	-0.28	-3.376	0.71	-1.796	0.270
CM 111 x KDMI 15	0.50	-1.065	1.24	1.483	-0.048
CM 111 x NEI 9208B	2.32	3.5568	3.23*	5.013*	-0.168
CM 111 x CI 4	-1.20	1.644	1.26	0.235	0.083
CM 111 x CML 446	-2.39	-2.128	-2.77	0.594	-0.078
CM 111 x HS 4	-3.23*	-0.487	-3.06	-3.278	0.033
CM 111 x HS 15	-0.54	-1.735	-2.57	0.920	0.090
CM 111 x HS 17	1.33	6.317*8	1.52	-0.301	-0.230
CM 111 x NEI 9202B	3.43*	3.822*	2.29	2.423	0.000
HS 2 x HS 7	-2.61	-0.072	-1.93	-0.565	0.039
HS 2 x HS 10	2.13	0.190	2.48	6.506**	-0.039
HS 2 x KDMI 15	0.86	-1.524	-0.31	-1.340	-0.027
HS 2 x NEI 9208B	1.56	0.172	0.29	-0.910	0.090
HS 2 x CI 4	-2.24	-1.940	-0.75	-0.908	-0.039
HS 2 x CML 446	0.92	1.888	-1.47	2.116	0.013
HS 2 x HS 4	-2.62	1.304	-3.62*	0.910	-0.121
HS 2 x HS 15	1.17	3.606*	1.29	-5.618**	-0.059
HS 2 x HS 17	0.09	-1.217	-0.23	-2.014	0.258*
HS 2 x NEI 9202B	2.09	2.488	2.45	2.523	-0.174
HS 7 x HS 10	-0.58	1.128	-1.08	1.527	0.051
Mean	49.53	43.93	47.00	30.06	1.030
CD (Sij) @ 5%	2.84	3.53	3.14	3.78	0.198
CD (Sij-Skl) @ 5%	4.01	4.96	4.42	5.32	0.278

* and ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel
 CHL1 – Chlorophyll content at 60 DAS CHL2 – Chlorophyll content at 90 DAS

Contd.....

Table 23 contd...

Hybrids	CHL1		CHL2		Drought susceptibility index
	Nonstress	Stress	Nonstress	Stress	
HS 7 x KDMI 15	-0.52	0.863	0.84	-0.754	-0.010
HS 7 x NEI 9208B	-0.38	-2.590	1.28	-0.689	-0.071
HS 7 x CI 4	-1.45	-1.053	-2.53	-0.727	0.013
HS 7 x CML 446	0.84	-2.949	0.18	-1.133	0.165
HS 7 x HS 4	-0.40	-2.083	-2.07	-0.150	-0.052
HS 7 x HS 15	1.06	0.469	1.80	4.878*	0.095
HS 7 x HS 17	-0.85	-1.530	-1.04	3.072	-0.193
HS 7 x NEI 9202B	0.53	3.826*	0.38	0.281	0.003
HS 10 x KDMI 15	-0.11	-0.449	1.22	-1.063	0.032
HS 10 x NEI 9208B	-0.51	-3.253	-2.52	-3.703	-0.091
HS 10 x CI 4	-1.58	1.885	0.13	2.659	0.067
HS 10 x CML 446	-0.03	0.738	-0.88	-3.422	-0.246
HS 10 x HS 4	-1.16	1.704	-3.09	1.492	0.028
HS 10 x HS 15	0.78	1.556	0.00	1.950	0.080
HS 10 x HS 17	0.57	1.133	0.41	3.344	-0.101
HS 10 x NEI 9202B	-2.11	-2.487	-2.46	1.887	0.095
KDMI 15 x NEI 9208B	-0.03	1.108	-1.79	1.456	0.125
KDMI 15 x CI 4	1.59	0.470	2.70	2.988	-0.044
KDMI 15 x CML 446	-0.67	0.949	-0.56	1.567	0.056
KDMI 15 x HS 4	1.14	-0.135	0.64	-0.045	-0.156
KDMI 15 x HS 15	-1.82	3.067	0.37	-2.497	-0.184
KDMI 15 x HS 17	1.05	2.869	-0.08	5.077*	-0.017
Mean	49.53	43.93	47.00	30.06	1.030
CD (Sij) @ 5%	2.84	3.53	3.14	3.78	0.198
CD (Sij-Skl) @ 5%	4.01	4.96	4.42	5.32	0.278

* and ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel
 CHL1 – Chlorophyll content at 60 DAS CHL2 – Chlorophyll content at 90 DAS

Contd.....

4.2.4.2.18 Drought susceptibility index

None of the 66 hybrids recorded significant negative (desirable) sca effects for the trait. However, two hybrids viz., Hyd Sel 2 x Hyd Sel 17 and NEI 9208B x Hyd Sel 4 proved undesirable specific combiners by recording significant positive sca effects for the trait.

4.2.5 Grain yield stability of hybrids

4.2.5.1 Grain yield stability of hybrids under stress

Twenty three hybrids which performed better under stress or nonstress or both during *rabi*/summer 2008-09 were selected and tested at Agricultural Research Station, Hagari of University of Agricultural Sciences, Raichur under managed drought during *rabi*/summer 2009-10. For stability analysis, yield (kg/ha) of these 23 hybrids and checks were picked from diallel set of crosses tested under 2008-09 and 2009-10 at College of Agriculture, Bheemarayanagudi. The results of the stability analysis are presented under the following headings.

4.2.5.1.1 ANOVA for grain yield stability

It is evident from the Table 24 that mean sum of squares due to varieties and varieties x environment were nonsignificant. The environmental component was larger than genotype and genotype x environment interaction components for yield. Mean sum of squares due to pooled deviation were significant indicating the importance of nonlinear (unpredictable) portion of G x E interaction for the trait.

The mean grain yield of 17 crosses along with checks is presented in Table 25. It is evident from the Table that environments varied greatly (-965.32 to 882.69). The mean grain yield of hybrids during 2008-09 ranged from 1891.65 (Hyd Sel 2 x Hyd Sel 17) to 3711.65 kg/ha (KDMI 15 x NEI 9202B). During 2009-10 at Bheemarayanagudi, the mean yield ranged from 2180.05 (Hyd Sel 2 x Hyd Sel 17) to 5310.25 kg/ha (NEI 9208B x Hyd Sel 15) whereas at Agricultural Research Station, Hagari it ranged from 750.00 (All-Rounder) to 2636.70 kg/ha (CML 446 x Hyd Sel 4).

The over all mean of three seasons indicated that KDMI 15 x NEI 9202B (3497.17 kg/ha), Hyd Sel 2 x NEI 9202B (3353.83 kg/ha) and Hyd Sel 15 x Hyd Sel 17 (3361.33 kg/ha) as promising hybrids under drought.

The stability parameters (Table 25) indicated that three hybrids viz., KDMI 15 x NEI 9202B, Hyd Sel 2 x NEI 9202B and Hyd Sel 7 x NEI 9202B showed mean value above the population mean (2762.50 kg/ha), bi values nearer to unity and nonsignificant S^2Di . The hybrid KDMI 15 x NEI 9202B emerged as the most stable drought tolerant hybrid among the tested hybrids and checks. Incidentally, the hybrids also recorded resistant reaction to important diseases of maize viz., turicum leaf blight and common rust (Table 40).

4.2.5.2. Grain yield stability of hybrids under nonstress situation

All the hybrids except two viz., (CM 111 x Hyd Sel 4 and Hyd Sel 2 x Hyd Sel 7) were tested at Agricultural Research Station, Arabhavi during *kharif* 2009-10 for yield. The grain yield (kg/ha) of nonstress (irrigated) experiments of 2008-09 and 2009-10 conducted at Bheemarayanagudi and yield obtained at Arabhavi was subjected to stability analysis. The results of the stability analysis are presented in Table 26 and Table 27.

4.2.5.2.1 ANOVA for stability

It is evident from Table 26 that mean sum of squares due to genotypes were significant for grain yield. The environmental component was much larger than the genotype and genotypes x environment interaction components for yield. The mean sum of squares due to pooled deviations, which indicate the non linear or unpredictable portion of G x E interactions were highly significant for the trait. The mean grain yield of hybrid and checks over seasons is presented in Table 27. It is evident from the results that environments varied widely (-1628.42 to 1019.28). The mean grain yield of hybrids ranged from 4423.35 (CM 111 x Hyd Sel 7) to 9121.65 kg/ha (All-Rounder) during 2008-09 at Bheemarayanagudi. During 2009-10, at the same location, it ranged from 3933.80 (CM 111 x Hyd Sel 7) to 9743.60 kg/ha (CM 111 x NEI 9202B). At Agricultural Research Station, Arabhavi, the mean grain yield ranged from 3666.65 (900M) to 5333.33 kg/ha (CM 111 x Hyd Sel 15).

The mean yield over three seasons indicated that All-Rounder (7661.03 kg/ha) followed by CM 111 x NEI 9202B (7501.20 kg/ha) and CML 446 x NEI 9202B (7263.78 kg/ha) were found promising. The stability parameters (Table 27) indicated that six hybrids viz., CM 111 x CI 4 (6791.28 kg/ha; $b_i = 0.96$), CM 111 x Hyd Sel 15 (6976.22 kg/ha; $b_i = 1.02$), Hyd Sel 7 x NEI 9202B (6674 kg/ha; $b_i = 1.01$), Hyd Sel 10 x NEI 9208B (7225.75 kg/ha; $b_i = 1.07$), CI 4 x Hyd Sel 15 (6405.18 kg/ha; $b_i = 1.05$) and Hyd Sel 15 x NEI 9202B (6831.70 kg/ha; $b_i = 1.05$) and were found to be stable hybrids as they recorded mean grain yield above population mean (6181.60 kg/ha), b_i value nearer to 1.0 and nonsignificant S^2Di .

4.3 Line x Tester analysis involving different drought tolerant sources

This study involved four drought tolerant commercial hybrids, four drought tolerant composites/populations and three drought tolerant inbreds. Commercial hybrids and composites were used as lines and inbreds as testers. The resulting hybrids were evaluated during post rainy season of 2009-10 under stress and nonstress and the data was analysed for stress and nonstress separately. The results of this study are presented in the following headings.

4.3.1 Analysis of variance

The ANOVA in respect of all the characters studied on hybrids (only) under nonstress and stress situations are presented in Table 28.

The mean sum of squares for crosses were significant for most of the traits in both the situations except days to maturity, cob length, number of kernels per row and relative water content at both the stages under irrigated situation and days to anthesis, cob girth, cobs per plant, relative water content at both the stages and drought susceptibility index under stress situation. Further, lines also showed significant differences for most of the traits in nonstress situation except plant height, ear height, days to maturity, number of kernels per row, cobs per plant, shelling percentage, yield per ha, relative water content at both the stages and chlorophyll content at 60 DAS. Under stress condition, lines showed significant differences for anthesis to silking interval, test weight and yield per plant only. The testers showed significant differences for days to anthesis, days to silking, cob girth, number of kernel rows per cob and test weight under nonstress situation. While in stress situation, they revealed significant differences for plant height days to 50% anthesis days to 50% silking, test weight and yield (kg/ha).

The interaction between lines and testers was significant for shelling percentage and chlorophyll content at both the stages under nonstress situation. Whereas, under stress situation, the interaction was significant for cob length, number of kernels per row and chlorophyll content at 90 DAS.

4.3.2 *Per se* performance and heterosis of crosses

Per se performance and heterosis over commercial check for different quantitative traits were studied in 24 crosses to assess the variability for combining ability and the results of which are presented in Table 29.

4.3.2.1 Plant height (cm)

The mean plant height among crosses ranged from 244.15 (NAC 6002 x Hyd Sel 17) to 333.06 cm (NAH 2049 x CML 446) with an overall mean of 260.15 cm under nonstress. Under stress, the mean plant height of crosses ranged from 208.66 (Karveer x Hyd Sel 17) to 261.10 cm (NAH 2049 x CML 446) with an overall mean of 233 cm.

The magnitude of heterosis over commercial check ranged from -10.11 to 22.62 per cent with a mean heterosis of -4.22% under nonstress situation. NAH 2049 x CML 446 exhibited significant positive heterosis over check under nonstress, but it was positive and nonsignificant under stress.

Table 24. Pooled ANOVA for grain yield stability with respect to yield (kg/ha) of selected hybrids tested under managed drought conditions

Sources of variation	Df	Mean sum of squares
Rep within Env.	3	242945.70
Varieties	27	554588.00
Env.+ (Var.* Env.)	56	1154972.00**
Environments	2	24049360.00**
Var.* Env.	54	307031.8
Environments (Lin.)	1	48098730.00**
Var.* Env.(Lin.)	27	309625.60
Pooled Deviation	28	293565.20**
Pooled Error	81	107950.50
Total	83	959666.60

* & ** - Significant at 0.05 and 0.01 level of probability, respectively

Table 25. Stability parameters of selected maize hybrids tested under managed drought conditions

Crosses	2008 (Bgudi)	2009 (Bgudi)	2009 (Hagari)	Mean	bi	S ² Di
CM 111 x CI 4	3510.00	4406.70	1266.70	3061.13	1.72	29110.1
CM 111 x Hyd Sel 15	2401.65	3305.60	1496.70	2401.32	0.97	-103097.5
CM 111 x Hyd Sel 17	3643.35	3110.25	1223.30	2658.97	1.09	1095023.0**
Hyd Sel 2 x KDMI 15	2541.70	3438.80	2351.70	2777.40	0.57	7751.3
Hyd Sel 2 x Hyd Sel 17	1891.65	2180.05	1545.00	1872.23	0.34	-112651.4
Hyd Sel 2 x NEI 9202B	3190.00	4342.35	2529.15	3353.83	0.96	-23339.2
Hyd Sel 7 x KDMI 15	3206.65	2553.00	1795.00	2518.22	0.46	526034.2*
Hyd Sel 7 x Hyd Sel 15	2923.35	3443.20	2129.15	2831.90	0.71	-111177.1
Hyd Sel 7 x NEI 9202B	2933.35	3683.00	1935.85	2850.73	0.95	-112740.7
Hyd Sel 10 x NEI 9202B	2345.15	3618.60	2547.50	2837.08	0.54	321738.6
KDMI 15 x NEI 920B	1934.65	3381.05	1320.85	2212.18	1.09	90967.9
KDMI 15 x CI 4	3118.35	3718.50	2110.00	2982.28	0.88	-106635.5
KDMI 15 x NEI 9202B	3711.65	4315.70	2464.15	3497.17	1.01	-86909.7
NEI 9208B x Hyd Sel 15	2613.30	5310.25	1935.85	3286.47	1.77	899728.3**
CI 4 x CML 446	2413.35	4681.95	2248.30	3114.53	1.26	865505.2**
CI 4 x Hyd Sel 4	3696.65	3747.35	2481.70	3308.57	0.71	51078.2
CI 4 x Hyd Sel 17	2330.00	3631.90	1298.35	2420.08	1.25	-56409.2
All-Rounder (c)	2416.65	3179.05	750.00	2115.23	1.33	-57340.6
Arjun (c)	3049.85	2706.20	1277.50	2344.52	0.82	500742.6*
NK 6240 (c)	3161.65	3023.65	1000.00	2395.10	1.14	568744.3*
900M (c)	2438.30	4242.45	1590.85	2757.20	1.40	172573.3
Rajkumar (c)	3510.00	4684.20	1575.00	3256.40	1.69	-93194.2
Environmental Index	82.63	882.69	-965.32			
Mean	2849.15	3649.21	1801.20	2762.50		
C. V.	17.14	15.51	16.55			
SE of Difference	488.43	565.91	298.14			
CD at 5 %	1002.18	1161.14	611.73			
CD at 1 %	1353.29	1567.94	826.04			

* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 25 contd.....

Crosses	2008 (Bgudi)	2009 (Bgudi)	2009 (Hagari)	Mean	bi	S ² Di
CI 4 x NEI 9202b	2531.70	3336.65	2445.00	2771.12	0.46	3530.6
CML 446 x Hyd Sel 4	2383.35	3421.00	2636.70	2813.68	0.39	210188.7
CML 446 x Hyd Sel 17	2608.15	2775.00	1496.70	2293.28	0.71	-13742.6
CML 446 x NEI 9202B	2251.65	3121.30	1580.00	2317.65	0.82	-85630.9
Hyd Sel 4 NEI 9202B	3843.35	3638.60	1676.70	3052.88	1.11	623590.8*
Hyd Sel 15 x Hyd Sel 17	3176.65	5181.50	1725.85	3361.33	1.85	58779
All-Rounder (c)	2416.65	3179.05	750.00	2115.23	1.33	-57340.6
Arjun (c)	3049.85	2706.20	1277.50	2344.52	0.82	500742.6*
NK 6240 (c)	3161.65	3023.65	1000.00	2395.10	1.14	568744.3*
900M (c)	2438.30	4242.45	1590.85	2757.20	1.40	172573.3
Rajkumar (c)	3510.00	4684.20	1575.00	3256.40	1.69	-93194.2
Environmental Index	82.63	882.69	-965.32			
Mean	2849.15	3649.21	1801.20			
C. V.	17.14	15.51	16.55			
SE of Difference	488.43	565.91	298.14			
CD at 5 %	1002.18	1161.14	611.73			
CD at 1 %	1353.29	1567.94	826.04			

* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Table 26. Pooled ANOVA for stability with respect to yield (kg/ha) in 12 × 12 half diallel set of crosses

Sources of variation	df	Mean sum of squares
Rep within Env.	3	3451181.00**
Varieties	68	1416831.00*
Env.+ (Var.* Env.)	138	2874033.00**
Environments	2	140129200.00**
Var.* Env.	136	855575.20
Environments (Lin.)	1	280258300.00**
Var.* Env.(Lin.)	68	870441.80
Pooled Deviation	69	828524.400**
Pooled Error	204	386813.90
Total	206	2393015.00

* & ** - Significant at 0.05 and 0.01 level of probability, respectively

Table 27. Stability parameters for grain yield in 12 x 12 diallel set of crosses under irrigated conditions

Crosses	2008 (Bgudi)	2009 (Bgudi)	2009 (Arabhavi)	Mean	bi	S ² Di
CM 111 x HS 2	6385.00	6102.80	4000.00	5495.93	0.91	-426843
CM 111 x HS 7	4423.35	3933.80	4416.65	4257.93	-0.07	-293930
CM 111 x HS 10	5233.35	6213.80	4500.00	5315.72	0.44	257393
CM 111 x KDMI 15	5293.30	5685.40	4083.35	5020.68	0.54	-238004
CM 111 x NEI 9208B	7983.35	5119.35	4416.65	5839.78	1.00	2642710.0**
CM 111 x CI 4	7853.35	7270.50	5250.00	6791.28	0.96	-412667
CM 111 x CML 446	7670.00	5374.60	4916.65	5987.08	0.76	1578216.0*
CM 111 x HS 15	8131.65	7463.65	5333.35	6976.22	1.02	-399575
CM 111 x HS 17	5291.65	6171.60	5333.30	5598.85	0.12	7739.3
CM 111 x NEI 9202B	8010.00	9743.60	4750.00	7501.20	1.57	2451830.0*
HS 2 x HS 10	6705.00	4946.20	4333.30	5328.17	0.69	682604.3
HS 2 x KDMI 15	8185.00	6728.80	4750.00	6554.60	1.16	60081
HS 2 x NEI 9208B	6560.00	7319.35	4250.00	6043.12	1.04	286819
HS 2 x CI 4	6683.35	5665.45	4250.00	5532.93	0.82	-194863
HS 2 x CML 446	6836.65	6777.65	4500.00	6038.10	0.93	-378418
HS 2 x HS 4	4756.65	6458.00	4916.65	5377.10	0.19	1185908
HS 2 x HS 15	6311.65	6813.20	4500.00	5874.95	0.80	-79240.9
HS 2 x HS 17	8238.30	7383.75	4583.30	6735.12	1.34	-383375
HS 2 x NEI 9202B	6900.00	7634.60	5083.30	6539.30	0.84	162665
HS 7 x HS 10	6118.35	5871.90	5000.00	5663.42	0.41	-428140
HS 7 x KDMI 15	6616.00	4848.50	4833.35	5432.62	0.45	848364.3
HS 7 x NEI 9208B	6763.35	5645.45	4333.30	5580.70	0.81	-114922
HS 7 x CI 4	7650.00	6358.05	4083.35	6030.47	1.24	-116636
HS 7 x CML 446	7795.00	6096.10	3750.00	5880.37	1.37	230309
HS 7 x HS 4	8036.65	6620.05	3833.35	6163.35	1.47	-94096.5
HS 7 x HS 15	8500.00	6349.20	4416.65	6421.95	1.32	894967.5
HS 7 x HS 17	5248.35	5403.50	4500.00	5050.62	0.32	-388950
HS 7 x NEI 9202B	8426.70	6429.15	5166.65	6674.17	1.01	850419.4
All-Rounder (c)	9121.65	9694.75	4166.70	7661.03	2.07	602804.1
Arjun (c)	6031.65	8733.50	4166.65	6310.60	1.15	4714705.0**
Bio 9681 (c)	7471.65	6089.45	3833.35	5798.15	1.25	-45687
NK 6240 (c)	8941.65	7110.65	3833.30	6628.53	1.77	190679.5
900M (c)	8438.35	6251.50	3666.65	6118.83	1.59	774536.3
Environmental Index	1019.28	609.14	-1628.42			
Mean	7200.83	6790.69	4553.13	6181.6		
C. V.	13.35	13.41	16.56			
SE of Difference	961.13	910.37	753.88			
CD at 5 %	1917.91	1816.61	1504.33			
CD at 1 %	2547.06	2412.54	1997.82			

* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 27 contd.....

Crosses	2008 (Bgudi)	2009 (Bgudi)	2009 (Arabhavi)	Mean	bi	S ² Di
HS 10 × KDMI 15	6685.00	7219.45	4833.35	6245.93	0.82	-43175
HS 10 × NEI 9208B	7973.35	8287.25	5416.65	7225.75	1.07	-141252
HS 10 × CI 4	6335.00	8507.05	5333.30	6725.12	0.73	2684640.0**
HS 10 × CML 446	7303.00	6418.00	4666.65	6129.22	0.92	-300530
HS 10 × HS 4	6913.35	5994.00	4833.35	5913.57	0.70	-226072
HS 10 × HS 15	7653.35	8573.60	4750.00	6992.32	1.30	648569.3
HS 10 × HS 17	7316.65	6016.20	4833.30	6055.38	0.80	51255.3
HS 10 × NEI 9202B	8143.30	8353.90	4666.70	7054.63	1.43	-108348
KDMI 15 × NEI 9208B	9466.65	6948.60	4166.65	6860.63	1.75	1225694
KDMI 15 × CI 4	7251.65	6575.65	5916.65	6581.32	0.43	-304567
KDMI 15 × CML 446	7240.00	7050.75	5833.30	6708.02	0.54	-430751
KDMI 15 × HS 4	6301.65	4582.05	4916.65	5266.78	0.30	871976.6
KDMI 15 × HS 15	6661.70	5023.85	4333.30	5339.62	0.69	507210.7
KDMI 15 × HS 17	6255.00	4497.75	4000.00	4917.58	0.64	709221.5
KDMI 15 × NEI 9202B	8706.65	9010.95	4166.70	7294.77	1.87	152821.8
NEI 9208B × CI 4	7888.35	7960.90	3500.00	6449.75	1.77	-105598
NEI 9208B × CML 446	7653.35	7920.95	4500.00	6691.43	1.30	-102350
NEI 9208B × HS 4	6585.00	8398.25	4500.00	6494.42	1.11	2194196.0*
NEI 9208B × HS 15	8703.35	7481.40	4583.30	6922.68	1.47	-235180
NEI 9208B × HS 17	6728.35	6633.35	4250.00	5870.57	0.98	-383202
NEI 9208B × NEI 9202B	4910.00	6295.90	4833.30	5346.40	0.24	692818.5
CI 4 × CML 446	9018.30	8236.20	4000.00	7084.83	1.90	-431204
CI 4 × HS 4	7508.35	6693.30	4000.00	6067.22	1.28	-388783
CI 4 × HS 15	6846.65	7785.55	4583.35	6405.18	1.05	525407
CI 4 × HS 17	7788.35	5292.50	4833.35	5971.40	0.81	1958568.0*
CI 4 × NEI 9202B	8085.00	7297.15	4500.00	6627.38	1.32	-400115
CML 446 × HS 4	8065.00	5787.55	4416.65	6089.73	1.12	1255595.0*
CML 446 × HS 15	7865.00	6875.30	4666.70	6469.00	1.13	-290669
All-Rounder (c)	9121.65	9694.75	4166.70	7661.03	2.07	602804.1
Arjun (c)	6031.65	8733.50	4166.65	6310.60	1.15	4714705.0**
Bio 9681 (c)	7471.65	6089.45	3833.35	5798.15	1.25	-45687
NK 6240 (c)	8941.65	7110.65	3833.30	6628.53	1.77	190679.5
900M (c)	8438.35	6251.50	3666.65	6118.83	1.59	774536.3
Environmental Index	1019.28	609.14	-1628.42			
Mean	7200.83	6790.69	4553.13	6181.6		
C. V.	13.35	13.41	16.56			
SE of Difference	961.13	910.37	753.88			
CD 95%	1917.91	1816.61	1504.33			
CD 99%	2547.06	2412.54	1997.82			

* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd Sel

Contd.....

Table 27 contd.....

Crosses	2008 (Bgudi)	2009 (Bgudi)	2009 (Arabhavi)	Mean	bi	S²Di
CML 446 x HS 17	6581.65	5292.50	4166.65	5346.93	0.78	50504.8
CML 446 x NEI 9202B	8078.35	9213.00	4500.00	7263.78	1.61	1209892
HS 4 x HS 15	7206.50	6877.55	4333.30	6139.12	1.10	-423464
HS 4 x HS 17	6121.65	7146.15	4666.65	5978.15	0.74	467539.3
HS 4 x NEI 9202B	7883.35	9368.40	4166.65	7139.47	1.71	2012034.0*
HS 15 x HS 17	6648.35	5669.90	4750.00	5689.42	0.61	-161753
HS 15 x NEI 9202B	7250.00	8245.10	5000.00	6831.70	1.05	607420.6
HS 17 x NEI 9202B	6625.00	6719.95	5000.00	6114.98	0.67	-362082
All-Rounder (c)	9121.65	9694.75	4166.70	7661.03	2.07	602804.1
Arjun (c)	6031.65	8733.50	4166.65	6310.60	1.15	4714705.0**
Bio 9681 (c)	7471.65	6089.45	3833.35	5798.15	1.25	-45687
NK 6240 (c)	8941.65	7110.65	3833.30	6628.53	1.77	190679.5
900M (c)	8438.35	6251.50	3666.65	6118.83	1.59	774536.3
Environmental Index	1019.28	609.14	-1628.42			
Mean	7200.83	6790.69	4553.13	6181.6		
C. V.	13.35	13.41	16.56			
SE of Difference	961.13	910.37	753.88			
CD 95%	1917.91	1816.61	1504.33			
CD 99%	2547.06	2412.54	1997.82			

* & ** - Significant at 0.05 and 0.01 level of probability, respectively; HS = Hyderabad Selection

Table 28. ANOVA for Line x Tester under nonstress and stress situations

Character	Mean sum of squares											
	Crosses		Line Effect		Tester Effect		Lines x Tester Effect		Error		Total	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
Plant height	579.22*	386.60*	644.19	337.73	960.31	1144.75*	492.29	302.73	254.5	173.06	423.27	407.1
Ear height	172.14*	135.87*	141.55	194.34	219.66	270.42	180.65	87.41	84.1	60.53	127.68	220.51
Days to 50% anthesis	7.29**	3.26	13.67**	2.46	23.56**	16.48**	1.77	1.76	1.49	2.83	4.3	3.32
Days to 50% silking	9.21**	6.52**	16.55**	3.84	31.75**	38.37**	2.32	3.31	1.29	2.31	5.14	5.87
ASI	1.17**	3.41*	2.64**	5.99*	0.64	5.85	0.51	1.77	0.4	1.53	0.77	2.85
Maturity	4.69	3.77*	8.18	5.52	0.33	1.08	3.57	3.27	2.78	1.73	3.7	3.89
Cob length (cm)	1.07	1.12**	1.93*	1.33	0.69	2.01	0.69	0.88*	0.63	0.34	1.05	0.76
Cob girth (cm)	0.33*	0.296	0.61**	0.353	0.80**	0.041	0.12	0.303	0.15	0.365	0.26	0.323
Kernel rows / Cob	0.61**	0.72*	1.31**	0.8	1.25**	1.64	0.16	0.56	0.12	0.27	0.36	0.49
No. of kernels / row	7	7.94*	12.12	7.69	5.23	12.15	4.69	7.46*	3.85	3.32	5.87	6.41
Cobs per plant	0.002*	0.003	0.004	0.003	0.003	0.007	0.002	0.003	0.001	0.005	0.002	0.004
Shelling %	2.37**	4.19*	1.87	3.1	7.08	11.34	1.94*	3.71	0.75	1.99	1.53	3.07
100-grain wt (g)	3.68*	4.33*	5.12*	8.06*	13.50**	7.69*	1.56	1.98	1.46	1.91	3	3.06
Yield/plant (g)	245.03*	88.35*	495.76*	116.38	99.90	129.19	140.4	68.5	108.36	38.76	205.21	64.43
Grain yield (kg/ha)	993837.60*	478507.70*	1589321	698052	425112.3	1283107.00*	777342.3	253792.8	372416.6	202747.5	751557.8	336932.9
RWC1	0.001	0.002	0.001.	0.002	0.00	0.004	0.001	0.002	0.001	0.003	0.001	0.002
RWC2	0.005	0.007	0.005	0.011	0.004	0.005	0.005	0.005	0.004	0.003	0.006	0.006
CHL1	10.58**	21.71*	10.47	21.72	26.94	22.77	8.29**	21.54	1.07	10.44	5.7	18.81
CHL2	21.47**	19.29*	39.54*	14.11	20.00	4.19	12.64*	24.04*	4.77	8.33	14.09	14.14
Drought susceptibility index		0.042		0.045		0.097		0.033		0.026		0.036

* and **, significant at 0.05 and 0.01 level of probability, respectively

RWC1 – Relative water content at 60 DAS

RWC2 – Relative water content at 90 DAS

CHL1 – Chlorophyll content at 60 DAS

CHL2 – Chlorophyll content at 90 DAS

4.3.2.2 Ear height (cm)

The variation for ear height among crosses was from 110.16 (NAC 6002 x Hyd Sel 17) to 142.19 cm (Parbhat x CML 446) with an overall mean of 122.34 cm under nonstress situation. Whereas, under stress, it ranged from 93.48 (NAC 6002 x Hyd Sel 17) to 119.61 cm (NAH 2049 x CML 446) with a mean of 108.58 cm.

The per cent heterosis over commercial check was from -13.01 to 12.28 with a mean heterosis of cross -3.39 per cent under nonstress situation. Under stress, it ranged from -12.97 (NAC 6002 x Hyd Sel 17) to 11.36 per cent (NAH 2049 x CML 446). None of the crosses exhibited either significantly positive or negative heterosis over check in both the situations.

4.3.2.3 Days to 50% anthesis

Among the crosses, the range of variation for this trait was from 58.73 (NAC 6002 x CI 4) to 66.45 days (Parbhat x CML 446) with an overall mean of 62.57 days under nonstress situation. Whereas, under stress, the overall mean of crosses slightly increased to 63.56 days. The days to 50% anthesis was minimum (60.18) G 57 x CI 4 and maximum (65.41) was observed in NAC 6002 x CML 446.

Significant negative heterosis over check was observed in four crosses viz., NAC 6002 x CI 4, NAC 6002 x Hyd Sel 17, NAH 2049 x CI 4 and NAH 2049 x Hyd Sel 17 under nonstress, whereas under stress, none of the crosses exhibited significant heterosis over check.

4.3.2.4 Days to 50% silking

The range of variation in this character among the crosses was from 61.15 (NAC 6002 x Hyd Sel 17) to 70.40 (Parbhat x CML 446) with an overall mean of 64.34 under nonstress. Under stress, this was increased from 63.52 (G 57 x CI 4) to 71.58 (Parbhat x CML 446) with a mean of 66.61. Significant negative heterosis over check was noticed in crosses involving NAC 6002 and NAH 2049 as female parents and CI 4 and Hyd Sel 17 as male parents, under nonstress. Whereas, under stress, G 57 x CI 4 exhibited significant negative heterosis and Parbhat x CML 446 exhibited significant positive heterosis.

4.3.2.5 Anthesis to silking interval (ASI)

The mean ASI values among crosses ranged from 0.83 (NK 6240 x CI 4) to 3.96 (Parbhat x CML 446) with an overall mean of 1.76, under nonstress. Under stress, the range increased from 1.30 (Karveer x CI 4) to 7.02 (Parbhat x CML 446) and the overall mean was 3.14. Under stress, G 57 x Hyd Sel 17 and Parbhat x CML 446 exhibited significant positive heterosis over check.

4.3.2.6 Days to maturity

Among the crosses, the mean values ranged from 103 (NAC 6002 x CI 4) to 108 (All-Rounder x CML 446, Parbhat x CI 4, Parbhat x Hyd Sel 17 and NK 6240 x CML 446) with an overall mean of 105.79 under nonstress conditions. Under stress it ranged from 98 (Karveer x Hyd Sel 17 and NAH 2049 x CI 4) to 103 (All-Rounder x CI 4 and NK 6240 x CML 446). Eight crosses under nonstress and five crosses under stress shared significant negative heterosis over check, respectively.

4.3.2.7 Cob length (cm)

The mean cob length among crosses ranged from 12.55 (NAC 6002 x Hyd Sel 17) to 15.18 cm (All-Rounder x Hyd Sel 17) with an overall mean of 13.84 cm under nonstress. Whereas, under stress conditions, it ranged from 9.76 (Karveer x CML 446) to 12.56 cm (Rajkumar x Hyd Sel 17) with an overall mean of 11.25 cm. Eight crosses under nonstress and 20 crosses under stress conditions recorded significantly negative heterosis over check, respectively.

4.3.2.7 Cob girth (cm)

Among the crosses, Karveer x CI 4 (12.48 cm) recorded the lowest mean value, while NAH 2049 x CML 446 (14.07 cm) recorded the maximum mean value for this trait. The overall mean of the trait was 13.32 cm under nonstress conditions.

The range for this trait under stress was from 10.56 (NAC 6002 x Hyd Sel 17) to 12.03 cm (Parbhat x Hyd Sel 17) with an overall mean of 11.29 cm.

Six crosses viz., G 57 x CI 4, G 57 x Hyd Sel 17, Karveer x CI 4 Karveer x Hyd Sel 17, NAC 6002 x CI 4 and NAC 6002 x Hyd Sel 17 recorded significantly negative heterosis over check under nonstress condition. None of the crosses showed significant heterosis over check, under stress.

4.3.2.9 Number of kernel rows per cob

The mean value for this trait among the crosses ranged from 12.94 (Karveer x CI 4) to 15.20 (NAH 2049 x CML 446) with an overall mean of 13.84 under nonstress. Whereas, under stress condition, it ranged from 12.31 to 14.58 observed in G 57 x CI 4 and NAH 2049 x CML 446, respectively. The overall mean of the trait under stress was 13.49.

Five crosses under nonstress recorded significantly positive heterosis over check. While under stress conditions, many of the crosses exhibited significantly negative heterosis over check. The mean heterosis under nonstress and stress was 1.47 and -8.46, respectively.

4.3.2.10 Number of kernels per row

The range for this trait under nonstress and stress was -19.25 to 4.51 and 17.79 to 24.73, respectively. The overall mean of the trait under nonstress and stress was 28.28 and 22.88, respectively. Four crosses in each situation recorded significantly negative heterosis over check.

4.3.2.11 Cobs per plant

Among the crosses, Karveer x Hyd Sel 17 (0.861) recorded the lowest and NAC 6002 x CI 4 (0.984) recorded the highest number of cobs per plant with an overall mean of 0.940 under nonstress. Whereas, under stress situation, Karveer x CI 4 (0.790) and All-Rounder x CI 4 (0.930) recorded lowest and highest mean values, respectively. The overall mean of the trait was 0.870.

Karveer x Hyd Sel 17 recorded significantly positive heterosis over check under nonstress. Whereas, none of the crosses showed significant heterosis over check, under stress.

4.3.2.12 Shelling percentage

Most of the crosses in both the situations recorded significantly negative heterosis over check. The mean heterosis for the trait was -4.09 and -4.82 under nonstress and stress, respectively.

4.3.2.13 Hundred grain weight (g)

Many of the crosses under nonstress situation expressed significantly negative heterosis over check and the mean heterosis under nonstress was -10.45. Similarly, under stress conditions also seven crosses recorded significantly negative heterosis over check.

4.3.2.14 Yield per plant (g)

Among the crosses, Parbhat x CML 446 (81.64) and NAH 2049 x CML 446 (124.65 g) recorded the lowest and highest yield per plant, respectively. The mean of crosses under nonstress was 100.58 g, whereas under stress, yield per plant varied from 38.93 (Parbhat x CML 446) to 62.06 g (Rajkumar x Hyd Sel 17) with an overall mean of 49.45 g.

Fifty per cent of the crosses under nonstress and six crosses under stress showed significant negative heterosis, respectively. The mean heterosis under nonstress and stress was -16.79 and -14.76, respectively.

4.3.2.15 Grain yield (kg /ha)

Variation for grain yield per ha ranged from 4840.69 (Parbhat x CML 446) to 7609.05 kg (NK 6240 x CI 4) with an overall mean of 6029.90 kg /ha under nonstress. Under stress situation, the grain yield of crosses ranged from 1695 (Parbhat x CML 446) to 3582 kg (Rajkumar x Hyd Sel 17) with an overall mean of 2765 kg/ha.

The magnitude of heterosis ranged from -30.58 to 9.15 % and -47.88 to 10.14% under nonstress and stress, respectively. Six crosses under nonstress and two crosses under stress situation showed significantly negative heterosis over check hybrid.

4.3.2.16 Relative water content at 60 DAS (RWC1)

The range of variation for the trait was 0.888 (NK 6240 x CI 4) to 0.952 (NAC 6002 x CI 4) with an overall mean of 0.922 under nonstress. Under stress, it ranged from 0.806 (NAH 2049 x CI 4) to 0.926 (G 57 x Hyd Sel 17) with an overall mean of 0.862.

None of the hybrids recorded significant heterosis over check either in positive or negative direction under nonstress and stress. The mean heterosis over check under nonstress and stress was -0.80 and -0.98%, respectively.

4.3.2.17 Relative water content at 90 DAS (RWC2)

Among the crosses, Rajkumar x Hyd Sel 17 (0.688) and Karveer x Hyd Sel 17 (0.905) recorded the lowest and highest RWC values with an overall mean of 0.843 under nonstress. Whereas, under stress, the RWC values decreased to 0.574 (Karveer x Hyd Sel 17) and 0.793 (NK 6240 x Hyd Sel 17) with an overall mean of 0.698.

All-Rounder x CI 4 and Rajkumar x Hyd Sel 17 recorded significantly negative heterosis over check. Whereas, none of the crosses showed significant heterosis over check, under stress.

4.3.2.18 Chlorophyll content at 60 DAS (CHL1) and 90 DAS (CHL2)

The chlorophyll content in the crosses ranged from 41.90 (All-Rounder x CML 446) to 51.75 (NAC 6002 x CML 446) with an overall mean of 47.89 under nonstress at 60DAS. The chlorophyll content decreased to 39.16 (overall mean) at 90 DAS from 47.89 at 60 DAS under nonstress. Under stress situation the chlorophyll content among the hybrids ranged from 34.90 (Karveer x CML 446) to 45.92 (NAC 6002 x CI 4) at 60 DAS and 23.99 (NAH 2049 x CI 4) to 34.61 (All-Rounder x Hyd Sel 17) at 90 DAS. The overall mean of crosses under stress at 60 DAS and 90 DAS was 39.90 and 28.60.

Two crosses, viz., Parbhat x CI 4 and All-Rounder x Hyd Sel 17 recorded significantly positive heterosis over check under nonstress. Whereas, none of the crosses showed significant heterosis over check, under stress at 60 DAS and 90 DAS.

4.3.2.19 Drought susceptibility index (DSI)

The mean values of crosses for DSI ranged from 0.707 to 1.344 in Karveer x CI 4 and NAH 2049 x CML 446, respectively with an over all mean of 1.020. Karveer x CI 4 and NAC 6002 x CI 4 recorded significantly desirable heterosis over check.

4.3.3 General combining ability (gca) effects

The gca effects of parent for all the traits under nonstress and stress are presented in Table 30.

4.3.3.1 Plant height (cm)

In nonstress environment, NAH 2049 among lines and CML 446 among testers recorded significant positive gca effects. Whereas, under stress, NAC 6002 among lines showed significant negative gca effect, while CML 446 among testers recorded significant positive gca effects.

4.3.3.2 Ear height (cm)

In nonstress environment, NAC 6002 showed significant negative gca effects whereas none of the testers exhibited significant gca effects. Under stress, NAC 6002 and All-Rounder recorded significant negative and positive gca effects, respectively. Among testers, CML 446 recorded significant positive gca effects for the trait.

4.3.3.3 Days to 50% anthesis

Five lines out of eight showed significant gca effects for the trait under nonstress conditions. G 57, NAC 6002 and NAH 2049 recorded significant negative gca effects whereas Parbhat and All-Rounder recorded significant positive gca effects.

Table 29. Per se performance and heterosis in top crosses / three way crosses and varietal hybrids (line x tester) for different traits under nonstress and stress situations

Crosses	Plant height (cm)				Ear height (cm)			
	Nonstress		Stress		Nonstress		Stress	
	Mean	Hcc	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	261.43	-3.75	222.81	-11.09	122.13	-3.56	95.76	-10.85
G 57 x CML 446	257.64	-5.14	252.91	0.92	117.74	-7.02	119.20	10.98
G 57 x HS 17	245.21	-9.72	224.63	-10.36	118.32	-6.57	102.84	-4.26
Karveer x CI 4	254.46	-6.31	244.59	-2.40	112.66	-11.03	109.59	2.03
Karveer x CML 446	266.15	-2.01	237.25	-5.33	136.51	7.80	114.49	6.59
Karveer x HS 17	255.77	-5.83	208.66	-16.74**	119.00	-6.03	99.72	-7.16
Parbhat x CI 4	249.96	-7.97	242.65	-3.17	114.15	-9.85	113.65	5.81
Parbhat x CML 446	265.01	-2.43	239.72	-4.34	142.19	12.28	116.04	8.03
Parbhat x HS 17	264.96	-2.45	225.37	-10.07	130.18	2.80	102.54	-4.54
NAC 6002 x CI 4	251.90	-7.26	221.20	-11.73*	110.53	-12.72	98.12	-8.65
NAC 6002 x CML 446	252.30	-7.11	216.81	-13.48*	120.20	-5.08	99.42	-7.44
NAC 6002 x HS 17	244.15	-10.11	212.90	-15.04**	110.16	-13.01	93.48	-12.97
All-Rounder x CI 4	249.52	-8.13	234.09	-6.59	116.13	-8.29	116.77	8.71
All-Rounder x CML 446	260.40	-4.13	248.79	-0.72	121.27	-4.23	117.28	9.18
All-Rounder x HS 17	263.13	-3.12	241.02	-3.82	125.08	-1.22	116.19	8.18
NAH 2049 x CI 4	269.38	-0.82	210.29	-16.09*	129.52	2.28	95.29	-11.29
NAH 2049 x CML 446	333.06	22.62*	261.10	4.19	134.95	6.57	119.61	11.36
NAH 2049 x HS 17	250.31	-7.84	230.87	-7.87	118.09	-6.74	109.81	2.24
NK 6240 x CI 4	267.99	-1.33	225.10	-10.18	124.24	-1.89	107.77	0.34
NK 6240 x CML 446	255.70	-5.86	238.57	-4.80	111.20	-12.19	110.26	2.65
NK 6240 x HS 17	257.87	-5.06	238.26	-4.93	127.02	0.31	112.34	4.59
Rajkumar x CI 4	254.28	-6.38	227.97	-9.03	116.03	-8.37	108.43	0.95
Rajkumar x CML 446	260.99	-3.91	248.87	-0.69	118.09	-6.74	110.02	2.43
Rajkumar x HS 17	252.06	-7.20	243.34	-2.90	140.74	11.14	117.44	9.34
Rajkumar (Check)	271.61		250.60		126.63		107.41	
Mean	260.15	-4.22	233.24	-6.93	122.34	-3.39	108.58	1.09
Range	244.15-333.06	-10.11-22.62	208.66-261.10	-16.74-4.19	110.16-142.19	-13.01-12.28	93.48-119.61	-12.97-11.36
CD at 5%	32.89		27.21		18.85		16.10	
CD at 1%	44.57		36.93		25.54		21.84	
Sem	11.27		9.30		6.46		5.50	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel

Contd.....

Table 29 contd....

Crosses	Days to 50% anthesis				Days to 50 % silking			
	Nonstress		Stress		Nonstress		Stress	
	Mean	Hcc	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	60.70	-4.06	60.18	-5.31	63.03	-3.49	63.52	-4.76*
G 57 x CML 446	61.91	-2.15	64.12	0.88	64.20	-1.69	68.20	2.25
G 57 x HS 17	61.45	-2.88	62.32	-1.95	62.94	-3.63	68.72	3.03
Karveer x CI 4	61.67	-2.53	64.47	1.43	63.00	-3.53	65.77	-1.39
Karveer x CML 446	62.98	-0.46	63.39	-0.27	64.05	-1.93	66.59	-0.16
Karveer x HS 17	61.84	-2.26	62.63	-1.46	63.10	-3.39	65.36	-2.01
Parbhat x CI 4	62.01	-1.99	62.19	-2.16	65.08	-0.35	66.10	-0.90
Parbhat x CML 446	66.45	5.02*	64.56	1.57	70.40	7.80*	71.58	7.31*
Parbhat x HS 17	62.62	-1.03	62.73	-1.31	65.35	0.06	66.31	-0.58
NAC 6002 x CI 4	58.73	-7.18*	63.35	-0.32	60.15	-7.91*	65.24	-2.19
NAC 6002 x CML 446	62.43	-1.33	65.41	2.92	63.75	-2.39	67.33	0.95
NAC 6002 x HS 17	58.88	-6.94*	61.93	-2.56	61.77	-5.42*	64.41	-3.43
All-Rounder x CI 4	64.66	2.20	64.25	1.09	65.80	0.75	67.27	0.85
All-Rounder x CML 446	65.45	3.45	65.28	2.71	67.53	3.40	68.69	2.98
All-Rounder x HS 17	63.08	-0.29	63.89	0.51	64.02	-1.97	66.51	-0.29
NAH 2049 x CI 4	60.77	-3.94*	62.21	-2.12	62.05	-4.99*	65.38	-1.99
NAH 2049 x CML 446	63.46	0.30	64.78	1.92	65.13	-0.27	68.13	2.15
NAH 2049 x HS 17	60.75	-3.98*	62.14	-2.23	62.23	-4.72*	65.03	-2.50
NK 6240 x CI 4	62.05	-1.93	62.76	-1.26	62.87	-3.73	64.84	-2.79
NK 6240 x CML 446	64.67	2.21	64.69	1.77	66.39	1.65	68.13	2.14
NK 6240 x HS 17	63.53	0.41	63.55	-0.02	65.02	-0.44	65.65	-1.58
Rajkumar x CI 4	64.60	2.10	64.13	0.90	66.00	1.06	66.49	-0.31
Rajkumar x CML 446	64.40	1.79	64.11	0.87	66.17	1.32	68.44	2.61
Rajkumar x HS 17	62.52	-1.19	62.12	-2.27	63.86	-2.22	64.88	-2.73
Rajkumar (Check)	63.27		63.56		65.31		66.70	
Mean	62.57	-1.11	63.38	-0.28	64.34	-1.50	66.61	-0.14
Range	58.73- 66.45	-7.18- 5.02	60.18- 65.41	-5.31- 2.92	61.15- 70.40	-7.91- 7.80	63.52- 71.58	-4.76- 7.31
CD at 5%	2.47		3.48		2.37		3.14	
CD at 1%	3.35		4.72		3.21		4.26	
Sem	0.85		1.19		0.81		1.07	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel

Contd.....

Table 29 contd....

Crosses	Anthesis to silking interval				Days to maturity			
	Nonstress		Stress		Nonstress		Stress	
	Mean	Hcc	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	2.33	14.37	3.34	6.39	107	-1.83	99.0	-2.94*
G 57 x CML 446	2.30	12.56	4.08	29.86	105	-3.67*	101.0	-0.98
G 57 x HS 17	1.49	-27.01	6.40	103.80*	106	-2.75	101.0	-0.98
Karveer x CI 4	1.33	-34.74	1.30	-58.46	104	-4.59*	102.0	0.00
Karveer x CML 446	1.07	-47.37	3.20	1.96	103	-5.50*	99.0	-2.94*
Karveer x HS 17	1.26	-38.27	2.73	-13.15	105	-3.67*	98.0	-3.92*
Parbhat x CI 4	3.07	50.55	3.92	24.71	108	-0.92	101.0	-0.98
Parbhat x CML 446	3.96	93.92**	7.02	123.54**	106	-2.75	101.0	-0.98
Parbhat x HS 17	2.73	33.90	3.58	14.07	108	-0.92	99.0	-2.94*
NAC 6002 x CI 4	1.42	-30.42	1.88	-40.00	103	-5.50*	101.0	-0.98
NAC 6002 x CML 446	1.32	-35.11	1.92	-38.82	105	-3.67*	101.0	-0.98
NAC 6002 x HS 17	2.89	41.65	2.48	-21.05	106	-2.75	100.0	-1.96
All-Rounder x CI 4	1.14	-44.29	3.02	-3.89	105	-3.67	103.0	0.98
All-Rounder x CML 446	2.08	1.95	3.41	8.48	108	-0.92	102.0	0.00
All-Rounder x HS 17	0.94	-54.12	2.62	-16.51	105	-3.67	102.0	0.00
NAH 2049 x CI 4	1.28	-37.37	3.16	0.77	104	-4.59*	98.0	-3.92*
NAH 2049 x CML 446	1.67	-18.04	3.36	6.86	106	-2.75	101.0	-0.98
NAH 2049 x HS 17	1.47	-27.94	2.89	-7.95	106	-2.75	101.0	-0.98
NK 6240 x CI 4	0.83	-59.53	2.08	-33.74	107	-1.83	101.0	-0.98
NK 6240 x CML 446	1.72	-15.77	3.44	9.60	108	-0.92	103.0	0.98
NK 6240 x HS 17	1.49	-26.78	2.10	-33.18	107	-1.83	102.0	0.00
Rajkumar x CI 4	1.40	-31.37	2.36	-24.77	107	-1.83	101.0	-0.98
Rajkumar x CML 446	1.77	-13.27	4.33	37.78	106	-2.75	101.0	-0.98
Rajkumar x HS 17	1.34	-34.42	2.76	-12.13	104	-4.59*	102.0	0.00
Rajkumar (Check)	2.04	-13.62	3.14		109		102.0	
Mean	1.76		3.22	2.67	105.79	-2.94	100.83	-1.14
Range	0.83-3.96	-59.53-93.92	1.30-7.02	1.30-123.54	103.00-108.00	-5.50-(-0.92)	98.0-103.0	-3.92-0.98
CD at 5%	1.35		2.56		3.37		2.72	
CD at 1%	1.83		3.47		4.57		3.69	
Sem	0.46		0.87		1.15		0.93	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel

Contd.....

Table 29 contd....

Crosses	Cob length (cm)				Cob girth (cm)			
	Nonstress		Stress		Nonstress		Stress	
	Mean	Hcc	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	12.91	-15.91**	10.31	-20.76**	12.87	-6.33*	11.54	-1.53
G 57 x CML 446	13.99	-8.89	11.32	-12.99**	13.47	-1.98	10.88	-7.17
G 57 x HS 17	14.32	-6.69	11.83	-9.08*	12.85	-6.48*	10.75	-8.24
Karveer x CI 4	12.60	-17.94**	11.47	-11.81*	12.48	-9.19**	11.62	-0.83
Karveer x CML 446	13.77	-10.30	9.76	-24.95**	13.43	-2.29	10.61	-9.50
Karveer x HS 17	13.95	-9.09	10.94	-15.95**	12.88	-6.27*	10.92	-6.85
Parbhat x CI 4	13.40	-12.73*	11.51	-11.51	13.13	-4.41	11.39	-2.78
Parbhat x CML 446	12.91	-15.89*	10.10	-22.35**	13.21	-3.85	11.24	-4.11
Parbhat x HS 17	13.80	-10.12	11.68	-10.21	13.27	-3.39	12.03	2.66
NAC 6002 x CI 4	12.70	-17.27*	12.01	-7.66	12.77	-7.09*	11.27	-3.87
NAC 6002 x CML 446	13.45	-12.40*	11.67	-10.28*	13.65	-0.62	11.57	-1.27
NAC 6002 x HS 17	12.55	-18.27*	10.32	-20.68**	12.85	-6.47*	10.56	-9.89
All-Rounder x CI 4	14.27	-7.03	11.77	-9.56*	13.44	-2.20	11.52	-1.67
All-Rounder x CML 446	14.01	-8.73	11.06	-15.00*	13.42	-2.32	11.33	-3.31
All-Rounder x HS 17	15.18	-1.09	11.80	-9.33*	13.57	-1.21	11.42	-2.59
NAH 2049 x CI 4	14.21	-7.41	10.34	-20.52**	13.46	-2.06	11.09	-5.40
NAH 2049 x CML 446	14.85	-3.23	10.08	-22.51**	14.07	2.40	11.06	-5.64
NAH 2049 x HS 17	13.87	-9.67	11.18	-14.10**	13.77	0.21	11.06	-5.62
NK 6240 x CI 4	14.40	-6.18	11.45	-11.98**	13.85	0.80	11.35	-3.17
NK 6240 x CML 446	14.20	-7.50	11.30	-13.14**	13.80	0.44	11.81	0.75
NK 6240 x HS 17	14.26	-7.11	12.38	-4.83	13.66	-0.58	11.72	0.02
Rajkumar x CI 4	14.71	-4.16	11.44	-12.07*	12.95	-5.75	11.05	-5.71
Rajkumar x CML 446	13.30	-13.37*	11.72	-9.94*	13.46	-2.01	11.67	-0.40
Rajkumar x HS 17	14.56	-5.12	12.56	-3.49	13.53	-1.56	11.64	-0.72
Rajkumar (Check)	15.35		13.01		13.74		11.72	
Mean	13.84	-9.84	11.25	-13.53	13.32	-3.01	11.29	-3.62
Range	12.55-15.18	-18.27-(-1.09)	9.76-12.56	-24.95-(-3.49)	12.48-14.07	-9.19-2.4	10.56-12.03	-9.89-2.66
CD at 5%	1.63		1.21		0.83		1.25	
CD at 1%	2.21		1.64		1.13		1.69	
Sem	0.56		0.41		0.29		0.43	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel

Contd.....

Table 29 contd....

Crosses	Kernel rows per cob				Number of kernels per row			
	Nonstress		Stress		Nonstress		Stress	
	Mean	Hcc	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	13.22	-3.06	12.31	-16.23**	26.56	-12.88	19.06	-16.70*
G 57 x CML 446	14.10	3.36	13.65	-7.06	30.60	0.38	22.34	-2.37
G 57 x HS 17	13.30	-2.50	13.63	-7.22	28.75	-5.68	21.51	-5.99
Karveer x CI 4	12.94	-5.15	13.98	-4.84	25.78	-15.41*	22.12	-3.32
Karveer x CML 446	13.47	-1.24	12.55	-14.56**	27.77	-8.88	18.25	-20.25
Karveer x HS 17	13.27	-2.75	12.78	-13.03**	27.26	-10.57	20.00	-12.58
Parbhat x CI 4	13.48	-1.18	13.23	-9.96*	27.08	-11.15	23.85	4.26
Parbhat x CML 446	13.89	1.80	14.03	-4.47	25.87	-15.11*	18.10	-20.91*
Parbhat x HS 17	13.44	-1.44	13.94	-5.11	27.52	-9.72	23.94	4.64
NAC 6002 x CI 4	13.82	1.30	13.16	-10.41**	25.59	-16.05*	22.03	-3.70
NAC 6002 x CML 446	13.41	-1.67	13.88	-5.53	29.35	-3.70	23.07	0.81
NAC 6002 x HS 17	13.36	-2.06	13.34	-9.18*	24.61	-19.25**	19.38	-15.32
All-Rounder x CI 4	14.44	5.89*	13.28	-9.61*	31.19	2.34	23.07	0.82
All-Rounder x CML 446	14.47	6.09*	14.14	-3.76	29.91	-1.87	21.86	-4.47
All-Rounder x HS 17	14.07	3.16	13.38	-8.89*	30.78	0.99	22.55	-1.46
NAH 2049 x CI 4	14.61	7.08*	13.59	-7.49*	28.89	-5.20	20.08	-12.23
NAH 2049 x CML 446	15.20	11.45**	14.58	-0.78	31.86	4.51	17.79	-22.25*
NAH 2049 x HS 17	13.83	1.37	13.57	-7.60*	27.33	-10.34	22.07	-3.54
NK 6240 x CI 4	14.17	3.90	13.08	-10.96**	29.38	-3.60	23.34	2.00
NK 6240 x CML 446	14.58	6.90**	14.48	-1.45	28.40	-6.82	20.92	-8.57
NK 6240 x HS 17	13.98	2.46	14.25	-3.01	28.13	-7.73	24.00	4.89
Rajkumar x CI 4	13.36	-2.03	12.61	-14.13**	29.34	-3.76	21.28	-6.99
Rajkumar x CML 446	14.10	3.34	13.03	-11.28**	27.75	-8.96	22.47	-1.79
Rajkumar x HS 17	13.67	0.23	13.34	-9.19*	29.03	-4.77	24.73	8.09
Rajkumar (Check)	13.63		14.69		30.48		22.88	
Mean	13.84	1.47	13.49	-8.16	28.28	-7.22	21.57	-5.71
Range	12.94-15.20	-5.15-11.45	12.31-14.58	-16.23-(-0.78)	24.61-31.86	-19.25-4.51	17.79-24.73	-22.25-8.09
CD at 5%	0.70		1.08		3.99		3.77	
CD at 1%	0.95		1.47		5.41		5.12	
Sem	0.24		0.37		1.37		1.29	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel

Contd.....

Table 29 contd....

Crosses	Cobs per plant				Shelling percentage			
	Nonstress		Stress		Nonstress		Stress	
	Mean	Hcc	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	0.948	-0.246	0.920	2.02	83.05	-3.87**	81.00	-4.10*
G 57 x CML 446	0.928	-2.325	0.810	-9.56	84.66	-2.00	79.55	-5.82**
G 57 x HS 17	0.970	2.073	0.890	-1.25	83.07	-3.84**	77.75	-7.96**
Karveer x CI 4	0.968	1.921	0.790	-12.40	83.21	-3.68**	81.61	-3.39
Karveer x CML 446	0.982	3.383	0.920	2.08	82.71	-4.26**	81.03	-4.07*
Karveer x HS 17	0.861	-9.357*	0.900	0.26	82.58	-4.41**	80.68	-4.49*
Parbhat x CI 4	0.886	-6.735	0.850	-5.56	83.03	-3.89**	79.33	-6.08**
Parbhat x CML 446	0.899	-5.392	0.800	-10.62	80.66	-6.63**	80.25	-5.00**
Parbhat x HS 17	0.896	-5.639	0.860	-4.91	83.86	-2.93**	80.15	-5.12**
NAC 6002 x CI 4	0.984	3.565	0.900	0.37	84.03	-2.73*	81.29	-3.77*
NAC 6002 x CML 446	0.979	3.070	0.850	-5.56	81.50	-5.66**	78.86	-6.64**
NAC 6002 x HS 17	0.932	-1.936	0.880	-2.72	82.30	-4.73**	79.85	-5.47**
All-Rounder x CI 4	0.944	-0.600	0.930	3.56	83.46	-3.39**	81.91	-3.02
All-Rounder x CML 446	0.921	-3.070	0.890	-0.91	82.89	-4.05**	80.78	-4.37*
All-Rounder x HS 17	0.967	1.754	0.900	-0.11	82.85	-4.09**	79.89	-5.43**
NAH 2049 x CI 4	0.983	3.448	0.830	-7.58	83.85	-2.94**	80.51	-4.68**
NAH 2049 x CML 446	0.964	1.434	0.850	-5.51	82.70	-4.27**	77.75	-7.96**
NAH 2049 x HS 17	0.963	1.365	0.880	-1.85	81.92	-5.17**	81.34	-3.71*
NK 6240 x CI 4	0.952	0.159	0.900	0.36	83.15	-3.75**	82.73	-2.06
NK 6240 x CML 446	0.912	-4.006	0.870	-3.83	80.19	-7.18**	77.00	-8.84**
NK 6240 x HS 17	0.925	-2.684	0.900	0.01	82.26	-4.78**	81.76	-3.20
Rajkumar x CI 4	0.983	3.509	0.920	1.78	84.94	-1.67	81.80	-3.17
Rajkumar x CML 446	0.981	3.314	0.810	-9.47	83.03	-3.89**	81.53	-3.48*
Rajkumar x HS 17	0.929	-2.206	0.920	1.89	82.59	-4.40**	81.26	-3.80*
Rajkumar (Check)	0.946		0.900		86.39		84.47	
Mean	0.940	-0.63	0.874	-2.90	82.85	-4.09	80.40	-4.82
Range	0.861- 0.984	-9.36- 3.57	0.788- 0.932	-12.40- 3.56	80.19- 84.94	-7.18(- 1.67)	77.00- 82.73	-8.84- (2.06)
CD at 5%	0.07		0.14		1.76		2.91	
CD at 1%	0.10		0.19		2.38		3.96	
Sem	0.03		0.05		0.60		1.00	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel

Contd.....

Table 29 contd....

Crosses	100-grain weight (g)				Yield per plant (g)			
	Nonstress		Stress		Nonstress		Stress	
	Mean	Hcc	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	28.38	-6.70	21.88	4.67	90.76	-24.92**	47.54	-18.05
G 57 x CML 446	26.25	-13.71**	17.70	-15.31*	109.95	-9.04	49.15	-15.28
G 57 x HS 17	26.67	-12.34**	19.30	-7.67	96.09	-20.51*	46.73	-19.45
Karveer x CI 4	26.32	-13.47**	18.20	-12.93	84.82	-29.83**	54.78	-5.57
Karveer x CML 446	27.45	-9.76*	19.08	-8.71	102.16	-15.48	39.10	-32.60**
Karveer x HS 17	28.23	-7.19	17.90	-14.35*	98.05	-18.89*	42.60	-26.56*
Parbhat x CI 4	26.70	-12.24**	17.16	-17.92*	93.40	-22.74*	50.42	-13.08
Parbhat x CML 446	24.48	-19.54**	15.66	-25.10**	81.64	-32.46**	38.93	-32.89**
Parbhat x HS 17	27.78	-8.68*	16.76	-19.79**	96.94	-19.81*	49.84	-14.08
NAC 6002 x CI 4	27.43	-9.82*	19.06	-8.82	84.79	-29.86**	53.39	-7.97
NAC 6002 x CML 446	25.94	-14.71**	16.91	-19.11*	93.07	-23.01*	53.14	-8.39
NAC 6002 x HS 17	28.03	-7.86	18.31	-12.37	84.42	-30.16**	41.03	-29.27*
All-Rounder x CI 4	24.30	-20.13**	20.47	-2.06	103.98	-13.98	58.53	0.89
All-Rounder x CML 446	25.45	-16.33**	17.41	-16.70*	105.02	-13.12	45.78	-21.08
All-Rounder x HS 17	27.57	-9.38*	20.76	-0.68	119.84	-0.86	57.05	-1.65
NAH 2049 x CI 4	27.30	-10.25*	18.20	-12.94	106.78	-11.66	40.40	-30.35**
NAH 2049 x CML 446	26.29	-13.57*	17.55	-16.03	124.65	3.12	41.67	-28.16*
NAH 2049 x HS 17	28.77	-5.44	17.96	-14.07	102.45	-15.24*	48.66	-16.11
NK 6240 x CI 4	29.07	-4.43	19.13	-8.49	114.32	-5.43	55.61	-4.13
NK 6240 x CML 446	27.47	-9.70*	18.40	-11.95	105.67	-12.58	48.20	-16.90
NK 6240 x HS 17	29.50	-3.02	19.64	-6.02	107.30	-11.23	59.44	2.46
Rajkumar x CI 4	28.27	-7.08	19.52	-6.60	102.93	-14.85	49.32	-14.98
Rajkumar x CML 446	27.32	-10.19*	20.28	-2.99	96.58	-20.11*	53.42	-7.91
Rajkumar x HS 17	28.82	-5.27	20.43	-2.26	108.34	-10.37	62.06	6.98
Rajkumar (Check)	30.42		20.90		120.88		58.01	
Mean	27.24	-10.45	18.65	-10.76	100.58	-16.79	49.45	-14.76
Range	24.30-29.50	-20.13-(3.02)	15.66-21.88	-25.10-4.67	81.64-124.65	-32.46-3.12	38.93-62.06	-32.89-6.98
CD at 5%	2.44		2.86		21.59		12.88	
CD at 1%	3.31		3.88		29.26		17.48	
Sem	0.84		0.98		7.4		4.40	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel

Contd.....

Table 29 contd....

Crosses	Yield (kg/ha)				RWC1			
	Nonstress		Stress		Nonstress		Stress	
	Mean	Hcc	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	5334	-23.49*	3038.00	-6.59	0.931	0.14	0.889	2.17
G 57 x CML 446	6227	-10.67	2410.92	-25.87	0.904	-2.81	0.873	0.31
G 57 x HS 17	6046	-13.27	2440.89	-24.95	0.949	2.08	0.926	6.41
Karveer x CI 4	5735	-17.73	3163.50	-2.73	0.898	-3.49	0.835	-4.07
Karveer x CML 446	6387	-8.38	2426.46	-25.39	0.910	-2.20	0.822	-5.52
Karveer x HS 17	5225	-25.05**	2254.41	-30.68*	0.923	-0.78	0.851	-2.13
Parbhat x CI 4	5613	-19.48*	2594.00	-20.24	0.898	-3.42	0.905	4.06
Parbhat x CML 446	4840	-30.58*	1694.97	-47.88**	0.947	1.81	0.815	-6.26
Parbhat x HS 17	5568	-20.13*	2656.23	-18.33	0.939	1.00	0.863	-0.79
NAC 6002 x CI 4	5746	-17.57	3076.92	-5.39	0.888	-4.55	0.896	2.99
NAC 6002 x CML 446	5319	-23.70*	2599.62	-20.07	0.914	-1.75	0.853	-1.96
NAC 6002 x HS 17	5144	-26.21**	2342.10	-27.99	0.935	0.50	0.890	2.33
All-Rounder x CI 4	6067	-12.96	3441.00	5.80	0.917	-1.38	0.875	0.60
All-Rounder x CML 446	5754	-17.45	2566.32	-21.09	0.925	-0.59	0.853	-1.92
All-Rounder x HS 17	7148	2.54	3456.54	6.28	0.896	-3.60	0.848	-2.53
NAH 2049 x CI 4	6763	-2.98	2113.44	-35.02*	0.941	1.21	0.806	-7.30
NAH 2049 x CML 446	7327	5.11	2311.02	-28.94*	0.933	0.31	0.905	4.08
NAH 2049 x HS 17	5920	-15.08	2870.46	-11.74	0.910	-2.15	0.877	0.77
NK 6240 x CI 4	7609	9.15	3468.75	6.66	0.952	2.35	0.878	0.94
NK 6240 x CML 446	6455	-7.41	2728.38	-16.11	0.925	-0.55	0.814	-6.45
NK 6240 x HS 17	5847	-16.12	3364.41	3.45	0.951	2.29	0.892	2.53
Rajkumar x CI 4	6751	-3.16	2943.72	-9.49	0.935	0.49	0.854	-1.79
Rajkumar x CML 446	5764	-17.31	2814.96	-13.45	0.921	-0.94	0.815	-6.30
Rajkumar x HS 17	6127	-12.10	3582.00	10.14	0.901	-3.13	0.839	-3.59
Rajkumar (Check)	6971		3252.30		0.930		0.870	
Mean	6029.90	-13.50	2764.96	-14.98	0.922	-0.80	0.862	-0.98
Range	4840.0-7609.0	-30.58-9.15	1694.97-3582.00	-47.88-10.14	0.888-0.952	-4.55	0.806-0.926	-7.30-6.41
CD at 5%	1237.31		931.46		0.05	2.35	0.10	
CD at 1%	1676.76		1264.07		0.07		0.14	
Sem	423.91		318.39		0.02		0.04	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel
RWC1 – Relative water content at 60 DAS

Contd.....

Table 29 contd....

Crosses	RWC2				CHL1			
	Nonstress		Stress		Nonstress		Stress	
	Mean	Hcc	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	0.882	0.22	0.713	3.636	49.40	4.22	38.05	-7.16
G 57 x CML 446	0.896	1.83	0.725	5.427	46.60	-1.69	36.21	-11.65
G 57 x HS 17	0.866	-1.54	0.760	10.465	48.10	1.48	41.12	0.33
Karveer x CI 4	0.860	-2.30	0.685	-0.375	49.60	4.64*	41.88	2.18
Karveer x CML 446	0.822	-6.64	0.697	1.291	45.65	-3.69	34.90	-14.86
Karveer x HS 17	0.905	2.80	0.574	-16.555	49.85	5.17*	38.57	-5.90
Parbhat x CI 4	0.782	-11.13	0.663	-3.633	50.30	6.12**	45.80	11.74
Parbhat x CML 446	0.867	-1.50	0.656	-4.662	44.05	-7.07*	38.54	-5.97
Parbhat x HS 17	0.855	-2.82	0.645	-6.284	48.20	1.69	43.31	5.66
NAC 6002 x CI 4	0.861	-2.13	0.640	-6.977	49.05	3.48	45.92	12.04
NAC 6002 x CML 446	0.896	1.79	0.735	6.876	51.75	9.18*	41.67	1.66
NAC 6002 x HS 17	0.826	-6.10	0.770	11.866	49.75	4.96*	38.70	-5.58
All-Rounder x CI 4	0.733	-16.72*	0.737	7.076	44.85	-5.38*	43.46	6.04
All-Rounder x CML 446	0.831	-5.60	0.673	-2.216	41.90	-11.60**	35.79	-12.69
All-Rounder x HS 17	0.897	1.94	0.761	10.559	49.65	4.75*	37.38	-8.81
NAH 2049 x CI 4	0.850	-3.46	0.607	-11.721	50.20	5.91	35.31	-13.86
NAH 2049 x CML 446	0.824	-6.37	0.674	-1.985	45.75	-3.48	40.57	-1.01
NAH 2049 x HS 17	0.828	-5.95	0.643	-6.600	47.85	0.95	39.91	-2.64
NK 6240 x CI 4	0.851	-3.28	0.730	6.105	47.25	-0.32	35.74	-12.81
NK 6240 x CML 446	0.887	0.83	0.733	6.525	48.20	1.69	37.86	-7.62
NK 6240 x HS 17	0.868	-1.38	0.793	15.285	49.75	4.96	41.41	1.04
Rajkumar x CI 4	0.821	-6.68	0.650	-5.523	48.25	1.79	38.63	-5.75
Rajkumar x CML 446	0.856	-2.71	0.785	14.099	47.25	-0.32	42.73	4.26
Rajkumar x HS 17	0.688	-21.79*	0.698	1.441	46.20	-2.53	44.42	8.37
Rajkumar (Check)	0.880		0.688		47.40		40.99	
Mean	0.843	-4.11	0.698	1.42	47.90	1.04	39.90	-2.62
Range	0.688-0.905	-21.79-2.80	0.574-0.793	-16.56-15.28	41.89-51.75	-11.60-9.18	34.90-45.92	-14.86-12.04
CD at 5%	0.13		0.12		2.09		6.70	
CD at 1%	0.17		0.16		2.83		9.09	
Sem	0.04		0.04		0.72		2.29	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel

RWC2 – Relative water content at 90 DAS

CHL1 – Chlorophyllt content at 60 DAS

Contd.....

Table 29 contd....

Crosses	CHL2				Drought susceptibility index	
	Nonstress		Stress			
	Mean	Hcc	Mean	Hcc	Mean	Hcc
G 57 x CI 4	39.10	-1.76	26.24	-11.46	0.951	-10.02
G 57 x CML 446	36.25	-8.92	28.01	-5.48	1.087	3.50
G 57 x HS 17	38.05	-4.40	30.12	1.64	1.029	-2.25
Karveer x CI 4	43.30	8.79	30.89	4.24	0.707	-34.37*
Karveer x CML 446	38.20	-4.02	24.06	-18.82	1.227	17.42
Karveer x HS 17	40.00	0.50	27.44	-7.39	1.146	9.32
Parbhat x CI 4	44.70	12.31*	33.57	13.28	0.944	-10.73
Parbhat x CML 446	39.05	-1.88	26.46	-10.70	1.053	0.07
Parbhat x HS 17	39.85	0.13	25.83	-12.84	0.962	-8.97
NAC 6002 x CI 4	39.80	0.00	33.49	13.01	0.734	-31.68*
NAC 6002 x CML 446	37.00	-7.04	32.85	10.85	0.961	-9.09
NAC 6002 x HS 17	36.35	-8.67	24.76	-16.44	1.039	-1.26
All-Rounder x CI 4	38.10	-4.27	31.79	7.29	0.860	-19.11
All-Rounder x CML 446	35.90	-9.80	27.34	-7.75	1.075	2.33
All-Rounder x HS 17	35.00	-12.06*	34.61	16.81	1.022	-2.97
NAH 2049 x CI 4	41.05	3.14	23.99	-19.03	1.242	18.90
NAH 2049 x CML 446	42.60	7.04	29.67	0.13	1.344	29.05
NAH 2049 x HS 17	43.25	8.67	26.33	-11.14	1.062	1.03
NK 6240 x CI 4	38.05	-4.40	24.77	-16.42	1.040	-1.20
NK 6240 x CML 446	45.60	14.57*	28.17	-4.94	1.098	4.54
NK 6240 x HS 17	41.50	4.27	29.82	0.64	0.887	-16.41
Rajkumar x CI 4	39.25	-1.38	28.41	-4.13	1.037	-1.46
Rajkumar x CML 446	31.65	-20.48*	28.43	-4.07	0.904	-14.70
Rajkumar x HS 17	36.25	-8.92	29.57	-0.20	1.052	0.05
Rajkumar (Check)	39.80		29.63		1.052	0.05
Mean	39.16	-1.61	28.60	-3.46	1.020	-3.25
Range	31.65-45.60	-20.48-14.57	23.99-34.61	-19.03-16.81	0.707-1.344	-34.37-29.05
CD at 5%	4.55		5.96		0.32	
CD at 1%	6.17		8.09		0.43	
Sem	1.56		2.04		0.11	

Hcc = Heterosis over commercial check.* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd. Sel

CHL2 – Chlorophyll content at 90 DAS

Under stress environment, none of the lines exhibited significant gca effects. CML 446 among tester recorded significant positive gca effects.

4.3.3.4 Days to 50% silking

In nonstress environment, NAC 6002 and NAH 2049 recorded significant negative gca effects. Among the three testers used, CI 4 and Hyd Sel 17 recorded significant negative gca effects for the trait.

Under stress environment, Parbhat among lines and CML 446 among tester recorded significantly undesirable gca effects, whereas CI 4, a tester recorded significantly desirable (negative) gca effects for the trait.

4.3.3.5 Anthesis to silking interval (ASI)

In nonstress environment, Karveer and Parbhat among lines exhibited significant negative and positive gca effects, respectively. None of the testers showed significant gca for ASI.

Under stress environment, G 57 and Parbhat recorded significant positive gca effects, whereas NAC 6002 recorded significantly desirable (negative) gca effects. None of the testers showed significant gca effects for the trait.

4.3.3.6 Days to maturity

Karveer recorded significant negative gca effects and Parbhat and NK 6240 recorded significant positive gca effects for this trait under nonstress environment, while none of the testers showed significant gca effects.

Under stress environment, Karveer recorded significant negative gca effects, whereas All-Rounder and NK 6240 showed significant gca effects for the trait. No tester recorded significant gca effects.

4.3.3.7 Cob length (cm)

None of the parents except NAC 6002 recorded significant gca effects under nonstress. Under stress environment, Karveer and NAH 2049 recorded significant negative gca effects for the trait while Rajkumar recorded significant positive gca effects among lines. Among testers, CML 446 and Hyd Sel 17 exhibited significant negative and positive gca effects, respectively.

4.3.3.8 Cob girth (cm)

In nonstress environment, G 57 and Karveer recorded significant negative gca effects for the trait. While NAH 2049 and NK 6240 among lines possessed significant positive gca effects. Among testers, CI 4 and CML 446 recorded significant negative and positive gca effects, respectively.

Under stress, none of the parents recorded significant gca effects.

4.3.3.9 Number of kernel rows per cob

In nonstress environment, all the lines except Parbhat and Rajkumar recorded significant gca effects. All-Rounder, NAH 2049 and NK 6240 recorded significant positive gca effects. Among testers, CML 446 and Hyd Sel 17 exhibited significant positive and significant negative gca effects, respectively. Under stress environment, NK 6240 and Rajkumar recorded significant positive and significant negative gca effects, respectively. Among testers, CI 4 (in negative direction) and CML 446 (in positive direction) recorded significant gca effects.

4.3.3.10 Kernels per row

For number of kernels per row, none of the parents recorded significantly positive gca effects under both the situations.

4.3.3.11 Cobs per plant

Among lines, Parbhat (negative), NAC 6002 (positive) and All-Rounder (positive) recorded significant gca effects under nonstress environment. Whereas, under stress environment, none of the parents exhibited significant gca effects for the trait.

4.3.3.12 Shelling percentage

In nonstress environment, G 57 (positive) and NK 6240 (negative) recorded significant gca effects. Among testers, CI 4 and CML 446 showed significant negative and significant positive gca effects, respectively. Whereas, under stress, none of the parents showed significant gca effects for the trait.

4.3.3.13 Hundred grain weight (g)

Among lines, All-Rounder and NK 6240 exhibited significant negative and significant positive gca effects, respectively under nonstress. CML 446 and Hyd Sel 17 showed significant negative and significant positive gca effects, respectively among testers.

Under stress environment, Parbhat and CML 446 (both in negative direction) and Rajkumar (in positive direction) recorded significant gca effects for the trait.

4.3.3.14 Yield per plant (g)

All-Rounder and NAH 2049 recorded significant positive gca effects for the trait. Whereas, Parbhat and NAC 6002 showed significant negative gca effects for yield per plant under nonstress environment.

Under stress environment, NAH 2049 and NK 6240 recorded significant negative and significant positive gca effects, respectively. Among testers, CML 446 recorded significant negative gca effects for yield per plant.

4.3.3.15 Grain yield (kg/ha)

In nonstress environment, Parbhat and NAC 6002 (both negative) and NAH 2049 and NK 6240 (both positive) recorded significant gca effects among lines. None of the testers showed significant gca effects for the trait. Under stress environment, All-Rounder and Rajkumar (lines) recorded significant positive gca effects for the trait.

4.3.3.16 Relative water content at 60 DAS (RWC1) and 90 DAS (RWC2)

None of the parents except Rajkumar (significant negative) at 90 DAS showed significant gca effects for relative water content at 60 DAS and 90 DAS under nonstress environment.

Similar trend was also observed under stress environment. NAH 2049 and NK 6240 recorded significant negative and significant positive gca effects, respectively at 90 DAS.

4.3.3.17 Chlorophyll content at 60 DAS and 90 DAS

Among the lines, NAC 6002 and Parbhat recorded significant positive and significant negative gca effects, respectively under nonstress environment at 60 DAS. NAC 6002, NAH 2049 and NK 6240 recorded significant positive gca effects at 90 DAS. Among the testers, CI 4 recorded significant positive gca effects at both the stages.

Under stress, none of the parents except All-Rounder (significant positive) at 90 DAS showed significant gca effects at 60 DAS and 90 DAS.

4.3.3.18 Drought susceptibility index (DSI)

Among lines, NAH 2049 recorded significant negative (desirable) gca effects for DSI. CI 4 and CML 446 among testers recorded significantly positive and negative gca effects, respectively.

4.3.4 Specific combining ability (sca) effects

The sca effects for all the traits studied under stress and nonstress situations are presented in Table 31.

4.3.4.1 Plant height (cm)

Four out of 24 crosses recorded significant sca effects under nonstress. Among them, All-Rounder x Hyd Sel 17 and NAH 2049 x CML 446 recorded significant positive sca effects and NAH 2049 x Hyd Sel 17 and NK 6240 x CML 446 recorded significant negative sca effects. Whereas, under stress none of the crosses showed significant sca effects.

Table 30. Estimates of gca effects of top crosses, three way crosses and varietal crosses (Line x Tester) for different quantitative characters under nonstress and stress

Parents	Plant height (cm)		Ear height (cm)		Day to 50% anthesis		Days to 50% silking		Anthesis to silking interval		Days to maturity	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
G 57	-5.39	0.21	-2.95	-2.66	-1.21*	-1.18	-0.94	0.21	0.28	1.381*	0.21	-0.50
Karveer	-1.36	-3.07	0.39	-0.65	-0.41	0.17	-0.95	-0.69	-0.54*	-0.814	-1.79*	-1.17*
Parbhat	-0.17	2.67	6.50	2.16	1.12*	-0.26	2.61**	1.39*	1.49**	1.617**	1.54*	-0.50
NAC 6002	-10.70	-16.27**	-8.71*	-11.58**	-2.56**	0.18	-2.44**	-0.95	0.12	-1.131*	-1.13	-0.17
All-Rounder	-2.47	8.06	-1.51	8.16*	1.83**	1.09	1.45*	0.88	-0.38	-0.208	0.21	1.50**
NAH 2049	24.10**	0.85	5.18	-0.35	-0.90	-0.34	-1.19*	-0.43	-0.29	-0.088	-0.46	-0.83
NK 6240	0.36	0.73	-1.52	1.54	0.85	0.28	0.43	-0.40	-0.42	-0.684	1.54*	1.17*
Rajkumar	-4.38	6.82	2.62	3.38	1.28*	0.07	1.01*	-0.004	-0.26	-0.073	-0.13	0.50
SE (g _i)	6.51	5.37	3.74	3.18	0.50	0.69	0.46	0.62	0.26	0.510	0.68	0.54
CD @ 5%	13.47	11.11	7.75	6.57	1.03	1.42	0.96	1.28	0.53	1.040	1.41	1.11
CD @ 1%	18.28	15.08	10.51	8.91	1.40	1.93	1.30	1.74	0.72	1.420	1.91	1.50
SEd (g _i -g _j)	9.21	7.60	5.29	4.49	0.70	0.97	0.66	0.88	0.36	0.710	0.96	0.76
CI 4	-2.79	-4.66	-4.17	-2.91	-0.67*	-0.44	-0.83**	-1.03*	-0.16	-0.590	-0.17	-0.08
CML 446	8.76*	9.76**	2.93	4.70*	1.40	1.16*	1.63*	1.78**	0.22	0.619	0.08	0.292
HS 17	-5.97	-5.11	1.24	-1.79	-0.73*	0.72	-0.80**	-0.75	-0.06	-0.029	0.08	-0.21
SE (g _i)	3.99	3.29	2.29	1.95	0.31	0.42	0.28	0.38	0.16	0.310	0.42	0.33
CD @ 5%	8.25	6.80	4.74	4.02	0.63	0.87	0.59	0.79	0.33	0.640	0.86	0.68
CD @ 1%	11.20	9.23	6.44	5.46	0.86	1.18	0.80	1.07	0.44	0.870	0.17	0.92
SEd (g _i -g _j)	5.64	4.65	3.24	2.75	0.43	0.59	0.40	0.54	0.22	0.440	0.59	0.46

* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd.Sel

Contd.....

Table 30 contd.....

Parents	Cob length (cm)		Cob girth (cm)		No. of kernel rows /Cob		Kernels /row		Cobs/plant		Shelling percentage	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
G 57	-0.10	-0.10	-0.26**	-0.24	-0.30*	-0.30	0.35	-0.61	0.003	-0.001	0.74*	-0.97
Karveer	-0.40	-0.53*	-0.40*	-0.25	-0.62**	-0.39	-1.34	-1.45	-0.007	-0.004	-0.02	0.71
Parbhat	-0.47	-0.15	-0.12	0.26	-0.24	0.24	-1.46	0.39	-0.050**	-0.039	-0.33	-0.49
NAC 6002	-0.94**	0.09	-0.24	-0.16	-0.31*	-0.03	-1.76**	-0.08	0.023*	0.001	-0.25	-0.40
All-Rounder	0.65	0.29	0.15	0.13	0.49**	0.11	2.35	0.92	0.001	0.036	0.21	0.46
NAH 2049	0.47	-0.72**	0.44*	-0.23	0.70**	0.42	1.08	-1.60*	0.025*	-0.018	-0.03	-0.53
NK 6240	0.45	0.46	0.44*	0.33	0.40**	0.44*	0.36	1.18	-0.015	0.016	-0.99**	0.10
Rajkumar	0.35	0.65*	-0.01	0.16	-0.13	-0.49*	0.42	1.25	0.021	0.009	0.67	1.13
SE (g _i)	0.32	0.24	0.16	0.25	0.14	0.21	0.80	0.74	0.013	0.03	0.35	0.58
CD @ 5%	0.67	0.49	0.33	0.51	0.29	0.44	1.66	1.54	0.023	0.06	0.73	1.19
CD @ 1%	0.91	0.67	0.45	0.69	0.39	0.60	2.25	2.09	0.039	0.08	0.99	1.61
SEd (g _i -g _j)	0.46	0.34	0.23	0.35	0.20	0.30	1.13	1.05	0.020	0.04	0.50	0.81
CI 4	-0.19	0.04	-0.21*	0.058	-0.09	-0.34*	-0.30	0.28	0.013	0.008	-2.86**	0.87*
CML 446	-0.03	-0.37*	0.24*	-0.02	0.31**	0.30*	0.66	-0.98*	0.001	-0.023	1.76**	-0.81*
HS 17	0.22	0.33*	-0.03	-0.03	-0.23**	0.04	-0.36	0.70	-0.014	0.015	1.10	-0.07
SE (g _i)	0.20	0.15	0.10	0.15	0.09	0.13	0.49	0.46	0.009	0.02	0.22	0.35
CD @ 5%	0.41	0.30	0.20	0.31	0.18	0.27	1.02	0.94	0.018	0.04	0.45	0.73
CD @ 1%	0.56	0.41	0.27	0.42	0.24	0.37	1.38	1.28	0.024	0.05	0.61	0.99
SEd (g _i -g _j)	0.28	0.21	0.14	0.21	0.12	0.18	0.69	0.64	0.012	0.02	0/31	0.50

* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd.Sel

Contd.....

Table 30 contd.....

Parents	100-grain weight (g)		Yield/plant (g)		Yield (kg/ha)		RWC1		RWC2	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
G 57	-0.14	0.97	-1.65	-1.65	-160.89	-135.02	0.004	0.031	0.036	0.035
Karveer	0.10	-0.26	-5.57	-3.96	-247.39	-150.17	-0.011	-0.025	0.018	-0.046
Parbhat	-0.93	-2.13**	-9.92*	-3.06	-689.89*	-449.89*	0.006	0.001	-0.010	-0.041
NAC 6002	-0.11	-0.56	-13.16**	-0.27	-626.72*	-92.08	-0.012	0.018	0.016	0.017
All-Rounder	-1.47**	0.89	9.03*	4.34	293.43	389.66*	-0.009	-0.002	-0.022	0.027
NAH 2049	0.21	-0.75	10.71*	-5.87*	640.10*	-333.32	0.006	0.001	-0.009	-0.056**
NK 6240	1.44**	0.41	8.52	4.97	607.10*	422.22*	0.019	-0.002	0.025	0.054**
Rajkumar	0.89	1.42*	2.04	5.48*	184.27	348.60	-0.004	-0.024	-0.055*	0.012
SE (g _i)	0.49	0.56	4.25	2.54	249.14	183.80	0.010	0.02	0.026	0.020
CD @ 5%	1.02	1.17	8.79	5.26	515.38	380.30	0.021	0.04	0.054	0.050
CD @ 1%	1.38	1.59	11.93	7.13	699.41	516.10	0.029	0.06	0.073	0.070
SEd (g _i -g _j)	0.70	0.80	6.01	3.59	352.33	260.00	0.015	0.03	0.037	0.030
CI 4	-0.02	0.55	0.74	1.80	172.41	214.96	-0.003	0.006	-0.014	-0.019
CML 446	-0.91**	-0.78*	-0.56	-3.28*	-20.83	-320.88**	0.000	-0.017	0.016	0.013
HS 17	0.93**	0.23	-0.18	1.48	-151.58	105.92	0.003	0.011	-0.002	0.006
SE (g _i)	0.30	0.35	2.60	1.56	152.56	112.56	0.006	0.010	0.016	0.010
CD @ 5%	0.62	0.72	5.38	3.22	315.60	232.90	0.013	0.030	0.003	0.030
CD @ 1%	0.85	0.97	7.31	4.37	428.30	316.00	0.018	0.040	0.045	0.040
SEd (g _i -g _j)	0.43	0.49	3.68	2.20	215.76	159.20	0.009	0.020	0.023	0.020

* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd.Sel
RWC1 – Relative water content at 60 DAS RWC2 – Relative water content at 90 DAS

Contd.....

4.3.4.2 Ear height (cm)

None of the crosses except Rajkumar x Hyd Sel 17 (significant positive) recorded significant sca effects under nonstress for the trait. Similar trend was also observed under stress situation for the trait.

4.3.4.3 Days to 50% anthesis

None of the crosses showed significant sca effects under nonstress. Similar was the trend under stress for days to 50% anthesis.

4.3.4.4 Days to 50% silking

None of the crosses except Parbhat x CML 446 (significant positive) recorded significant sca effects under nonstress situation. Similar trend was also observed for the trait under stress situation.

4.3.4.5 Anthesis to silking interval

None of the crosses except NAC 6002 x Hyd Sel 17 (significant positive) exhibited significant sca effects under nonstress situation. Under stress situation G 57 x Hyd Sel 17 recorded significant positive sca effects for ASI.

4.3.4.6 Days to maturity

Under nonstress, none of the crosses showed significant sca effects for days to maturity. Similarly, under stress situation, only one cross i.e. Karveer x CI 4 recorded significant positive sca effects for the trait.

4.3.4.7 Cob length (cm)

No significant sca effects were observed among crosses for cob length under both the situations.

4.3.4.8 Cob girth (cm)

None of the crosses showed significant sca effects for cob girth under both the situations.

4.3.4.9 Number of kernel rows per cob

No significant sca effects were observed among crosses for the trait under nonstress environment while under stress situation, two crosses viz., Karveer x CI 4 and Karveer x CML 446 exhibited significant positive and significant negative sca effects for the trait, respectively.

4.3.4.10 Number of kernels per row

No significant sca effects were observed among crosses under nonstress situation. Whereas, under stress, two crosses viz., Parbhat x CML 446 and NAC 6002 x Hyd Sel 17 recorded significant negative Sca effects for the trait.

4.3.4.11 Cobs per plant

None of crosses except Karveer x Hyd Sel 17 (significant negative) showed significant sca effects for the trait under nonstress. Similar trend was also observed under stress environment for cobs per plant.

4.3.4.12 Shelling percentage

Four out of 24 crosses showed significant sca effects under nonstress for the trait. G 57 x CML 446 and Parbhat x Hyd Sel 17 recorded significant positive and G 57 x CI 4 and Parbhat x CML 446 recorded significant negative sca effects, respectively. Under stress environment, NK 6240 x CML 446 recorded significant negative sca effects for the trait.

4.3.4.13 Hundred grain weight (g)

None of the crosses showed significant sca effects in nonstress as well as stress environments.

4.3.4.14 Yield per plant (g)

In nonstress environment, none of the crosses showed significant sca effects for yield per plant. Whereas, under stress situation, one cross (NAC 6002 x Hyd Sel 17) recorded significant negative sca effects for the trait.

4.3.4.15 Grain yield (kg/ha)

In nonstress environment, All-Rounder x Hyd Sel 17 recorded significant positive sca effects for grain yield. Under stress, none of the crosses exhibited significant sca effects for the trait.

4.3.4.16 Relative water content at 60 DAS (RWC1) and 90 DAS (RWC2)

None of the crosses showed significant sca effects at 60 DAS under both nonstress and stress environments. However, at 90 DAS, Rajkumar x Hyd Sel 17 (under nonstress) and Karveer x Hyd Sel 17 (under stress) recorded significant negative sca effects.

4.3.4.17 Chlorophyll content at 60 DAS (CHL1) and 90 DAS (CHL2)

Ten out of 24 crosses under nonstress recorded significant sca effects for chlorophyll content at 60 DAS. Parbhat x CI 4 NAC 6002 x CML 446, All-Rounder x Hyd Sel 17, NAH 2049 x CI 4 and Rajkumar x CML 446 recorded significant positive sca effect at 60 DAS. Under stress, none of the crosses showed significant sca effects for chlorophyll content at 60 DAS.

NK 6240 x CML 446 (under nonstress) and Parbhat x CI 4 (under stress) recorded significant positive sca effects for chlorophyll content at 90 DAS.

4.3.4.18 Drought susceptibility index (DSI)

None of the crosses except Karveer x CI 4 recorded significantly desirable (negative) sca effects for DSI.

4.4 Evaluation of crosses derived from two different sources of drought tolerance under stress and nonstress conditions

The material/ crosses for evaluation included four drought tolerant composites/populations, four drought tolerant hybrids and three drought tolerant inbred lines. Drought tolerant hybrids and drought tolerant composites were used as females and drought tolerant inbred lines as males to produce 24 three way/top crosses. Four drought tolerant composites were crossed among themselves to produce six varietal/ population crosses. A total of 30 crosses were evaluated along with parents and check hybrids under stress and nonstress conditions during post rainy seasons of 2008-09 and 2009-10. But only yield (kg/ha) of 2008 was considered for analysis and interpretation. The results of the study are presented in the following headings.

4.4.1 Analysis of variance

The analysis of variance (Table 32) revealed that variation due to moisture stress was significant for all the traits. Similarly, variation due to genotypes was also significant for all the traits. The interaction between stress and genotypes was significant for maturity, kernel rows per cob, number of kernels per row, yield per plant (g) yield (kg/ha), chlorophyll content at 60 DAS and chlorophyll content at 90 DAS.

4.4.2 Effect of moisture stress on morpho-physiological, yield and yield related traits

The expression of the character under moisture stress and nonstress condition revealed that there was significant reduction in plant height (cm), ear height (cm), maturity, cob length (cm), cob girth (cm), kernel rows per cob, number of kernel per row, cobs per plant, shelling percentage, 100 grain weight (g), yield per plant (g), yield (kg/ha), relative water content at 60 DAS (RWC2), chlorophyll content at 60 DAS (CHL1) and chlorophyll content at 90 DAS. However, the moisture stress increased significantly the number of days required for 50% anthesis, 50% silking and anthesis to silking interval (Table 33).

Table 31. Estimates of sca effects of top crosses/ three way crosses (line x tester) for different quantitative characters under nonstress and stress situations

Hybrids	Plant height (cm)		Ear height (cm)		Day to 50% anthesis		Days to 50% silking		ASI	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
G 57 x CI 4	9.46	-5.98	6.90	-7.26	0.02	-1.59	0.47	-2.26	0.45	-0.68
G 57 x CML 446	-5.87	9.69	-4.58	8.57	-0.84	0.76	-0.81	-0.39	0.03	-1.15
G 57 x HS 17	-3.59	-3.71	-2.31	-1.31	0.83	0.83	0.34	2.66	-0.49	1.82*
Karveer x CI 4	-1.54	19.08	-5.90	4.57	0.18	1.41	0.45	0.90	0.27	-0.52
Karveer x CML 446	-1.40	-2.68	10.86	1.85	-0.59	-1.27	-0.96	-1.10	-0.37	0.17
Karveer x HS 17	2.95	-16.40	-4.96	-6.42	0.41	-0.14	0.51	0.20	0.10	0.34
Parbhat x CI 4	-7.23	11.40	-10.52	5.82	-1.02	-0.53	-1.03	-0.87	-0.02	-0.33
Parbhat x CML 446	-3.73	-5.96	10.42	0.59	1.35	0.24	1.84*	1.80	0.48	1.56
Parbhat x HS 17	10.95	-5.44	0.10	-6.41	-0.34	0.29	-0.80	-0.94	-0.46	-1.23
NAC 6002 x CI 4	5.23	8.88	1.06	4.03	-0.62	-0.23	-0.91	0.61	-0.30	0.38
NAC 6002 x CML446	-5.90	-9.92	3.64	-2.29	1.01	0.68	0.24	-0.11	-0.78	-0.79
NAC 6002 x HS 17	0.67	1.04	-4.70	-1.74	-0.40	-0.91	0.68	-0.50	1.07*	0.42
All-Rounder x CI 4	-5.38	-2.56	-0.53	2.94	0.93	0.22	0.85	0.81	-0.09	0.59
All-Rounder x CML446	-6.04	-2.27	-2.49	-4.17	-0.35	-0.35	0.12	-0.58	0.47	-0.23
All-Rounder x HS 17	11.41*	4.83	3.02	1.24	-0.58	0.14	-0.97	-0.23	-0.39	-0.36
NAH 2049 x CI 4	-12.08	-19.15	6.17	-10.03	-0.22	-0.39	-0.26	0.22	-0.03	0.62
NAH 2049 x CML446	40.05**	17.26	4.50	6.67	0.40	0.57	0.37	0.17	-0.03	-0.40
NAH 2049 x HS 17	-27.97*	1.89	-10.66	3.36	-0.18	-0.18	-0.12	-0.40	0.06	-0.22
NK 6240 x CI 4	10.26	-4.22	7.59	0.56	-0.70	-0.47	-1.06	-0.34	-0.36	0.13
NK 6240 x CML 446	-13.58*	-5.17	-12.55	-4.57	-0.15	-0.14	0.00	0.15	0.15	0.28
NK 6240 x HS 17	3.32	9.39	4.97	4.00	0.85	0.63	1.06	0.19	0.21	-0.41
Rajkumar x CI 4	1.29	-7.44	-4.76	-0.62	1.43	1.12	1.49	0.92	0.06	-0.20
Rajkumar x CML446	-3.54	-0.95	-9.79	-6.65	-0.84	-0.50	-0.80	0.06	0.04	0.56
Rajkumar x HS 17	2.25	8.39	14.55*	7.27	-0.59	-0.62	-0.69	-0.98	-0.11	-0.36
Mean	260.15	233.24	122.34	108.58	62.57	63.38	64.34	66.61	1.76	3.22
CD (Sij) @ 5%	11.28	19.24	13.41	11.38	1.79	2.46	1.66	2.22	0.92	1.81
CD (Sij-Skl) @ 5%	33.0	27.21	18.97	16.09	2.53	3.48	2.35	3.14	1.30	2.56

* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd.Sel

Contd.....

Table 31 contd....

Hybrids	Days to maturity		Cob length (cm)		Cob girth (cm)		No. of kernel rows /Cob		Kernels /row	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
G 57 x CI 4	1.17	-1.25	-0.64	-0.88	0.02	0.42	-0.23	-0.55	-1.78	-2.19
G 57 x CML 446	-1.08	0.38	0.28	0.54	0.17	-0.15	0.25	0.16	1.30	2.35
G 57 x HS 17	-0.08	0.88	0.37	0.34	-0.18	-0.27	-0.01	0.40	0.47	-0.16
Karveer x CI 4	0.17	2.42*	-0.66	0.71	-0.24	0.51	-0.20	1.22**	-0.85	1.72
Karveer x CML 446	-1.08	-0.96	0.36	-0.59	0.26	-0.41	-0.06	-0.85*	0.18	-0.90
Karveer x HS 17	0.92	-1.46	0.29	-0.12	-0.02	-0.10	0.27	-0.37	0.68	-0.82
Parbhat x CI 4	0.83	0.75	0.22	0.38	0.14	-0.22	-0.04	-0.17	0.56	1.61
Parbhat x CML 446	-1.42	0.38	-0.43	-0.62	-0.23	-0.29	-0.03	0.00	-1.61	-2.891*
Parbhat x HS 17	0.58	-1.13	0.21	0.25	0.10	0.51	0.07	0.17	1.05	1.28
NAC 6002 x CI 4	-1.50	0.42	-0.01	0.64	-0.12	0.08	0.37	0.04	-0.63	0.26
NAC 6002 x CML 446	0.25	0.04	0.58	0.71	0.33	0.46	-0.43	0.12	2.18	2.55
NAC 6002 x HS 17	1.25	-0.46	-0.57	-1.35	-0.21	-0.54	0.06	-0.16	-1.55	-2.813*
All-Rounder x CI 4	-0.83	0.75	-0.03	0.19	0.17	0.04	0.20	0.01	0.87	0.30
All-Rounder x CML 446	1.92	-0.63	-0.45	-0.11	-0.30	-0.07	-0.17	0.24	-1.38	0.34
All-Rounder x HS 17	-1.08	-0.13	0.48	-0.08	0.13	0.03	-0.03	-0.25	0.51	-0.64
NAH 2049 x CI 4	-1.17	-1.92	0.09	-0.23	-0.10	-0.04	0.15	0.01	-0.16	-0.18
NAH 2049 x CML 446	0.58	0.71	0.57	-0.08	0.07	0.01	0.34	0.36	1.84	-1.21
NAH 2049 x HS 17	0.58	1.21	-0.67	0.31	0.03	0.03	-0.49	-0.38	-1.68	1.39
NK 6240 x CI 4	-0.17	-0.92	0.31	-0.30	0.29	-0.34	0.01	-0.52	1.05	0.31
NK 6240 x CML 446	0.58	0.71	-0.06	-0.04	-0.21	0.21	0.03	0.24	-0.90	-0.86
NK 6240 x HS 17	-0.42	0.21	-0.25	0.34	-0.08	0.13	-0.04	0.28	-0.16	0.55
Rajkumar x CI 4	1.50	-0.25	0.71	-0.50	-0.16	-0.46	-0.26	-0.04	0.94	-1.83
Rajkumar x CML 446	0.25	-0.63	-0.86	0.18	-0.09	0.25	0.08	-0.27	-1.61	0.62
Rajkumar x HS 17	-1.75	0.88	0.15	0.32	0.24	0.22	0.19	0.31	0.68	1.21
Mean	105.79	100.83	13.84	11.25	13.32	11.29	13.84	13.49	28.28	21.57
CD (Sij) @ 5%	2.44	1.92	1.16	0.85	0.57	0.88	0.50	0.76	2.87	2.67
CD (Sij-Skl) @ 5%	3.45	2.71	1.64	1.21	0.81	1.25	0.71	1.08	4.06	3.77

* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd.Sel

Contd.....

Table 31 contd.....

Hybrids	Cobs/plant		Shelling percentage		100-grain weight (g)		Yield/plant (g)		Yield (kg/ha)	
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress
G 57 x CI 4	-0.01	0.039	-1.28*	0.69	1.30	1.70	-5.31	-2.06	-707.92	193.11
G 57 x CML 446	-0.02	-0.035	1.63*	0.92	0.06	-1.15	9.26	4.62	378.83	101.86
G 57 x HS 17	0.04	-0.004	-0.34	-1.62	-1.36	-0.56	-3.94	-2.55	329.08	-294.97
Karveer x CI 4	0.02	-0.088	-0.36	-0.38	-0.99	-0.74	-7.34	7.49	-219.42	333.75
Karveer x CML 446	0.04	0.073	0.44	0.73	1.03	1.47	5.39	-3.12	625.33	132.55
Karveer x HS 17	-0.06*	0.015	-0.08	-0.36	-0.03	-0.73	1.94	-4.37	-405.92	-466.30
Parbhat x CI 4	-0.02	0.007	-0.22	-1.45	0.40	0.08	5.60	2.23	100.58	63.98
Parbhat x CML 446	0.01	-0.012	-1.30*	1.15	-0.93	-0.09	-10.78	-4.19	-479.67	-299.22
Parbhat x HS 17	0.02	0.005	1.52*	0.30	0.53	0.01	5.18	1.97	379.08	235.24
NAC 6002 x CI 4	0.01	0.017	0.68	0.42	0.32	0.42	0.23	2.40	170.92	189.08
NAC 6002 x CML446	0.01	-0.002	-0.55	-0.33	-0.29	-0.41	3.88	7.23	-63.33	247.62
NAC 6002 x HS 17	-0.02	-0.015	-0.13	-0.08	-0.03	-0.01	-4.11	-9.632*	-107.58	-436.70
All-Rounder x CI 4	-0.01	0.017	-0.35	0.18	-1.46	0.37	-2.78	2.94	-428.75	71.42
All-Rounder x CML446	-0.02	0.008	0.39	0.72	0.59	-1.35	-6.36	-4.73	-548.00	-267.42
All-Rounder x HS 17	0.03	-0.025	-0.04	-0.91	0.87	0.98	9.13	1.79	976.75*	196.00
NAH 2049 x CI 4	0.00	-0.029	0.29	-0.23	-0.13	-0.25	-1.66	-4.97	-79.42	-533.16
NAH 2049 x CML446	-0.01	0.016	0.44	-1.31	-0.25	0.43	11.59	1.37	677.83	200.26
NAH 2049 x HS 17	0.01	0.013	-0.73	1.53	0.38	-0.17	-9.94	3.61	-598.42	332.90
NK 6240 x CI 4	0.01	0.007	0.55	1.36	0.41	-0.48	8.08	-0.61	799.58	66.61
NK 6240 x CML 446	-0.02	-0.002	-1.12	-2.693*	-0.30	0.12	-5.19	-2.94	-161.67	-137.92
NK 6240 x HS 17	0.01	-0.005	0.57	1.33	-0.11	0.36	-2.90	3.54	-637.92	71.31
Rajkumar x CI 4	0.01	0.029	0.69	-0.61	0.15	-1.10	3.18	-7.41	364.42	-384.80
Rajkumar x CML446	0.01	-0.045	0.07	0.81	0.10	0.98	-7.80	1.76	-429.33	22.28
Rajkumar x HS 17	-0.02	0.016	-0.76	-0.20	-0.25	0.12	4.63	5.65	64.92	362.52
Mean	0.94	0.874	82.85	80.40	27.24	18.65	100.58	49.45	6029.90	2764.96
CD (Sij) @ 5%	0.049	0.100	1.27	2.06	1.77	2.02	15.22	9.10	892.66	658.64
CD (Sij-Skl) @ 5%	0.071	0.14	1.79	2.91	2.50	2.86	21.53	12.87	1262.41	931.46

* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd.Sel

Contd.....

Table 31 contd.....

Hybrids	RWC1		RWC2		CHL1		CHL2		Drought susceptibility index
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	
G 57 x CI 4	0.006	-0.014	0.014	0.001	0.65	-1.10	0.04	-2.42	0.010
G 57 x CML 446	-0.026	-0.006	-0.001	-0.021	0.07	-0.87	-0.67	0.37	-0.010
G 57 x HS 17	0.020	0.020	-0.013	0.020	-0.71	1.97	0.63	2.04	0.000
Karveer x CI 4	-0.009	-0.007	0.012	0.053	0.51	2.75	1.54	2.89	-0.241*
Karveer x CML 446	-0.001	0.005	-0.052	0.035	-1.22	-2.17	-1.42	-2.92	0.128
Karveer x HS 17	0.010	0.002	0.041	-0.088*	0.71	-0.57	-0.12	0.03	0.113
Parbhat x CI 4	-0.030	0.036	-0.040	0.028	2.06*	2.56	2.24	4.42*	0.039
Parbhat x CML 446	0.022	-0.026	0.016	-0.010	-1.98*	-2.63	-1.27	-1.67	-0.007
Parbhat x HS 17	0.008	-0.010	0.024	-0.018	-0.09	0.07	-0.97	-2.74	-0.032
NAC 6002 x CI 4	-0.022	0.014	0.014	-0.056	-1.85*	3.14	0.83	2.59	-0.096
NAC 6002 x CML446	0.000	-0.013	0.019	0.007	3.07**	0.95	0.16	2.97	-0.027
NAC 6002 x HS 17	0.022	-0.001	-0.033	0.049	-1.21	-4.09	-0.99	-5.56*	0.123
All-Rounder x CI 4	0.010	0.009	-0.073	0.029	-1.34	3.90	0.51	0.01	-0.045
All-Rounder x CML 446	0.012	0.012	-0.007	-0.063	-2.07**	-1.71	0.45	-3.42	0.015
All-Rounder x HS 17	-0.022	-0.021	0.081	0.034	3.41**	-2.19	-0.95	3.41	0.030
NAH 2049 x CI 4	0.015	-0.064	0.029	-0.012	1.55*	-3.98	-2.51	-3.21	0.105
NAH 2049 x CML446	0.007	0.064	-0.026	0.020	-0.69	3.35	1.18	3.49	0.055
NAH 2049 x HS 17	-0.022	0.000	-0.003	-0.008	-0.86	0.62	1.33	-0.29	-0.160
NK 6240 x CI 4	0.011	0.014	-0.005	-0.002	-1.87*	-3.29	-4.93**	-3.35	0.110
NK 6240 x CML 446	-0.016	-0.033	0.001	-0.030	1.30	0.90	4.76**	1.07	0.015
NK 6240 x HS 17	0.005	0.019	0.004	0.032	0.57	2.39	0.16	2.28	-0.125
Rajkumar x CI 4	0.020	0.011	0.050	-0.041	0.30	-3.98	2.28	-0.93	0.117
Rajkumar x CML446	0.002	-0.001	0.051	0.062	1.52*	2.18	-3.19*	0.11	-0.169
Rajkumar x HS 17	-0.022	-0.010	-0.101*	-0.021	-1.81*	1.80	0.91	0.82	0.051
Mean	0.922	0.862	0.843	0.698	47.89	39.90	39.16	28.60	1.020
CD (Sij) @ 5%	0.037	0.074	0.093	0.084	1.51	4.73	3.19	4.22	0.236
CD (Sij-Skl) @ 5%	0.052	0.104	0.131	0.119	2.14	6.70	4.51	5.96	0.334

* and **, significant at 0.05 and 0.01 level of probability, respectively; HS = Hyd .Sel

Table 32. Mean sum of squares due to stress / nonstress and genotypes for morphological, yield and yield related traits in three way, top crosses/ varietal hybrids of maize

Trait	MSS			
	Stress / Nonstress	Genotypes	Interaction	Error
Plant height (cm)	34488.38**	792.21**	244.94	346.66
Ear height (cm)	9111.36**	276.97**	91.56	132.37
Days to 50% anthesis	18.64**	11.61**	1.86	2.08
Days to 50% silking	186.01**	13.42**	2.47	2.8
ASI	86.90**	3.76**	0.93	0.82
Maturity	1151.31**	6.60**	3.31*	1.91
Cob length (cm)	265.73**	2.05**	1.00	0.69
Cob girth (cm)	175.82**	0.60**	0.24	0.23
Kernel rows / Cob	6.55**	1.09**	0.40*	0.22
No. of kernels / row	1796.27**	12.12**	8.51**	4.01
Ears per plant	0.170**	0.005**	0.004	0.003
Shelling %	250.74**	9.52**	2.39	1.68
100-grain wt (g)	3168.25**	6.78**	2.51	2.04
Yield/plant (g)	106105.60**	307.77**	173.86*	110.07
Grain yield (kg/ha)	411098000.00**	1732662.00**	881510.10**	349031.30
RWC1	0.200**	0.002	0.003	0.003
RWC2	1.250**	0.007*	0.005	0.004
CHL1	2397.20**	26.43**	14.44**	6.00
CHL2	5044.29**	23.71**	14.96**	7.15

* and ** - Significant at 0.05 and 0.01 level of probability, respectively

4.4.3 Performance of three way /top crosses/varietal hybrids under stress and nonstress situations

The performance of three way crosses/top crosses varietal hybrids under stress and nonstress is presented in Table 34 and Table 35.

Among the 12 top crosses, Parbhat x CI 4 (2806.28 kg/ha) and NAC 6002 x CI 4 (2727.95 kg/ha) recorded better yield as indicated by the mean yield of two years under stress. However, they were numerically inferior to promising drought tolerant commercial hybrids Rajkumar (3211.15 kg/ha) and NK 6240 (3316.01 kg/ha) under stress conditions (Table 35).

Among the 12 three way crosses, All-Rounder x Hyd Sel 17 (3124.50 kg/ha), NK 6240 x CI 4 (2888.63 kg/ha), NK 6240 x Hyd Sel 17 (2942.20 kg/ha), and Rajkumar x CML 446 (3038.23 kg/ha), recorded higher yield under stress as indicated by the mean yield of two years. However, they were also numerically inferior to the best checks / parents under drought viz., Rajkumar and NK 6240.

Among the six varietal/population hybrids evaluated, G 57 x NAC 6002 recorded comparable yield with the best checks under stress (Table 35). Under nonstress environment, Karveer x CML 446 (6946.83 kg/ha) among top crosses; NK 6240 x CML 446 (6891.90 kg/ha) among three way crosses and Karveer x Parbhat (7043.60 kg/ha) among varietal/population hybrids recorded comparable yield with Rajkumar (7209.40 kg/ha) and All-Rounder (7380.30 kg/ha). However they were significantly inferior to NK 6240 (8322.18 kg/ha) as indicated by the mean yield of two years under nonstress conditions. The overall mean of crosses/parents under stress and nonstress was (2481.38 kg/ha) and 6259.00 kg/ha, respectively.

4.4.4 Important secondary traits

Other two important traits that contribute to yielding ability under /moisture stress in maize include cobs per plant and anthesis to silking interval (Table 34). Among the top crosses, Karveer x CI 4 (1.34), NAC 6002 x CI 4 (1.88) and NAC 6002 x CML 446 (1.98) recorded low ASI values under stress. NK 6240 x CI 4 (2.08), NK 6240 x Hyd Sel 17 (2.10) and Rajkumar x CI 4 (2.37) among three way crosses recorded low ASI values under stress. Whereas, Karveer x NAC 6002 (2.95) recorded lower ASI value among varietal hybrids under stress.

With respect to cobs per plant, G 57 x CI 4 (0.920) and Karveer x CML 446 (0.920) among top crosses; All-Rounder x CI 4 (0.935), Rajkumar x CI 4 (0.920) and Rajkumar x Hyd Sel 17 (0.915) among three way crosses and G 57 x Parbhat (0.970) and G 57 x NAC 6002 (0.935) among varietal/population hybrids recorded better cob per plant under stress as compared to other crosses and were comparable to cobs per plant of best checks under drought Rajkumar (0.900) and NK 6240 (0.930).

4.4.5 Drought susceptibility index (yield per plant)

Among the 12 top crosses, Parbhat x CI 4 (0.95), NAC 6002 x CI 4 (0.74) and Karveer x CI 4 (0.71) recorded low DSI values (Table 35). Whereas, All-Rounder x CI 4 (0.86), NK 6240 x Hyd Sel 17 (0.89) and Rajkumar x CML 446 (0.91) among three way crosses and G 57 x NAC 6002 (0.89) and G 57 x Parbhat (0.94) under varietal hybrids recorded low DSI values. The checks, Rajkumar and NK 6240 recorded 1.17 and 0.86 DSI value, respectively.

4.4.6 Relative water content at 60 DAS and 90 DAS

The crosses which exhibited mean + 1SD RWC under stress at 60 DAS were: G 57 x Hyd Sel 17, (0.925) Parbhat x CI 4 (0.905), NAC 6002 x CI 4 (0.900) and NAH 2049 x CML 446 (0.910). The checks, Rajkumar and NK 6240 recorded RWC of 0.870 and 0.930, respectively at 60 DAS. At 90 DAS, G 57 x Hyd Sel 17, NAC 6002 x Hyd Sel 17, All-Rounder x Hyd Sel 17, NK 6240 x Hyd Sel 17 and Rajkumar x CML 446 recorded mean + 1SD RWC under stress (Table 34).

Two crosses, Parbhat x CI 4 and NAC 6002 x CI 4 recorded mean + 1SD chlorophyll content at both the stages under stress.

Table 33. Effect of stress on morphological, yield and yield related traits in three way, top crosses/varietal hybrids of maize

Trait	Nonstress	Stress	Difference	CD at 5 %
Plant height (cm)	259.80	231.47	28.33*	5.65
Ear height (cm)	120.33	105.78	14.55*	3.49
Days to 50% anthesis	62.71	63.37	-0.66*	0.44
Days to 50% silking	64.69	66.77	-2.08*	0.51
Anthesis to silking interval	1.98	3.40	-1.42*	0.27
Maturity	105.88	100.71	5.17*	0.42
Cob length (cm)	13.71	11.22	2.49*	0.25
Cob girth (cm)	13.25	11.23	2.02*	0.15
Kernel rows / Cob	13.82	13.43	0.39*	0.14
No. of kernels / row	27.86	21.40	6.46*	0.61
Ears per plant	0.939	0.876	0.063*	0.016
Shelling %	82.91	80.50	2.41*	0.39
100-grain wt (g)	27.01	18.42	8.59*	0.43
Yield/plant (g)	98.04	48.36	49.68*	3.18
Grain yield (kg/ha)	5776.65	2684.66	3091.99*	179.13
RWC1	0.927	0.859	0.068*	0.016
RWC2	0.834	0.673	0.161*	0.019
CHL1	47.72	40.26	7.46*	0.74
CHL2	38.50	27.67	10.83*	0.81

* - Significant at 0.05 level of probability

RWC1 – Relative water content at 60 DAS

CHL1 – Chlorophyll content at 60 DAS

RWC2 – Relative water content at 90 DAS

CHL2 – Chlorophyll content at 90 DAS

Table 34. Performance of three way, top crosses/ varietal hybrids of maize for yield under stress and nonstress situations

Crosses	Plant height (cm)		Ear height (cm)		Days to 50% anthesis	
	NS	S	NS	S	NS	S
G 57 x CI 4	261.43	222.81	122.13	95.76	60.70	60.18
G 57 x CML 446	257.65	252.91	117.74	119.20	61.91	64.13
G 57 x Hyd Sel 17	245.21	224.63	118.32	102.84	61.45	62.32
Karveer x CI 4	254.47	244.59	112.66	109.59	61.68	64.47
Karveer x CML 446	266.15	237.25	136.52	114.49	62.98	63.40
Karveer x Hyd Sel 17	255.77	208.66	119.00	99.72	61.84	62.64
Parbhat x CI 4	249.97	242.65	114.16	113.65	62.01	62.19
Parbhat x CML 446	265.01	239.72	142.19	116.04	66.45	64.56
Parbhat x Hyd Sel 17	264.97	225.37	130.18	102.54	62.62	62.73
NAC 6002 x CI 4	251.90	221.20	110.53	98.12	58.73	63.36
NAC 6002 x CML 446	252.31	216.81	120.21	99.42	62.43	65.41
NAC 6002 x Hyd Sel 17	244.15	212.91	110.17	93.48	58.88	61.94
All-Rounder x CI 4	249.52	234.09	116.14	116.77	64.67	64.25
All-Rounder x CML 446	260.41	248.80	121.28	117.28	65.45	65.29
All-Rounder x Hyd Sel 17	263.13	241.02	125.09	116.20	63.09	63.89
NAH 2049 x CI 4	269.38	210.29	129.52	95.29	60.78	62.22
NAH 2049 x CML 446	333.06	261.11	134.95	119.61	63.47	64.78
NAH 2049 x Hyd Sel 17	250.32	230.87	118.10	109.81	60.76	62.15
NK 6240 x CI 4	267.99	225.10	124.24	107.78	62.05	62.76
NK 6240 x CML 446	255.70	238.57	111.20	110.26	64.67	64.69
NK 6240 x Hyd Sel 17	257.87	238.26	127.02	112.34	63.53	63.55
Rajkumar x CI 4	254.28	227.97	116.03	108.44	64.60	64.13
Rajkumar x CML 446	260.99	248.87	118.09	110.02	64.41	64.12
Rajkumar x Hyd Sel 17	252.06	243.34	140.74	117.44	62.52	62.12
G 57 x Karveer	260.88	233.73	116.05	96.92	62.10	62.62
G 57 x NAC 6002	262.28	247.51	114.58	109.12	59.26	60.21
G 57 x Parbhat	260.98	228.08	126.99	99.31	62.94	62.93
Mean	259.80	231.47	120.33	105.78	62.71	63.37
SD	19.91	17.81	10.49	12.12	2.26	1.90

NS = Nonstress

S = Stress

Contd.....

Table 34 contd....

Crosses	Plant height (cm)		Ear height (cm)		Days to 50% anthesis	
	NS	S	NS	S	NS	S
Karveer x NAC 6002	253.43	227.84	111.98	91.70	61.33	64.13
Karveer x Parbhat	272.77	220.91	125.53	96.02	61.14	63.81
NAC 6002 x Parbhat	257.84	249.81	116.17	111.27	59.01	59.65
G 57	247.37	213.83	107.49	92.86	62.49	62.96
Karveer	264.91	242.08	122.39	107.70	62.68	64.42
Parbhat	317.52	254.16	125.76	123.32	62.74	63.67
NAC 6002	240.49	206.13	100.82	76.46	58.86	59.66
All-Rounder	257.18	215.38	121.47	102.66	65.93	65.70
Arjun (c)	264.77	221.72	123.02	99.06	62.39	62.84
Bio 9681 (c)	247.34	212.66	107.63	86.66	65.22	64.68
NK 6240	266.08	249.00	128.12	119.70	64.54	63.50
Rajkumar	271.61	250.60	126.63	107.41	63.27	63.56
900M (c)	253.16	211.22	121.51	97.13	65.84	64.31
CI 4	236.54	209.51	106.88	101.28	64.32	65.86
CML 446	261.41	238.40	123.35	109.88	67.47	65.52
Hyd Sel 17	231.03	223.13	112.01	114.10	63.54	63.75
Mean	259.80	231.47	120.33	105.78	62.71	63.37
SD	19.91	17.81	10.49	12.12	2.26	1.90

NS = Nonstress

S = Stress

Contd.....

Table 34 contd....

Crosses	Days to 50% silking		Anthesis to silking interval		Days to maturity	
	NS	S	NS	S	NS	S
G 57 x CI 4	63.03	63.52	2.33	3.34	107.00	99.00
G 57 x CML 446	64.21	68.20	2.30	4.08	105.00	101.00
G 57 x Hyd Sel 17	62.94	68.72	1.49	6.40	106.00	101.00
Karveer x CI 4	63.01	65.78	1.33	1.31	104.00	102.00
Karveer x CML 446	64.05	66.60	1.08	3.20	103.00	99.00
Karveer x Hyd Sel 17	63.10	65.36	1.26	2.73	105.00	98.00
Parbhat x CI 4	65.08	66.10	3.08	3.92	108.00	101.00
Parbhat x CML 446	70.41	71.58	3.96	7.02	106.00	101.00
Parbhat x Hyd Sel 17	65.35	66.31	2.73	3.59	108.00	99.00
NAC 6002 x CI 4	60.15	65.24	1.42	1.88	103.00	101.00
NAC 6002 x CML 446	63.76	67.34	1.33	1.92	105.00	101.00
NAC 6002 x Hyd Sel 17	61.77	64.41	2.89	2.48	106.00	100.00
All-Rounder x CI 4	65.80	67.27	1.14	3.02	105.00	103.00
All-Rounder x CML 446	67.53	68.69	2.08	3.41	108.00	102.00
All-Rounder x Hyd Sel 17	64.02	66.51	0.94	2.63	105.00	102.00
NAH 2049 x CI 4	62.05	65.38	1.28	3.17	104.00	98.00
NAH 2049 x CML 446	65.14	68.14	1.67	3.36	106.00	101.00
NAH 2049 x Hyd Sel 17	62.23	65.04	1.47	2.89	106.00	101.00
NK 6240 x CI 4	62.87	64.84	0.83	2.08	107.00	101.00
NK 6240 x CML 446	66.39	68.13	1.72	3.44	108.00	103.00
NK 6240 x Hyd Sel 17	65.03	65.65	1.49	2.10	107.00	102.00
Rajkumar x CI 4	66.00	66.50	1.40	2.37	107.00	101.00
Rajkumar x CML 446	66.18	68.44	1.77	4.33	106.00	101.00
Rajkumar x Hyd Sel 17	63.86	64.88	1.34	2.76	104.00	102.00
G 57 x Karveer	63.53	65.66	1.43	3.04	104.00	98.00
G 57 x NAC 6002	62.40	65.03	3.14	4.82	104.00	98.00
G 57 x Parbhat	66.34	66.08	3.41	3.16	105.00	102.00
Mean	64.69	66.77	1.98	3.40	105.88	100.71
SD	2.40	2.14	1.03	1.43	2.00	1.65

NS = Nonstress

S = Stress

Contd.....

Table 34 contd....

Crosses	Days to 50% silking		Anthesis to silking interval		Days to maturity	
	NS	S	NS	S	NS	S
Karveer x NAC 6002	62.77	67.09	1.45	2.95	105.00	99.00
Karveer x Parbhat	63.30	67.48	2.16	3.67	104.00	102.00
NAC 6002 x Parbhat	62.00	64.79	2.99	5.14	103.00	99.00
G 57	64.69	68.02	2.20	5.06	108.00	100.00
Karveer	64.31	67.29	1.63	2.88	105.00	101.00
Parbhat	67.16	69.17	4.42	5.51	106.00	101.50
NAC 6002	61.92	64.86	3.06	5.21	103.00	98.00
All-Rounder	67.57	68.24	1.64	2.54	108.00	101.00
Arjun (c)	64.21	67.66	1.82	4.83	105.00	102.00
Bio 9681 (c)	67.61	68.15	2.40	3.48	108.00	102.00
NK 6240	65.35	64.60	0.82	1.10	107.00	102.00
Rajkumar	65.31	66.70	2.04	3.14	109.00	102.00
900M (c)	67.28	66.92	1.45	2.61	109.00	101.00
CI 4	66.04	69.44	1.72	3.58	107.00	101.00
CML 446	71.22	69.28	3.75	3.76	106.00	101.00
Hyd Sel 17	64.86	66.14	1.32	2.39	108.00	100.00
Mean	64.69	66.77	1.98	3.40	105.88	100.71
SD	2.40	2.14	1.03	1.43	2.00	1.65

NS = Nonstress

S = Stress

Contd.....

Table 34 contd....

Crosses	Cob length (cm)		Cob girth (cm)		Kernel rows per Cob	
	NS	S	NS	S	NS	S
G 57 x CI 4	12.91	10.31	12.87	11.54	13.23	12.31
G 57 x CML 446	13.99	11.32	13.47	10.88	14.10	13.66
G 57 x Hyd Sel 17	14.33	11.83	12.85	10.76	13.30	13.63
Karveer x CI 4	12.60	11.48	12.48	11.62	12.94	13.98
Karveer x CML 446	13.77	9.77	13.43	10.61	13.48	12.55
Karveer x Hyd Sel 17	13.96	10.94	12.88	10.92	13.27	12.78
Parbhat x CI 4	13.40	11.52	13.14	11.40	13.48	13.23
Parbhat x CML 446	12.91	10.11	13.21	11.24	13.89	14.03
Parbhat x Hyd Sel 17	13.80	11.68	13.28	12.00	13.45	13.94
NAC 6002 x CI 4	12.70	12.02	12.77	11.27	13.82	13.16
NAC 6002 x CML 446	13.45	11.68	13.66	11.57	13.42	13.88
NAC 6002 x Hyd Sel 17	12.55	10.32	12.85	10.56	13.36	13.34
All-Rounder x CI 4	14.27	11.77	13.44	11.52	14.45	13.28
All-Rounder x CML 446	14.01	11.06	13.42	11.33	14.48	14.14
All-Rounder x Hyd Sel 17	15.19	11.80	13.58	11.42	14.07	13.39
NAH 2049 x CI 4	14.22	10.34	13.46	11.09	14.61	13.59
NAH 2049 x CML 446	14.86	10.09	14.07	11.06	15.20	14.58
NAH 2049 x Hyd Sel 17	13.87	11.18	13.77	11.07	13.83	13.58
NK 6240 x CI 4	14.41	11.45	13.85	11.35	14.17	13.08
NK 6240 x CML 446	14.20	11.31	13.80	11.81	14.58	14.48
NK 6240 x Hyd Sel 17	14.26	12.38	13.66	11.72	13.98	14.25
Rajkumar x CI 4	14.72	11.44	12.95	11.05	13.37	12.62
Rajkumar x CML 446	13.30	11.72	13.47	11.68	14.10	13.03
Rajkumar x Hyd Sel 17	14.57	12.56	13.53	11.64	13.67	13.34
G 57 x Karveer	12.82	10.92	13.00	10.97	13.65	13.11
G 57 x NAC 6002	13.19	10.47	13.58	11.58	14.17	13.29
G 57 x Parbhat	13.91	11.52	12.69	11.61	13.66	13.07
Mean	13.71	11.22	13.25	11.23	13.82	13.43
SD	1.16	0.93	0.60	0.54	0.70	0.69

NS = Nonstress

S = Stress

Contd.....

Table 34 contd....

Crosses	Cob length (cm)		Cob girth (cm)		Kernel rows per cob	
	NS	S	NS	S	NS	S
Karveer x NAC 6002	13.36	11.01	13.66	11.21	13.73	12.64
Karveer x Parbhat	14.56	11.76	13.33	11.32	13.60	13.24
NAC 6002 x Parbhat	14.06	10.94	13.43	10.94	14.90	12.96
G 57	13.17	11.61	12.92	11.20	13.09	13.10
Karveer	12.34	11.45	13.19	11.00	13.22	13.05
Parbhat	13.58	11.82	13.11	11.45	14.13	13.57
NAC 6002	11.58	9.39	12.11	10.12	12.97	12.75
All-Rounder	15.72	10.21	13.90	11.19	14.76	13.81
Arjun (c)	14.03	10.44	13.79	11.08	14.62	13.80
Bio 9681 (c)	12.36	11.25	12.70	10.98	13.50	13.42
NK 6240	15.68	12.24	13.94	11.72	14.50	14.30
Rajkumar	15.35	13.01	13.75	11.72	13.64	14.70
900M (c)	14.18	11.13	13.92	11.09	15.36	13.76
CI 4	11.97	10.34	12.48	10.69	12.81	13.20
CML 446	12.80	11.90	12.82	11.29	13.15	13.04
Hyd Sel 17	12.74	11.22	11.73	10.69	12.59	12.86
Mean	13.71	11.22	13.25	11.23	13.82	13.43
SD	1.16	0.93	0.60	0.54	0.70	0.69

NS = Nonstress

S = Stress

Contd.....

Table 34 contd....

Crosses	Kernels per row		Ears per plant		Yield per plant (g)	
	NS	S	NS	S	NS	S
G 57 x CI 4	26.56	19.06	0.945	0.920	90.76	47.54
G 57 x CML 446	30.60	22.34	0.925	0.815	109.95	49.15
G 57 x Hyd Sel 17	28.75	21.51	0.970	0.885	96.09	46.73
Karveer x CI 4	25.79	22.12	0.970	0.790	84.82	54.78
Karveer x CML 446	27.78	18.25	0.980	0.920	102.17	39.10
Karveer x Hyd Sel 17	27.26	20.00	0.860	0.900	98.05	42.60
Parbhat x CI 4	27.08	23.86	0.885	0.850	93.40	50.42
Parbhat x CML 446	25.88	18.10	0.900	0.800	81.65	38.93
Parbhat x Hyd Sel 17	27.52	23.94	0.895	0.855	96.94	49.84
NAC 6002 x CI 4	25.59	22.04	0.985	0.900	84.79	53.39
NAC 6002 x CML 446	29.36	23.07	0.980	0.850	93.07	53.14
NAC 6002 x Hyd Sel 17	24.61	19.38	0.935	0.875	84.42	41.03
All-Rounder x CI 4	31.20	23.07	0.945	0.935	103.98	58.53
All-Rounder x CML 446	29.91	21.86	0.925	0.895	105.02	45.79
All-Rounder x Hyd Sel 17	30.78	22.55	0.965	0.900	119.85	57.06
NAH 2049 x CI 4	28.90	20.08	0.985	0.835	106.78	40.41
NAH 2049 x CML 446	31.86	17.79	0.960	0.850	124.65	41.67
NAH 2049 x Hyd Sel 17	27.33	22.07	0.960	0.885	102.46	48.67
NK 6240 x CI 4	29.39	23.34	0.950	0.905	114.32	55.61
NK 6240 x CML 446	28.40	20.92	0.910	0.865	105.68	48.21
NK 6240 x Hyd Sel 17	28.13	24.00	0.925	0.900	107.30	59.44
Rajkumar x CI 4	29.34	21.28	0.985	0.920	102.94	49.32
Rajkumar x CML 446	27.75	22.47	0.980	0.815	96.58	53.42
Rajkumar x Hyd Sel 17	29.03	24.73	0.930	0.915	108.35	62.06
G 57 x Karveer	26.94	20.35	0.985	0.870	92.86	41.26
G 57 x NAC 6002	26.52	22.09	0.940	0.935	96.80	54.33
G 57 x Parbhat	29.65	22.25	0.915	0.970	89.72	46.24
Mean	27.86	21.40	0.939	0.876	98.04	48.36
SD	2.93	2.41	0.045	0.070	16.47	7.55

NS = Nonstress

S = Stress

Contd.....

Table 34 contd....

Crosses	Kernels per row		Ears per plant		Yield per plant (g)	
	NS	S	NS	S	NS	S
Karveer x NAC 6002	28.05	20.06	0.960	0.910	100.34	49.64
Karveer x Parbhat	28.12	21.15	0.985	0.825	100.80	46.54
NAC 6002 x Parbhat	29.23	20.11	0.930	0.880	97.77	44.95
G 57	27.68	24.50	0.865	0.710	87.73	52.64
Karveer	24.51	21.52	0.965	0.885	81.69	46.62
Parbhat	28.53	22.92	0.915	0.880	88.10	48.70
NAC 6002	22.50	15.89	0.900	0.700	63.69	35.13
All-Rounder	33.92	19.87	1.000	0.880	122.38	46.09
Arjun (c)	28.80	19.99	0.950	0.890	109.61	43.14
Bio 9681 (c)	24.62	20.94	0.960	0.865	78.90	45.09
NK 6240	30.37	21.10	0.970	0.930	122.80	50.54
Rajkumar	30.48	22.89	0.945	0.900	120.89	58.01
900M (c)	30.45	21.87	0.920	0.965	114.92	51.05
CI 4	23.04	18.63	0.880	0.870	75.99	43.72
CML 446	22.99	23.92	0.880	0.900	83.38	45.88
Hyd Sel 17	23.07	22.43	0.865	0.930	73.27	43.24
Mean	27.86	21.40	0.939	0.876	98.04	48.36
SD	2.93	2.41	0.045	0.070	16.47	7.55

NS = Nonstress

S = Stress

Contd.....

Table 34 contd....

Crosses	Shelling percentage		100-grain weight (g)		RWC1	
	NS	S	NS	S	NS	S
G 57 x CI 4	83.05	81.00	28.38	21.88	0.930	0.885
G 57 x CML 446	84.66	79.55	26.25	17.70	0.900	0.870
G 57 x Hyd Sel 17	83.08	77.75	26.67	19.30	0.950	0.925
Karveer x CI 4	83.22	81.61	26.33	18.20	0.900	0.835
Karveer x CML 446	82.71	81.04	27.46	19.08	0.910	0.825
Karveer x Hyd Sel 17	82.58	80.69	28.24	17.90	0.925	0.850
Parbhat x CI 4	83.04	79.34	26.70	17.16	0.895	0.905
Parbhat x CML 446	80.67	80.25	24.48	15.66	0.950	0.820
Parbhat x Hyd Sel 17	83.87	80.15	27.78	16.77	0.940	0.865
NAC 6002 x CI 4	84.03	81.29	27.44	19.06	0.885	0.900
NAC 6002 x CML 446	81.50	78.86	25.94	16.91	0.910	0.850
NAC 6002 x Hyd Sel 17	82.30	79.85	28.03	18.31	0.935	0.890
All-Rounder x CI 4	83.46	81.92	24.30	20.47	0.920	0.875
All-Rounder x CML 446	82.90	80.78	25.46	17.41	0.925	0.855
All-Rounder x Hyd Sel 17	82.86	79.89	27.57	20.76	0.895	0.850
NAH 2049 x CI 4	83.85	80.52	27.30	18.20	0.940	0.805
NAH 2049 x CML 446	82.71	77.75	26.30	17.55	0.935	0.910
NAH 2049 x Hyd Sel 17	81.92	81.34	28.77	17.96	0.910	0.875
NK 6240 x CI 4	83.15	82.74	29.08	19.13	0.950	0.880
NK 6240 x CML 446	80.19	77.00	27.47	18.40	0.925	0.810
NK 6240 x Hyd Sel 17	82.26	81.77	29.50	19.65	0.950	0.890
Rajkumar x CI 4	84.95	81.80	28.27	19.52	0.935	0.855
Rajkumar x CML 446	83.03	81.53	27.32	20.28	0.920	0.820
Rajkumar x Hyd Sel 17	82.59	81.27	28.82	20.43	0.900	0.840
G 57 x Karveer	83.70	79.66	26.47	17.19	0.930	0.860
G 57 x NAC 6002	84.24	83.31	28.00	18.69	0.915	0.810
G 57 x Parbhat	82.79	80.95	23.91	17.25	0.925	0.855
Mean	82.91	80.50	27.01	18.42	0.927	0.859
SD	1.94	1.66	1.54	2.30	0.045	0.045

NS = Nonstress S = Stress
RWC1 – Relative water content at 60 DAS

Contd.....

Table 34 contd....

Crosses	Shelling percentage		100-grain weight (g)		RWC 1	
	NS	S	NS	S	NS	S
Karveer x NAC 6002	82.88	77.43	27.66	18.08	0.935	0.875
Karveer x Parbhat	82.36	81.26	29.07	17.18	0.895	0.790
NAC 6002 x Parbhat	83.37	82.65	25.05	18.67	0.920	0.860
G 57	82.64	80.52	28.77	19.67	0.950	0.870
Karveer	81.12	77.41	26.15	19.74	1.120	0.825
Parbhat	83.40	82.91	24.78	16.75	0.930	0.860
NAC 6002	84.58	82.55	23.49	16.07	0.900	0.915
All-Rounder	85.28	82.46	25.29	17.07	0.940	0.860
Arjun (c)	83.80	80.33	27.53	17.96	0.895	0.865
Bio 9681 (c)	80.80	78.22	25.16	18.56	0.910	0.865
NK 6240	82.18	83.47	29.26	17.32	0.940	0.930
Rajkumar	86.39	84.48	30.42	20.90	0.930	0.870
900M (c)	84.78	83.02	24.72	17.70	0.910	0.855
CI 4	82.29	76.49	26.29	18.90	0.950	0.815
CML 446	79.63	76.21	28.52	19.43	0.915	0.810
Hyd Sel 17	80.56	78.54	26.98	17.45	0.925	0.860
Mean	82.91	80.50	27.01	18.42	0.927	0.859
SD	1.94	1.66	1.54	2.30	0.045	0.045

NS = Nonstress S = Stress
RWC1 – Relative water content at 60 DAS

Contd.....

Table 34 contd....

Crosses	RWC 2		CHL 1		CHL 2	
	NS	S	NS	S	NS	S
G 57 x CI 4	0.880	0.715	49.40	38.05	39.10	26.24
G 57 x CML 446	0.895	0.725	46.60	36.21	36.25	28.01
G 57 x Hyd Sel 17	0.865	0.760	48.10	41.12	38.05	30.12
Karveer x CI 4	0.860	0.685	49.60	41.88	43.30	30.89
Karveer x CML 446	0.825	0.700	45.65	34.90	38.20	24.06
Karveer x Hyd Sel 17	0.900	0.570	49.85	38.57	40.00	27.44
Parbhat x CI 4	0.780	0.665	50.30	45.80	44.70	33.57
Parbhat x CML 446	0.865	0.660	44.05	38.54	39.05	26.46
Parbhat x Hyd Sel 17	0.855	0.645	48.20	43.31	39.85	25.83
NAC 6002 x CI 4	0.860	0.640	49.05	45.92	39.80	33.49
NAC 6002 x CML 446	0.895	0.735	51.75	41.67	37.00	32.85
NAC 6002 x Hyd Sel 17	0.825	0.770	49.75	38.70	36.35	24.76
All-Rounder x CI 4	0.735	0.735	44.85	43.46	38.10	31.79
All-Rounder x CML 446	0.830	0.675	41.90	35.79	35.90	27.34
All-Rounder x Hyd Sel 17	0.900	0.765	49.65	37.38	35.00	34.61
NAH 2049 x CI 4	0.850	0.610	50.20	35.31	41.05	23.99
NAH 2049 x CML 446	0.825	0.675	45.75	40.57	42.60	29.67
NAH 2049 x Hyd Sel 17	0.830	0.640	47.85	39.91	43.25	26.33
NK 6240 x CI 4	0.850	0.730	47.25	35.74	38.05	24.77
NK 6240 x CML 446	0.885	0.735	48.20	37.86	45.60	28.17
NK 6240 x Hyd Sel 17	0.870	0.790	49.75	41.41	41.50	29.82
Rajkumar x CI 4	0.825	0.650	48.25	38.63	39.25	28.41
Rajkumar x CML 446	0.855	0.785	47.25	42.73	31.65	28.43
Rajkumar x Hyd Sel 17	0.685	0.695	46.20	44.42	36.25	29.57
G 57 x Karveer	0.820	0.560	49.05	39.10	38.05	23.44
G 57 x NAC 6002	0.855	0.595	51.60	39.97	39.95	23.45
G 57 x Parbhat	0.800	0.535	49.25	41.70	40.85	31.22
Mean	0.834	0.673	47.72	40.26	38.50	27.67
SD	0.060	0.080	3.48	3.71	3.60	3.66

NS = Nonstress

S = Stress

RWC2 – Relative water content at 90 DAS

CHL1 – Chlorophyll content at 60 DAS

CHL2 – Chlorophyll content at 90 DAS

Contd.....

Table 34 contd....

Crosses	RWC 2		CHL 1		CHL 2	
	NS	S	NS	S	NS	S
Karveer x NAC 6002	0.840	0.690	50.90	39.53	42.95	25.98
Karveer x Parbhat	0.815	0.665	49.85	43.29	38.40	28.13
NAC 6002 x Parbhat	0.855	0.675	55.80	42.86	36.05	27.26
G 57	0.845	0.615	51.75	41.09	39.10	27.50
Karveer	0.900	0.630	45.55	42.91	35.40	27.39
Parbhat	0.875	0.695	44.95	43.01	33.00	26.72
NAC 6002	0.800	0.580	52.40	43.57	34.30	21.91
All-Rounder	0.785	0.645	42.10	33.75	34.65	22.76
Arjun (c)	0.835	0.740	48.65	39.23	38.55	26.10
Bio 9681 (c)	0.825	0.605	43.15	40.54	34.55	27.38
NK 6240	0.845	0.520	46.95	39.83	41.45	27.82
Rajkumar	0.880	0.685	47.40	40.99	39.80	29.63
900M (c)	0.865	0.680	45.55	40.44	34.75	27.11
CI 4	0.865	0.660	46.40	39.08	40.60	26.20
CML 446	0.840	0.740	35.25	37.90	33.20	24.33
Hyd Sel 17	0.860	0.650	46.20	44.52	40.15	29.02
Mean	0.834	0.673	47.72	40.26	38.50	27.67
SD	0.060	0.080	3.48	3.71	3.60	3.66

NS = Nonstress

S = Stress

RWC2 – Relative water content at 90 DAS

CHL1 – Chlorophyllt content at 60 DAS

CHL2 – Chlorophyllt content at 90 DAS

Table 35. Performance of three way, top crosses / varietal hybrids for yield under stress and nonstress situations and drought susceptible index

Crosses	Grain yield (kg/ha) under drought			Grain yield (kg/ha) under nonstress			Drought susceptibility index (YPP) 2009
	2008	2009	Mean	2008	2009	Mean	
G 57 x CI 4	2056.00	3038.07	2547.03	6866.70	5333.55	6100.13	0.96
G 57 x CML 446	1416.50	2410.92	1913.73	7012.50	6227.10	6619.80	1.09
G 57 x Hyd Sel 17	2661.50	2440.89	2551.20	6699.20	6046.20	6372.70	1.03
Karveer x CI 4	2115.00	3163.50	2639.25	6802.50	5735.35	6268.93	0.71
Karveer x CML 446	2011.00	2426.46	2218.73	7506.70	6386.95	6946.83	1.23
Karveer x Hyd Sel 17	1709.00	2254.41	1981.70	5642.50	5224.75	5433.63	1.15
Parbhat x CI 4	3018.50	2594.07	2806.28	7402.50	5613.25	6507.88	0.95
Parbhat x CML 446	1769.00	1694.97	1732.00	7695.85	4839.60	6267.73	1.06
Parbhat x Hyd Sel 17	2556.50	2656.23	2606.38	7869.20	5567.75	6718.48	0.96
NAC 6002 x CI 4	2379.00	3076.92	2727.95	6406.70	5746.45	6076.58	0.74
NAC 6002 x CML 446	2249.50	2599.62	2424.58	6193.30	5319.10	5756.20	0.96
NAC 6002 x Hyd Sel 17	2427.00	2342.10	2384.55	6669.15	5143.70	5906.43	1.04
All-Rounder x CI 4	1863.50	3441.00	2652.25	5835.00	6067.25	5951.13	0.86
All-Rounder x CML 446	2472.50	2566.32	2519.40	6111.65	5754.25	5932.95	1.08
All-Rounder x Hyd Sel 17	2792.50	3456.54	3124.50	5870.00	7148.40	6509.20	1.02
NAH 2049 x CI 4	2170.00	2113.44	2141.73	6035.85	6763.20	6399.53	1.24
NAH 2049 x CML 446	1275.00	2311.02	1793.03	5684.15	7327.10	6505.63	1.35
NAH 2049 x Hyd Sel 17	1978.50	2870.46	2424.48	6508.30	5919.60	6213.95	1.06
NK 6240 x CI 4	2308.50	3468.75	2888.63	5865.00	7609.05	6737.03	1.04
NK 6240 x CML 446	2347.50	2728.38	2537.95	7329.15	6454.65	6891.90	1.10
NK 6240 x Hyd Sel 17	2520.00	3364.41	2942.20	7538.30	5847.45	6692.88	0.89
Rajkumar x CI 4	2358.50	2943.72	2651.10	6432.50	6751.05	6591.78	1.04
Rajkumar x CML 446	3261.50	2814.96	3038.23	7318.30	5764.20	6541.25	0.91
Rajkumar x Hyd Sel 17	1672.50	3581.97	2627.25	6188.35	6127.20	6157.78	1.06
G 57 x Karveer	2140.50	2384.28	2262.40	6946.65	5885.20	6415.93	1.11
G 57 x NAC 6002	2607.50	3266.73	2937.10	6760.00	5265.85	6012.93	0.89
G 57 x Parbhat	2151.00	3078.03	2614.53	6393.30	5069.35	5731.33	0.94
Mean	2278.09	2684.67	2481.38	6743.34	5776.64	6259.99	1.00
CD at 5%	1008.98	1023.13	378.88	1311.12	1447.55	962.26	0.31
Cv (%)	21.94	18.88		11.25	10.64		15.07

Contd.....

Table 35 contd.....

Crosses	Grain yield (kg/ha) under drought			Grain yield (kg/ha) under nonstress situation			Drought susceptibility index (YPP) 2009
	2008	2009	Mean	2008	2009	Mean	
Karveer x NAC 6002	2445.00	2453.10	2449.05	6659.15	5722.05	6190.60	1.02
Karveer x Parbhat	1850.00	2407.59	2128.80	7385.00	6702.20	7043.60	1.08
NAC 6002 x Parbhat	2423.50	2654.01	2538.75	7105.00	5858.55	6481.78	1.09
G 57	2420.00	2208.90	2314.45	5695.85	3631.90	4663.88	0.81
Karveer	1720.00	2264.40	1992.20	5848.35	4810.70	5329.53	0.87
Parbhat	1651.00	2433.12	2042.05	8118.35	5199.25	6658.80	0.90
NAC 6002	1939.50	1469.64	1704.58	4975.00	3675.20	4325.10	0.91
All-Rounder (c)	2620.50	2558.55	2589.53	7041.65	7718.95	7380.30	1.26
Arjun (c)	2085.00	2408.70	2246.85	7665.00	6545.70	7105.35	1.24
Bio 9681 (c)	3740.00	2560.77	3150.39	7748.35	4377.85	6063.10	0.73
NK 6240	3377.50	3254.52	3316.01	8623.50	8020.85	8322.18	0.86
Rajkumar	3170.00	3252.30	3211.15	7448.00	6970.80	7209.40	1.17
900M (c)	2501.00	2871.57	2686.29	9342.50	5677.65	7510.08	1.06
CI 4	2015.00	2395.38	2205.19	5981.65	4216.90	5099.28	1.04
CML 446	1365.00	2663.56	2014.28	5799.65	4588.75	5194.20	0.84
Hyd Sel 17	2347.00	2496.39	2421.70	4943.35	3740.70	4342.03	0.84
Mean	2278.09	2684.67	2481.38	6743.34	5776.64	6259.99	1.00
CD at 5%	1008.98	1023.13	378.88	1311.12	1447.55	962.26	0.31
Cv (%)	21.94	18.88		11.25	10.64		15.07

4.5 Magnitude and nature of variability in three way /top crosses and varietal/population hybrids

Variability is very important for improvement of any trait. The nature and magnitude of variation for different traits apart from mean performance decides the worth of the cross for exploitation after hybridization. Adopting the procedures described in the material and methods crosswise phenotypic and genotypic variances were computed for different traits. In order to know the nature and magnitude of variances for divergent traits, genetic parameters viz., phenotypic and genotypic coefficients of variation, heritability in broad sense and genetic advance over mean were computed and presented in Table 36.

4.5.1 Plant height (cm)

The genotypic variances for plant height in some of the crosses viz., G 57 x CML 446, Karveer x CI 4, Karveer x CML 446, Karveer x Hyd Sel 17, Parbhat x CML 446, Parbhat x Hyd Sel 17, Rajkumar x CML 446 were negative indicating higher variances in the parents as compared to crosses. Hence, the genetic parameters were non estimable in those crosses (Table 36) under nonstress situation. Similarly, under stress situation they were non estimable in G 57 x Hyd Sel 17, NAC 6002 x Hyd Sel 17, NK 6240 x CML 446 and G 57 x NAC 6002. The plant height decreased under stress in all the crosses as indicated by the mean values of the crosses. Under stress, it recorded relatively high level of variation as revealed by PCV and / or GCV under stress as compared to nonstress. The trait showed moderate level of heritability with moderate values of genetic advance.

The crosses involving CI 4 as male parent recorded moderate level heritability with moderate values of genetic advance.

4.5.2 Ear height (cm)

For ear height, the variation was low to moderate. The crosses G 57 x CML 446, All-Rounder x CI 4, NK 6240 x CI 4, Rajkumar x CI 4 and G 57 x Parbhat recorded high heritability with moderate to high genetic advance.

4.5.3 Days to 50% anthesis

The variation for this trait was very low in all the crosses as indicated by PCV and or GCV. It recorded low to moderate heritability in all the crosses except All-Rounder x CML 446 and NK 6240 x CML 446 under nonstress. The genetic advance for the trait was very low.

4.5.4 Days to 50% silking

Similar situation as that of days to 50% anthesis existed for days to silking.

4.5.5 Anthesis to silking interval

Genetic parameters were non estimable in many of the crosses under nonstress, and varietal hybrids under stress due to high parental variances for the trait. However, it recorded very high variation both under nonstress and stress conditions as indicated by PCV and / or GCV. Many of the crosses showed high heritability for the trait with low genetic advance.

4.5.6 Cob length (cm)

The magnitude of variation as indicated PCV and GCV was low to moderate. Few crosses viz., G 57 x CML 446, G 57 x Hyd Sel 17, NAC 6002 x CML 446, NAC 6002 x Hyd Sel 17 recorded high heritability with low genetic advance under nonstress situation. The heritability of the trait decreased under stress. It recorded low moderate heritability with very low genetic advance under stress.

4.5.7 Cob girth (cm)

The character showed low magnitude of variability as revealed by PCV and GCV under both the environments. Heritability for the trait ranged from very low to high among crosses with very low genetic advance.

Table 36a. Genetic components of variation for plant height (cm) under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h^2 (bs)	GA	Mean	PCV	GCV	h^2 (bs)	GA
G 57 x CI 4	264.72	7.79	3.35	0.18	7.84	219.49	17.07	13.84	0.66	50.73
G 57 x CML 446	260.57	7.72	-	-	-	247.17	20.14	17.89	0.79	80.95
G 57 x Hyd Sel 17	248.49	11.50	9.43	0.67	39.64	234.02	10.07	-	-	-
Karveer x CI 4	255.78	7.53	-	-	-	226.97	17.02	13.71	0.65	51.63
Karveer x CML 446	267.09	9.05	-	-	-	228.96	18.15	14.89	0.67	57.59
Karveer x Hyd Sel 17	256.89	5.65	-	-	-	220.14	15.07	10.11	0.45	30.77
Parbhat x CI 4	250.24	14.34	11.04	0.59	43.80	237.43	17.50	14.92	0.73	62.25
Parbhat x CML 446	266.54	9.30	-	-	-	243.84	10.48	4.88	0.22	11.42
Parbhat x Hyd Sel 17	265.98	5.02	-	-	-	222.73	17.10	13.46	0.62	48.65
NAC 6002 x CI 4	252.00	12.36	9.65	0.61	39.14	225.39	18.06	13.50	0.56	46.87
NAC 6002 x CML 446	249.94	14.00	10.99	0.62	44.41	210.85	18.10	12.41	0.47	36.93
NAC 6002 x Hyd Sel 17	247.40	10.17	7.41	0.53	27.51	216.64	12.19	-	-	-
All-Rounder x CI 4	253.64	9.81	7.80	0.63	32.40	238.34	13.91	11.18	0.65	44.16
All-Rounder x CML 446	265.13	7.35	2.93	0.16	6.37	255.08	13.25	10.47	0.62	43.45
All-Rounder x Hyd Sel 17	264.29	8.06	6.62	0.68	29.65	247.96	11.76	7.88	0.45	26.94
NK 6240 x CI 4	267.90	7.17	4.27	0.35	14.05	229.48	14.81	11.98	0.65	45.82
NK 6240 x CML 446	255.07	9.76	6.66	0.47	23.93	241.86	8.67	-	-	-
NK 6240 x Hyd Sel 17	261.60	8.40	6.89	0.67	30.51	239.42	11.37	6.75	0.35	19.76
Rajkumar x CI 4	254.95	14.41	11.99	0.69	52.45	233.74	14.83	11.29	0.58	41.41
Rajkumar x CML 446	260.66	6.73	-	-	-	248.44	16.71	13.81	0.68	58.42
Rajkumar x Hyd Sel 17	251.86	11.37	8.75	0.59	34.97	247.77	14.21	10.32	0.53	38.27
G 57 x Karveer	260.48	9.28	3.19	0.12	5.90	230.17	13.55	9.29	0.47	30.24
G 57 x NAC 6002	264.30	8.28	3.89	0.22	9.92	248.61	7.89	-	-	-
G 57 x Parbhat	265.69	11.74	8.01	0.47	29.90	232.69	20.40	15.68	0.59	57.80
Karveer x NAC 6002	252.43	10.39	4.74	0.21	11.25	232.45	15.00	9.15	0.37	26.72
Karveer x Parbhat	272.97	10.48	4.11	0.15	9.08	225.74	18.31	15.37	0.71	60.03
NAC 6002 x Parbhat	257.20	10.62	5.42	0.26	14.69	252.17	13.11	7.75	0.35	23.82

- Non-estimable due to high parental variances

Table 36b. Genetic components of variation for ear height (cm) under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h^2 (bs)	GA	Mean	PCV	GCV	h^2 (bs)	GA
G 57 x CI 4	124.51	11.02	-	-	-	93.61	23.59	16.32	0.48	21.81
G 57 x CML 446	119.49	16.78	11.92	0.50	20.83	120.41	31.35	27.21	0.75	58.58
G 57 x Hyd Sel 17	120.60	13.09	6.81	0.27	8.80	107.33	15.18	-	-	-
Karveer x CI 4	113.55	12.52	-	-	-	105.13	19.93	10.94	0.30	13.02
Karveer x CML 446	121.40	13.24	-	-	-	114.89	15.72	-	-	-
Karveer x Hyd Sel 17	119.44	9.92	-	-	-	103.07	18.31	-	-	-
Parbhat x CI 4	112.83	12.96	-	-	-	109.30	18.84	14.14	0.56	23.87
Parbhat x CML 446	128.98	14.73	8.85	0.36	14.13	116.77	18.73	11.96	0.41	18.37
Parbhat x Hyd Sel 17	130.86	12.67	6.01	0.23	7.70	101.09	18.80	-	-	-
NAC 6002 x CI 4	112.20	16.92	9.01	0.28	11.08	101.31	15.59	8.25	0.28	9.13
NAC 6002 x CML 446	120.33	11.38	-	-	-	97.56	23.32	15.89	0.46	21.75
NAC 6002 x Hyd Sel 17	111.67	16.65	9.30	0.31	11.93	94.93	25.53	10.17	0.16	7.91
All-Rounder x CI 4	118.16	8.02	-	-	-	118.72	21.05	16.74	0.63	32.56
All-Rounder x CML 446	124.54	11.40	-	-	-	121.33	21.07	14.89	0.50	26.29
All-Rounder x Hyd Sel 17	125.75	10.92	-	-	-	119.74	17.99	-	-	-
NK 6240 x CI 4	124.76	11.99	-	-	-	110.04	18.94	15.81	0.70	29.92
NK 6240 x CML 446	111.61	16.51	9.17	0.31	11.69	111.22	17.19	10.49	0.37	14.68
NK 6240 x Hyd Sel 17	130.06	18.06	14.06	0.61	29.34	112.60	14.66	-	-	-
Rajkumar x CI 4	116.31	13.48	3.83	0.08	2.60	108.83	26.07	22.28	0.73	42.70
Rajkumar x CML 446	118.44	11.94	-	-	-	116.60	22.70	16.84	0.55	30.02
Rajkumar x Hyd Sel 17	121.14	14.02	7.51	0.29	10.05	119.75	21.35	9.87	0.21	11.26
G 57 x Karveer	115.86	16.75	9.35	0.31	12.46	96.55	15.73	-	-	-
G 57 x NAC 6002	114.96	9.49	-	-	-	109.04	15.25	4.91	0.10	3.55
G 57 x Parbhat	128.55	11.86	5.90	0.25	7.76	100.57	25.52	20.01	0.61	32.49
Karveer x NAC 6002	111.20	14.91	-	-	-	94.12	21.80	11.66	0.29	12.09
Karveer x Parbhat	125.76	10.39	-	-	-	98.55	27.43	20.89	0.58	32.30
NAC 6002 x Parbhat	115.92	13.04	-	-	-	110.60	19.65	15.47	0.62	27.75

- Non-estimable due to high parental variances

Table 36c. Genetic components of variation for days to 50% anthesis under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h^2 (bs)	GA	Mean	PCV	GCV	h^2 (bs)	GA
G 57 x CI 4	60.55	6.23	3.27	0.28	2.14	59.70	6.87	4.52	0.43	3.67
G 57 x CML 446	62.15	4.01	-	-	-	63.89	4.63	-	-	-
G 57 x Hyd Sel 17	61.26	6.27	3.53	0.32	2.50	62.02	4.22	-	-	-
Karveer x CI 4	61.63	4.76	1.82	0.15	0.88	64.77	5.00	3.32	0.44	2.94
Karveer x CML 446	62.64	3.37	1.37	0.17	0.73	63.25	2.91	-	-	-
Karveer x Hyd Sel 17	61.84	4.80	2.10	0.19	1.16	62.18	4.34	1.80	0.17	0.95
Parbhat x CI 4	61.77	4.64	-	-	-	62.56	3.74	1.53	0.17	0.82
Parbhat x CML 446	66.37	4.80	3.33	0.48	3.15	64.47	2.35	-	-	-
Parbhat x Hyd Sel 17	62.16	4.95	1.37	0.08	0.49	62.47	3.45	-	-	-
NAC 6002 x CI 4	58.69	5.78	2.98	0.27	1.87	63.12	7.65	5.04	0.43	4.32
NAC 6002 x CML 446	62.51	4.37	2.62	0.36	2.02	65.56	4.49	-	-	-
NAC 6002 x Hyd Sel 17	58.71	4.97	0.94	0.03	0.21	62.64	6.00	-	-	-
All-Rounder x CI 4	64.58	4.77	3.38	0.50	3.17	64.19	3.36	1.85	0.30	1.34
All-Rounder x CML 446	65.00	3.73	3.37	0.82	4.09	65.18	3.26	0.98	0.09	0.40
All-Rounder x Hyd Sel 17	63.17	4.42	2.88	0.42	2.43	63.50	3.64	2.20	0.36	1.74
NK 6240 x CI 4	62.02	3.80	1.32	0.12	0.59	62.13	3.57	-	-	-
NK 6240 x CML 446	64.70	4.38	4.03	0.85	4.96	64.24	3.40	-	-	-
NK 6240 x Hyd Sel 17	63.29	4.35	2.70	0.39	2.20	63.32	5.22	3.74	0.52	3.51
Rajkumar x CI 4	64.54	4.67	2.48	0.28	1.75	63.56	4.49	3.01	0.45	2.63
Rajkumar x CML 446	64.40	3.21	-	-	-	63.63	2.59	-	-	-
Rajkumar x Hyd Sel 17	62.22	4.96	2.88	0.34	2.15	61.94	4.21	2.37	0.32	1.71
G 57 x Karveer	62.00	4.50	-	-	-	62.54	3.89	-	-	-
G 57 x NAC 6002	58.91	3.91	-	-	-	60.11	4.61	-	-	-
G 57 x Parbhat	62.69	4.56	-	-	-	62.58	4.50	-	-	-
Karveer x NAC 6002	61.31	5.37	2.90	0.29	1.98	63.74	6.84	3.75	0.30	2.70
Karveer x Parbhat	61.14	4.26	-	-	-	63.51	4.13	2.33	0.32	1.73
NAC 6002 x Parbhat	59.08	4.72	-	-	-	58.21	4.06	-	-	-

- Non-estimable due to high parental variances

Table 36d. Genetic components of variation for days to 50% silking under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h^2 (bs)	GA	Mean	PCV	GCV	h^2 (bs)	GA
G 57 x CI 4	62.58	7.43	3.82	0.26	2.53	62.70	7.92	3.97	0.25	2.58
G 57 x CML 446	64.43	6.17	2.55	0.17	1.40	67.98	6.96	3.37	0.23	2.29
G 57 x Hyd Sel 17	62.74	6.05	0.67	0.01	0.10	67.59	10.79	8.26	0.59	8.80
Karveer x CI 4	62.95	5.87	-	-	-	66.32	6.01	-	-	-
Karveer x CML 446	63.64	4.67	-	-	-	66.33	5.88	-	-	-
Karveer x Hyd Sel 17	63.02	6.63	3.62	0.30	2.57	64.80	8.03	2.64	0.11	1.16
Parbhat x CI 4	64.37	6.45	1.96	0.09	0.79	66.69	9.09	4.80	0.28	3.49
Parbhat x CML 446	70.17	5.40	1.72	0.10	0.79	71.12	7.22	1.50	0.04	0.46
Parbhat x Hyd Sel 17	64.90	5.73	-	-	-	64.87	5.28	-	-	-
NAC 6002 x CI 4	60.11	6.47	2.16	0.11	0.89	64.71	8.04	-	-	-
NAC 6002 x CML 446	63.98	6.72	4.36	0.42	3.74	68.02	7.04	-	-	-
NAC 6002 x Hyd Sel 17	61.31	6.13	2.50	0.16	1.28	63.98	8.41	-	-	-
All-Rounder x CI 4	65.52	5.39	2.79	0.27	1.96	67.09	7.23	5.72	0.63	6.27
All-Rounder x CML 446	67.00	5.49	4.01	0.53	4.04	67.94	5.63	3.93	0.49	3.85
All-Rounder x Hyd Sel 17	64.13	6.69	5.18	0.60	5.28	65.69	6.07	2.86	0.22	1.82
NK 6240 x CI 4	62.76	4.03	-	-	-	64.11	5.73	2.81	0.24	1.82
NK 6240 x CML 446	66.44	5.59	3.81	0.46	3.54	67.22	7.58	6.13	0.65	6.87
NK 6240 x Hyd Sel 17	64.58	5.70	3.47	0.37	2.82	64.78	6.57	3.18	0.24	2.07
Rajkumar x CI 4	65.83	5.40	1.46	0.07	0.54	65.81	8.00	5.56	0.48	5.23
Rajkumar x CML 446	66.14	5.52	3.19	0.33	2.51	67.17	7.72	5.52	0.51	5.48
Rajkumar x Hyd Sel 17	63.44	5.64	2.65	0.22	1.62	64.35	6.66	1.03	0.02	0.21
G 57 x Karveer	63.57	5.92	-	-	-	65.71	6.73	-	-	-
G 57 x NAC 6002	61.83	4.32	-	-	-	64.56	6.22	-	-	-
G 57 x Parbhat	65.83	5.85	-	-	-	65.57	5.15	-	-	-
Karveer x NAC 6002	62.80	6.67	2.87	0.19	1.60	66.10	9.62	-	0.08	1.10
Karveer x Parbhat	63.32	4.50	-	-	-	66.32	6.63	-	-	-
NAC 6002 x Parbhat	61.96	3.50	-	-	-	62.48	5.90	-	-	-

- Non-estimable due to high parental variances

Table 36e. Genetic components of variation for anthesis to silking interval under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h^2 (bs)	GA	Mean	PCV	GCV	h^2 (bs)	GA
G 57 x CI 4	2.33	107.24	-	-	-	3.32	66.69	-	-	-
G 57 x CML 446	2.30	125.94	-	-	-	4.24	163.72	144.29	0.78	11.10
G 57 x Hyd Sel 17	1.48	133.97	-	-	-	6.21	95.82	80.98	0.72	8.78
Karveer x CI 4	1.32	183.57	-	-	-	1.30	189.70	-	-	-
Karveer x CML 446	1.08	163.56	-	-	-	3.21	99.58	-	-	-
Karveer x Hyd Sel 17	1.23	208.31	-	-	-	2.80	109.51	-	-	-
Parbhat x CI 4	3.07	103.59	-	-	-	3.89	115.43	49.09	0.18	1.67
Parbhat x CML 446	3.92	88.11	-	-	-	7.02	70.78	40.75	0.33	3.39
Parbhat x Hyd Sel 17	2.74	88.03	-	-	-	3.74	106.63	10.42	0.01	0.08
NAC 6002 x CI 4	1.42	206.71	-	-	-	1.85	166.82	-	-	-
NAC 6002 x CML 446	1.37	188.28	-	-	-	2.59	120.77	-	-	-
NAC 6002 x Hyd Sel 17	2.90	96.89	-	-	-	4.93	82.25	42.00	0.26	2.17
All-Rounder x CI 4	1.09	188.18	-	-	-	2.95	131.54	107.83	0.67	5.37
All-Rounder x CML 446	2.08	103.45	-	-	-	3.29	99.67	73.49	0.54	3.68
All-Rounder x Hyd Sel 17	0.96	352.07	134.30	0.38	2.67	2.66	126.12	99.96	0.63	4.36
NK 6240 x CI 4	0.84	219.31	-	-	--	2.08	146.74	111.50	0.58	3.64
NK 6240 x CML 446	1.71	140.49	-	-	-	3.42	126.06	112.16	0.79	7.02
NK 6240 x Hyd Sel 17	1.49	141.48	28.10	0.20	0.86	2.05	180.98	158.82	0.77	5.90
Rajkumar x CI 4	1.40	144.18	-	-	-	2.65	175.25	141.93	0.66	6.29
Rajkumar x CML 446	1.77	140.08	-	-	-	4.29	122.25	104.59	0.73	7.92
Rajkumar x Hyd Sel 17	1.35	179.57	18.31	0.10	0.51	2.74	147.38	113.63	0.59	4.93
G 57 x Karveer	1.42	180.82	-	-	-	3.05	110.98	-	-	-
G 57 x NAC 6002	3.15	65.99	-	-	-	4.83	82.28	-	-	-
G 57 x Parbhat	3.41	83.76	-	-	-	3.03	98.86	-	-	-
Karveer x NAC 6002	1.51	175.58	-	-	-	2.81	156.20	-	-	-
Karveer x Parbhat	2.16	111.03	-	-	-	3.67	104.15	-	-	-
NAC 6002 x Parbhat	3.00	81.65	-	-	-	5.08	65.29	-	-	-

- Non-estimable due to high parental variances

Table 36f. Genetic components of variation for Cob length (cm) under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h ² (bs)	GA	Mean	PCV	GCV	h ² (bs)	GA
G 57 x CI 4	12.91	20.12	-	-	-	10.38	26.63	12.91	0.23	1.33
G 57 x CML 446	13.99	21.02	15.65	0.55	3.36	11.27	28.22	15.44	0.30	1.96
G 57 x Hyd Sel 17	14.28	23.59	18.28	0.60	4.18	11.92	22.50	-	-	-
Karveer x CI 4	12.55	23.58	-	-	-	11.53	26.20	13.00	0.25	1.54
Karveer x CML 446	13.57	20.01	11.35	0.32	1.79	9.81	29.21	3.26	0.01	0.07
Karveer x Hyd Sel 17	13.81	20.61	11.30	0.30	1.76	11.03	26.39	-	-	-
Parbhat x CI 4	13.44	23.06	-	-	-	11.51	26.96	16.68	0.38	2.45
Parbhat x CML 446	12.94	23.84	12.91	0.29	1.86	10.00	20.71	-	-	-
Parbhat x Hyd Sel 17	13.77	23.17	12.13	0.28	1.81	11.56	22.73	--	-	-
NAC 6002 x CI 4	12.70	20.19	-	-	-	12.04	23.03	-	-	-
NAC 6002 x CML 446	13.37	19.36	16.46	0.72	3.83	11.66	20.82			
NAC 6002 x Hyd Sel 17	12.55	25.84	22.48	0.76	5.07	10.01	28.96			
All-Rounder x CI 4	14.43	18.96	-	-	-	11.89	22.96	5.72	0.06	0.35
All-Rounder x CML 446	13.76	25.15	18.82	0.56	3.98	10.99	26.00	-	-	-
All-Rounder x Hyd Sel 17	15.13	19.95	11.76	0.35	2.17	11.93	21.63	-	-	-
NK 6240 x CI 4	14.44	17.92	-	-	-	11.44	22.35	13.29	0.35	1.87
NK 6240 x CML 446	14.21	19.83	13.30	0.45	2.61	11.29	16.83	-	-	-
NK 6240 x Hyd Sel 17	14.44	25.90	20.71	0.64	4.93	12.32	24.18	13.56	0.31	1.93
Rajkumar x CI 4	14.73	23.04	-	-	-	11.39	25.32	-	-	-
Rajkumar x CML 446	13.27	24.22	15.07	0.39	2.56	11.51	27.89	7.30	0.07	0.45
Rajkumar x Hyd Sel 17	14.55	21.84	12.10	0.31	2.01	12.54	28.34	12.36	0.19	1.38
G 57 x Karveer	12.83	19.88	-	-	-	10.76	24.15	9.29	0.14	0.77
G 57 x NAC 6002	13.07	19.98	13.69	0.47	2.51	10.56	24.31	-	-	-
G 57 x Parbhat	13.81	24.38	12.24	0.25	1.75	11.61	20.33	7.32	0.13	0.64
Karveer x NAC 6002	13.28	21.07	13.11	0.39	2.23	11.00	30.98	18.09	0.34	2.40
Karveer x Parbhat	14.59	20.12	-	-	-	11.69	25.75	15.31	0.35	2.18
NAC 6002 x Parbhat	14.16	15.40	-	-	-	10.81	25.37	8.51	0.11	0.64

- Non-estimable due to high parental variances

Table 36g. Genetic components of variation for Cob girth (cm) under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h^2 (bs)	GA	Mean	PCV	GCV	h^2 (bs)	GA
G 57 x CI 4	12.90	12.39	3.10	0.06	0.21	11.54	14.40	9.53	0.45	1.54
G 57 x CML 446	13.50	12.51	4.52	0.13	0.46	10.82	16.95	12.02	0.50	1.89
G 57 x Hyd Sel 17	12.84	9.88	-	-	-	10.75	16.13	9.30	0.33	1.16
Karveer x CI 4	12.49	10.87	-	-	-	11.70	13.42	8.20	0.37	1.20
Karveer x CML 446	13.37	10.92	-	-	--	10.62	14.70	7.91	0.29	0.94
Karveer x Hyd Sel 17	12.73	10.71	-	-	-	11.01	15.03	7.45	0.25	0.84
Parbhat x CI 4	13.13	12.54	3.12	0.06	0.21	11.41	17.08	13.23	0.60	2.40
Parbhat x CML 446	13.22	12.55	2.50	0.04	0.14	11.21	12.99	5.80	0.20	0.60
Parbhat x Hyd Sel 17	13.27	14.88	10.70	0.51	2.09	12.03	16.40	11.30	0.48	1.94
NAC 6002 x CI 4	12.77	8.54	-	-	-	11.25	14.89	-	-	-
NAC 6002 x CML 446	13.62	15.35	11.53	0.56	2.41	11.00	16.01	3.18	0.04	0.14
NAC 6002 x Hyd Sel 17	12.85	17.45	15.26	0.77	3.54	10.48	12.50	-	-	-
All-Rounder x CI 4	13.46	8.75	-	-	-	11.62	11.66	2.15	0.14	0.40
All-Rounder x CML 446	13.34	9.68	-	-	-	11.40	11.80	2.46	0.04	0.12
All-Rounder x Hyd Sel 17	13.54	11.96	8.57	0.51	1.71	11.46	11.33	-	-	-
NK 6240 x CI 4	13.86	10.28	-	-	-	11.38	15.87	13.10	0.68	2.53
NK 6240 x CML 446	13.80	12.05	-	-	-	11.80	11.37	6.52	0.33	0.92
NK 6240 x Hyd Sel 17	13.73	10.54	1.02	0.01	0.02	11.72	11.37	4.10	0.13	0.35
Rajkumar x CI 4	12.95	11.64	2.32	0.04	0.13	11.07	16.16	11.20	0.48	1.78
Rajkumar x CML 446	13.46	11.34	1.63	0.02	0.07	11.59	20.18	16.47	0.67	3.21
Rajkumar x Hyd Sel 17	13.52	8.94	-	-	-	11.60	11.20	-	-	-
G 57 x Karveer	13.00	12.21	3.46	0.08	0.26	10.91	9.95	-	-	-
G 57 x NAC 6002	13.51	11.92	7.03	0.35	1.17	11.61	16.34	8.18	0.25	0.98
G 57 x Parbhat	12.69	11.78	-	-	-	11.68	9.62	-	--	-
Karveer x NAC 6002	13.57	9.45	-	-	-	11.23	17.49	9.44	0.29	1.17
Karveer x Parbhat	13.40	8.54	-	-	-	11.32	13.61	8.30	0.37	1.18
NAC 6002 x Parbhat	13.43	9.21	-	-	-	10.75	13.93	-	-	-

- Non-estimable due to high parental variances

Table 36h. Genetic components of variation for kernel rows per cob under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h ² (bs)	GA	Mean	PCV	GCV	h ² (bs)	GA
G 57 x CI 4	13.17	13.79	-	-	-	12.34	16.23	5.11	0.10	0.41
G 57 x CML 446	14.10	14.99	8.93	0.36	1.56	13.60	16.28	9.93	0.37	1.69
G 57 x Hyd Sel 17	13.32	13.70	5.33	0.15	0.57	13.57	14.13	125.32	0.01	0.04
Karveer x CI 4	12.88	13.18	-	-	-	14.07	17.30	14.00	0.65	3.27
Karveer x CML 446	13.39	14.50	-	-	-	12.58	15.80	12.48	0.62	2.55
Karveer x Hyd Sel 17	13.16	10.50	-	-	-	12.82	16.07	11.55	0.51	2.18
Parbhat x CI 4	13.46	16.62	5.87	0.12	0.57	13.24	18.99	14.80	0.61	3.15
Parbhat x CML 446	13.89	17.62	11.59	0.43	2.19	14.19	13.26	8.95	0.46	1.77
Parbhat x Hyd Sel 17	13.44	13.54	-	-	-	13.91	19.41	15.81	0.66	3.67
NAC 6002 x CI 4	13.82	16.47	10.93	0.44	2.08	13.14	12.59	-	-	-
NAC 6002 x CML 446	13.41	13.86	9.25	0.45	1.72	13.61	14.41	8.74	0.37	1.51
NAC 6002 x Hyd Sel 17	13.35	16.07	12.44	0.60	2.64	13.47	12.32	-	-	-
All-Rounder x CI 4	14.45	11.52	-	-	-	13.36	18.22	14.22	0.61	3.06
All-Rounder x CML 446	14.44	16.02	12.74	0.63	3.00	14.10	15.16	11.92	0.62	2.73
All-Rounder x Hyd Sel 17	14.08	14.20	10.23	0.52	2.13	13.46	11.52	2.23	0.04	0.13
NK 6240 x CI 4	14.19	14.43	7.40	0.26	1.11	13.11	17.19	13.81	0.64	2.99
NK 6240 x CML 446	14.55	13.38	8.94	0.45	1.79	14.47	13.50	11.06	0.67	2.70
NK 6240 x Hyd Sel 17	14.10	16.10	12.48	0.60	2.82	14.22	14.30	10.69	0.56	2.34
Rajkumar x CI 4	13.36	15.90	8.09	0.26	1.13	12.57	22.42	14.32	0.41	2.37
Rajkumar x CML 446	14.06	14.54	9.60	0.44	1.84	12.98	20.57	13.33	0.42	2.31
Rajkumar x Hyd Sel 17	13.67	13.06	6.88	0.28	1.02	13.37	14.37	-	-	-
G 57 x Karveer	13.65	14.15	-	-	-	13.13	12.14	-	-	-
G 57 x NAC 6002	14.15	18.87	14.70	0.61	3.35	13.28	18.36	9.26	0.25	1.28
G 57 x Parbhat	13.60	17.00	7.58	0.20	0.96	13.22	13.66	-	-	-
Karveer x NAC 6002	13.69	11.18	-	-	-	12.64	17.28	10.99	0.40	1.82
Karveer x Parbhat	13.63	16.23	4.55	0.08	0.37	13.23	13.93	7.71	0.31	1.16
NAC 6002 x Parbhat	14.92	14.92	8.64	0.33	1.53	12.74	16.34	8.09	0.24	1.25

- Non-estimable due to high parental variances

Table 36i. Genetic components of variation for number of kernels per row under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h ² (bs)	GA	Mean	PCV	GCV	h ² (bs)	GA
G 57 x CI 4	26.72	24.85	-	-	-	19.02	39.91	20.77	0.27	4.23
G 57 x CML 446	30.90	24.84	14.05	0.32	5.05	22.21	36.26	-	-	-
G 57 x Hyd Sel 17	28.67	26.97	13.92	0.27	4.25	21.91	34.55	7.80	0.05	0.79
Karveer x CI 4	25.71	27.30	10.89	0.16	2.30	22.07	31.29	20.07	0.41	5.85
Karveer x CML 446	27.50	23.72	17.85	0.57	7.62	18.28	35.51	-	-	-
Karveer x Hyd Sel 17	26.84	22.35	13.82	0.38	4.74	20.14	36.33	17.93	0.24	3.68
Parbhat x CI 4	27.13	34.98	21.05	0.36	7.07	23.89	36.65	28.51	0.61	10.92
Parbhat x CML 446	25.96	34.54	26.08	0.57	10.55	17.77	36.16	-	-	-
Parbhat x Hyd Sel 17	27.46	31.25	21.67	0.48	8.50	23.72	29.19	9.74	0.11	1.58
NAC 6002 x CI 4	25.61	24.06	-	-	-	22.06	33.64	22.89	0.46	7.09
NAC 6002 x CML 446	28.96	25.48	16.33	0.41	6.26	21.10	30.62	-	-	-
NAC 6002 x Hyd Sel 17	24.53	27.87	13.54	0.24	3.31	19.02	38.33	17.61	0.21	3.17
All-Rounder x CI 4	31.41	22.00	-	-	-	23.11	38.74	33.49	0.75	13.80
All-Rounder x CML 446	29.18	30.16	23.85	0.63	11.35	21.82	39.50	25.61	0.42	7.48
All-Rounder x Hyd Sel 17	30.64	23.77	14.72	0.38	5.77	22.80	28.60	13.82	0.23	3.13
NK 6240 x CI 4	29.44	17.40	-	-	-	23.30	33.75	28.97	0.74	11.94
NK 6240 x CML 446	28.45	29.36	24.25	0.68	11.75	20.96	24.62	-	-	-
NK 6240 x Hyd Sel 17	28.44	26.69	19.80	0.55	8.62	23.82	23.10	5.37	0.05	0.61
Rajkumar x CI 4	29.36	30.13	12.20	0.16	2.99	21.15	37.34	22.93	0.38	6.14
Rajkumar x CML 446	27.90	26.19	11.86	0.21	3.09	21.94	38.88	15.18	0.15	2.69
Rajkumar x Hyd Sel 17	29.02	21.25	-	-	-	24.65	27.66	-	-	-
G 57 x Karveer	26.98	26.30	8.78	0.11	1.63	20.04	26.36	-	-	-
G 57 x NAC 6002	26.30	23.51	-	-	-	22.24	28.99	-	-	-
G 57 x Parbhat	29.42	27.20	6.12	0.05	0.83	22.43	30.56	-	-	-
Karveer x NAC 6002	28.00	25.69	13.86	0.29	4.31	19.95	41.99	29.57	0.50	8.57
Karveer x Parbhat	28.59	25.99	13.99	0.29	4.45	21.06	30.37	10.49	0.12	1.57
NAC 6002 x Parbhat	29.49	26.51	9.83	0.14	2.22	19.82	31.91	7.97	0.06	0.81

- Non-estimable due to high parental variances

Table 36j. Genetic components of variation for yield per plant (g) under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h ² (bs)	GA	Mean	PCV	GCV	h ² (bs)	GA
G 57 x CI 4	91.43	31.47	-	-	-	48.02	51.65	28.34	0.30	15.39
G 57 x CML 446	110.49	41.54	31.73	0.58	55.16	50.34	61.69	35.24	0.33	20.86
G 57 x Hyd Sel 17	95.58	40.40	28.01	0.48	38.25	47.18	46.90	-	-	-
Karveer x CI 4	83.57	36.78	-	-	-	55.05	44.10	29.57	0.45	22.49
Karveer x CML 446	99.22	38.25	25.00	0.43	33.39	39.41	54.74			
Karveer x Hyd Sel 17	94.91	36.96	22.57	0.37	26.94	43.27	60.15	28.85	0.23	12.33
Parbhat x CI 4	93.64	44.94	20.63	0.21	18.26	51.94	62.25	50.65	0.66	44.09
Parbhat x CML 446	82.25	53.40	38.25	0.51	46.41	37.88	53.18	-	-	-
Parbhat x Hyd Sel 17	96.46	44.34	31.83	0.52	45.40	48.55	45.38	-	-	-
NAC 6002 x CI 4	84.89	32.08	-	-	-	53.74	53.50	44.08	0.68	40.21
NAC 6002 x CML 446	91.03	40.98	34.63	0.71	54.88	43.46	53.38	16.57	0.10	4.60
NAC 6002 x Hyd Sel 17	84.28	45.34	39.64	0.76	60.16	39.40	49.57	-	-	-
All-Rounder x CI 4	105.27	35.31	-	-	-	59.09	53.03	45.86	0.75	48.38
All-Rounder x CML 446	101.48	43.26	31.10	0.52	46.73	46.23	52.79	24.55	0.22	10.86
All-Rounder x Hyd Sel 17	118.94	35.76	25.65	0.51	45.10	57.68	48.48	31.93	0.43	24.99
NK 6240 x CI 4	114.60	33.88	3.89	0.01	1.05	55.81	44.03	37.06	0.71	35.86
NK 6240 x CML 446	105.87	41.29	28.04	0.46	41.55	48.20	34.99	-	-	-
NK 6240 x Hyd Sel 17	109.12	39.53	27.25	0.48	42.21	59.00	41.68	25.80	0.38	19.41
Rajkumar x CI 4	103.08	45.29	17.33	0.15	14.08	49.11	53.45	20.83	0.15	8.22
Rajkumar x CML 446	96.46	45.35	23.44	0.27	24.07	51.19	54.21	-	-	-
Rajkumar x Hyd Sel 17	108.24	36.48	13.41	0.14	10.99	61.82	45.55	5.55	0.01	0.86
G 57 x Karveer	93.01	39.22	7.34	0.04	2.64	39.98	42.10	-	-	-
G 57 x NAC 6002	95.74	47.50	36.35	0.59	54.86	54.50	45.28	25.73	0.32	16.41
G 57 x Parbhat	89.13	48.75	24.81	0.26	23.18	46.24	38.90	-	-	-
Karveer x NAC 6002	99.20	34.53	19.35	0.31	22.18	49.46	55.82	43.15	0.60	33.99
Karveer x Parbhat	102.13	37.33	10.12	0.07	5.78	46.17	47.18	19.32	0.17	7.52
NAC 6002 x Parbhat	98.58	33.81	14.05	0.17	11.86	44.61	48.10	25.02	0.27	11.96

- Non-estimable due to high parental variances

Table 36k. Genetic components of variation for 100-grain weight under stress and nonstress situations

Crosses	Nonstress					Stress				
	Mean	PCV	GCV	h^2 (bs)	GA	Mean	PCV	GCV	h^2 (bs)	GA
G 57 x CI 4	28.30	21.23	10.71	0.26	3.16	22.04	26.33	20.01	0.58	6.89
G 57 x CML 446	26.38	22.88	10.65	0.22	2.70	17.57	26.54	14.35	0.29	2.81
G 57 x Hyd Sel 17	26.64	17.37	7.13	0.17	1.60	19.16	25.74	16.75	0.42	4.30
Karveer x CI 4	26.27	20.20	-	-	-	17.95	20.13	-	-	-
Karveer x CML 446	27.40	17.95	--	-	-	19.03	22.98	8.93	0.15	1.35
Karveer x Hyd Sel 17	28.21	16.64	-	-	-	18.03	26.48	15.58	0.35	3.41
Parbhat x CI 4	26.77	15.44	-	-	-	18.47	32.57	25.61	0.62	7.66
Parbhat x CML 446	24.43	20.77	-	-	-	15.59	19.15	-	-	-
Parbhat x Hyd Sel 17	27.68	16.57	6.83	0.17	1.61	16.64	22.53	4.15	0.03	0.26
NAC 6002 x CI 4	27.43	20.32	10.46	0.27	3.05	19.10	21.08	-	-	-
NAC 6002 x CML 446	25.84	18.76	0.00	-0.04	-0.39	15.98	24.74	-	-	-
NAC 6002 x Hyd Sel 17	28.09	17.35	11.25	0.42	4.23	18.14	22.27	-	-	-
All-Rounder x CI 4	24.32	16.46	-	-	-	20.68	24.18	17.21	0.51	5.23
All-Rounder x CML 446	25.27	18.18	-	-	-	17.43	21.43	4.25	0.04	0.30
All-Rounder x Hyd Sel 17	27.45	16.19	9.36	0.33	3.06	20.73	19.26	9.50	0.24	2.01
NK 6240 x CI 4	29.33	17.52	-	-	-	19.26	27.76	22.22	0.64	7.07
NK 6240 x CML 446	27.50	19.30	-	-	-	18.51	17.86	-	-	-
NK 6240 x Hyd Sel 17	29.55	15.99	4.23	0.07	0.68	19.66	25.85	20.24	0.61	6.43
Rajkumar x CI 4	28.28	15.20	-	-	-	19.63	23.66	13.81	0.34	3.25
Rajkumar x CML 446	27.12	18.48	-	-	-	20.01	21.62	9.20	0.18	1.61
Rajkumar x Hyd Sel 17	28.91	18.63	12.73	0.47	5.20	20.39	19.87	7.65	0.15	1.24
G 57 x Karveer	26.49	20.27	8.19	0.16	1.81	17.05	21.18	7.57	0.13	0.95
G 57 x NAC 6002	27.92	18.23	11.86	0.42	4.44	18.68	24.35	14.34	0.35	3.25
G 57 x Parbhat	23.81	20.08	8.57	0.18	1.80	17.24	20.81	9.74	0.22	1.62
Karveer x NAC 6002	27.57	15.54	-	-	-	18.12	24.98	13.63	0.30	2.77
Karveer x Parbhat	29.14	16.18	0.00	-0.07	-0.69	17.09	19.34	0.00	0.00	0.00
NAC 6002 x Parbhat	25.03	18.24	9.99	0.30	2.83	18.43	24.44	14.54	0.35	3.29

- Non-estimable due to high parental variances

4.5.8 Number of kernel rows per cob

The magnitude of variation for the trait was low as indicated by PCV and GCV. The character recorded moderate to high heritability with low genetic advance under nonstress and stress conditions.

4.5.9 Number of kernels per rows

The magnitude of variability for the trait was low to moderate as indicated by PCV and GCV. Heritability for the trait was moderate to high with low genetic advance under nonstress and stress situation. Again, the heritability of the trait decreased under stress. The crosses viz., Parbhat x CI 4, All-Rounder x CI 4 and NK 6240 x CI 4 recorded high heritability with moderate genetic advance under stress. Similarly All-Rounder x CML 446 and NK 6240 x CML 446 recorded high heritability with moderate genetic advance among the crosses under nonstress.

4.5.10 Grain yield per plant (g)

The magnitude of variation for the trait was high next only to Anthesis to silking interval as indicated by PCV and GCV. The heritability of the trait was also moderate to high with moderate to high genetic advance under nonstress and stress conditions. Under nonstress, G 57 x CML 446, NAC 6002 x CML 446, NAC 6002 x Hyd Sel 17, All-Rounder x CML 446, All-Rounder x Hyd Sel 17 and G 57 x NAC 6002 recorded high heritability with high genetic advance. The crosses viz., Parbhat x CI 4, NAC 6002 x CI 4, All-Rounder x CI 4, NK 6240 x CI 4 and Karveer x NAC 6002 recorded high heritability with high genetic advance.

4.5.11 Hundred grain weight (g)

The variability for the trait ranged from low to moderate as indicated by PCV and GCV of the crosses. The character showed low heritability with low genetic advance under nonstress and stress conditions. The crosses, G 57 x CI 4 and NK 6240 x Hyd Sel 17 recorded high heritability with low genetic advance under stress.

5. DISCUSSION

Maize is an important cereal crop of the world as well as India. Drought is the most pervasive limitation of yield potential in maize (Edmeades *et al.*, 2001). Moisture stress in maize affects both yield and yield stability. Within a given maize field, variation in soil depth and texture induce moisture stress across the field allowing portion to appear unstressed, while others suffer from severe stress. Kitchen *et al.* (1999) reported variation in yield within the same plot from 3.4 (in compacted / sandy soils) to 11.3 tonnes/ha (in deep black soils / runoff impounded patch). Since a farmer grows a single variety/ hybrid, the variety/hybrid needs to withstand a wide range of water stress without sacrificing the yield in the better areas of the field.

Besides this, the effect of climate change is looming large on agricultural production in India, as nearly 65% of the total cultivable area depends on rain. The *El Nino* effects disturb the distribution patterns of rainfall; some areas may receive scanty rainfall and concentrated rainfall in other, causing water logging coupled with heavy nutrient loss in light soils.

About 58 per cent of the maize area in Karnataka is dependent on rains and drought appears once in 5-6 years. During drought years, maize under rainfed situation is likely to suffer heavily. Therefore, breeding maize for drought tolerance is important to close the gap between rainfed and well watered yields as genetic solutions can be more easily packed, promoted and adopted than agronomic and other input dependent practices.

With this view in mind, screening of available germplasm at All India Coordinated Maize Improvement Project (AICMIP), Agricultural Research Station (ARS), Arabhavi and limited germplasm received from Senior Maize Breeder, AICMIP, ARS, Nagenahalli along with leading commercial hybrids available in the market was initiated during *rabi* / summer of 2007-08, under stress and nonstress situations. From that study, 12 inbred lines varying for drought tolerance, four drought tolerant commercial hybrids and four drought tolerant populations / composites were identified. During the following *kharif* season (2008), 66 single cross hybrids by utilizing 12 inbred lines in half diallel fashion, six population crosses, 24 top crosses / three way crosses (in L x T fashion) were produced and they were evaluated during *rabi*/summer seasons of 2008-09 and 2009-10 to meet the set objectives of the investigation. The parents and hybrids of half diallel were evaluated under stress and nonstress during 2008-09 and 2009-10. The pooled data of 2008-09 and 2009-10 was used for analysis separately for nonstress and stress. Similarly, the top cross /three way/ population crosses derived from various drought tolerant sources were evaluated in *rabi*/summer 2008-09 and 2009-10 under stress and nonstress along with parents and checks. During 2009-10, out of 30 different top / three ways crosses generated from different drought tolerant sources, in 27 crosses individual plant observations were recorded to study the genetic components of variance for drought tolerance. The results obtained during the investigation are discussed under the following headings.

5.1 Screening of inbred lines, commercial hybrids and populations/ composites under stress and nonstress situations

Plant breeders have debated the question of optimum environment (the environment that improves efficiency and effectiveness of the breeding programme) for selection for yield. Three strategies have been considered (Byrne *et al.*, 1995). Given that the optimum environment for selection is one, which maximizes the genetic variation and hence, the response to selection in the target environment. The first strategy is based on the assumption that when the growing conditions are optimum, high yielding cultivars selected under optimal growing conditions will perform well under all conditions. The second strategy assumes that the optimum environment for selection should be as representative as possible of the target environments. In the third strategy involves the use of both optimum and stressed conditions for selecting the genotypes that yield well in both the situations.



Plate 1: Field view of the experiment during 2008-09

In an attempt to verify the role of different morphological, yield and yield related traits under stress, 82 inbred lines, 10 commercial hybrids and seven composites / populations evaluated under stress and nonstress environments in accordance with the principles of third strategy.

5.1.1 Morphological and yield and yield related traits

The extent of variability for various quantitative traits available to the breeder determines the success that can be achieved in genetic improvement of that species. The analysis of variance revealed that variation due to moisture stress was significant for all the traits (Table 2). The genotypes differed significantly for all the traits. Availability of significant variability for morphological, yield and yield related traits in the genotypes would facilitate screening of the genotypes to moisture stress tolerance and to assess the character contribution towards stress tolerance.

The effect of moisture stress on morphological traits was drastic and it significantly reduced the expression of many traits but significantly increased days to anthesis, silking and ASI (Table 3).

Severe drought stress in early growing stage affects the length of internodes (Jurgens *et al.*, 1978). Reduction of plant height under drought stress was reported in several studies (Pandey *et al.*, 1987; Fischer *et al.*, 1989; Gu *et al.*, 1989; Hemalatha Devi, 1989; Abellandsa and Cauny, 1991; Babu, 1992 and Subba Rao, 1992 and Desai, 1997).

Reduction in ear height was also reported in maize when subjected to drought (Hemalatha Devi, 1989; Abellandsa and Cauny, 1991; Subba Rao, 1992; Babu, 1992; Tej Pal, 1992 and Desai, 1997).

Drought stress during grain filling period primarily affects kernel weight due to decrease in leaf carbon exchange rates (Jurgens *et al.*, 1978). The reduced yield under water stress could be due to reduced grain number, kernel weight and cob length (Hall *et al.*, 1981; Coasta *et al.*, 1988; Subba Rao, 1992 and Vinodkumar, 1996).

Floral development and flowering stages are very sensitive to moisture stress. Stress period of drought / water shortages cause delay in anthesis, silking and anthesis to silking interval in maize (Grant *et al.*, 1989, Fredrick *et al.*, 1989; Fischer *et al.*, 1989; Skylar and Gontarovskii, 1990; Fussel *et al.*, 1991; Babu, 1992; Nesmith and Ritchie, 1992; Subba Rao, 1992; Tej Pal, 1992; Bolanos and Edmeades, 1993; Ribaut *et al.*, 1996).

Drought resistance is a complex trait, expression of which depends on action and interaction of different morpho-physiological and bio-chemical reactions. The morphological traits that contribute to the drought tolerance in maize have been identified. They include shorter ASI and cobs per plant (Bolanos and Edmeades, 1996; Banziger and Lafitte, 1997).

Drought at flowering causes severe barrenness and destabilizes the grain yield. Ability of a genotype to produce an ear under such adverse conditions is an important characteristic of drought tolerance in maize. Ears per plant showed high heritability and strong relationship with grain yield and hence it has been used as a trait in selection for water limited environment. It received high importance, next to grain yield, in terms of weight in selection index (Banziger *et al.*, 2000b).

Anthesis to silking interval is another important trait. In maize, ASI is a symptom of ear growth rate and that differences in ASI among genotypes growing in the same environment reflect differences in the partitioning efficiency to the ear. Under drought, ASI showed comparatively high variance and high broad sense heritability.

Apart from these, leaf senescence, leaf rolling and tassel size can also be used as traits for selecting drought tolerant genotypes. Many other traits for tolerance were evaluated at CIMMYT and other institutions but have been discouraged to be used in selection as they have low heritability or poor correlation with grain yield under stress (Zaidi *et al.*, 2007).

For cobs per plant, Hyd Sel 9, KDMI 20 and Hyd Sel 4 (among inbred lines); NAC 6002 (among populations) and NK 6240 (among hybrids) recorded the highest cobs per plant. Whereas, CM 133, Hyd Sel 9, CML 426, Hyd Sel 4, Hyd Sel1, KDMI 16 and CI 4 (among inbred lines), Yellow pool and Parbhat (among populations) and NK6240 and All-Rounder (among hybrids) showed lower ASI under stress.

CI 4 and Hyd Sel 4 among inbreds, Karveer among populations and NK6240 and 900M among hybrids recorded higher yield under both the situations. However, KDMI 16, KDMI 17, KDMI 19, KDMI 10, Hyd Sel 2 and Hyd Sel 10 among inbred lines recorded higher yield under nonstress. The results suggest that it is possible to classify inbred lines (which are hitherto not classified and bred under optimal environment conditions) for their adaptation to stress and from among the given accessions it may be possible to identify inbred lines that yield under both stress and nonstress situations within a short period of time.

For drought susceptibility index, CI 4, an inbred and G 57, a composite recorded lowest DSI values for all the traits (Table 5). Whereas, among hybrids, Rajkumar recorded lower DSI value for all the traits except yield (kg/ha).

Twelve inbred lines were selected based on grain yield per plant, yield (kg/ha), cobs per plant, ASI and DSI.

5.1.2 Stability of inbred lines

Duvick (1997) proposed that the major goal of tropical maize improvement programme should be to improve and stabilize yield and broaden adaptation through increased tolerance to abiotic stresses.

In the present study, 12 inbred lines, which were evaluated along with other germplasm during post rainy seasons(*rabi* / summer) of 2007, 2008 and 2009 were selected for stability analysis under drought for grain yield (kg/ha). The stability analysis revealed that CI 4 as the most stable inbred line for grain yield under stress among the 12 inbred lines by recording mean value above the population mean, regression value of 1.01 and non significant S^2 Di value (Table 9).

5.2 Genetic analysis of morpho-physiological, yield and its components under nonstress and stress environments

Success of any breeding programme depends on the knowledge and understanding of the inheritance of the characters of interest. But the main drawback in breeding for drought tolerance is that, it is a very complex character. Drought resistance as such, is not a simple character governed by one or two genes apparently determined by a number of morpho-physiological characters being independently controlled by more than one or two genes (Fukai and Cooper 1995). Under moisture stress conditions it is more realistic to carryout

selection process, on the basis of those putative characters, which serve as effective tools for screening for drought tolerance. However, confirmatory evidences are still lacking on characters of drought tolerance either at vegetative and / or reproductive phases and that are governed by the same set of genes (Morgan, 1984).

An investigation was carried out to understand the genetics and inheritance of characters associated with drought resistance at grain filling stage in maize. Sixty six hybrids obtained by crossing 12 inbred lines in diallel fashion (excluding reciprocals) were evaluated along with parents and checks under stress and nonstress during *rabi* / summer 2008-09 and 2009-10. The pooled data was subjected to diallel analysis (separately for stress and nonstress) as proposed by Griffing (1956) model-1 and method-2 extended by Singh (1973). The results of the study are discussed here under.

5.2.1 Variability studies

The extent of variability for morpho-physiological, yield and yield related traits available to breeder determines the success that can be achieved in the genetic improvement of that species. The analysis of variance revealed highly significant variation for most of the traits in both the situations indicating considerable variation among parents and hybrids (Table 10). Parents vs hybrid comparison was significant for all the traits except ASI, days to maturity, DSI and RWC1 (under stress) and ASI number of kernel rows per cob, cobs per plant 100 grain weight RWC1 RWC2, CHL1 and CHL2 (under nonstress) in both the situations.

5.2.2 Combining ability

Modern concepts of breeding aim at genetic reconstruction with respect to number of vital components. The information on combining ability and gene action for different agronomic characters is very important to decide upon choice of parents for hybridization and to achieve superior genotype from the segregating population or exploitation of heterosis. The combining ability analysis also provides such information as to frame the breeding programme effectively. Hence, it is desirable to generate information on combining ability of popularly used inbred lines. In the present study, an attempt was made to estimate the combining ability, variances and effects for drought related traits under stress and nonstress separately.

The ANOVA for combining ability (Table 21) revealed that variances due to GCA and SCA were significant for most of the traits in both situations indicating both additive and nonadditive gene action in controlling the traits. For days to maturity, variance due to GCA alone was significant under stress and nonstress environments indicating the importance of additive gene action in controlling the trait.

The magnitude of GCA variance was greater than SCA variance for all the traits under both the situations (except RWC1 and CHL2 under stress) indicating the predominance of additive variance in controlling the expression of these traits. Higher magnitude of GCA than SCA for days to 50 per cent silking, plant height, ear height was reported by Dhillon and Singh (1976), Muchena (1978). Bhalla and Khera (1977) reported the importance of both GCA and SCA for grain yield, 500 grain weight, cob length and cob girth. Alika (1994) reported significant GCA estimates for ear length, ear diameter, ear weight per plant and 100 grain weight. Significant GCA and SCA estimates were also reported by Desai (1997) for all the traits.

Betran *et al.* (2003b) reported that under drought, additive effects were more important and the importance of additive effects increased with intensity of drought suggesting the need for drought tolerance in both parental lines to achieve acceptable hybrid performance under severe drought.

Marker and Joshi (2005) reported that additive genetic variance was more important than dominance variance for all the traits in two N levels under rainfed situations.

Fu *et al.* (2008) reported that the variances of specific combining ability (SCA) were about double that of the general combining ability (GCA) for plant height, ASI and grain yield per plant, although they were about equal for leaf emergence rate and root weight.

5.2.3 General combining ability effects

General combining ability of parents is reckoned as a factor in predicting the performance of cross combinations. It has not been fully established that there exists a relationship between GCA of parents and the performance of hybrids and segregants from the cross. It is still a debatable subject among breeders. However, a majority of the published literature lends support to the view that the gca can be related with the performance of the progeny of the cross predicted on the basis of combining ability effects. Generally, parents with high mean values are preferred in hybridization programme as they are predicted to produce desirable segregants. Gilbert (1958) suggested that parents with good mean performance would result in better genotypes. But this need not be the case all the times, in such situation, the combining ability effects will have to be considered.

The results obtained on these aspects are presented in Table 22 and summarized in Table 37. To evaluate the overall gca status of parents and sca status of hybrids, the procedure suggested by Arunachalam and Bandyopadhyay (1979) was followed.

The gca effects of parents in stress and nonstress environments exhibited variation both in direction and magnitude. The diallel analysis revealed that different parents were general combiners for different traits (Table 22).

The traits that showed good heritability and genetic advance under stress in the study were grouped into morphological (plant height and anthesis to silking interval), yield and yield related (included number of kernels per row, cobs per plant, 100- grain weight, yield per plant and grain yield, kg/ha) and physiological traits (relative water content and chlorophyll content at 60 and 90 days) and DSI.

Combining ability status of the genotypes would give an indication as to how well they combine with a given genotype to produce potential productive populations. Hence, combining ability of the parents plays an important role in choosing the parents for crop improvement. CI 4 and Hyd Sel 15 recorded good general combining ability status under both nonstress and stress situations for all the group of traits. Hence, these inbred lines could be utilized for developing drought tolerant hybrids by extensively testing their specific combining ability with a set proven inbred lines under both the situations.

5.2.4 Specific combining ability

Genetic worth of the parents is decided on the basis of combining ability. Hayman and Mather (1955) suggested that gca was the result of simple additive gene effects and sca was associated with dominance and nonallelic interactions. They observed that gca and sca referred to the properties of the individuals rather than properties of the genes for a particular cross combinations. The sca value of any cross combination is helpful in predicting the performance of the hybrids far better than the gca of parents (Peng and Virmani, 1990).

Like gca effects, sca effects of hybrids in stress and nonstress exhibited variation both in direction and magnitude. Different parents combined well for different traits under nonstress and stress situations. The sca effects of hybrids are presented in Table 23 and summarised in Table 38.

In any breeding programme, grain yield is the ultimate goal. Occurrence and intensity of drought can not be predicted in advance. Hence, genotypes selected or developed should be able to withstand drought and give fairly good yield under drought, but at the same time they should also be able to utilize the resources better under stress free situations and give much better yields under stress free environment. This is very true because moisture stress / drought may occur in one year and may not occur next year; under such situations, there should not be any yield penalty to the growers of drought tolerant hybrids/ genotypes. With this view in mind, the discussion on sca status, heterosis and yield under both the situations is presented below.

From the Table 38, it is evident that CM 111 x NEI 9202B, CML 446 x NEI 9202B and Hyd Sel 4 x NEI 9202B showed high sca status under both the situations for all the traits. The hybrids viz., CM 111 x NEI 9202B and Hyd Sel 4 x NEI 9202B also exhibited highly significant positive heterosis over mid parent under both the environments. While, CML 446 x NEI 9202B recorded only significant positive heterosis under nonstress situation.

Table 37. General combining ability (gca) status of parents of diallel single cross hybrids for morpho-physiological, yield and yield related traits under stress and nonstress situations in maize

Parents	gca status of morphological traits		gca status of yield and yield related traits		gca status of physiological traits		Drought susceptibility index
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	
CM 111	L	L	L	H	L	H	H
HS 2	L	L	L	H	H	L	H
HS 7	L	L	L	L	L	L	L
HS 10	H	L	L	L	L	L	L
KDMI 15	H	H	L	H	H	L	H
NEI 9208 B	H	H	H	H	L	L	H
CI 4	H	H	H	H	H	H	H
CML 446	H	H	H	L	L	L	L
HS 4	H	L	L	H	H	L	H
HS 15	H	H	H	H	H	H	H
HS 17	H	L	L	H	L	L	H
NEI 9202B	H	H	H	L	L	L	L

HS= Hyd sel; H= High; L= Low

Hyd Sel 7 x Hyd Sel 17 and Hyd Sel 15 x NEI 9202B recorded high sca status under both the situations for all the traits except yield and yield related traits under nonstress. But only Hyd Sel 15 x NEI 9202B translated sca status into yield by recording significant positive heterosis over mid-parent under both the situations.

NEI 9208B x Hyd Sel 15 exhibited high sca status for all the traits except physiological traits (under nonstress) under both the situations. This hybrid also translated high sca status of the traits into high yield under both situations by recording significant positive heterosis over mid-parent.

KDMI 15 x NEI 9202B also revealed high status of sca for all the traits except physiological traits under both the situations. This was the most promising hybrid among 66 hybrids tested for both the situations. It also recorded significant positive heterosis over mid-parent under both the situations for grain yield.

The mean performance of top five single cross hybrids of maize under stress and nonstress situations tested over two years with their parents gca and sca status is given in Table 39.

Both the parents in three of the top five hybrids viz., KDMI 15 x NEI 9202B, NEI 9208B x Hyd Sel 15 and CI 4 x CML 446 had high gca status for morphological traits under both the situations. Whereas, Hyd Sel 4 x NEI 9202B and CM 111 x NEI 9202B had the parents with H x L under stress for morphological traits. All the five hybrids except NEI 9208B x Hyd Sel 15 had one parent with high gca and the other with low gca for yield and yield related traits under stress. Under nonstress also, majority of the hybrids (three) had their parents with same status (L x H) for yield and yield related traits. For physiological traits, all hybrids except KDMI 15 x NEI 9202B had one parent with high gca and the other with low gca under stress. Under nonstress also same trend was observed in majority (four) of the hybrids.

The crosses with high and low gca combinations were reported earlier in rice by Peng and Virmani (1990), Ramalingam *et al.* (1993), Yolanda and Vijendra Das (1996) and Sharma and Mani (1998). Similarly, in cotton by Patel *et al.* (1997); in wheat by Rajara and Maheshwari (1996) and in sorghum by Patil (2001) indicating the presence of additive x additive and / or additive x dominance genetic interactions in the crosses.

Heterosis in high x high combinations would involve interaction between positive x positive alleles (Singh *et al.*, 1971). However, Sarsara *et al.* (1986) reported that crosses involving high x high, high x low, high x average and low x average combiners could also produce high sca effects due to involvement of nonallelic interactions of fixable and nonfixable genetic variance for the traits concerned.

Further, it appears that high sca effect of any cross combination does not necessarily depend on gca effects of the parents involved (Sharma and Mani, 1998). This view was vindicated in a cross (CM 111 x NEI 9202B) in which both the parents had low gca under nonstress but the hybrid showed high sca status for the trait in stress and nonstress situations.

5.2.5 Stability of single cross maize hybrids

Maize is essential for global food security. But natural resource base (soil and ground water) is becoming depleted through compaction, erosion, salinization, net nutrient export and diminishing water supply (Cassman, 1999). On the other hand, global climate change is now generally considered to be under way (Hillel and Rosenzweig, 2002) and is expected to result in a long term trend towards higher temperatures, greater evapo-transpiration and an increased incidence of drought in specific regions. These trends coupled with an expansion of cropping into marginal areas are generating increasingly drought-prone maize production environments (Campos *et al.*, 2004). Occurrence of drought is unpredictable. Average annual global losses due to drought range from 15 per cent in temperate zone to 17 per cent in tropical zone (Edmeades *et al.*, 2000b). Further, Kitchen *et al.* (1999) reported large variation within the same fields. Therefore, there is a necessity of evolving hybrids that are able to withstand stress throughout their life cycle at no cost to yield potential under nonstressed conditions.

Table 38. Specific combining ability (sca) status of single cross hybrids for morpho-physiological, yield and yield related traits under stress and nonstress situations in maize

Hybrids	sca status of morphological traits		sca status of yield related traits		sca status of physiological traits		Drought susceptibility index
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	
CM 111 x HS 2	L	L	H	L	H	H	H
CM 111 x HS 7	L	L	L	H	H	H	H
CM 111 x HS 10	H	L	H	L	H	H	H
CM 111 x KDMI 15	L	H	L	H	H	H	H
CM 111 x NEI 9208B	L	L	H	H	H	H	H
CM 111 x CI 4	L	L	H	H	L	H	H
CM 111 x CML 446	L	L	L	L	L	H	H
CM 111 x HS 4	L	L	L	L	L	L	H
CM 111 x HS 15	L	L	H	L	H	H	H
CM 111 x HS 17	L	L	H	H	H	H	H
CM 111 x NEI 9202B	H	H	H	H	H	H	H
HS 2 x HS 7	L	L	H	H	L	H	H
HS 2 x HS 10	L	L	H	H	H	H	H
HS 2 x KDMI 15	L	L	H	H	H	L	H
HS 2 x NEI 9208B	L	L	L	L	H	H	H
HS 2 x CI 4	L	L	L	L	L	H	H
HS 2 x CML 446	L	L	H	L	L	H	H
HS 2 x HS 4	L	L	H	L	L	H	H
HS 2 x HS 15	L	L	L	L	H	L	H
HS 2 x HS 17	L	L	H	L	H	H	H
HS 2 x NEI 9202B	L	H	H	H	H	L	H
HS 7 x HS 10	L	H	L	L	H	L	H

HS= Hyd sel; H= High; L= Low

Contd.....

Table 38 contd....

Hybrids	sca status of morphological traits		sca status of yield related traits		sca status of physiological traits		Drought susceptibility index
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	
HS 7 x KDMI 15	L	L	H	L	H	H	H
HS 7 x NEI 9208B	L	L	L	H	H	H	H
HS 7 x CI 4	L	L	H	H	L	H	H
HS 7 x CML 446	L	L	L	L	H	H	H
HS 7 x HS 4	L	L	H	H	L	L	H
HS 7 x HS 15	L	L	L	L	H	H	H
HS 7 x HS 17	H	H	L	H	H	H	H
HS 7 x NEI 9202B	L	L	H	L	H	H	H
HS 10 x KDMI 15	L	L	L	L	H	H	H
HS 10 x NEI 9208B	L	L	L	L	H	L	H
HS 10 x CI 4	L	L	H	L	L	H	H
HS 10 x CML 446	L	H	L	H	H	H	H
HS 10 x HS 4	L	L	H	H	L	H	H
HS 10 x HS 15	L	L	H	L	H	H	H
HS 10 x HS 17	L	L	L	L	H	L	H
HS 10 x NEI 9202B	H	H	H	L	L	H	H
KDMI 15 x NEI 9208B	L	L	H	L	L	H	H
KDMI 15 x CI 4	L	L	L	L	L	H	H
KDMI 15 x CML 446	L	L	H	H	H	L	H
KDMI 15 x HS 4	L	L	L	L	H	H	H
KDMI 15 x HS 15	L	L	L	H	L	L	H
KDMI 15 x HS 17	L	L	H	L	H	H	H

HS= Hyd sel; H= High; L= Low

Contd.....

Table 38 contd....

Hybrids	sca status of morphological traits		sca status of yield related traits		sca status of physiological traits		Drought susceptibility index
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	
KDMI 15 x NEI 9202B	H	H	H	H	L	L	H
NEI 9208B x CI 4	L	L	H	L	L	H	H
NEI 9208B x CML 446	L	L	H	L	H	H	L
NEI 9208B x HS 4	H	L	H	L	H	L	H
NEI 9208B x HS 15	H	H	H	H	L	H	H
NEI 9208B x HS 17	L	L	H	L	H	H	H
NEI 9208B x NEI 9202B	L	L	L	L	L	H	H
CI 4 x CML 446	L	L	H	L	H	H	H
CI 4 x HS 4	L	L	H	H	H	H	H
CI 4 x HS 15	L	L	H	L	H	H	H
CI 4 x HS 17	L	H	H	L	L	L	H
CI 4 x NEI 9202B	L	L	L	L	H	L	H
CML 446 x HS 4	L	L	L	L	H	H	H
CML 446 x HS 15	L	L	H	L	L	L	H
CML 446 x HS 17	H	L	L	L	L	H	H
CML 446 x NEI 9202B	H	H	H	H	H	H	H
HS 4 x HS 15	L	L	L	L	H	H	H
HS 4 x HS 17	L	L	H	L	H	H	H
HS 4 x NEI 9202B	H	H	H	H	H	H	H
HS 15 x HS 17	L	L	H	H	L	H	H
HS 15 x NEI 9202B	H	H	L	H	H	H	H
HS 17 x NEI 9202B	L	H	H	L	H	H	H

HS= Hyd sel; H= High; L= Low

Table 39. Mean performance, gca status of parents and sca status of top five hybrids selected on the basis of grain yield (kg/ha) over two years under both the situations

Hybrids	Grain yield (kg/ha)		gca status of parents for						sca status of hybrids					
			Morphological traits		Yield and yield related traits		Physiological traits		Morphological traits		Yield and yield related traits		Physiological traits	
	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S
KDMI 15 x NEI 9202B	8859	4041	H x H	H x H	L x H	H x L	H x L	L x L	H	H	H	H	L	L
NEI 9208B x Hyd sel 15	8092	3961	H x H	H x H	H x H	H x H	L x H	L x H	H	H	H	H	L	H
Hyd Sel 4 x NEI 9202B	8826	3741	H x H	L x H	L x H	H x L	H x L	L x L	H	H	H	H	H	H
CI 4 x CML 446	8627	3547	H x H	H x H	H x H	H x L	H x L	H x L	L	L	H	L	H	H
CM 111 x NEI 9202B	8877	3238	L x H	L x H	L x H	H x L	L x L	H x L	L	L	H	H	H	H

NS= nonstress; S= Stress; H=High; L= Low

The use of genetics to improve drought tolerance and provide yield stability is an important part of the solution to stabilizing global maize production. However, agronomic interventions that aim to maximize water availability at key growth stages are also important because it is not possible to close more than 30 per cent of the gap between potential and realized yield under water stress (Edmeades *et al.*, 2004.) But genetic solutions can be more easily packed, promoted and adopted more easily than agronomic and other input dependent practices.

Fortunately, under stressful conditions the performance advantage of modern elite germplasm over its less improved and older counterparts becomes clear. Further much of the observed genetic gain in yield during the past 30 years has been attributed to greater stress tolerance rather than to an increase yield *per se* (Duvick, 1977, 1984, 1992; Briggs 1998; Cassman, 1999; Tollenaar and Lee, 2002; Duvick *et al.*, 2004).

5.2.5.1 Yield stability of hybrids under drought/stress

Twenty three hybrids which performed better under stress or nonstress or both during *rabi*/summer 2008-09 were selected and tested at Agricultural Research Station, Hagari of University of Agricultural Sciences, Raichur during *rabi*/summer 2009-10 under managed drought. For stability analysis, yield (kg/ha) of these 23 hybrids and checks were picked from diallel set of crosses tested under 2008-09 and 2009-10 at College of Agriculture, Bheemarayanagudi.

The stability parameters (Table 25) indicated that three hybrids viz., KDMI 15 x NEI 9202B, Hyd Sel 2 x NEI 9202B and Hyd Sel 7 x NEI 9202B showed high mean value and bi values nearer to unity and non significant S^2Di . Single crosses as stable as double crosses were reported (Machado *et al.*, 2008) indicating prospects for identifying elite hybrids. Whereas, Romay *et al.* (2010) reported that commercial hybrids were high yielding and more stable than populations under stress.

Incidentally, these hybrids also recorded resistant reaction to the most important diseases of maize i.e., turicum leaf blight and common rust.

5.2.5.2 Yield stability of hybrids under nonstress conditions

Out of 66 hybrids produced in diallel fashion, 64 hybrids were evaluated for yield under nonstress conditions at Agricultural Research Station, Arabhavi during *kharif* 2009-10. For stability analysis, the yield (kg/ha) of nonstress experiments of 2008-09 and 2009-10 conducted at College of Agriculture, Bheemarayanagudi and yield obtained at Arabhavi were used. The results of the study are discussed here.

The stability parameters (Table 27) revealed that six hybrids viz CM 111 x CI 4, CM 111 x Hyd Sel 15, Hyd Sel 7 x NEI 9202B, Hyd Sel 10 x NEI 9202B, CI 4 x Hyd Sel 15 and Hyd Sel 15 x NEI 9202B were stable across seasons and locations by recording high mean value, bi values nearer to unity and non significant S^2Di . It is suggested that genetic improvement in maize yield is associated neither with yield potential *per se*, nor with heterosis *per se*. However, it is associated with increased stress tolerance, which is consistent with the improvement in the genotype x management interaction (Tollenaar and Lee, 2002). They further opined that the mechanism by which maize breeders have improved stress tolerance is not known, but they speculated that increased stress tolerance might result from the selection for yield stability. They finally concluded from their study that high yield and stability of hybrids are not mutually exclusive.

Incidentally, among these hybrids, CM 111 x Hyd Sel 15, and CI 4 x Hyd Sel 15 recorded resistant reaction to two important diseases of maize i.e., turicum leaf blight and common rust (Table 40). Whereas, Hyd Sel 15 x NEI 9202B recorded highly resistant reaction to the above diseases. Hyd Sel 7 x NEI 9202B accorded moderately resistant reaction to both the diseases. While Hyd Sel 10 x NEI 9202B indicated moderately resistant reaction to turicum leaf blight and resistant reaction to common rust. Thus, these hybrids are not only high yielding under drought but also stable and resistant to diseases.

5.3 Line x Tester analysis involving non conventional hybrids

Development of superior heterotic populations which can be used for development of hybrids will remain an important thrust of maize research (Patil *et al.*, 2000).

An investigation was carried out to understand the pattern of heterosis and to identify heterotic groups by evaluating three way crosses and double top crosses under stress and nonstress situations. Four drought tolerant (DT) commercial hybrids and four DT populations or composites were crossed with DT inbred lines in L x T fashion. The resulting 24 hybrids evaluated under stress and nonstress situations. The results obtained from the study are discussed here under.

5.3.1 Variability studies

The extent of variability for various traits available to the breeder determines success that can be achieved in the genetic improvement of that species. The analysis of variance revealed that significant differences among hybrids for many traits under stress and nonstress situations (Table 28). Further, lines also recorded significant differences for most of the traits in nonstress situations except plant height, ear height, days to maturity, number of kernels per row, cobs per plant, shelling percentage and yield (kg/ha), relative water content at the both the stages and chlorophyll content at 60 days. Under stress, lines showed significant differences only for anthesis to silking interval, test weight and yield per plant.

5.3.2 gca status of parents and sca status of hybrids

Combining ability analysis helps in identifying the parents for hybridization and exploitation of heterosis in maize. Further, the information on combining ability of inbred lines along with their *per se* performance is of immense value to the breeder in deciding the method of breeding to be employed for genetic improvement of the crop.

The results obtained on these aspects are presented in Table 30 and 31 and summarized in Table 41 and 42, respectively. The overall gca status of parents and sca status of hybrids was determined as per the procedure suggested by Arunachalam and Bandopadhyay (1979).

The gca effects of parents in stress and nonstress environments exhibited variation both in direction and magnitude. The Line x Tester analysis revealed that the parents of three way / top crosses were general combiners for different traits (Table 30).

The traits that showed good heritability and genetic advance under stress in the study were grouped into morphological (plant height and anthesis to silking interval), yield and yield related (number of kernels per row, cobs per plant, 100- grain weight, yield per plant and grain yield, kg/ha) and physiological traits (relative water content and chlorophyll content at 60 and 90 days) and DSI.

Combining ability status of parents revealed that All-Rounder, NK 6240 and Rajkumar showed high gca status for all the group of traits both under stress and nonstress situations (Table 41) among lines. Among the testers, CI 4 recorded high gca status for all the group of traits except morphological (under stress) traits in both the situations. Whereas, Hyd Sel 17 showed high gca status for yield and yield related traits under both the situations. Hence, these genotypes could be utilized for the development of drought tolerance in maize by recurrent selection method. Like gca effects, sca effects of hybrids in stress and nonstress exhibited variation both in direction and magnitude. Different parents combined well for different traits under nonstress and stress situations. The sca effects of hybrids are presented in Table 31 and summarized in Table 42.

The overall sca status of hybrids indicated that All-Rounder x Hyd Sel 17 and NK 6240 x Hyd Sel 17 recorded high sca status for all the traits considered under both the situations. Whereas, Parbhat x Hyd Sel 17, NAC 6002 x CI 4 and NK 6240 x CI 4 showed high sca status for all the traits except physiological traits (under nonstress) in both the situations. Other three way crosses, NAH 2049 x CI 4 and Rajkumar x CI 4 exhibited high sca status for all the traits except morphological traits (under nonstress) in both the situations. High sca status of the hybrids indicated the involvement of dominance factors in determining the expression of the traits.

Table 40. Disease reaction of single cross hybrids produced in 12 x 12 half diallel in comparison with private and public bred hybrids (kharif 2009 at MARS, Dharwad)

Sr. No.	Hybrid	Disease rating (1-5 scale)		Sr. No.	Hybrid	Disease rating (1-5 scale)	
		TLB	CR			TLB	CR
1	CM 111 x HS 2	2	2	34	HS 10 x CML 446	4	2
2	CM 111 x HS 7	2	3	35	HS 10 x HS 4	2	4
3	CM 111 x HS 10	3	3	36	HS 10 x HS 15	2	2
4	CM 111 x KDMI 15	2	2	37	HS 10 x HS 17	2	2
5	CM 111 x NEI 9208B	1	4	38	HS 10 x NEI 9202B	3	2
6	CM 111 x CI 4	2	4	39	KDMI 15 x NEI 9208B	2	2
7	CM 111 x CML 446	3	3	40	KDMI 15 x CI 4	2	2
8	CM 111 x HS 4	2	2	41	KDMI 15 x CML 446	2	2
9	CM 111 x HS 15	2	2	42	KDMI 15 x HS 4	3	2
10	CM 111 x HS 17	4	3	43	KDMI 15 x HS 15	2	4
11	CM 111 x NEI 9202B	2	4	44	KDMI 15 x HS 17	3	3
12	HS 2 x HS 7	2	2	45	KDMI 15 x NEI 9202B	2	2
13	HS 2 x HS 10	2	2	46	NEI 9208B x CI 4	3	2
14	HS 2 x KDMI 15	2	2	47	NEI 9208B x CML 446	1	1
15	HS 2 x NEI 9208B	2	2	48	NEI 9208B x HS 4	3	2
16	HS 2 x CI 4	1	2	49	NEI 9208B x HS 15	2	1
17	HS 2 x CML 446	2	3	50	NEI 9208B x HS 17	1	1
18	HS 2 x HS 4	1	4	51	NEI 9208B x NEI 9202B	2	1
19	HS 2 x HS 15	1	2	52	CI 4 x CML 446	2	2
20	HS 2 x HS 17	1	1	53	CI 4 x HS 4	2	4
21	HS 2 x NEI 9202B	3	2	54	CI 4 x HS 15	2	2
22	HS 7 x HS 10	2	2	55	CI 4 x HS 17	2	2
23	HS 7 x KDMI 15	4	2	56	CI 4 x NEI 9202B	2	1
24	HS 7 x NEI 9208B	2	3	57	CML 446 x HS 4	1	1
25	HS 7 x CI 4	2	2	58	CML 446 x HS 15	1	1
26	HS 7 x CML 446	2	2	59	CML 446 x HS 17	1	1
27	HS 7 x HS 4	2	4	60	CML 446 x NEI 9202B	3	2
28	HS 7 x HS 15	1	1	61	HS 4 x HS 15	2	2
29	HS 7 x HS 17	1	1	62	HS 4 x HS 17	2	2
30	HS 7 x NEI 9202B	3	3	63	HS 4 x NEI 9202B	2	2
31	HS 10 x KDMI 15	4	3	64	HS 15 x HS 17	2	2
32	HS 10 x NEI 9208B	2	5	65	HS 15 x NEI 9202B	1	1
33	HS 10 x CI 4	2	2	66	HS 17 x NEI 9202B	2	1
	All-Rounder	3	3		DMH 2	3	3
	Arjun	3	3		900M	3	4
	Bio 9681	4	4		Swarna	2	2

Disease Rating scale

Upto 1 - highly resistant

1.1 - 2.0 - Resistant

2.1 - 3.0 - Moderately resistant

3.1 - 4.0 - Susceptible

4.1 - 5.0 - Highly susceptible

TLB- Turicum leaf blight

CR- Common rust



Plate 2: Cobs of promising hybrids under managed stress as compared to NK 6240 (check)

Table 41. General combining ability (gca) status of parents for morpho-physiological, yield and yield related traits under stress and nonstress situations in maize

Parents	gca status of morphological traits		gca status of yield and yield related traits		gca status of physiological traits		Drought susceptibility index
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	
G 57	H	L	L	L	H	H	H
Karveer	H	H	L	L	H	L	H
NAC 6002	H	L	L	L	H	L	H
Parbhat	H	L	L	L	H	H	H
All-Rounder	H	H	H	H	L	H	H
NAH 2049	L	H	H	L	H	L	L
NK 6240	H	H	H	H	H	H	H
Rajkumar	H	H	H	H	L	H	H
CI 4	H	L	H	H	H	H	H
CML 446	H	L	L	H	L	H	L
Hyd Sel 17	H	L	L	H	H	H	H

HS= Hyd Sel; H= High; L= Low

5.3.3 Characterization of potential three way / top crosses under stress and nonstress situations

The mean performance, gca status of parents and sca status of top five three way/ top crosses is presented in Table 43. The top five crosses that showed good yield under both the situations were: All-Rounder x Hyd Sel 17, NK 6240 x CI 4, NK6240 x Hyd Sel 17, Rajkumar x CML 446 and Parbhat x CI 4. All the crosses except Parbhat x CI 4 recorded positive heterosis over check (Rajkumar).

The yield superiority of three way crosses might be due to the opportunity for segregation and recombination that exists in the single cross/ F_1 parent of a three way cross resulting in genetically heterogeneous populations unlike single cross hybrids, which are heterozygous and homogeneous in their genetic constitution (Kide *et al.*, 1985; Walsh and Atkins, 1973). The superior performance of three way hybrids can also be attributed to the efficient utilization of dominance effects and epistatic interaction of genes from the three parental lines.

The parents of all these three way/ top crosses showed high x high gca and high x low gca status except Parbhat x CI 4 under nonstress and stress situations, respectively for morphological traits. Parents of majority of the crosses showed H x L gca status for yield and yield related traits under both the situations. While for physiological traits, most of the parents exhibited high x high gca status. All these indicated that better performance of these crosses was due to both additive and nonadditive gene effects inviting reciprocal recurrent selection for further improvement.

The F_2 populations of these crosses could be subjected for one or two cycles of recurrent selection before producing the S_1 progeny for isolation of inbred lines for drought tolerance. Meanwhile, the testers viz., CI 4, CML 446 and Hyd Sel 17 could be intermated among themselves to produce opposite population for the exploitation of variability for combining ability.

5.4 Evaluation of crosses derived from two different sources of drought tolerance under stress and nonstress conditions

The objective of this study was to know whether the drought tolerance of the progeny improves further are not with combining to different drought tolerance sources. Thirty crosses derived from drought tolerant (DT) population x DT inbred lines; DT commercial hybrids x DT inbred lines and DT population x DT populations were evaluated under stress and nonstress. The results obtained in the study are discussed here under.

5.4.1 Morpho-physiological, yield and yield related traits

The analysis of variance revealed that the variations due to moisture stress and genotypes were significant for all the traits indicating the availability of sufficient variability in the derivatives (Table 32). Presence of sufficient variability is encouraging from the point of view of screening the derivatives for drought tolerance and to assess the character contribution towards stress tolerance.

The effects of moisture stress on morphological, physiological, yield and yield related traits was drastic and significantly reduced the expression of the many traits but it increased the flowering related traits significantly (Table 33).

Severe drought stress in early growing stage affects the length of internodes (Jurgens *et al.*, 1978). Plant height reduction was reported when crop was subjected to drought in several studies (Pandey *et al.*, 1987; Fischer *et al.*, 1989; Gu *et al.*, 1989; Hemalatha Devi, 1989; Abellandsa and Cauny, 1991; Babu, 1992; Subba Rao, 1992; Desai, 1997).

Reduction in ear height was also reported in maize when subjected to drought (Hemalatha Devi, 1989; Abellandsa and Cauny, 1991; Subba Rao, 1992; Babu, 1992; Tej Pal, 1992).

Table 42. Specific combining ability (sca) status of single cross hybrids for morpho-physiological, yield and yield related traits under stress and nonstress situations in maize

Crosses	sca status of morphological traits		sca status of yield related traits		sca status of physiological traits		Drought susceptibility index
	Nonstress	Stress	Nonstress	Stress	Nonstress	Stress	
G 57 x CI 4	H	H	L	H	H	H	L
G 57 x CML 446	L	H	H	H	L	H	L
G 57 x Hyd Sel 17	L	L	L	H	L	H	L
Karveer x CI 4	L	H	L	H	L	H	H
Karveer x CML 446	L	H	H	H	L	H	L
Karveer x Hyd Sel 17	H	H	L	H	H	L	L
Parbhat x CI 4	L	H	L	H	H	H	L
Parbhat x CML 446	L	H	L	L	L	H	L
Parbhat x Hyd Sel 17	H	H	H	H	L	H	L
NAC 6002 x CI 4	H	H	H	H	L	H	L
NAC 6002 x CML 446	L	H	L	H	H	H	L
NAC 6002 x Hyd Sel 17	L	H	L	L	L	H	L
All-Rounder x CI 4	L	H	L	H	L	H	L
All-Rounder x CML 446	L	H	H	H	L	H	L
All-Rounder x Hyd Sel 17	H	H	H	H	H	H	L
NAH 2049 x CI 4	L	H	H	H	H	H	L
NAH 2049 x CML 446	H	H	H	H	L	H	L
NAH 2049 x Hyd Sel 17	L	H	L	H	L	H	L
NK 6240 x CI 4	H	H	H	H	L	H	L
NK 6240 x CML 446	L	H	L	L	H	H	L
NK 6240 x Hyd Sel 17	H	H	H	H	H	H	L
Rajkumar x CI 4	L	H	H	H	H	H	L
Rajkumar x CML 446	L	H	L	H	H	H	L
Rajkumar x Hyd Sel 17	L	H	L	H	L	L	L

H=High; L= Low

Table 43. Mean performance, gca status of parents and sca status of top five derivatives selected on the basis of grain yield (kg/ha) over two years under both the situations

Hybrids	Grain yield (kg/ha)		gca status of parents for						sca status of hybrids					
			Morphological traits		Yield and yield related traits		Physiological traits		Morphological traits		Yield and yield related traits		Physiological traits	
	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S
All-Rounder x Hyd Sel 17	6509	3125	H x H	H x L	H x L	H x H	L x H	H x H	H	H	H	H	H	H
NK 6240 x CI 4	6737	2889	H x H	H x L	H x H	H x H	H x H	H x H	H	H	H	H	L	H
NK 6240 x Hyd Sel 17	6693	2942	H x H	H x L	H x L	H x H	H x H	H x H	L	H	L	H	L	H
Rajkumar x CML 446	6541	3038	H x H	H x L	H x L	H x H	L x L	H x H	L	H	L	H	L	L
Parbhat x CI 4	6508	2806	H x H	L x L	L x H	L x H	H x H	H x H	L	H	L	H	H	H

NS= nonstress; S= Stress; H=High; L= Low

Drought stress during grain filling period primarily affects kernel weight due to decrease in leaf carbon exchange rates (Jurgens *et al.*, 1978). The reduced yield under water stress conditions could be due to reduced kernel number, kernel weight and cob length (Hall *et al.*, 1981; Coasta *et al.*, 1988; Subba Rao, 1992 and Vinodkumar, 1996).

Floral development and flowering stages are very sensitive to moisture stress. Stress period of drought / water shortages cause delay in anthesis, silking and anthesis to silking interval in maize (Grant *et al.*, 1989, Fredrick *et al.*, 1989; Fischer *et al.*, 1989; Skylar and Gontarovskii, 1990; Fussel *et al.*, 1991; Babu, 1992; Nesmith and Ritchie, 1992; Subba Rao, 1992; Tej Pal, 1992; Bolanos and Edmeades, 1993; Ribaut *et al.*, 1996).

5.4.2 Performance of three way / top cross/ population hybrids under stress and nonstress situations

None of the derivatives were superior to commercial checks for grain yield, which were also used as one of the parents in producing three way crosses in both the environments (Table 35). Romay *et al.* (2010) reported that commercial hybrids were high yielding and more stable than populations under stress.

However, All-Rounder x Hyd Sel 17, NK1 6240 x Hyd Sel 17, Rajkumar x CML 446 and G57 x NAC 6002 recorded on par yield with best checks (NK 6240 and Rajkumar) under stress. Under nonstress environment, Karveer x CML 446, NK 6240 x CML 446 and Karveer x Parbhat were promising. The yield superiority of three way crosses might be due to the opportunity for segregation and recombination that exists in the single cross/F₁ parent of a three way cross resulting in genetically heterogeneous populations unlike single cross hybrids, which are heterozygous and homogeneous in their genetic constitution (Kide *et al.*, 1985; Walsh and Atkins 1973). The superior performance of three way hybrids can also be attributed to the efficient utilization of dominance effects and epistatic interaction of genes from the three parental lines.

The inferior yield of three way crosses as compared to checks may be due to nonsignificant specific combining ability effects of the crosses indicating the absence of dominance and epistatic interaction between genes, which are important for the expression of heterosis.

Among the derivatives, Karveer x CI 4, NAC 6002 x CI 4, NAC 6002 x CML 446, NK 6240 x CI 4, NK 6240 x Hyd Sel 17, Rajkumar x CI 4 and Karveer x NAC 6002 recorded lower anthesis to silking interval under stress. Whereas, the progeny of the cross G 57 x Parbhat, G57 x NAC 6002 and All-Rounder x CI 4 recorded better cobs per plant under stress. The progeny of the cross Karveer x CI 4 recorded lowest drought susceptibility index among all the derivatives.

The purpose of evaluation of three way cross hybrids or top cross or population crosses is to identify heterotic groups with hybrids/ population on one side, lines or population on the other side so that the base material can be exploited by following selection for combining ability in later generation.

5.4.3 Physiological Traits

Relative water content and chlorophyll content in the leaves was estimated at 60 and 90 days. Relative water content under stress decreased from 0.927 to 0.859 at 60 DAS and 0.834 to 0.673 at 90 DAS respectively. Among the derivatives, G57 x Hyd Sel 17 showed high RWC at both the stages under stress (Table 34).

Chlorophyll concentration is a measure of functional stay green (Barker *et al.*, 2004). The chlorophyll content decreased with the age but it was drastic under stress. It decreased to 27.67 from 45.26 mg/cm² under drought. The derivatives which recorded higher concentration of chlorophyll under stress at both the stages were: Parbhat x CI 4 and NAC 6002 x CI 4.

5.5 Variability in top cross / three way cross and population crosses derived from different sources of drought tolerance

Variability is one of the major considerations to assess the potential worth of a cross. The individual plant observations were recorded in F_1 derived from populations $\times$ inbred lines, commercial hybrids $\times$ inbred lines and population $\times$ population crosses as they are heterozygous and completely or partially heterogeneous for all the traits under nonstress and stress. These crosses were assessed for extent of variability indifferent characters using genetic parameters viz PCV, GCV, heritability (in broad sense) and genetic advance.

Among the traits, anthesis to silking interval followed by grain yield per plant and kernels per row showed higher variability as indicated by mean PCV and GCV of 27 crosses (Table 44) in both the situations. The heritability in broad sense of the traits viz., days to 50 per cent anthesis, days to 50 per cent silking, cob length, number of kernels per row and yield per plant decreased under drought. Whereas, the heritability of ear height, anthesis to silking interval, cob girth, kernel rows per cob and 100 grain weight increased under drought. But the heritability for plant height remained same under both the situations. Decreased heritability for various traits under severe drought was reported earlier (Bolanos and Edmeades, 1996). The decreased heritability for various traits under stress reminds the breeders about selection of genotypes under specific environment for better results. Plant height recorded high genetic advance with moderate heritability under drought. Ear height and yield per plant showed moderate genetic advance with low to moderate heritability. Number of kernels per row and 100 grain weight recorded low genetic advance with low to moderate heritability.

5.6 Relative drought tolerances of derivatives obtained from crossing different sources of drought tolerance

To workout the relative drought tolerance of derivatives obtained from crossing different sources of drought tolerance, 15 single crosses obtained from DT inbred $\times$ DT inbred; nine DT hybrid $\times$ DT inbred crosses; 12 DT population $\times$ DT inbred crosses and six DT population $\times$ DT population crosses were considered. The mean values computed from nearly 55 to 60 individual plants under stress were used in DT hybrid $\times$ DT inbred, DT population $\times$ DT inbred and DT population $\times$ DT population crosses. Whereas, for DT inbred $\times$ DT inbred single crosses, the mean values of the hybrids under stress tested for two years for yield per plant and anthesis to silking to interval were used.

Group-wise mean and standard deviation (SD) were computed for yield per plant and anthesis to silking interval. Then each hybrid was scored for yield per plant and anthesis to silking interval. Those crosses which recorded mean + 1 SD for yield per plant and mean - 1 SD for anthesis to silking interval were given +1 score, those crosses which recorded mean - 1 SD for yield per plant and mean + 1 SD for anthesis to silking interval were given -1 score and those crosses which recorded values in between these were given '0' (zero) score. Cross-wise sum of the scores was computed and the results are presented in Table 45.

It is evident from the Table 45 that the overall mean of DT inbred $\times$ DT inbred was higher for yield per plant (61.58 g) and lesser for anthesis to silking interval (2.38) followed by DT hybrid $\times$ DT inbred with corresponding values of 54.23 g and 2.90, respectively.

The frequency of crosses which showed total positive score for DT inbred $\times$ DT inbred was 18 per cent, whereas for DT population $\times$ DT inbred it was 16.7 per cent though their mean values of the crosses was lesser than DT hybrid $\times$ DT inbred crosses. None of the DT hybrid $\times$ DT inbred and DT population $\times$ DT population crosses gave total positive score of 1. Moray *et al.* (2010) also reported that commercial hybrids were high yielding and more stable than populations under stress. Further, when crosses were assessed group-wise for producing frequency of desirable (mean + 1 SD for yield/plant) derivatives for drought tolerance, only two crosses viz., G 57 $\times$ CI 4 and Karveer $\times$ CML 446 gave more number of desirable derivatives in DT population $\times$ DT inbred crosses. In DT hybrid $\times$ DT inbred crosses, All-Rounder $\times$ CML 446 and Rajkumar $\times$ CI 4 showed more number of desirable derivatives. In DT population $\times$ DT population crosses, only G 57 $\times$ Karveer showed more number of desirable derivatives for drought tolerance (Table 46).

Table 44. Mean values (involving 27 crosses) of PCV, GCV, heritability and genetic advance in top crosses, three way crosses and population crosses/ varietal hybrids of maize under stress and non stress situations

Traits	Mean of the trait		PCV		GCV		h^2_{bs}		GA	
	NS	S	NS	S	NS	S	NS	S	NS	S
Plant height (cm)	259.03	234.73	9.57	14.77	6.86	11.76	0.44	0.44	25.37	35.18
Ear height (cm)	119.96	107.91	13.14	20.42	8.48	14.74	-0.03	0.20	0.98	12.21
Days to 50% anthesis	62.20	62.93	4.61	4.69	2.59	3.61	0.14	-0.14	0.95	0.19
Days to 50% silking	64.05	65.92	5.70	7.11	2.93	4.09	-0.05	-0.14	0.22	-0.58
Anthesis to silking interval	1.94	3.47	148.22	120.79	60.23	92.76	-1.05	-0.01	-5.26	0.85
Cob length (cm)	13.72	11.28	21.56	24.77	14.79	11.47	0.19	0.03	1.31	0.32
Cob girth (cm)	13.26	11.30	11.37	14.16	5.75	8.49	-0.04	0.18	0.04	0.74
Kernel rows / Cob	13.77	13.35	14.68	15.77	9.27	16.10	0.20	0.32	0.98	1.50
No. of kernels / row	28.10	21.49	26.31	33.36	15.64	17.88	0.18	0.13	3.21	2.46
Yield per plant (g)	98.10	49.16	40.14	49.71	24.10	29.89	0.27	0.14	24.34	9.87
100-grain wt (g)	27.08	18.54	18.15	23.23	8.13	12.82	0.10	0.20	1.09	2.14

Table 45. Relative performance of derivatives obtained from different sources of drought tolerance in maize

Crosses	ASI	YPP	ASI score	YPP score	Total score
Inbred x Inbred					
CI 4 x CML 446	2.25	69.96	0	+1	+1
CI 4 x Hyd Sel 4	2.25	64.17	0	0	0
CI 4 x Hyd Sel 15	3	62.81	-1	0	-1
CI 4 x Hyd Sel 17	2.5	55.14	0	-1	-1
CI 4 x NEI 9202B	2.25	63.52	0	0	0
CML 446 x Hyd Sel 4	3	52.07	-1	-1	-2
CML 446 x Hyd Sel 15	3.25	52.99	-1	-1	-2
CML 446 x Hyd Sel 17	2.75	57.48	0	0	0
CML 446 x NEI 9202B	2.25	65.08	0	0	0
Hyd Sel 4 x Hyd Sel 15	2.5	65.09	0	0	0
Hyd Sel 4 x Hyd Sel 17	2.75	60.84	0	0	0
Hyd Sel 4 x NEI 9202B	1.25	69.08	+1	+1	+2
Hyd Sel 15 x Hyd Sel 17	2	62.96	0	0	0
CI 4 x CML 446	2	66.08	0	0	0
CI 4 x Hyd Sel 4	1.75	56.57	+1	0	+1
Mean	2.38	61.58			
SD	0.52	5.56			
Population x population					
G 57 x Karveer	3.05	39.98	0	-1	-1
G 57 x NAC 6002	4.83	54.5	-1	+1	0
G 57 x Parbhat	3.03	46.24	0	0	0
Karveer x NAC 6002	2.81	49.46	0	0	0
Karveer x Parbhat	3.67	46.17	0	0	0
NAC 6002 x Parbhat	5.08	44.61	-1	0	-1
Mean	3.75	46.83			
SD	0.98	4.86			

Contd.....

Table 45 contd.....

Crosses	ASI	YPP	ASI score	YPP score	Total score
Population × inbred					
G 57 x CI 4	2.95	48.02	0	0	0
G 57 x CML 446	3.29	50.34	0	0	0
G 57 x Hyd Sel 17	2.66	47.18	-1	0	-1
Karveer x CI 4	2.08	55.05	+1	0	+1
Karveer x CML 446	3.42	39.41	0	-1	-1
Karveer x Hyd Sel 17	2.05	43.27	0	0	0
Parbhat x CI 4	2.65	51.94	0	0	0
Parbhat x CML 446	4.29	37.88	-1	-1	-2
Parbhat x Hyd Sel 17	2.74	48.55	0	0	0
NAC 6002 x CI 4	2.95	53.74	+1	0	+1
NAC 6002 x CML 446	3.29	43.46	0	0	0
NAC 6002 x Hyd Sel 17	2.66	39.4	0	-1	-1
Mean	2.90	46.52			
SD	0.69	5.81			
Hybrid x Inbred					
All-Rounder x CI 4	2.95	59.09	0	0	0
All-Rounder x CML 446	3.29	46.232	0	-1	-1
All-Rounder x Hyd Sel 17	2.66	57.68	-1	0	-1
NK 6240 x CI 4	2.08	55.81	-1	0	-1
NK 6240 x CML 446	3.42	48.2	0	-1	-1
NK 6240 x Hyd Sel 17	2.05	59	-1	0	-1
Rajkumar x CI 4	2.65	49.11	-1	0	-1
Rajkumar x CML 446	4.29	51.19	0	0	0
Rajkumar x Hyd Sel 17	2.74	61.82	-1	+1	0
Mean	2.9	54.23			
SD	0.69	5.63			

Table 46. Potential derivatives for drought tolerance (plant showing mean - 1 SD and mean + 1 SD for anthesis to silking interval and yield per plant) observed from different populations / crosses in maize

Crosses	Anthesis to silking interval		Yield per plant	
	Range	No. of potential plants observed	Range	No. of potential plants observed
Population x inbred				
G 57 x CI 4	0-16	0	3.9-81.0	12
G 57 x CML 446	-1-8	5	8.4-111.0	8
G 57 x Hyd Sel 17	0-19	4	7.2-90.67	8
Karveer x CI 4	-1-10	0	5.6-109.5	7
Karveer x CML 446	0-11	4	7.3-97.2	10
Karveer x Hyd Sel 17	0-10	0	0.8-136.3	5
Parbhat x CI 4	0-14	0	5.1-129.7	6
Parbhat x CML 446	0-17	4	0.2-90.1	7
Parbhat x Hyd Sel 17	-1-14	1	9.8-110.8	8
NAC 6002 x CI 4	-1-16	3	3.3-154.3	7
NAC 6002 x CML 446	-1-4	1	13.4-105.5	7
NAC 6002 x Hyd Sel 17	-1-14	2	4.7-86.8	8
Mean		2.00		7.75
SD		1.91		1.82
Hybrid x inbred				
All-Rounder x CI 4	-1-13	0	12.4-128.4	6
All-Rounder x CML 446	0-12	0	4.0-95.8	10
All-Rounder x Hyd Sel 17	-1-16	0	6.7-134.6	8
NK 6240 x CI 4	0-11	0	4.6-1047.0	9
NK 6240 x CML 446	0-9	0	19.3-98.9	9
NK 6240 x Hyd Sel 17	0-16	0	13.2-107.9	7
Rajkumar x CI 4	-1-7	3	6.4-113.1	10
Rajkumar x CML 446	-1-12	0	10.9-129.8	9
Rajkumar x Hyd Sel 17	1-21	1	7.2-124.9	5
Mean		0.44		8.11
SD		1.01		1.76
Population x population				
G 57 x Karveer	-1-12	0	4.2-111.3	6
G 57 x NAC 6002	0-16	3	2.8-106.1	10
G 57 x Parbhat	0-14	4	3.5-104.5	8
Karveer x NAC 6002	0-19	0	8.5-124.4	8
Karveer x Parbhat	0-20	0	12.4-95.7	8
NAC 6002 x Parbhat	0-13	1	14.6-108.0	7
Mean		1.33		7.83
SD		1.75		1.33

Future line of work

The highlight of the results obtained and inferences drawn from the different aspects of the study have given rise to some directions for future line of work. They are as follows:

1. The potential single cross hybrids obtained in diallel fashion are to be tested further under various water regimes at different locations especially under rainfed conditions for their drought tolerance, stability, disease resistance and yielding ability. This could be done by testing the hybrids under rainfed and productive environments in farmers' fields as a part of participatory varietal selection scheme.
2. The seeds of single cross hybrids, which have recorded highly resistant reaction to turicum leaf blight and common rust of maize, be increased, tested and registered along with their parents.
3. The important inbred lines viz., CI 4, CML 446, Hyd Sel 15, Hyd Sel 17, Hyd Sel 4, KDMI 15, NEI 9202B and NEI 9208B may be characterized at molecular level for protection of rights.
4. The F_2 populations of five three way/ top crosses are to be produced and recurrent selection procedure be adopted for the production of drought tolerant source populations for the development of drought tolerant inbred lines for future use.

6. SUMMARY AND CONCLUSIONS

Maize is essential for global food security. But natural resource base (soil and ground water) is becoming depleted through compaction, erosion, salinization, net nutrient export and diminishing water supply (Cassman 1999). On the other hand, global climate is now generally considered to be under way (Hillel and Rosenzweig, 2002) and is expected to result in a long term trend towards higher temperatures, greater evapo-transpiration and an increased incidence of drought in specific regions. These trends coupled with an expansion of cropping into marginal areas are generating increasingly drought-prone maize production environments (Campos *et al.*, 2004). Further, the occurrence and intensity of drought is unpredictable, adding to the complexity in real practical situation.

Average annual global losses due to drought range from 15 per cent in temperate zone to 17 per cent in tropical zone (Edmeades *et al.*, 2000b). Further, Kitchen *et al.* (1999) reported large variation within the same fields. Therefore, there is a necessity of evolving hybrids that are able to withstand stress throughout their life cycle at no cost to yield potential under nonstressed conditions.

The use of genetics to improve drought tolerance and provide yield stability is an important part of the solution to stabilizing global maize production. However, agronomic interventions that aim to maximize water availability at key growth stages are also important because it is not possible to close more than 30 per cent of the gap between potential and realized yield under water stress (Edmeades *et al.*, 2004.) But genetic solutions can be more easily packed, promoted and adopted more easily than agronomic and other input dependent practices.

In Karnataka, drought appears once in every 5-6 years. During drought years the maize grown under rainfed situations especially, in Davanagere, Haveri, Shimoga, Chitradurga and Bellary districts (where about 45 per cent of *kharif* maize area is under rainfed conditions) suffers heavily. Hence, there is a need to identify /develop drought tolerant maize germplasm to cater to the needs of rainfed situations. Therefore, an investigation entitled "Identification of drought tolerant maize (*Zea mays* L.) germplasm" with the objectives of screening the available maize germplasm for drought, identifying drought tolerant inbred lines, hybrid and composites /populations was undertaken. The present study also aimed to analyse the combining ability and variance with respect to drought tolerance traits and to know whether drought tolerance of the derivatives increases or not when two different drought tolerance sources are combined.

The entire investigation spanning three years, was carried out during post rainy seasons (*rabi* / summer) to avoid rains during cropping season and there by reducing the errors in screening experiments.

The material for the initial screening work included 82 inbred lines, 10 commercial hybrids and seven populations. The screening was carried out during *rabi* / summer 2007-08 under stress and nonstress situations. From this study, six drought susceptible and six drought tolerant inbred lines were identified based on grain yield, cobs per plant, anthesis to silking interval and drought susceptibility index. Inbred lines which showed good yield (nearer to mean+ 1SD) and less ASI (nearer to mean – 1SD), cobs per plant (nearer to mean+ 1SD) and drought susceptibility index (nearer to mean – 1SD) were selected for the production of single crosses in half diallel fashion. The list of inbred lines selected for hybridization are: CM 111, Hyd Sel 2 , Hyd Sel 7, Hyd Sel 10, KDMI 15, NEI 9208B, CI 4, CML 446, Hyd Sel 4, Hyd Sel 15, Hyd Sel 17 and NEI 9202B. Similarly, four drought tolerant hybrids *viz.*, All-Rounder, NAH 2049, NK 6240 and Rajkumar and four drought tolerant composites / populations (G 57, Karveer, NAC 6002 and Parbhat) were identified for further studies.

To assess the combining ability and variances of drought tolerance traits, 66 single cross hybrids were produced by utilizing 12 inbred lines varying for drought tolerance identified during 2007-08 (12 x 12 diallel, excluding reciprocals). Sixty six hybrids along with parents and check were evaluated under stress and nonstress during *rabi* /summer 2008-09 and 2009-10. The combined data of two years under stress and nonstress was analysed separately as per Griffing's (1956) model-1 and method -2 extended by Singh (1973). The analysis of variance revealed highly significant variation for most of the characters under both

the situations. Further, combining ability analysis indicated that variance due to GCA and SCA were significant for most of the traits under both the situations indicating the importance of both additive and nonadditive gene action in controlling the traits. Variance due to GCA alone was significant for days to maturity under both the situations indicating the importance of additive gene action in controlling the trait.

The gca status of parents and sca status of hybrids were determined as suggested by Arunachalam and Bandopadhyay (1979). The gca status of parents revealed that CI 4 and Hyd Sel 15 as good general combiners among 12 inbred lines under both nonstress and stress situations for morphological, yield and yield related and physiological traits. The hybrids viz., CM 111 x NEI 9202B, CML 446 x NEI 9202B and Hyd Sel 4 x NEI 9202B showed high sca status under both the situations for all the traits. CM 111 x NEI 9202B and Hyd Sel 4 x NEI 9202B also exhibited highly significant positive heterosis over mid parent for grain yield (kg/ha) under both the environments. While CML 446 x NEI 9202B recorded only significant positive heterosis for grain yield under nonstress situation.

KDMI 15 x NEI 9202B also revealed high status of sca for all the traits except physiological traits under both the situations. This was the most promising hybrid among 66 hybrids tested for both the situations. It also recorded significant positive heterosis over mid-parent under both the situations for grain yield (kg/ha).

Stability analysis of inbred lines for grain yield under stress depicted that CI 4 was the most drought tolerant and stable inbred line among the 12 inbred lines tested for three seasons at College of Agriculture, Bheemaranagudi.

Stability analysis of 23 selected single cross hybrids and checks under managed stress indicated that three hybrids viz., KDMI 15 x NEI 9202B, Hyd Sel 2 x NEI 9202B and Hyd Sel 7 x NEI 9202B were stable across locations and seasons for grain yield under stress.

Stability analysis of 64 single cross hybrids under irrigation indicated that six hybrids viz., CM 111 x CI 4, CM 111 x Hyd Sel 15, Hyd Sel 7 x NEI 9202B, Hyd Sel 10 x NEI 9202B, CI 4 x Hyd Sel 15 and Hyd Sel 15 x NEI 9202B were stable across seasons and locations.

Incidentally, the high yielding as well as drought tolerant hybrids also recorded resistant reaction to the most important diseases of maize i.e., turicum leaf blight and common rust.

In order to know whether drought tolerance of the derivatives increases or not when two different drought tolerance sources are combined, three different types of crosses were produced. They included drought tolerant (DT) commercial hybrid crossed with DT inbred lines, DT composites were crossed with DT inbred lines and one DT population crossed with another DT population. In this way, four DT commercial hybrids and four DT population were crossed with three DT inbred lines (in L x T fashion) and four DT populations were crossed among themselves to produce six varietal hybrids (population crosses). A total of 12 three way crosses (DT hybrids x DT inbred lines), 12 top crosses (DT populations x DT inbred lines) and six population crosses were produced during *kharif* 2008 and evaluated along with parents and checks during *rabi* summer 2008-09 and 2009-10 under stress and nonstress situations. The trial was conducted in factorial RBD with two replications. During 2008, only yield per plot was recorded, whereas during 2009, individual plant observations were recorded on these derivatives as they were heterozygous and heterogeneous. In each cross, observations were recorded on about 55-60 plants (28-30 plants per replication). The mean values of all the plants in a replication was considered for L x T analysis as per Kempthorne (1957) to identify the heterotic crosses for recurrent selection and mean values of all the plants (55-60) for working out the genetic components of variance for different drought tolerance traits.

The results of this study indicated that in general, the derivatives were inferior to the best check available in the market. However, few crosses (All-Rounder x Hyd Sel 17, NK 6240 x CI 4, NK6240 x Hyd Sel 17, Rajkumar x CML 446 and Parbhat x CI 4) recorded on par yield with the best checks under both the situations.

Combining ability status of parents (commercial hybrids and populations) revealed that All-Rounder, NK 6240 and Rajkumar showed high gca status for all the traits both under stress and nonstress situations among lines. Among the testers, CI 4 recorded high gca status for all the traits except morphological (under stress) traits in both the situations.

The parents of all the above crosses viz., All-Rounder x Hyd Sel 17, NK 6240 x CI 4, NK6240 x Hyd Sel 17, Rajkumar x CML 446, which recorded on par yield with commercial checks, showed high x high gca status and high x low gca status under nonstress and stress situations, respectively for morphological traits. Parents of majority of the crosses showed H x L gca status for yield and yield related traits under both the situations. While for physiological traits, most of the parents exhibited high x high gca status. All these indicated that better performance of these crosses was due to both additive and nonadditive gene effects and hence, good progress could be made by reciprocal recurrent selection for drought tolerance.

The genetic components of variation revealed that under drought, anthesis to silking interval followed by grain yield per plant and kernels per row showed higher variability as indicated by their PCV and GCV. The heritability of most the traits except ear height, anthesis to silking interval, cob girth, kernel rows per cob and 100 grain weight decreased under drought suggesting the essentiality of target specific selection for better results.

Under nonstress, G 57 x CML 446, NAC 6002 x CML 446, NAC 6002 x Hyd Sel 17, All-Rounder x CML 446, All-Rounder x Hyd Sel 17 and G57 x NAC 6002 recorded high heritability with high genetic advance for grain yield. The crosses, Parbhat x CI 4, NAC 6002 x CI 4, All-Rounder x CI 4, NK 6240 x CI 4 and Karveer x NAC 6002 recorded high heritability with high genetic advance for the same trait.

From the study, it was possible to identify stable drought tolerant inbred lines and few stable drought tolerant single cross hybrids. These single cross hybrids were also equally high yielding under optimal environment. Therefore, the farmers will gain from cultivating such hybrids under drought and do not lose yields when they receive good rains during good Monsoon years. Besides this, resistant reaction of these single cross hybrids to turicum leaf blight and common rust diseases will further make them more acceptable among farmers.

When derivatives obtained from different sources of drought tolerance, DT inbred x DT inbred recorded higher mean yield under stress and more number of crosses with positive scores as compared to DT hybrid x DT inbred, DT population x DT inbred and DT population x DT population crosses. Hence, one should concentrate on producing single cross hybrids which give high yield under stress as compared to other type of crosses.

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* Original not seen

Appendix I. Monthly rainfall, temperature and relative humidity (RH) during the crop growth period

Month	Rainfall (mm)			Temperature (°C)						Relative humidity (%)					
	2007-08	2008-09	2009-10	2007-08		2008-09		2009-10		2007-08		2008-09		2009-10	
				Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Oct	13.5	46.0	268.5	31.6	20.3	32.1	20.0	31.3	21.0	71.1	55.5	75.0	56.9	75.65	64.06
Nov	18.5	9.0	70.5	30.5	16.3	31.0	17.3	29.9	19.3	66.6	49.4	66.7	46.5	80.2	69.0
Dec	0.0	14.0	5.5	30.3	16.3	30.8	15.8	28.7	16.4	67.4	43.6	73.1	44.9	84.0.	65.5
Jan	0.0	0.0	16.5	30.5	14.8	30.9	15.8	29.3	17.0	64.9	34.4	68.3	38.1	79.4	58.2
Feb	0.0	0.0	6.5	32.3	18.1	34.8	18.2	33.0	19.0	61.0	35.6	52.4	28.1	70.3	42.8

IDENTIFICATION OF DROUGHT TOLERANT MAIZE (*Zea mays* L.) GERMPLASM

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ABSTRACT

An investigation was carried out to assess the drought tolerance of inbred lines, hybrids and populations besides studying combining ability and variance with respect to drought tolerance traits and effect of combining different sources of drought tolerance.

Eighty two inbred lines, 10 commercial hybrids and seven populations were screened for drought tolerance during *rabi*/summer 2007-08 under stress and nonstress situations. From this study, six inbred lines, four hybrids and four populations tolerant to drought were identified based on grain yield, cobs per plant, anthesis to silking interval and drought susceptibility index.

Sixty six hybrids produced by utilizing 12 inbred lines varying for drought tolerance were evaluated along with parents and check under stress and nonstress during *rabi*/summer 2008-09 and 2009-10. The combined data of two years under stress and nonstress was analyzed separately as per Griffing's (1956) model-1 and method-2 extended by Singh (1973). Combining ability analysis indicated that variances due to GCA and SCA were significant for most of the traits under both the situations indicating the importance of both additive and non-additive gene action in controlling the traits.

The gca status of parents revealed that CI4 and HydSel 15 as good general combiners among 12 inbred lines under both nonstress and stress situations for morphological, yield and yield related and physiological traits. The hybrids viz., CM111 x NEI9202B, KDMI15 x NEI9202B and HydSel 4 x NEI9202B exhibited high sca status and highly significant positive heterosis over mid parent for grain yield (kg/ha) under both the environments.

When derivatives obtained by crossing different sources of drought tolerance were evaluated, DT inbred x DT inbred recorded higher mean grain yield under stress and more number of crosses with positive scores as compared to DT hybrid x DT inbred, DT population x DT inbred and DT population x DT population crosses.