"LINE X TESTER ANALYSIS IN MAIZE (*Zea mays* L.)"

A thesis submitted to the

Mahatma Phule Krishi Vidyapeeth, Rahuri- 413 722
Dist. Ahmednagar, Maharashtra State, India

By

THOTE AJIT SHIVAJI
(Reg. No. 10/059)

In partial fulfillment of the requirements for the degree
of

MASTER OF SCIENCE (Agriculture)
in

AGRICULTURAL BOTANY

(GENETICS AND PLANT BREEDING)

DIVISION OF AGRICULTURAL BOTANY
COLLEGE OF AGRICULTURE, KOLHAPUR
MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI-413 722
MAHARASHTRA (INDIA)

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Approved by

Dr. U. M. BORLE
(Chairman and Research Guide)

Prof. L. C. Mohatkar (Committee member)

Prof. S. R. Kulkarni (Committee member)

Dr. R. B. Pawar (Committee member)

Prof. M. R. Shewale (Committee member)

DIVISION OF AGRICULTURAL BOTANY
COLLEGE OF AGRICULTURE, KOLHAPUR
MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI-413 722
MAHARASHTRA (INDIA)

2013

Candidate's Declaration

I hereby declare that this thesis or part there of

has not been submitted by me or any other

person to any other University

or Institute for Degree

or Diploma

Place : Kolhapur **(THOTE A.S.)**

Dated : / /2013

Dr. U. M. BORLE

Assistant Maize Breeder,
AICRP on Maize, Kolhapur.
Maharashtra State (India)

C E R T I F I C A T E

This is to certify that the thesis entitled, **"LINE X TESTER ANALYSIS IN MAIZE (*Zea mays L.*)"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL BOTANY (GENETICS AND PLANT BREEDING)**, embodies the results of a piece of *bona fide* research work carried out by **Mr. THOTE AJIT SHIVAJI** under my guidance and supervision and that no part of this thesis has been submitted for any other degree or diploma in any other form.

Place: Kolhapur **Dr. U. M. BORLE**

Date: / /2013 Research Guide

Dr. N. Y. PATIL

Associate Dean,
College of Agriculture,
Kolhapur - 416 004.
Maharashtra State (India)

C E R T I F I C A T E

This is to certify that the thesis entitled, **"LINE X TESTER ANALYSIS IN MAIZE (*Zea mays L.*)"** submitted to the faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in, **AGRICULTURAL BOTANY GENETICS AND PLANT BREEDING** embodies the results of a piece of *bona fide* research work carried out by **Mr. THOTE AJIT SHIVAJI** under the guidance and supervision of **Dr. U. M. BORLE**, Assistant Maize Breeder, AICRP on Maize, Kolhapur and that no part of this thesis has been submitted for any other degree or diploma in any other form.

Place: Kolhapur **Dr. N. Y. PATIL**

Date: / /2013 Associate Dean

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Place: Kolhapur

Date: / /2013 *(Thote A. S.)*

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LIST OF ABBREVIATIONS

-	:	minus
%	:	Per cent
/	:	Per
+	:	Plus
<.	:	Less than
=	:	Equal to
>	:	Greater than
μ	:	population mean
Adv.	:	Advances
Agric.	:	Agricultural
Agron.	:	Agronomy
AICRP	:	All India Coordinated Research Project
Am.	:	American
Ann.	:	Annals
Aust.	:	Australian
B.P.	:	Better parent
Biol.	:	Biology
Bot.	:	Botany
Breed.	:	Breeding
Bull.	:	Bulletin
C.D.	:	Critical differences
C.V	:	Coefficient of variance
cm	:	Centimeters
Cov.	:	Co-variance
Cyto.	:	Cytology
D.F.	:	Degree of freedom
Dev.	:	Development
Ed.	:	Edition
Electro.	:	Electronic

et al.	:	et all (and others)
F_1s	:	First flial generation
FYM	:	Farm Yard Manure
g	:	gram
GCA/gca	:	General Combining Ability
GCV	:	Genotypic coefficient of variation
Genet.	:	Genetics
GPM	:	Germplasm
h^2 (ns)	:	Heritability in narrow sense
ha	:	hectare
Hyd.	:	Hyderabad
Inb.	:	Inbred
i.e	:	That is (id est)
Improv.	:	Improvement
Inter.	:	International
J.	:	Journal
Kg/ha	:	kilogram per hectare
L x T	:	Line X Tester
L.S.D	:	Least significant difference.
Me	:	Error mean sum of square
mg	:	milligram
mmT	:	million metric tones
MP	:	Mid parent
Natl.	:	National
No.	:	Number
P/p	:	Parent
PCV	:	Phenotypic coefficient of variation
Per se	:	Actual
Pl.	:	Plant
Prod.	:	Product

Proc.	:	Proceedings
Publ.	:	Publications
r	:	Replication
RBD	:	Randomized Block Design
Res.	:	Research
S.E.	:	Standard error
SCA/sca	:	Specific combining ability
SC	:	Standard check
S.S.	:	Sum of squares
Sci.	:	Science
SP	:	superior parents
Soc.	:	Society
Univ.	:	University
USA	:	United States of America
via	:	through
viz.,	:	Videlicet (namely)
Y	:	Yield
Y..	:	Grand total of all hybrids
σ^2A	:	Additive genetic variance
σ^2D	:	Non-additive genetic variance
σ^2 g.c.a	:	Variance for general combining ability
σ^2_e	:	Environmental variance
σ^2_g	:	Genotypic variance
σ^2_p	:	Phenotypic variance
σ^2 s.c.a.	:	Variance for specific combining ability.

ABSTRACT

LINE X TESTER ANALYSIS IN MAIZE

(*Zea mays* L.)

By

THOTE AJIT SHIVAJI

A Candidate for the degree

Of

MASTER OF SCIENCE (AGRICULTURE)

In

Agricultural Botany
(GENETICS AND PLANT BREEDING)

College of Agriculture, Kolhapur.

Mahatma Phule Krishi Vidyapeeth,

Rahuri- 431 722 (M.S.) India.

2012

Research Guide	:	**Dr. U. M. Borle**
Department	:	Agricultural Botany
Major Field	:	Genetics and Plant Breeding

The present investigation entitled "Line X tester analysis in Maize (Zea mays L.) was carried out at the Department of Botany, College of Agricultural, Kolhapur, Mahatma Phule Krishi Vidyapeeth, Rahuri. A study was conducted to assess the magnitude of cross material involving 40 hybrids, 13 parents and two commercial checks (Rajarshi and Bio-9637) in maize during 2010-11; to study the nature and magnitude of heterosis for grain yield and other yield attributing characters, general and specific combining ability effects, gene action and heritability for thirteen characters *viz*; days to 50% tasseling, days to 50% silking, days to maturity, plant height, earhead height, ear length, ear circumference, number of kernel rows per cob, number of kernels per row, 100 grain weight, shelling percentage, grain yield per plant and starch content.

Considerable amount of genetic variability was observed among the parents and hybrids for all characters studied. Among the females and males, female Hyd-08R-2630-2, N-8211-35, 2372-1 and males N-8203-1, N-8215-4 were superior for days to 50% tasseling and days to 50% silking, for days to maturity females Hyd-08R-8214-43, Hyd-08R-2630-2, N-8211-35 and male N-8215-4, for plant height females Hyd-08R-2630-2, 2372-1 and males N-8203-1, N-8215-4, for earhead height females Hyd-08R-8214-43, 2392-2, Hyd-08R-8214-31, N-8211-35 and males N-8213-48, N-8215-4, 644-1, for ear length females Hyd-08R-2630-2, 2392-2, 673-2 and males N-8203-1, N-8215-4, for ear circumference Hyd-08R-8214-43, 673-2, 679-1 and males N-8203-1, N-8215-4, for number of kernel rows per cob females 679-1, N-8211-35 and males N-8213-48, N-8215-4, for number of kernels per row 2392-2, N-8211-35 and 679-1 and males N-8215-4, 644-1, for 100 grain weight females Hyd-08R-8214-31, 2372-1 and Hyd-08R-2630-2 and males N-8203-1, N-8215-1, for shelling percentage females 679-1, 673-2, Hyd-08R-2630-2 and male N-8203-1, for grain yield per plant females 679-1, 673-2 and males N-8215-1, N-8213-48, for starch content female 679-1 were found to be promising.

The considerable amount of heterosis was observed for all characters. Out of forty crosses, studied the positive heterosis for grain yield per plant was observed in twenty three crosses over mid parant, twelve over better parent, two over the check Rajarshi and nine over the check Bio-9637.

Among the crosses showing significant positive heterosis, for grain yield per plant very high percentages were noted in 679-1 X N-8215-1 and 673-2 X N-8215-4 crosses. The cross combination *viz*. hybrids 679-1 X N-8215-1, 673-2 X N-8215-4, Hyd-08R-2630-2 X N-8215-1, 673-2 X N-8203-1, Hyd-08R-2630-2 X N-8203-1, 679-1 X N-8203-1, 2372-1 X N-8215-4, 679-1 X N-8213-48, 673-2 X N-8215-1 were found to be promising.

As regards the general combining ability effects among the females, female Hyd-08R-2630-2 was the best general combiner for days to 50% tasseling, days to 50% silking, days to maturity plant height, ear length, 100 grain weight, shelling percentage and grain yield per plant, female 679-1 for ear circumference, number of kernel rows per cob, number of kernels per row, shelling percentage, grain yield per plant and starch content, female N-8211-35 for days to 50% tasseling, days to 50% silking, days to maturity, earhead height, number of kernel rows per cob and number of kernels per row, female 2372-1 for days to 50% tasseling, days to 50% silking, plant height, ear length, 100 grain weight, female 673-2 for ear length, ear circumference, shelling percentage, grain yield per plant, female Hyd-08R-8214-43 for days to maturity, earhead height, ear circumference, number of kernel rows per cob, female 2392-2 for earhead height, ear length, number of Kernels per row, females Hyd-08R-8214-31 for ear length, 100 grain weight. However among the males N-8215-4 was good general combiner for days to 50% tasseling, days to 50% silking, days to maturity, plant height, earhead height, ear length, ear circumference, number of kernel rows per cob, number of kernels per row, male N-8203-1 for days to 50% tasseling, days to 50% silking, plant height, ear length, ear circumference, 100 grain weight, shelling percentage, male N-8213-48 for earhead height, number of kernel rows per cob, grain yield per plant, male 644-1 for earhead height, number of kernels per row. Best general combiners for grain yield were also the best general combiner for one or more yield contributing characters.

The best specific combination for days to 50% tasseling and days to 50% silking was N-8211-35 X 644-1, for days to maturity Hyd-08R-8214-43 X N-8215-4, for plant height Hyd-08R-8214-43 X N-8203-1, for earhead height 2372-1 X N-8203-1, for ear length 673-2 X 644-1, for ear circumference N-8211-35 X N-8215-1 and 679-1 X N-8215-4, for number of Kernel rows per cob N-8211-35 X N-8215-1, for number of kernels per row 673-2 X N-8215-1, for 100 grain weight 2392-2 X N-8215-4, for shelling percentage 2372-1 X N-8215-4, for grain yield per plant 679-1 X N-8215-1 and for starch content 679-1 X 644-1.

The significance of positive s.c.a. effects for grain yield was found to be influenced by significance of positive effects for one or more yield contributing traits. Significance of g.c.a and s.c.a effects indicated the importance of both additive and non-additive gene effects with predominance of later for all the traits except days to 50% tasseling and silking and earhead height.

Considering the *per se* performance, heterosis percentage and s.c.a. effects, the crosses which out yielded Rajarshi and Bio-9637 the standard checks and high yielding parents and could be considered for exploiting hybrid vigour were 679-1 X N-8215-1, 673-2 X N-8215-4, Hyd-08R-2630-2 X N-8215-1, 673-2 X N-8203-1, Hyd-08R-2630-2 X N-8203-1, 679-1 X N-8203-1 over Rajarshi. In addition to these crosses 2372-1 X N-8215-4 and 679-1 X N-8213-48, 673-2 X N-8215-1 showed better performances over check Bio-9637.

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1. INTRODUCTION

Maize (Zea mays L.) is one of the staple food crops. In world, it ranks third next to wheat and rice in production. It is an important cereal crop belonging to tribe Maydeae of the grass family, Poaceae. Tribe *Maydeae* comprises eight genera, five of which are Oriental (*Coix, Schlerachne, Polytoca, Chinonachne* and *Trilobachene*) and are relatively unimportant. They are native to an area extending from India to Burma through East Indies and into Australia. Its diploid with chromosome 2n = 20. *Tripsacum* (Gama grass) 2n = 18 and teosinte (*Eucleana spp.*) 2n = 36 are the two close relatives.

Euchalaena (teosinte), which appears to be the closest wild relative of maize, occurs in Mexico and Guatemala. The annual form has 10 pairs of chromosomes like maize and is the most common type. Perennial teosinte has 20 pairs of chromosomes and is found in a restricted area in Mexico. The annual form is used as a forage plant.

It is grown from 58°N to 40°S, from below sea level to altitudes higher than 3000 m and in areas with 250 mm to more than 5000 mm of rainfall per year (Downswell *et al.,* 1996). Most of the crop is however, grown in the warmer parts of temperate regions and in humid subtropical climate and the greatest production is in area having the warmest month isotherms from 210° to 270° C and a frost-free season of 120 to 180 days duration.

Maize is also called as Miracle Crop and Queen of the Cereals due to its high productivity potential compared to other Graminaceae family members. It is a seasonal crop, and annually it can be harvested thrice, i.e., in *Kharif*, *Rabi* and *summer* seasons. Maize is usually grown as a pure crop and generally it can be grown as an inter crop with different crop combinations like Cotton, sugarcane, vegetables, legume crops, etc.

Maize is a cross pollinated crops which belongs to genus Zea. Maize is the largest of the cereals, a tall erect, annual grass attaining a height from 2 to 3 meter high (maximum 7 meter) produce single leaf at each node. Stem is round to oval green divided into nodes and internodes. Jointed stem is solid and contains good amount of sugar when young. Leaves are alternatives, distichously, simple linear lanceolate. Each leaf consists of sheath surrounding stem and an expanded leaf blade connected to the sheath by a blade joint. The number of leaves may vary 4 to 48.

Maize is a monoecious plant, that is, the reproductive organ is partitioned in two separate pistillate (ear) and staminate (tassel) inflorescence on the same plant. The male inflorescence (tassel) is located at the top of the plant, while the female inflorescence known as cob or ear arises about midway at a node on the main stalk. Maize is generally protandrous, that is, the male spikelets mature earlier than female spikelets, however protogyny is not ruled out. Within each male spikelet, there are usually two functional florets. Each floret contains three anthers and each plant produces about 3 to 5 million pollen grain. Pollen grains are very small visible to naked eye, light in weight and easily carried or flown out by wind. The wind borne nature of the pollen and protandry leads to cross pollination but there may also be about 5% self pollination.

Many forms of maize are used for food, sometimes classified in the various subspecies related to the amount of starch each had Flour corn -*Zea mays* var. amylacea , Popcorn-*Zea mays* var. everta, Dent corn-*Zea mays* var. indentata, Flint corn-*Zea mays* var. indurrata, Sweet corn-*Zea mays* var. saccharata and *Zea mays* var. rugosa, Waxy corn *Zea mays* var. certain, Amylomaize-*Zea mays* Pod corn -*Zea mays* var. tunicata Larrañaga ex A. St. Hil. Striped maize-*Zea mays* var. japonica. The floury and opaque are nutritional quality type contains high tryptophan and lysine.

Maize has become one of the important food, fodder and industrial crop of the world. The total area under maize cultivation in world is 139 M/ha with production of 598 million MT (mmT). In India the total area under this crop is 82.60 Lakh hectares with the production of 167.20 Lakh tonnes. The average productivity is 2020 Kg/ha (Anonymous, 2010). The area under maize in Maharashtra is 7.94 lakh hectares with a production of 18.28 lakh tones and productivity is 2302 Kg/ha (Anonymous, 2011).

Presently 85% of grain produced is used for human consumption. A hand out of India Maize Development Association has listed more than Industrial uses of maize. Zein protein in maize being used in artificial fiber with good tensile strength and wool like properties. The grains of maize are used for production of *Maida,* instant starch and for many other purposes due to its high starch content (66.2%). It contains protein (11.1%), fat (3.6%), fiber (2.75%), mineral matter (1.9%), calcium (20 mg/100g), phosphorus (24.8 mg/100g), iron (0.11 mg/100g) and vitamin (thimine 0.05 mg, riboflavin 0.08 mg, ascorbic acid 11 mg/100g). Maize is only cereal crop, which contains maximum 4 to 7 per cent oil. It is also now emerging as source of edible oil due to high unsaturated fatty acid content. This oil is emerging good to the heart patient.

The invention of heterosis phenomenon, the development of hybrid breeding technology and successful commercial exploitation of heterosis in maize are considered to be significant achievements and land marks in the history of biological sciences during the present century. A number of genotypes e.g., single crosses, three way crosses, double crosses, composites, synthetics, pools, populations etc. are feasible to maize growing farmers for commercial cultivation by virtue of the crop being a highly cross pollinated species.

The recent trend even in the developing and under developed countries is to go for single crosses than for double crosses as the single crosses show higher uniformity and heterosis than the double and three-way crosses. Moreover, seed production in single crosses involves less cost than the double crosses.

In heterosis breeding programme, the selection of parents/inbreds based on their morphological diversity with good combining ability is very important in producing superior hybrids. The analysis of general combining ability and specific combining ability helps in identifying potential parents/inbreds for the production of superior hybrids. The line X tester analysis (Kempthorne, 1957) is one of the simplest and efficient methods of evaluating large number of inbreds/parents for their combining ability.

With this in view, an attempt was made to evaluate eight lines through line X tester design model using five diverse testers with the following objectives.

- To estimate heterosis for grain yield and its components.
- To estimate the general combining ability and specific combining ability effects.
- To estimate the gene effects of grain yield and its component.
- To estimate heritability for different characters.
- To isolate promising inbred lines for exploiting hybrid vigour.

2. REVIEW OF LITERATURE

The literature pertaining to the present investigation has been reviewed under the following headings.

i. Hetrosis
ii. Combining ability
iii. Gene acton
iv. Heritability

2.1 HETEROSIS

The phenomenon of heterosis is of wide spread occurrence in the field of biological science. The study of heterosis has direct bearing on the breeding methodology to be employed for varietal improvement.

Heterosis refers to the superiority of F_1^s (hybrids) in one or more characters over its parents. In other words heterosis refers to increase or decrease in fitness or vigour of over the parental values.

Shull, (1908) suggested the term 'heterosis' for hybrid vigour; heterozygosity or heterotic stimulus.

In brief review of research work done on heterosis in maize has been given below.

2.1.1 Days to 50% tasseling:

Hassaballa *et al.,* (1980), Singh *et al.*, (1998), Sain Dass and Pawan Arora (1999), Chattopadhyay and Dhiman (2005) reported negative heterosis for days to 50% tassseling. However Satya-narayana *et al.*, (1994) reported the heterobeltiosis for maturity components for this trait. Significant average heterosis was noticed by Gomes-e-Gamma *et al.*, (1995), Turgut *et al.*, (1995).

Perez Velasquez *et al.*, (1995) and Ashish-Shrivastava and Singh (2003) also noticed considerable heterotic effects for this traits. Significant standard heterosis was noticed by Mohanraj *et al.*, (2005). significant mid parant and better parent heterosis was reported by Appunu *et al.*, (2007) and Alam and Alam (2009) for days to 50% tasseling.

2.1.2 Days to 50% silking:

The negative heterosis for days to 50% silking was reported over mid, better parents and check by Shrivastava and Singh (2003), Chattopadhyay and Dhiman (2005), Manpreet *et al.*, (2007).

Vasal *et al.*, (1992), Altinbos (1995), Konak *et al.*, (1999) noticed the heterobeltiosis for days to silking. Akthar and Singh (1981) observed mid parent heterosis. Beck *et al.*, (1990) reported low heterosis for this trait. Perez-Velasquez *et al.*, (1995) found heterotic effects. Setiyono and Subandi (1996) in their study of heterosis found that all hybrids showing days to 50% silking earlier than the mid parents values and Appunu *et al.*, (2007) reported that the heterosis over mid and better parent respectively. Mohanraj *et al.*, (2005) and Premalatha *et al.*, (2011) noticed significant desirable standard heterosis for days to 50 percent silking.

2.1.3 Days to maturity:

The negative heterosis over mid and better parents was reported for days to maturity by Kalsy and Sharma (1970), Murthy *et al.*, (1981), Sain Dass and Pawan Arora (1999), Chatopadhyay and Dhiman (2005) and Alam A.K.M.M. Ahmed *et al.*, (2008)

2.1.4 Plant height:

Ganguli *et al.*, (1989), Beck *et al.*, (1990), Vasal *et al.*, (1992), Reddy and Agrawal (1992), Alvarez *et al.*, (1993) and Farhan Ali *et al.*, (2012) reported the positive over better parent. However Gomes-e-Goma *et al.*, (1995) noticed that non-significant heterosis for plant height. San-Vicente *et al.*, (2001), Saleh *et al.*, (2002) was reported positive heterosis for plant height. Appunu *et al.*, (2007) noticed positive heterosis over mid and better respectively. Gissa *et al.*, (2007) noticed significant positive mid parent heterosis for plant height.

2.1.5 Earhead height:

The negative heterosis for earhead height was reported by Mukherjee *et al.*, (1974), Altinbos (1995), Dickert and Tracy (2002), Gissa *et al.*, (2007), Manpreet *et al.*, (2007) and Farhan Ali *et al.*, (2012). However Ganguli *et al.*, (1989) and Petrovic (1998) reported positive heterosis for earhead height.

2.1.6 Ear length:

Verma and Singh (1980), Debnath (1987), Farhan Ali *et al.*, (2012) found positive heterosis over mid and better parants. Kabdal *et al.*, (2003) and Gissa *et al.*, (2007) showed positive heterosis over mid prents. Turgut *et al.*, (1995), Mohanraj *et al.*, (2005), Oja *et al.*, (2007) and Sundarajan and Senthil Kumar (2011) found significant positive heterosis for ear length.

2.1.7 Ear circumferance:

The positive heterosis for ear circumferance was reported by Saleh *et al.*, (2002), Manpreet *et al.*, (2007) and Vijayabharathi *et al.*, (2009). However Debnath (1987) observed low mid parent heterosis for ear circumference. A considerable heterotic effect for this trait was noticed by Turgut *et al.*, (1995). Mohanraj *et al.*, (2005) noticed positive significant standard heterosis. Konak *et al.*, (1999). Gissa *et al.*, (2007) and Oja *et al.*, (2007) reported high heterosis for ear circumference.

2.1.8 Number of Kernel rows per cob:

Mukherjee *et al.*, (1974), Beck *et al.*, (1990), Sharma and Bhalla (1993), Gupta *et al.*, (1994), Netaji *et al.*, (2000), Geetha and Jayaraman (2001) reported the significant positive heterosis for number of kernel rows per cob. However Genova (1984) reported negative heterosis for this trait. Kravencheko *et al.*, (1971) reported that heterosis occured in number of kernel rows per cob. While Rao *et al.*, (1996), Singh (1996), Saleh *et al.*, (2002), Premlatha *et al.*, (2011), Sudarajan and Senthil Kumar (2011) noticed significant positive heterosis for number of kernel rows per cob.

2.2.9 Number of Kernels per row:

Appadurai and Nagarajan (1975), Debnath (1987), Ganguli *et al.*, (1986), Yurankova *et al.*, (1986), Presolka and Kamara (1991), De (1996), Rao *et al.*, (1996), Geetha and Jayaraman (2001), Saad Imran malik *et al.*, (2004) and Vijayabharathi *et al.*, (2009) reported the positive heterosis for number of kernel per row. Mohanraj *et al.*, (2005) and Sundarajan and Senthil Kumar (2011) noticed significant standard heterosis for this trait. Gissa *et al.*, (2007) observed mid parents heterosis for number of kernels per row.

2.1.10 100 grain weight:

The positve heterosis was reported for 100 grain weight by Salillari and Hoxha (1998), Netaji *et al.*, (2000) and Vijayabharthi *et al.*, (2009) over mid and better parent. However

Choudhari and Choudhari (2000) observed heterosis for 100 grain weight.

Kravencheko *et al.*, (1971), Shetty (1974) recorded the significant positive heterosis over mid parents. Radovic (1979) and Shakoor and Ataullah (1980), Verma and Singh (1980) noticed positive heterosis over better parent. However Mukherjee and Shah (1984) and Saha and Mukherjee (1985) reported the positive heterosis over mid and better parent, respectively. Ganguli (1986) observed a considerable range of heterosis over the parental value and also over the standard check variety for the same characters. Petrovic (1998), Kabir (1988), Yurenkova *et al.*, (1986). noticed significant heterosis for 100 grain weight. Premlatha *et al.*, (2011) got significant standard heterosis for 100 grain weight.

2.1.11 Shelling percentage:

For shelling percentage the positive was reported by Muthiah (1989), Saleh *et al.*, (2002), Oja *et al.*, (2007) and Vijayabharthi *et al.*, (2009) over mid, better parents and checks.

2.1.12 Grain yield per plant:

The positive heterosis for grain yield per plant was recorded by Murthy *et al.*, (1981), Pal and Pradhan (1994), Dass (1997), Joshi *et al.*, (1998) and Mahantesh (2006). However Verma and Singh (1980), Ganguli *et al.*, (1989) showed positive heterosis over better parents. Vasal *et al.*, (1992), Satyanarayana *et al.*, (1995) and Parez-Velsquez *et al.*, (1995), Larish and Brewbakar (1999), Ashish–Shrivastva Singh (2003), Gissa *et al.*, (2007) reported positive heterosis over mid parent. Welcker *et al.*, (2005), Selvaraj *et al.*, (2006) reported positive heterosis over both mid and better parents. However San-Vicente *et al.*, (2001) found highly significant heterosis. Nigussie and Zelleke (2001) found considerable heterosis. Turgut *et al*., (1995) and Turgut and Dhuman (2004); Konak *et al*., (1999) reported heterobeltiosis. Shashidhar (2009) and Mahesh (2010) have reported mid, Better parents and standard heterosis for grain yield per plant.

2.1.13 Starch content:

Dubey *et al*., (2001), Idikut *et al*., (2009) and Vijayabharati *et al*., (2009) reported the positive heterosis for the inheritance of starch content.

2.2 Combining ability:

The concept of combining ability is important in the plant breeding as a measure provides the gene action involved in control of yield and other important attributes and thus also provides a basis for adopting a suitable breeding procedure (Sparague and Tatum 1942). The line x tester analysis is a precise approach to estimate the general and specific combining ability effects of parents and at the same time is useful in estimating various types of gene effects (Kempthorne 1957). Sparague and Tatum (1942) defined the term “general combining ability as an average performance of a line in hybrid combination” and the term specific combining ability is used to designate those classes in which certain combination to relatively better or worse than that would be expected on the basis of the average performance of the line involved.

Allard (1960) defined the general combining ability as “the average performance of strain in the series of crosses” and specific combining ability as "the deviation from the performance predicated on the basis of general combining ability”. In general combining ability is defined as "the relative ability of a genotype to transmit its desirable performance to its crosses."

Griffing (1956) is of the opinion tha g.c.a. involved both additive effects as well as additive interaction. (Kempthorne 1957) precisely defined the g.c.a. and s.c.a. variance of half sib and full sib in random mating population as under.

Where,

σ^2 g.c.a = cov. (H.S.) and

σ^2 s.c.a = cov. (F.S.)-2 cov. (H.S.)

General combining ability (g.c.a) is relatively more important in previously unselected material. But, specific combining ability (s.c.a.) seems to have greater importance for the material which is previously selected for general combining ability.

The literature pertaining to the studies on combining ability in maize has been reviewed as given below.

2.2.1 Days to 50% tasseling:

The g.c.a. effects were found to be predominant for day 50% tasseling in studies conducted by Hassaballa *et al.*, (1980), Sanghi (1982), Vasal *et al.,* (1992), EI-Hosary et al., (1994), Altinbos (1995), Mathur and Bhatanagar (1995), Tulu and Ramchandrappa (1998), Paul and Debnath (1999), Talleei and Kochaksaraei (1999), Suryaprakash and Ganguli (2004), Singh *et al.*, (2005) and Farhan Ali *et al.*, (2012). While the significance of s.c.a. effects for this character was noticed by Sanghi (1982), Lee (1983) and Guo *et al.*, (1986). However the significance of both g.c.a. and s.c.a. effects for this character was reported by Tulu *et al.*, (1998), Suneetha *et al.*, (2000), Katna *et al.*, (2005), Alamnie Atnaw *et al.*, (2003).

2.2.2 Days to 50% silking:

Hassaballa *et al.*, (1980), Murty *et al.*, (1981), Sanghi *et al.*, (1982), Vasal *et al.*, (1992), EI-Hosary *et al.*, (1994), Altinbos (1995), San-Vicente *et al.*, (1998), Talleei and Kochaksaraei (1999), Devi and Pradhan (2004), Kumar (2008) reported the g.c.a. effects for days to 50% silking and Seldhom (1994), Deghanapour *et al.*, (1997), Suneetha *et al.*, (2000), Jayakumar and Sundaram (2007) and Alam *et al.*, (2008) reported the positive s.c.a. effects. However significance of both s.c.a. and g.c.a. effects were reported for days to 50% silking by Hassaballa *et al.*, (1980), Lee *et al.*, (1986), Preciado *et al.*, (1997), Paul and Debnath (1999) and Premlatha (2011).

2.2.3 Days to maturity:

The s.c.a. effects were found to be predominant for days to maturity in the studies conducted by Murthy *et al.*, (1981), Sanghi *et al.*, (1982), Satyanarayana *et al.*, (1994), Paul and Debnath (1999) and Mahantesh (2006). However Kalsy and Sharma (1970) and Alam *et al.*, (2008) noticed that predominant role of g.c.a. effects for this traits. The significance of both g.c.a. and s.c.a. effects for days to maturity was noticed by Mathur and Bhatnagar (1995), Habtamu (2000), Zelleke (2000) and Alamnie Atnaw *et al.*, (2003).

2.2.4 Plant height:

The s.c.a. effects were found to be predominant for plant height in studies conducted by Herbert and Gallis (1986), EI-Hoasary *et al.*, (1994), Dehghanapour *et al.*, (1997), Petrovic (1998), Rana and Vinod (2001), Rakesh-Kumar *et al.*, (2005), Jayakumar and Sundaram (2007), Alam *et al.*, (2008) and Premlatha and Kalmani (2011). While Cross *et al.*, (1987), Vasal *et al.*, (1992), Zheng-Zuping *et al.*, (1995), Tulu *et al.*, (1998), Konak *et al.*, (1999), Nigusse and Zelleke (2001), Vacaro *et al.*, (2002), Shreenivasa *et al.*, (2003), Wu-Guang Cheng *et al.*, (2003), Suryaprakash *et al.*, (2004) and Kumar (2008) reported the g.c.a. effects for inheritance of plant height. However Paul and Debnath (1999), Zelleke (2000), Singh (2001), Alamine *et al.*, (2003) noticed the significance of both g.c.a. and s.c.a. effects for plant height.

2.2.5 Earhead height:

Dhillon and Singh (1976), Hassaballa *et al.,* (1980), Sanghi (1982), Vasal *et al.,* (1992), EI-Hosary *et al.*, (1994), Altinbos (1995), Tulu and Ramchandrappa (1998), Talleei and Kochaksaraei (1999) and Premlatha and Kalamani (2010) reported the significance effects for earhead height. While Seldhom (1994), Saikumar (2002) and EI-Moula *et al.*, (2004) reported the predominant of s.c.a effects for this character. However Narain (1978), Zambezi *et al.*, (1986), Catherine and Pollak (1988), Paul and Debnath (1999) and Zelleke (2000) reported the significance of both g.c.a. and g.c.a. effects for earhead height.

2.2.6 Ear length:

The s.c.a. effects were found to be predominant for ear length in the studies conducted by Ali and Topera (1986), Pal and Pradhan (1994), Seldhom (1994), Sinobas and Monteagudo (1994), Khristova *et al.*, (1995), Konak *et al.*, (1999), Suneetha (2000), Rana and Vinod kumar (2001), Kara (2001), Rakesh-Kumar *et al.*, (2005) and Jayakumar and Sundaram (2007). While Ijardar (1977), Debnath and Sarkar (1990), Aly (1999), Habtambu (2000), Zelleke (2000), Li-Jizhu *et al.*, (2004) noticed that the significance of both s.c.a. and g.c.a. effects for ear length. However Mathur and Bhatnagar (1995), Mathur *et al.*, (1998), Ashish and Singh (2003), Yu-Hai Qui *et al.*, (2003), Wu-Guang Cheng *et al.*, (2003), Surya-Prakash and Ganguli (2004), Rakesh-Kumar *et al.*, (2005), Kumar (2008).

2.2.7 Ear circumference:

Bhalla and Khehra (1977), Mohammad (1993), EI-Hosary *et al.*, (1994), Sinobas and Monteagudo (1994), Oja *et al.*, (2007) reported significant s.c.a. effects for ear circumference. However Gul *et al.*, (1998) and Aly (1999) noticed that both g.c.a. and s.c.a. effects predominant for ear circumference. Dhillion and Singh (1976), Quadri *et al.*, (1983), Pal and Pradhan (1994), Altinbos (1995) and Mathur and Bhatnagar (1995) reported significant g.c.a. effects for ear circumference.

2.2.8 Number of kernel rows per cob:

The s.c.a. effects were found to be predominant for number of kernel per cob in the studies conducted by Pal and Pradhan (1994), Packiaraj (1995), Dehghanapour *et al.*, (1997), Kumar *et al.*, (1998) and Premlatha *et al.*, (2011). However Narain (1978), Mathur *et al.*, (1998) and Petrovic (1998), Singh and Singh (1998), Malik *et al.*, (2004) reported g.c.a. effects for number of kernel rows per cob.

2.2.9 Number of Kernels per row:

The s.c.a. effects were found to be predominant for number of kernels per row in studies conducted by Pal and Pradhan (1994), Deghanapour *et al.*, (1997), Kumar *et al.*, (1998), Rakesh kumar *et al.*, (2005) and Ali Akeel Wannows *et al.*, (2010). The significance of both s.c.a. and g.c.a. effects was reported by Prasad *et al.*, (1988), Debnath and Sarkar (1990), Kumar *et al.*,

(1998) and Neha Singhal (2000). However, Satyanarayana *et al.*, (1990), Pal and Pradhan (1994), Mathur *et al.*, (1998), EI-Shouny *et al.*, (2005), Premlatha *et al.*, (2011) reported predominant role of g.c.a effects for the number of kernels per row.

2.2.10 100 Grain weight:

Bhalla and Khehra (1977), Verma and Singh (1980), Kimani (1984), Alika (1994), Pal and Pradhan (1994), Mathur and Bhatnagar (1995), Turgut *et al.*, (1995), Shrivastava and Singh (2003), Malik *et al.*, (2004), Manpreet *et al.*, (2007), Alam *et al.*, (2008) reported significant g.c.a. effects for 100 grain weight. While the significance of both s.c.a. and g.c.a. effects were significant in the studies conducted by Habtamu (2000) and Zelleke (2000). However Murty *et al.*, (1981), Mohamed (1993), Deghanapour *et al.*, (1997). Saikumar (2002), Singh *et al.*, (2005) and Premlatha *et al.*, (2011) noticed that g.c.a. effect were significant for 100 grain weight.

2.2.11 Shelling percentage:

The s.c.a. effects were found be predominant for shelling percentage in the studies conducted by Muthiah (1989), Saleh *et al.*, (2002) and Vijayabharati *et al.*, (2009). However Cross and Wildakas (1975), Pakiaraj (1995), Mathur *et al.*, (1998) and Oja *et al.*, (2007) reported significant g.c.a. effects for shelling percentage.

2.2.12 Grain yield per plant:

The predominance of s.c.a. effects for grain was recorded by Ramamurthy (1980), EI-Hosary *et al.*, (1994), Seldhom (1994), Packiaraj (1995), Satyanarayana (1995), Saikumar (2002), EI-Moula *et al.*, (2004), Rodrigues *et al.*, (2005). While Cross and Wildakas (1975), Singh *et al.*,(1977), Vasal (1992), Mohamed

(1993), San-Vicente *et al.*, (1998), Tulu and Ramchandrappa (1998), Talleei and Kochaksaraei (1999), Shreenivasa *et al.*, (2003), Vacaro *et al.*, (2002) and EI-Shouny *et al.*, (2005) reported the significance of g.c.a. effects for grain yield per plant. However the significance of both s.c.a. and g.c.a. effects for grain yield per plant was reported by Zambezi *et al.*,(1986), Turgut *et al.*, (1995), Saindass *et al.*, (1992), Pal and Pradhan (1994), Preciado *et al.*, (1997), Aly (1999), Habtamu (2000) and Premlatha and Kalamani (2010) for grain yield per plant.

2.2.13 Starch content:

The s.c.a. effects were found to be predominant for starch content in the studies conducted by Satyanarayana *et al.*, (1994), Joshi (1998) and Has, V. (1999).

2.3 Gene action:

The literature on gene action governing various characters in maize is reviewed in brief as follows:

2.3.1 Days to 50% tasseling:

The additive genetic effects were found to be controlling days to 50% tasseling in studies conducted Hassaballa *et al.*, (1980), Mathur and Bhatnagar (1995), Gul *et al.*, (1998), San-Vicente *et al.*, (1998), Paul and Debnath (1999), Suryaprakash and Ganguli (2004). However Lee (1983), Guo *et al.*, (1986), Ashish-Shrivastava *et al.*, (2003), Rakesh Kumar *et al.*, (2005), Jayakumar and Sundaram *et al.*, (2007) reported the importance of non-additive genetic effects. The significance of both additive and non-additive gene action for days to 50% tasseling was reported by Singh and Singh (1998), Tulu *et al.*, (1998), Suneetha *et al.*, (2000), Zelleke (2000), Arun kumar (2001), Singh (2005), AL-Alhmad *et al* ., (2004), Katna (2005), Alamnie Atnaw *et al.,* (2003).

2.3.2 Days to 50% Silking:

The importance of additive genetic effects for days to 50% silking was reported by Singh *et al.*, (1983), Vasal *et al.*, (1992), EI-Hosary *et al.*, (1994), Altinbos (1995), Mathur *et al.*, (1998), Paul and Debnath (1999), Talleei and Kochaksaraei (1999), Nigussie and Zelleke (2001), Ashish and Singh (2003), Devi and Pradhan (2004), Kumar (2008). However non-additive genetic effects were reported by Paul and Duara (1991), Dehghanapour *et al.*, (1997), Seldhom (1994), Suneetha *et al.*, (2000), Jayakumar and Sundaram (2007) and Alam *et al.*, (2008) and the significance of both additive and non-additive gene action was noticed Hassaballa *et al.*, (1980), Lee *et al.*, (1986), Dahlan *et al.*, (1997), Singh *et al.*, (1998), Arun Kumar (2001), Alamnie Atanaw *et al.*, (2003) for inheritance of days to 50% silking.

2.3.3 Days to maturity:

The non-additive genetic effects were found to be controlling days to maturity in studies of the Satayanarayana *et al.*, (1994), Paul and Debnath (1999) and Alam *et al.*, (2008). While the additive gene action for days to maturity were reported by Kalsy and Sharma (1970), Alam *et al.*, (2008). However importance of both additive and non-additive gene action for days to maturity was showed by Mathur and Bhatnagar (1995) and Alamine Atnaw *et al.*, (2003).

2.3.4 Plant height:

The plant height was found to be controlled by additive genetic effects in the studies conducted by Zheng-Zuping *et al.*, (1995), Cross *et al.*, (1987), Cross *et al.*, (1990), Vasal *et al.*, (1992), Konak *et al.*, (1999), Nigussie and Zelleke (2001), Katna *et al.*, (2002), Vacaro *et al.*, (2002), Suraprakash *et al.*, (2004), Jumbo *et al.*, (2008), Premlatha and Kalmani (2010). While EI-Hosary *et al.*, (1994a), Dehghanapour *et al.*, (1997), Petrovic (1998), Rana and Vinod (2001), Suryaprakash and Ganguli (2004), Jayakumar and Sundaram (2007), reported the non-additive gene action for plant height. However significance of both additive and non-additive gene action for plant height was showed by Kumar *et al.*, (1998), San Vicente *et al.*, (1998), Singh *et al.*, (1998), Suneetha (2000), Zelleke (2000), Katna *et al.*, (2005), Singh (2005) and Gautam *et al.*, (2008).

2.3.5 Earhead height:

The importance of additive genetic effects for earhead height was reported by Nawar (1986), Pal *et al.*, (1986), Zambezi *et al.*, (1986), Shahi and Singh (1986), Mahajan and Khehra (1991), EI-Hosary *et al.*, (1994), Altinbos (1995) and Paul *et al.*, (1999). While the significance of non-additive gene action for earhead height was showed by Alamnie *et al.*, (2003), Deghanapour *et al.*, (1997), Alam *et al.*, (2008) and Permlatha and Kalamani (2010). However significance of both additve and non-additive gene action was reported by Debnath and Sarkar (1987), Kumar *et al.*, (1998) and Malik *et al.*, (2004).

2.3.6 Ear length:

EI-Hosary *et al.*, (1994), Mathur and Bhatnagar (1995), Ashish and Singh (2003), Wu-Guangcheng *et al.*, (2003), Devi and Pradhan (2004), Suryaprakash *et al.*, (2004), Rakesh Kumar *et al.*, (2005), Kumar (2008) reported the additive genetic effects for ear length. However, Ali and Topera (1986) and Khristova *et al.*, (1995) reported the non-additive gene effects for this traits and significance of both additive and non-additive gene action was showed Shen and Lai (1987), Debnath and Sarkar (1990), Singh (1996), Li-Jizhu *et al.*, (2004), Katna *et al.*, (2005), Neha-Singhal *et al.*, (2006) for ear length.

2.3.7 Ear circumferance:

EI-Hosary *et al.*, (1994a), Sinobas and Monteagudo (1994), Kumar *et al.*, (1998), Rana and Vinod Kumar (2001), Devi and Pradhan (2004), Rakesh Kumar *et al.*, (2005) and Jayakumar and Sundaram (2007) reported the greater influence of the non-additive gene action for ear circumference. Sanghi (1982) and Mathur and Bhatnagar *et al.*, (1995), Mathur *et al.*, (1998), Kumar (2008) observed the influence of the additive gene action. However the significance of both additive and non-additive gene action was reported by Sharma *et al.*, (1982) and Turgut *et al.*, (1995), Zelleke (2000), Katna *et al.*, (2005), Neha-Singhal *et al.*, (2006) for ear circumference.

2.3.8 Number of kernel rows per cob:

Nevada and Cross (1990), Mathur *et al.*, (1995), Singh (1996), Mathur (1998), Petrovic (1998), Suryaprakash and Ganguli (2004) and Devi (2007) showed the additive genetic effects for number of kernel per rows cob. However Pal and Pradhan (1994), Singh (1996) Kumar *et al.*, (1998), Kabdal *et al.*, (2003) and Li-jizhu *et al.*, (2004) reported that non-additive gene action for number of kernel rows per cob. While the significance of both additive and non-additive for this character was reported by Singh (2005).

2.3.9 Number of Kernels per row:

In the studies conducted by Muthiah *et al.*, (1989), Satyanarayana *et al.*, (1990), Pal and Pradhan (1994), Dehghnapour *et al.*, (1997), Rakesh Kumar *et al.*, (2005), Ali Akeel Wannows *et al.*, (2010) the preponderance of non-additive genetic effects was observed for number of kernel per row. However Mathur *et al.*, (1998), Devi and Pradhan (2004), Surya Prakash *et al.*, (2004) and Premlatha *et al.*, (2011) reported additive gene action for this traits. The significance of both additive and non- additive gene action was showed by Kumar *et al.*, (1998) and Neha-Singhal *et al.*, (2006)

2.3.10 100 Grain weight:

Dehghanapour *et al.*, (1997), Satyanarayana *et al.*, (1990), Anuradha *et al.*, (1993), Suneetha *et al.*, (2000), Shrivastava and Singh (2003), Yu-HaiQui *et al.*, (2003), Manpreet *et al.*, (2007) and Vijayabharathi *et al.*, (2009) reported the non-additive gene action for 100 grain weight. However the significance of additive gene action for inheritance of 100 grain weight was reported by Ramamurthy (1980), Shahi and Singh (1986), Pal and Pradhan (1994), Turgut *et al.*, (1995), Joshi *et al.*, (1998). While the significance of both the additive and non-additive gene action was showed Yadhav *et al.*, (2002), Katna *et al.*, (2005), Neha-Singhal *et al.*, (2005).

2.3.11 Shelling percentage:

The importance of non-additive genetic effects found for shelling percentage was showed by Muthiah (1989), Saleh *et al.*, (2002) and Vijayabharathi *et al.*, (2009). Mathur *et al.*, (1998) reported additive gene action for shelling percentage. However the significance of both additive and non-additive gene action for this trait was showed by Mahto and Ganguli (2001).

2.3.12 Grain yield per plant:

Cross *et al.*, (1990), Debnath and Sarkar (1990), Pal and Daura (1991), Mohammad (1993), Damborsky *et al.*, (1994), Pal and Pradhan (1994), Zheng-Zuping *et al.*, (1995), Rodrigues *et al.,* (2005), Manpreet (2007), Dubey *et al.,* (2009), Vijayabharathi *et al .,* (2009) reported non-additive gene action for grain yield per plant. However Sanghi *et al.*, (1982), Vasal *et al.*, (1992), Mathur (1998), Devi and Pradhan (2004), Surya-Prakash *et al.*, (2004), Selvaraj *et al.*, (2006) showed the additive gene action for grain yield per plant. The significance of both additive and non-additive gene action was observed by Tulu *et al.*, (1998), Turgut *et al.*, (1995), Mahto and Ganguli (2001), Zelleke (2000), Gautam (2008) for grain yield per plant.

2.3.13 Starch content:

The reports by Satnarayana *et al.*, (1994), Joshi (1998) and Has, V. (1999) showed the importance of non-additive gene effects for inheritance of starch content.

2.4 Heritability:

Heritability is a useful measure of considering the ratio of genetic variance to the total phenotypic variance. Lush (1945) has defined the heritability as the “the portion of observed variance for which difference in the heritability is responsible.

According to Allard (1960) heritability specifies, “The proportion of total variability that is due to the genetic variance".

Heritability in narrow sense is the ratio of "additive genetic variance to the total phenotypic variance” and measure the portion of the total variation which can be utilized for the improvement of given population with respects to that trait by selection.

The literature on the previous studies on heritability in maize has been reviewed as given below.

2.4.1 Days to 50% tasseling:

Singh *et al.*, (1989) reported high values of heritability for days to 50% tasseling.

2.4.2 Days to 50% Silking:

For days to 50% silking high heritability was recorded by Singh *et al.*, (1989), while the medium heritability was showed by Amer and Mosa (2004), Saleh *et al.*, (2002) noticed low heritability for days to 50% silking.

2.4.3 Plant height:

The high heritability for plant height was reported by Yassein (1999). However Amer and Mosa (2004) noticed medium heritability for this trait.

2.4.4 Earhead height:

For earhead height high heritability was reported by Mohammad and Mohammad (2000) and medium heritability by Amer and Mosa (2004).

2.4.5 Ear length:

The medium heritability for ear length was reported by Yassein (1999) and low heritability by Amer and Mosa (2004).

2.4.6 Ear circumference:

Yassein (1999) reported high heritability for ear circumference, while the medium heritability was showed by Amer and Mosa (2004).

2.4.7 Number of Kernel rows per cob:

Geetha (1997), Yassein (1999) and Mohammad. Y. and Mohammad S. (2002) reported medium heritability for number of kernel rows per cob. However Saleh (2002) noted low heritability.

2.4.8 Number of kernels per row:

Amer and Mosa (2004) and Abdolhamid Rezaei *et al., (*2004) reported the low heritability for number of kernels per row. While medium heritability was showed by Amer and Mosa (2004). However Yassein (1999) reported high heritability for this trait.

2.4.9 100 grain weight:

The medium heritability for 100 grain weight was showed by Yassein (1999). However Saleh (2002) reported the low heritability.

2.4.10 Grain yield per plant:

Low heritability was reported by Yassein (1999), Aboudeif, M. H. (2003) and Ali Akheel Wannows (2010). However Satyanarayana (1994), Saleh et al., (2002) and Amer and Mosa (2004) noticed medium heritability for grain yield per plant.

3. MATERIAL AND METHODS

The present investigations on “Line X tester analysis in maize (Zea mays L.)” were conducted during *Kharif* 2011 at Post Graduate Research Farm, College of Agricultural, Kolhapur. The crossing programme was implemented during Rabi-2010-2011 at Maize Improvement, Project Kasba Bawada, Kolhapur. The material used and statistical procedures followed during the course of investigation are described as below.

3.1 Experimental Material

The present study was undertaken on Line X tester analysis in which set of 40 different crosses, 13 inbred lines, comprising 8 females and 5 males and 2 checks were used. The inbred lines were collected from Maize Improvement Project Kasba Bawda, Kolhapur. Genotype possessing diversity for yield and other component were selected.

3.1.1 Females:

1) 673-2

The height of the inbred is 165 to 170 cm and matured in 92 days. The seed is flint in shape and orange yellow in colour.

2) Hyd-08R-8214-43

This inbred was matured in 97.00 days with plant height of 170 to 175 cm. The seed is flint in shape and orange yellow in colour.

3) Hyd-08R-2630-2

This inbred grows 160 to 170 cm and matured in 96.00 days. The seed is flint in shape and yellow in colour.

Pedigree of 13 Parents

Sr. No.	Parents	Pedgree	Days to maturity	Plant height (cm)	Earhead height (cm)	Shape and Grain colour
	Females					
1	673-2	EC619144	92	165-170	80-85	Flint, Orange yellow
2	Hyd-08R-8214-43		97	170-175	65-75	Flint, Orange yellow
3	Hyd-08R-2630-2	JCY-1-2-1-1B-1-2-3-1-1-1	96	160-170	60-65	Flint, yellow
4	N-8211-35		99	165-175	60-70	Flint, yellow
5	679-1	EC619150	98	170-180	75-80	Flint, yellow
6	2372-1	PFSR/51016-1	95	160-170	70-75	Dent, Orange
7	2392-2	LM6	98	155-165	70-75	Flint, Orange yellow
8	Hyd-08R-8214-31		97	160-170	72-75	Flint, yellow
	Males					
1	N-8203-1		95	160-170	70-75	Flint, yellow
2	N-8215-1		96	170-180	70-75	Dent, Orange yellow
3	644-1	EC619115	95	160-170	65-75	Dent, yellow
4	N-8213-48		96	180-190	100-105	Flint, Orange
5	N-8215-4		97	190-200	70-80	Flint, Orange yellow

4) N-8211-35

The plant height of this inbred is 165 to 175 cm and takes 99.00 days for maturity with flint yellow grain.

5) 679-1

This inbred matured in 98.00 days with plant height 170 to 180 cm. The seed is flint in shape and yellow in colour.

6) 2372-1

The height of inbred is 160 to 170 cm and matured in 95.00 days. The seed is dent in shape and orange in colour.

7) 2392-1

This inbred matured in 98.00 days with plant height 155-165 cm. The seed is flint in shape and orange yellow in colour

8) Hyd-08R-8214-31

This inbred grows 160 to 170 cm tall and matured in 97.00 days. The seed flint in shape and yellow in colour.

3.1.2 Males:

1) N-8203-1

This inbred grows in 160-170 cm and matured in 95 days. The seed is flint and yellow in colour.

2) N-8215-1

This inbred matures in 96.00 days with plant height 170-180 cm. The seed is dent in shape and orange yellow in colour.

3) 644-1

The plant height of this inbred is 160-170 cm and matures in 95 days. The seed is dent in shape and yellow in colour.

4) N-8213-48

This inbred matures in 96.00 days with plant height 180-190. The seed was flint in shape and orange in colour.

5) N-8215-4

The plant height of the inbred is 190-200 cm and matures in 97.00 days .The seed is flint and orange yellow in colour.

3.2 Methods:

Total 40 crosses were effected. The crossed seed was obtained during Rabi-2010-2011 at AICRP on Maize, Kasba Bawda, Kolhapur. The hybrids along with parents (13) were grown and tested in RBD with three replications during *Kharif* 2011 at Post Graduate Research Farm, College of Agricultural, Kolhapur.

Maize is a monoecious and cross-pollinated crop. To effect crosses the ear shoot were covered with butter paper bag (silk bags) firmly anchored between stem and ear-leaf aurical, before silk emergence from husk tips. The tassel of pollinator parents were covered with tassel bags in the afternoon and the pollens were collected for pollination next day morning to avoid contamination with the wind borne pollen. The ears were pollinated in the morning between 8 to 11 a.m. within two to three days of silk emergence. The silk bags were carefully lifted and pollen dusted on the silk. Silk bags were placed over ear node and fastened around the stem. The parents were selfed to get the seed. The seed of each cross and parent was separately harvested, dried, labeled and preserved properly.

All possible care was taken at the time of pollination to avoid contamination. The crossing was done in Line X tester fashion and selfing of parents to obtain seeds of 40 crosses and 13 parents. All the package of practices were followed for good crop growth.

3.3 Experimental trial

3.3.1 Layout :

The experiment was laid out randomized block design with three replication. The total number of treatment were 55 comprising of 40 crosses, 8 females and 5 males parents and checks *viz*; Rajarshi and Bio-9637 were included.

A uniform piece of land was selected for the trial. It was ploughed, harrowed and stubbles of previous crop were collected and brought to the fine tilth. F.Y.M. (10 tons/ha.) was applied. The experiment was laid out in the randomized block design with three replications.

3.3.2 Sowing:

The final experiment comprising 55 treatments and 2 checks with three replication sown in light soil during Kharif-2011 at Post Graduate Research farm, College of Agriculture, Kolhapur. The sowing was completed by dibbling 2-3 seeds per hill at the spacing of 75 x 20 cm. Each treatment had two rows of 4 m length. Gap filling was done after a week. Two weeks after germination, only one healthy plant was kept at each hill and a basal dose of 60 kg N, 60 kg P_2O_5 and 40 kg K_2O per ha was applied through urea, diamonium phosphate and murate of potash. After 30 days from sowing a dose of 30 Kg N/ha and after 45 days remaining 30 Kg N/ha was given through urea. Timely and proper cultural practices were followed to have satisfactory crop growth.

3.4 Observations recorded

Five random plants from each treatment in each replication were selected for recording observations. The selected plants were tagged at the age of 35 days. The following observations were recorded on the five plants from each genotype at different growth stages of crop and average values per plant were worked out.

3.4.1 Morphological characters:

3.4.1.1 Days for 50% tasseling

The number of days from date of sowing to pollen shedding by 50% plants in each genotype was recorded.

3.4.1.2 Days to 50% silking

The number of days taken from the date of sowing to the appearance of silk in 50 per cent of plants was recorded as days to 50% silking.

3.4.1.3 Days to maturity

Number of days required for drying of first husk of the ear in 50% of plants in each plot was recorded as days to maturity.

3.4.1.4 Plant height (cm)

Plant height was measured from ground level to flag leaf of shoot in cm with the help of meter scale.

3.4.1.5 Earhead height (cm)

It was taken from ground level to the lower end of ear.

3.4.1.6 Ear length (cm)

It was taken from base of earhead to the top of earhead.

3.4.1.7 Ear circumference (cm)

Girth of cobs was measured in cm from the middle portion of the cobs and average cob girth of five cobs drawn at random was considered as ear circumference.

3.4.1.8 Number of Kernel rows per cob

Total number of kernel rows on each cob/ear of observational plants was counted and average was recorded as number of kernel rows per cob.

3.4.1.9 Number of Kernels per row

Number of kernels in each kernel row was counted and average was recorded as number of kernels per row.

3.4.1.10 100 grain weight (g)

Weight of 100 grain drawn from a random sun dried sample from each plot was recorded in grams.

3.4.1.11 Shelling percentage (%)

The ratio of total grain weight per cob to the total weight of earhead in percentage was worked out as shelling percentage.

$$\text{Shelling}\,(\%) = \frac{\text{Grain weight}}{\text{Total weight (Grain weight + pitch weight)}} \times 100$$

3.4.1.12 Grain yield per plant (g)

Dried cobs from observational plants in each plot were shelled and the weight was recorded. The average of the weight was recorded as in grams grain yield per plant.

3.4.2 Qualitative characters:

3.4.2.1 Grain colour:

The colour was recorded by visual observations in the parents, hybrids and checks.

3.4.2.2 Grain shape:

In Maize the shape of grain yield is dent, semi-dent, flint and semi-flint. It was recorded by visual observations in the parents, hybrids and checks.

3.4.3 Bio-chemical characters:

Starch:

Starch content in seed was estimated by usual chemical analysis using Anthrone Reagent method as per procedure given by Om Prakash *et al.*, (2012). The absorbance or optical density recorded on Spectronic-20 Spectrophotometer at 620 nm was scored against the concentration of a stock solution on a standard curve.

3.5 Statistical analysis

The mean data collected for each character on individual plant basis for five observational plants were averaged and the mean values thus obtained were used for statistical analysis.

3.5.1 Analysis of variance:

The first step in the line x tester analysis is to perform analysis of variance for Randomized Block Design (R.B.D.) to test the significance of differences among the genotypes including crosses and parents.

The analysis of variance for all metric traits under study was carried out as follows.

ANOVA

Sr. No.	Source of	D.F.	S.S.	M.S.S.	F value Calculated Tab.	Table value
1.	Replications	(r-1)	R.S.S.	$\frac{R.S.S.}{(r-1)}$	$\frac{R.M.S.S.}{E.M.S.S.}$	
2.	Treatments	(n-1)	T.S.S.	$\frac{T.S.S.}{(n-1)}$	$\frac{T.M.S.S.}{E.M.S.S.}$	
3.	Error	(r-1)(n-1)	E.S.S.	$\frac{E.S.S.}{(r-1)(n-1)}$	--	
	Total	**(rn-1)**				

1. C.F. $= \frac{(G.T.)^2}{r \times n}$

2. Total S.S. = Total sum of square of all the observations – C.F.

3. Replication S.S. $= \frac{\text{S.S. for all replication totals}}{n} - C.F$

4. Treatment S.S. $= \frac{\text{S.S. for all treatment totals}}{r} - C.F.$

5. Error S.S. = Total S.S –(Replication S.S. + Treatment S.S.)

Where,

r	=	Number of replications.
n	=	Number of treatments.
G.T.	=	Grand total.
S.S.	=	Sum of square.
C.F.	=	Correction factor.
R.S.S.	=	Replication sum of squares.
T.S.S.	=	Treatment sum of squares.
E.S.S.	=	Error sum of squares.
M.S.S.	=	Mean sum of squares.

The metric traits which appeared to be significant were further subjected to line x tester analysis.

In order to test the significance of crosses and parents individually; further partitioning of treatment S.S. was done for males, females, male's Vs females, hybrids and hybrids Vs parents.

Sr. No.	Source of	D.F.	Mean sum of square	F value Calculated Tab.	Table value
1.	Replications	(r-1)			
2.	Treatments	(n-1)			
3.	Parents	(p-1)			
4.	Hybrids	(h-1)			
5.	Parents Vs hybrids	(1)			
6.	Males	(m-1)			
7.	Females	(f-1)			
8.	Males Vs females	(1)			
9.	Error	(r-1)(n-1)			
	Total				

Where,

r = Number of replications.

n = Number of treatments.

p = Number of parents.

h = Number of hybrids.

m = Number of males.

f = Number of females.

3.5.2 Estimation of values of heterosis over superior and mid parental values:

The values of the estimates of the heterosis were estimated as given below.

1. Per cent heterosis over BP = $\dfrac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$

Where,

$\overline{F_1}$ = Mean of F_1 hybrid.

$\overline{BP}$ = Mean performance of Better parent.

2. Per cent heterosis over MP = $\dfrac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$

Where,

$\overline{F_1}$ = Mean of F_1 hybrid.

$\overline{MP}$ = Mean of the two Check of that particular F_1.

$$= \frac{\overline{P_1} + \overline{P_2}}{2}$$

$$3.\ \text{Per cent heterosis over SC} = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$$

Where,

$\overline{F_1}$ = Mean of F_1 hybrid.

$\overline{SC}$ = Mean performance of the Standard Check.

The heterosis was tested by the least significant difference as below.

LSD for BP and SC

$$= \sqrt{\frac{2\ me}{2r}} \times t \text{ at 5\% and 1\% level of significance for error d.f.}$$

$$\text{LSD for MP} = \sqrt{\frac{3\ me}{2r}} \times t \text{ at 5\% and 1\% level of significance for error d.f.}$$

Where,

me = Error mean sum of squares

r = Number of replications

3.5.3 Analysis of variance for combining ability:

Combining ability analysis for 40 hybrids was based on the procedure developed by Kempthorne (1957); related to Design-II Comstock and Robinson (1952). The sum of square due to different factors was partitioned as shown below.

Sr. No.	Source of	D.F.	S.S.	M.S.S.	Expected M.S.
1	Replications	(r-1)	$\frac{\sum x^2...k}{mf} - \frac{x^2...}{mfr}$	———	———
2	Hybrids	(mf-1)	$\frac{\sum x^2 (ij)..}{r} - \frac{x^2...}{mfr}$	———	———
3	i) Males	(m-1)	$\frac{\sum x^2 1..}{fr} - \frac{x^2...}{mfr}$	M1	δ2 + r [Cov. (F.S.)-2Cov. (H.S.)] + [fr. Cov. (H.S.)]
	ii) Females	(f-1)	$\frac{\sum x^2 j..}{mr} - \frac{x^2...}{mfr}$	M2	δ2 + r [cov. (F.S.)-2 cov. (H.S.)] + [mr. Cov. (H.S.)]
	iii) Males X Females	(m-1) (f-1)	$\frac{\sum x^2 (ij).}{r} - \frac{x^2 1...}{fr}$	M3	δ2 + r [Cov. (F.S.) - 2 Cov. (H.S.)]
	iv) Error	(r-1) (mf-1)	By subtraction	M4	
	Total	**(mfr-1)**	$\sum \mathbf{x2(ij)K} - \frac{\mathbf{x2...}}{\mathbf{mfr}}$		

Where,

m = Number of male parents.

f = Number of female parents.

r = Number of replications.

x... = Grand total.

x..k = Sum of the k^{th} replication.

x.j. = Sum of the j^{th} female parent over all male parents and replications.

x(ij) = Sum of the ij^{th} hybrid combination over all replications.

xi.. = Sum of the i^{th} male parents over all females and replications.

xijk = $(ij)^{th}$ observation in k^{th} replication

M_1 = Mean sum of squares of males.

M_2 = Mean sum of squares of females.

M_3 = Mean sum of squares of males x females interaction.

M_4 = Error mean sum of squares.

From the expectation of mean square Co-variance of full sibs /Cov. (F.S.)/ and Co-variance of half sib /Cov. (H.S.)/ were estimated as follows.

$$\text{Cov. (H.S.)} = \frac{(M_1 - M_3) + (M_2 - M_3)}{r\,(M+f)}$$

$$\text{Cov. (F.S.)} = \frac{(M_1 - M_4) + (M_2 - M_4) + (M_3 - M_4)}{3r} + \frac{6r\ \text{Cov. (H.S.)} - r(M+f)\ \text{Cov. (H.S.)}}{3r}$$

After estimating the Cov. (H.S.) and Cov. (F.S.) by above equations; variance due to general combining ability (δ^2 g.c.a.) and variance due to specific combining ability (δ^2 s.c.a.) were estimated as.

δ^2 g.c.a. = Cov. (H.S.)

here breeding coefficient =1

δ^2 s.c.a. = [Cov. (F.S.)-2 Cov. (H.S.)]

3.5.4 Percentage contribution of males; females; males X females interaction to S.S. for hybrids:

The percentage contribution of males; females and males X females to the hybrid were calculated as.

1. Percentage contribution of males. $= \frac{\text{Male S.S.}}{\text{Hybrid S.S.}} \times 100$

2. Percentage contribution of females $= \frac{\text{Females S.S.}}{\text{Hybrid S.S.}} \times 100$

3. Percentage contribution of males X females $= \frac{\text{Male X Female S.S.}}{\text{Hybrid S.S}} \times 100$

3.5.5 Estimation of general and specific combining ability effects:

The model used to estimate the general and specific combining ability effects of the ijkth observation was:

xijk = U + gi + gj + sij + ei jk

Where;

U = Population mean.

gi = g.c.a. effect of i^{th} male parent.

gj = g.c.a. effect of j^{th} female parent.

Sij = s.c.a. effect of the $(ij)^{th}$ combination.

ei jk = Error associated with the observation Xi jk.

i = Number of male parents 1,2,....m.

j = Number of female parents, 1,2,....f.

k = Number of replications, 1,2,3,....r.

The individual effects were estimated as follows.

a) $$U = \frac{x...}{mfr}$$

Where,

x... = Grand total.

b) $$gi = \frac{xi..}{fr} - \frac{x...}{mfr}$$

Where,

xi.. = Total of i^{th} male parent over all female and replications.

c) $$gj = \frac{x.j.}{mr} - \frac{x...}{mfr}$$

Where,

Xij.= Total of j^{th} female parent over all male parents and replications.

d) $$sij = \frac{xij.}{r} - \frac{Xi..}{fr} - \frac{x.j.}{mr} + \frac{x...}{mfr}$$

Where,

Xij = $(ij)^{th}$ combination total over all replications.

m = Number of male parents.

f = Number of female parents.

r = Number of replications.

3.5.6 Calculation of S.E. of difference between general and specific combining ability effects of two parents:

i) $$\text{Var. } (gi_1 - gi_2) \text{ males} = \frac{2 \text{ (Error variance)}}{fr.}$$

$$\text{S.E. } (gi_1 - gi_2) \text{ males} = \sqrt{\text{var. } (gi_1 - gi_2) \text{ males}}.$$

ii) $$\text{Var. } (gj_1 - gj_2) \text{ females} = \frac{2 \text{ (Error variance)}}{rm}$$

$$\text{S.E. } (gj_1 - gj_2) \text{ females} = \sqrt{\text{var. } (gj_1 - gj_2) \text{ females}}.$$

iii) $$\text{var. } (sij_1 - sij_2) \text{ males X female} = \frac{2 \text{ (Error variance)}}{r}$$

$$\text{S.E. } (sij_1 - sij_2) \text{ males X females} = \sqrt{\text{Var.}(sij_1 - sij_2)\text{males x females}}$$

1. S.E. (g.c.a. for lines) = $\sqrt{me/rt}$

2. S.E. (g.c.a. for testers)= $\sqrt{me/rl}$

3. S.E. (s.c.a. effects) = $\sqrt{me/r}$

3.5.7 Gene action:

The following formula was used to know the gene action.

Gene action = δ^2 g.c.a./ δ^2 s.c.a.

The ratio > 1 indicate the additive gene action and < 1 indicate non-additive gene action.

3.5.8 Heritability:

Heritability in narrow sense was computed from the variance components. The heritability was calculated by the following formula of Lush (1945):

$$h^2 = \frac{\delta^2 g}{\delta^2 g + \delta^2 s + \delta^2 e} \text{ (in narrow sense)}$$

Where,

δ^2 g = Estimated variance due to g.c.a.

δ^2 s = Estimated variance due to s.c.a.

δ^2 e = Error mean sum of squares.

As suggested by Johnson *et al.,* (1955a) heritability values are categorized as follow:

Low	=	Less than 30%.
Moderate	=	30-60%.
High	=	More than 60%.

4. EXPERIMENTAL RESULTS

The results of the present investigation entitled "Line X testers after analysis are presented under following headings.

i. Mean and variance

ii. Heterosis

iii.Combining ability

iv. Gene action

v. Heritability

vi. Quality characters

4.1 Mean and analysis of variance:

The mean performance of parents and hybrids and analysis of variance for different characters are presented in Table 1. and 2, respectively and are described in brief as given below.

4.1.1 Day to 50% tasseling:

From the data presented in the Table 1, it is observed that 'F' test for days to flowering was highly significant.

Among the females Hyd-08R-2630-2, N-8211-35 and 2372-1 were earlier and tasseling in 59.00 days, while the female 679-1 was late and took 61.66 days to tasseling. The range of 50% among females was 59.00 to 61.66 days.

Among the male parents, N-8203-1 was earliest which tasseled in 58.33 days, while the range of 50% tasseling among the male was 58.33 to 59.33 days.

Among the hybrids, the Hyd-08R-2630-2 X N-8213-48 and N-8211-35 X 644-1 was earlier, which are flowered in 56.66 days followed by hybrid 2372-1 X N-8203-1 (57.00) days, while the range of 50% tasseling among hybrids was 56.66 to 60.66 days.

Among 40 hybrids, 7 hybrids were earlier than the check Rajarshi. While none of these hybrids earlier than the check Bio-9637.

4.1.2 Days to 50 % Silking:

'F' test is highly significant for days to 50% silking.

Among female Hyd-08R-2630-2, N-8211-35 and 2372-1 (60.00) days were earliest for 50% silking followed by female 2392-2 (60.66) days. While the female 679-1 was late and took 62.66 days to silking. The range of 50% silking among female was 60.00 to 62.66 days.

Among the male parents N-8203-1 was earliest and silking in 59.33 days. The range of 50% silking among male was 59.33 to 60.33 days.

Among the hybrids, N-8211-35 X 644-1 was the earlier and 50 % silking was in 57.66 days, while hybrid 679-1 X N-8215-1 was late and took 62.66 days to silking.

The range of the 50% silking was 57.66 to 62.66 days. Among the 40 hybrids, five hybrids recorded earlier silking than check Rajarshi. While none of these hybrids earlier than check Bio-9637.

Table: 1 Mean performance of parents, hybrids and checks for different thirteen characters in L X T design.

Sr. No.	Parents/Hybrids/ Checks	Days to 50% tasseling	Days to 50 % silking	Days to maturity	Plant height (cm)	Earhead height (cm)	Ear length (cm)	Ear circumference (cm)
Females								
1	673-2	59.33	61.33	91.66	167.46	82.73	17.33	14.46
2	Hyd-08R-8214-43	60.66	61.66	96.33	173.66	70.80	17.53	14.46
3	Hyd-08R-2630-2	59.00	60.00	96.00	168.93	63.86	17.93	15.33
4	N-8211-35	59.00	60.00	98.66	169.60	65.20	15.60	14.06
5	679-1	61.66	62.66	98.00	172.73	76.13	16.40	15.53
6	2372-1	59.00	60.00	95.00	163.86	70.40	18.13	14.13
7	2392-2	59.66	60.66	97.66	160.80	75.80	17.60	15.66
8	Hyd-08R-8214-31	59.66	61.33	96.66	164.46	72.40	18.80	15.80
Male								
1	N-8203-1	58.33	59.33	94.66	163.66	74.00	17.43	14.60
2	N-8215-1	59.33	60.33	95.53	171.20	73.26	16.00	15.66
3	644-1	59.00	60.00	94.33	164.53	71.33	18.20	14.33
4	N-8213-48	59.33	60.33	95.66	184.33	101.06	18.53	15.16
5	N-8215-4	59.00	60.00	97.00	196.26	74.60	16.33	15.16

1	2	3	4	5	6	7	8	9
Hybrids								
1	673-2 X N-8203-1	59.33	60.33	93.33	193.73	100.60	18.26	15.66
2	673-2 X N-8215-1	60.00	61.66	94.33	193.00	99.80	19.46	14.86
3	673-2 X 644-1	60.00	61.00	96.00	170.60	92.73	19.93	15.53
4	673-2 X N-8213-48	60.66	61.66	95.66	188.06	91.13	17.00	15.50
5	673-2 X N-8215-4	60.33	60.66	93.66	180.93	92.13	17.40	15.53
6	Hyd-08R-8214-43 X N-8203-1	58.00	59.33	93.33	201.73	102.46	16.80	16.13
7	Hyd-08R-8214-43 X N-8215-1	59.66	60.66	98.66	168.86	78.13	14.06	14.56
8	Hyd-08R-8214-43 X 644-1	58.33	60.00	93.33	174.26	83.80	17.06	15.53
9	Hyd-08R-8214-43 X N-8213-48	59.33	60.66	94.33	170.46	80.93	17.16	15.70
10	Hyd-08R-8214-43 X N-8215-4	60.33	61.66	90.33	172.13	**72.66**	17.73	15.36
11	Hyd-08R-2630-2 X N-8203-1	57.33	58.33	91.33	**214.33**	110.56	20.93	15.20
12	Hyd-08R-2630-2 X N-8215-1	59.00	60.00	93.66	203.66	97.60	20.26	14.40
13	Hyd-08R-2630-2 X 644-1	58.33	59.66	95.33	194.20	100.33	18.53	14.90
14	Hyd-08R-2630-2 X N-8213-48	**56.66**	58.33	91.66	191.06	101.13	18.66	14.26
15	Hyd-08R-2630-2 X N-8215-4	57.33	58.33	93.00	211.53	95.40	19.93	15.06
16	N-8211-35 X N-8203-1	58.33	59.66	93.33	188.26	88.93	17.33	14.90
17	N-8211-35 X N-8215-1	59.00	60.00	95.00	190.46	91.93	16.86	15.56

1	2	3	4	5	6	7	8	9
18	N-8211-35 X 644-1	**56.66**	**57.66**	90.66	187.80	79.53	16.70	14.10
19	N-8211-35 X N-8213-48	58.00	58.66	**89.33**	173.13	87.26	16.93	14.46
20	N-8211-35 X N-8215-4	57.66	58.66	91.66	187.60	92.60	16.13	14.86
21	679-1 X N-8203-1	59.00	60.66	96.00	184.73	98.46	18.83	15.30
22	679-1 X N-8215-1	60.66	62.66	94.66	177.93	88.66	19.06	15.46
23	679-1 X 644-1	60.00	61.33	98.00	188.60	89.00	16.73	14.40
24	679-1 X N-8213-48	60.33	61.33	97.33	167.86	87.40	17.20	14.56
25	679-1 X N-8215-4	59.33	60.33	98.66	182.26	90.06	17.00	**16.40**
26	2372-1 X N-8203-1	57.00	58.33	92.00	203.93	93.93	17.80	14.60
27	2372-1 X N-8215-1	59.00	60.33	94.00	209.06	102.93	18.86	14.56
28	2372-1 X 644-1	59.00	60.00	95.00	203.86	102.00	18.06	14.53
29	2372-1 X N-8213-48	57.66	58.66	92.66	199.53	93.20	18.20	15.40
30	2372-1 X N-8215-4	58.00	58.66	94.00	193.96	94.26	19.26	15.10
31	2392-2 X N-8203-1	58.66	60.00	94.66	204.26	89.13	19.50	14.86
32	2392-2 X N-8215-1	60.33	61.33	96.33	170.93	84.73	19.20	14.86
33	2392-2 X 644-1	60.00	61.33	94.66	172.33	85.66	18.90	14.46
34	2392-2 X N-8213-48	60.66	61.66	94.66	181.66	80.13	18.60	15.13
35	2392-2 X N-8215-4	58.33	59.33	90.33	210.26	83.26	**21.00**	14.13

1	2	3	4	5	6	7	8	9
36	Hyd-08R-8214-31 X N-8203-1	58.00	59.66	93.00	184.40	91.46	18.93	15.26
37	Hyd-08R-8214-31 X N-8215-1	59.00	60.00	95.00	167.40	85.13	15.86	14.50
38	Hyd-08R-8214-31 X 644-1	59.66	60.66	97.66	183.20	77.13	15.56	14.20
39	Hyd-08R-8214-31 X N-8213-48	60.00	61.66	97.00	165.60	82.16	17.20	15.00
40	Hyd-08R-8214-31 X N-8215-4	58.33	60.00	93.33	170.46	86.13	17.46	15.46
Checks								
1	Rajarshi	58	58.66	91.33	202.93	84.00	18.73	15.86
2	Bio-9637	56.66	57.66	91.66	197.93	96.46	19.56	16.20
	'F' test.. highly significant							
	Mean	59	60.16	93.94	183.64	86.84	17.90	15.03
	S.E.	0.52	0.48	0.56	1.41	1.78	0.26	0.18
	C.D. 5%	1.46	1.34	1.57	3.95	5.00	0.74	0.51
	C.D. 1%	1.93	1.78	2.07	5.23	6.61	0.98	0.68

Table: 1 Contd.....

Sr. No	Parents/Hybrids/Checks	Number of kernel rows per cob	Number kernels per row	100 grain weight (g)	Shelling (%)	Grain yield per plant (g)	Starch content (%)
Females							
1	673-2	14	36.33	33.12	86.76	152.92	67.49
2	Hyd-08R-8214-43	16	37.73	25.15	86.50	146.87	69.33
3	Hyd-08R-2630-2	16	41.73	34.51	84.23	113.32	66.06
4	N-8211-35	14	33.46	22.05	88.77	150.11	70.18
5	679-1	16	33.13	26.80	83.16	141.84	71.16
6	2372-1	14	35.33	37.00	86.88	158.12	69.47
7	2392-2	14	36.46	23.59	82.48	140.12	65.84
8	Hyd-08R-8214-31	14	37.00	36.53	81.60	142.40	68.56
Male							
1	N-8203-1	16	38.93	26.58	80.02	110.96	70.32
2	N-8215-1	14	36.66	27.05	80.76	141.18	67.35
3	644-1	16	38.20	27.04	84.88	117.62	67.19
4	N-8213-48	14	41.66	25.23	80.18	116.44	68.45
5	N-8215-4	16	38.26	25.10	79.71	133.16	71.03

1	2	3	4	5	6	7	8
Hybrids							
1	673-2 X N-8203-1	14	37.00	34.81	89.20	170.78	68.43
2	673-2 X N-8215-1	14	44.93	28.65	87.28	160.18	69.14
3	673-2 X 644-1	12	39.33	36.76	84.26	150.34	68.98
4	673-2 X N-8213-48	16	35.46	30.53	85.11	144.76	69.75
5	673-2 X N-8215-4	16	43.00	21.74	87.59	180.37	68.42
6	Hyd-08R-8214-43 X N-8203-1	16	41.80	32.26	85.30	131.26	68.60
7	Hyd-08R-8214-43XN-8215-1	14	29.20	25.90	87.71	129.26	68.30
8	Hyd-08R-8214-43 X 644-1	16	46.53	28.69	85.66	147.19	69.31
9	Hyd-08R-8214-43 X N-8213-48	16	43.60	25.81	85.74	141.66	69.12
10	Hyd-08R-8214-43 X N-8215-4	16	38.33	26.82	83.66	124.42	69.78
11	Hyd-08R-2630-2 X N-8203-1	14	39.40	32.93	87.62	169.15	69.59
12	Hyd-08R-2630-2 X N-8215-1	16	40.66	36.36	86.15	171.64	69.21
13	Hyd-08R-2630-2 X 644-1	14	43.26	32.11	84.99	139.72	70.69
14	Hyd-08R-2630-2 X N-8213-48	16	37.33	34.51	84.58	147.14	68.18
15	Hyd-08R-2630-2 X N-8215-4	14	42.66	25.76	85.93	151.36	69.21
16	N-8211-35 X N-8203-1	14	41.20	27.66	82.24	113.82	69.41
17	N-8211-35 X N-8215-1	18	44.20	23.40	84.02	128.64	69.74

1	2	3	4	5	6	7	8
18	N-8211-35 X 644-1	16	43.26	26.50	86.72	135.00	67.49
19	N-8211-35 X N-8213-48	16	45.26	31.62	85.45	150.72	70.92
20	N-8211-35 X N-8215-4	16	41.53	24.79	86.19	124.15	72.08
21	679-1 X N-8203-1	16	45.06	34.42	87.50	165.02	69.95
22	679-1 X N-8215-1	16	35.66	35.84	88.79	214.42	70.54
23	679-1 X 644-1	16	47.20	26.22	86.95	156.64	73.00
24	679-1 X N-8213-48	18	37.13	27.44	87.66	161.86	69.47
25	679-1 X N-8215-4	18	43.46	28.72	85.23	157.89	69.81
26	2372-1 X N-8203-1	14	37.80	36.70	85.33	141.05	69.86
27	2372-1 X N-8215-1	14	44.23	36.81	83.96	137.32	68.53
28	2372-1 X 644-1	14	39.66	33.14	83.81	129.26	69.11
29	2372-1 X N-8213-48	14	38.00	32.38	84.10	148.16	69.10
30	2372-1 X N-8215-4	16	41.26	26.48	88.25	163.94	70.16
31	2392-2 X N-8203-1	16	45.13	28.08	85.04	132.65	69.11
32	2392-2 X N-8215-1	14	46.46	31.03	85.39	146.16	68.40
33	2392-2 X 644-1	14	38.26	27.40	83.23	106.27	67.12
34	2392-2 X N-8213-48	16	41.13	26.70	85.82	147.84	67.09
35	2392-2 X N-8215-4	14	44.93	33.92	84.24	131.06	69.56

1	2	3	4	5	6	7	8
36	Hyd-08R-8214-31 X N-8203-1	12	36.86	35.46	83.85	150.82	69.51
37	Hyd-08R-8214-31 X N-8215-1	14	30.86	36.45	81.03	109.49	70.81
38	Hyd-08R-8214-31 X 644-1	12	32.73	34.21	85.25	125.21	69.32
39	Hyd-08R-8214-31 X N-8213-48	14	41.06	35.73	84.96	147.20	69.27
40	Hyd-08R-8214-31 X N-8215-4	16	38.53	32.96	83.21	144.34	69.55
Checks							
1	Rajarshi	16	40.53	34.64	87.56	164.00	68.03
2	Bio-9637	16	44.33	36.14	83.18	149.74	71.21
	‘F’…………………………………. highly significant						
	Mean	15.05	39.87	30.33	85.01	143.76	69.22
	S.E.	0.26	0.91	0.98	0.59	3.17	0.93
	C.D. 5%	0.75	2.55	2.76	1.67	8.89	2.62
	C.D. 1%	1.00	3.38	3.65	2.21	11.76	3.47

4.1.3 Days to maturity:

From the data presented in Table 1, it is observed that 'F' test for days to maturity was highly significant.

The female 673-2 was earlier and matured in 91.66 days. While N-8211-35 (98.66) followed by 679-1 were late and took 98.66 and 98.00 days respectively. The range of the days to maturity among females was 91.66 to 98.66 days.

Among the male parents, 644-1 was earliest and matured in 94.33 days followed by male N-8203-1 (94.66) days. While male N-8215-4 was late and took 97.00 days to matured. The range of day maturity in male was 94.33 to 97.00 days.

Among the hybrids N-8211-35 X N-8213-48 earliest which matured in 89.33 days followed by Hyd-08R-8214-43 X N-8215-4 and 2392-2 X N-8215-4 (90.66 cm). While hybrids Hyd-08R-8214-43 X N-8215-1 and 679-1 X N-8215-4 were late and took 98.66 days for maturity. The range of days to maturity among the hybrids was 89.33 to 98.66 days.

Among the 40 hybrids, three and four hybrids were earlier than standard check Rajarshi and Bio-9637 respectively.

4.1.4 Plant height (cm):

The range of plant height among the females was 160.80 to 173.66 cm. The female 2392-2 (160.80 cm) was dwarfest followed by 2372-1 (163.86 cm). While Hyd-08R-8214-43 (173.66 cm) was tallest followed by 679-1 (172.73 cm).

Among the male range of plant height was 163.60 to 196.26 cm. The male N-8203-1 (163.60 cm) was dwarfest followed by 644-1 (164.53 cm), While the male N-8215-4 (196.26) was tallest followed by N-8213-48 (184.33).

Among the hybrids, range of the plant height was 165.60 cm to 214.33 cm. The hybrid Hyd-08R-8214-31 X N-8213-48 (165.60 cm) was dwarfest followed by Hyd-08R-8214-31 X N-8215-1 (167.40 cm) and 679-1 X N-8213-48 (167.86 cm)

While the hybrid Hyd-08R-2630-2 X N-8203-1 (214.33 cm) was tallest in plant height followed by Hyd-08R-2630-2 X N-8215-4 (211.53 cm).

Among the 40 hybrids, total eight and ten hybrids were taller than check Rajarshi and Bio-9637, respectively.

4.1.5 Earhead height (cm):

From the data presented in Table 1, it is observed that 'F' test for earhead height was highly significant.

The range of earhead height among the females was 63.86 to 82.73 cm. The earhead height was least in case of females Hyd-08R-2630-2 (63.86 cm) followed by N-8211-35 (65.20 cm), while 673-2 (82.73 cm) showed maximum earhead height followed by 679-1 (76.13 cm).

Table: 2 Partitioning of variance for thirteen different characters in L x T mating design in Maize.

S N	Source of Variation	DF	Days to 50% tasseling	Days to 50% sillking	Days to maturity	Plant height (cm)	Earhead height (cm)	Ear length (cm)	Ear circumference (cm)	Number of kernel rows per cob	Number of kernel per row	100 grain weight(g)	Shelling percentage	Grain yield per plant (g)	Starch content (%)
1	Replication	2	13.15**	11.77**	18.73**	1.023	4.72	0.19	0.25	0.22	0.66	2.66	2.43	90.87	27.08**
2	Parent	12	2.19**	2.50**	10.06**	284.76**	255.86**	3.02**	1.18**	3.23**	20.34**	76.03**	27.77**	770.13**	9.51**
3	Female	7	2.73**	2.80**	14.45**	59.51**	112.73**	3.03**	1.55**	3.21**	21.85**	111.22**	19.29**	549.92**	10.96**
4	Male	4	0.50	0.50	3.23*	591.34**	467.12**	3.73**	0.82**	3.60**	10.06**	2.79	13.78**	485.21**	9.04*
5	Female Vs. Male	1	5.19**	8.47**	6.66**	635.14**	412.72**	0.12	0.02	1.86**	50.83**	122.71**	143.14**	3451.20**	1.19
6	Hybrids	39	3.98**	4.30**	100.83**	593.27**	206.71**	6.59**	0.91**	6.76**	54.19**	55.22**	9.53**	1249.88**	3.91
7	Parents Vs Hybrids	1	8.21**	6.35**	183.67**	7603.17**	7419.25**	12.05**	0.09	0.47	317.61**	149.14**	110.96**	2902.96**	16.21*
8	Error	104	0.74	0.62	0.95	5.67	9.64	0.21	0.10	0.22	2.23	2.98	1.08	31.16	2.66

*, ** indicates at 5% and 1% level of significant, respectively.

Among the male, range of earhead height was 71.33 to 101.06 cm. The earhead height was least in case of male 644-1 (71.33 cm) followed by N-8215-1 (73.26 cm).

Among the hybrids, the range of the earhead height was 72.66 to 110.56 cm. The hybrid Hyd-08R-8214-43 X N-8215-4 (72.66 cm) recorded least earhead height followed Hyd-08R-8214-31 X 644-1 (77.13 cm). The hybrid Hyd-08R-2630-2 X N-8203-1 (110.56 cm) recorded highest earhead height followed by 2372-1 X N-8215-1 (102.93 cm).

Among the 40 hybrids, nine and thirty hybrids showed least earhead height than standard check Rajarshi and Bio-9637.

4.1.6 Ear length (cm):

From the data 'F' test was highly significant for this trait.

Among the females, the range of the ear length was 15.60 to 18.80 cm. The female Hyd-08R-8214-31 (18.80 cm) had shown longest ear length followed by female 2372-1 (18.13 cm). While female N-8211-35 (15.60 cm) produced shortest earhead length.

The range of the ear length among the male was 16.00 to 18.53 cm. The male N-8213-48 (18.53) had shown longest ear length followed by 644-1 (18.20). While, male N-8215-1 (16.00) had shown shortest ear length.

Among the hybrids, the range of ear length was 14.06 to 21.00 cm. The hybrid 2392-2 X N-8215-4 (21.00 cm) had shown longest ear length followed by Hyd-08R-2630-2 X N-8203-1

(20.93 cm) and Hyd-08R-2630-2 X N-8215-1 (20.26). While the hybrid Hyd-08R-8214-43 X N-8215-1 (14.06) had shown shortest ear length.

Out of the 40 hybrids studied, fourteen showed longest earlength than check Rajarshi and five than Bio-9637.

4.1.7 Ear circumference (cm):

From the data, it is observed that 'F' test is highly significant for ear circumference.

The female Hyd-08R-8214-31 (15.80 cm) recorded maximum ear circumference followed by female 2392-2 (15.66 cm) and 679-1 (15.53 cm).

Among the males, range of the ear circumference was 14.33 to 15.66 cm. The male 8215-1 (15.66 cm) recorded maximum ear circumference followed by male N-8213-48 and N-8215-4 (15.16 cm).

Among the hybrids, the range of ear circumference was 14.10 to 16.40 cm. The hybrids 679-1 X N-8215-4 (16.40 cm), Hyd-08R-8214-43 X N-8203-1 (16.13 cm) recorded higher ear circumference. While the hybrid 2392-2 X N-8215-4 (14.13 cm) N-8211-35 X 644-1 (14.10 cm) and Hyd-08R-8214-31 X 644-1 (14.20 cm) recorded lower values.

Among the forty hybrids, 679-1 X N-8215-4 (16.40) and Hyd-08R-8214-43 X N-8203-1 (16.13) recorded higher ear circumferance than the check Rajarshi. While only one hybrid 679-1 X N-8215-4 (16.40 cm) had exhibited highest ear circumference than check Bio-9637.

4.1.8 Number of Kernel rows per cob:

From the data presented in Table 1. it is observed that 'F' test for number of kernels rows per cob was highly significant.

The range of number of kernel rows per cob among the males as well as female was 14.00 to 16.00. The females Hyd-08R-8214-43 (16.00), Hyd-08R-2630-2 and 679-1 (16.00) showed maximum kernel rows per cob. The males N-8203-1, 644-1 and N-8215-4 recorded maximum kernel rows per cob (16.00).

Among the hybrids the range of number of kernel rows per cob was 12.00 to 18.00. The hybrids N-8211-35 X N-8215-1, 679-1 X N-8213-48 and 679-1 X N-8215-4 (18.00) recorded highest number of kernel rows per cob. While the hybrid 673-2 X 644-1, Hyd-08R-8214-31 X N-8203-1 and Hyd-08R-8214-31 X 644-1 had produced less number of kernel rows per cob.

Among the 40 cross combinations, the crosses N-8211-35 X N-8215-1, 679-1 X N-8213-48 (18.00) and hybrid 679-1 X N-8215-4 (18.00) recorded more number of kernel rows per cob than both check Rajarshi and Bio-9637.

4.1.9 Number of Kernels per row:

From the data presented in Table 1. it is clear that 'F' test for number of kernels per row was highly significant.

The range of number of kernels per row among the females was 33.13 to 41.73. The female Hyd-08R-2630-2 (41.73) recorded maximum kernel row per followed by Hyd-08R-8214-43

(37.33) and Hyd-08R-8214-3 (37.00). While female 679-1 (33.13) and N-8211-35 (33.46) produced low number of kernels per row.

Among the males, range of kernels per row was 36.66 to 41.66. The males parents N-8213-48 (41.66), N-8203-1 (38.93) and N-8215-4 (38.26) recorded maximum kernels per row. While the males N-8215-1 (38.66) produced less number of kernels per row.

The range of the number of kernels per row among the hybrids was 29.20 to 47.20. The hybrids 679-1 X 644-1 (47.20), Hyd-08R-8214-43 X 644-1 (46.53) and 2392-2 X N-8215-1 (46.46) recorded higher number of kernels per row. While the hybrid Hyd-08R-8214-43 X N-8215-1 (29.20), Hyd-08R-8214-31 X N-8215-1 (30.86) produced low number of kernels per row.

Among the forty hybrids, twenty three and eight hybrids exceeded its number of kernel per row than check Rajarshi and Bio-9637, respectively.

4.1.10 100 Grain weight (g).

The 'F' test for 100 grain weight is highly significant.

The range of 100 grain weight among the female was 22.05 to 37.00g. The female 2372-1 (37.00 g) had greater size of grain followed by female Hyd-08R-8214-31 (36.53g) and Hyd-08R-2630-2 (34.51g). While the female N-8211-35 (22.05g) produced lighter grain.

Among the males, the range for 100 grain weight was 25.10 to 27.05g. The males N-8215-1 (27.05g) and 644-1 (27.04g).

produced heavier grain. While the male N-8215-4 (25.10g) produced lighter grain.

Among the hybrids, the range for 100 grain weight was 21.74 to 36.81 g. The heaviest grains were observed in hybrids 2372-1 X N-8215-1 (36.81g), 673-2 X 644-1 (36.76g), 2372-1 X N-8203-1 (36.70), Hyd-08R-8214-31 X N-8215-1 (36.45) and hybrid Hyd-08R-2630-2 X N-8215-1 (36.36). While the hybrid 673-2 X N-8215-4 (21.74) and N-8211-35 X N-8215-1 (23.40g) produced lighter grain.

Among the forty hybrids, nine hybrids produced heavier grain weight than the Rajarshi and five hybrids produced heavier weight than superior check Bio-9637.

4.1.11 Shelling percentage:

From the data presented in Table 1. it is clear that 'F' test for shelling percentage was highly significant.

The range of shelling percentage among the female was 81.60 to 88.77%. The females N-8211-35 (88.77%) and 2372-1 (86.88%) had recorded highest shelling percentage. The magnitude of shelling percentage was low for females Hyd-08R-8214-31 (81.60%) and 2392-2 (82.48%).

The range for shelling percentage was (79.71%) to (84.88%)g. Among the males, the male 644-1 (84.88%) recorded highest shelling percentage. While N-8215-4 (79.71%) recorded the lowest shelling percentage.

Among the hybrids, the range of shelling percentage was 81.03 to 89.20%. The hybrid 673-2 X N-8203-1 (89.20%) had recorded highest shelling percentage. The other hybrids with higher shelling percentages were 679-1 X N-8215-1 (88.79%), 2372-1 X N-8215-4 (88.25), Hyd-08R-8214-43 X N-8215-1 (87.71) and 679-1 X N-8213-48 (87.66). While the hybrid Hyd-08R-8214-31 X N-8215-1 (81.03%) and N-8211-35 X N-8203-1 (82.24%) was lowest shelling percentage.

Among forty hybrids, seven hybrids had recorded highest shelling percentage than the superior than Rajarshi. While thirty eight hybrids showed higher shelling percentage than check Bio-9637.

4.1.12 Grain yield per plant (g):

The range of grain yield per plant among females was 113.32 to 158.12(g). The female 2372-1 (158.12g) produced highest grain yield per plant followed by female 673-2 (152.92g). While the female Hyd-08R-2630-2 (113.32g) was the poorest yielder.

Among the male, the range of grain yield per plant was 110.96 to 141.18 g. The male N-8215-1 (141.18g) produced highest grain yield per plant followed by male N-8215-4 (133.16g). While the male N-8203-1 (110.96g) was the poorest yielder.

The range of grain yield per plant was 106.27 (g) to 214.42 (g) among the hybrids. The hybrid 679-1 X N-8215-1 (214.42g) had recorded highest grain yield per plant. The other hybrids recording higher grain yield per plant 673-2 X N-8215-4 (180.37g), Hyd-08R-2630-2 X N-8215-1 (171.64g) and 673-2 X

N-8203-1 (170.78g). While the hybrids 2392-2 X 644-1 (106.27g) and Hyd-08R-8214-31 X N-8215-1 (109.49g) showed lowest grain yield per plant.

Among the forty hybrids, hybrid 679-1 X N-8215-1 (214.42g.), 673-2 X N-8215-4 (180.37g.), Hyd-08R-2630-2 X N-8215-1 (171.64g), 673-2 X N-8203-1 (170.78g), Hyd-08R-2630-2 X N-8203-1 (169.15g) and 679-1 X N-8203-1 (165.02g) produced highest grain yield per plant than the superior check Rajarshi and fifteen hybrids recorded higher grain yield plant than the check Bio-9637.

4.1.13 Starch content (%):

From the data presented in Table 1, it is observed that 'F' test for starch content was significant.

The range of starch content among the female was from 65.84 to 71.16%. The female 679-1 (71.16%), and N-8211-35 (70.18%) recorded maximum starch content. while the female 2392-2 (65.84%) showed least starch content.

Among the male, the range of starch content was 67.19 to 71.03%. The highest starch content was recorded by the males N-8215-4 (71.03%) and N-8203-1 (70.32%). While the male 644-1 (67.19%) had recorded the lowest starch content followed by male N-8215-1 (67.35%).

Among the hybrids, the range of starch content was 67.09 to 73.00%. The hybrid 679-1 X 644-1 (73.00%) had recorded highest starch content followed by hybrid N-8211-35 X N-8215-4

(72.08%), While the hybrid 2392-2 X N-8213-48 (67.09%) and N-8211-35 X 644-1 (67.49%) recorded the lowest starch content.

Among the forty hybrids, thirty seven hybrids recorded highest starch content than the check Rajarshi and Hybrid 679-1 X 644-1 (73.00) and Hybrid N-8211-35 X N-8215-4 (72.08) recorded higher starch content than superior check Bio-9637.

4.2 Analysis of variance:

The analysis of variance is presented in Table 2. The mean sums square due to females and males for all the characters were highly significant except for days to tasseling, day to 50% silking and 100 grain weight in case of males. The mean sum squares female $V_{s.}$ male, hybrids and parents $v_{s.}$ hybrids were highly significant for all character except ear length, ear circumference and starch content for female $V_{s.}$ Male, starch content for hybrids, ear circumference and number of kernel rows per cob for parent V_s hybrids.

4.3 Heterosis:

The percentage of increase or decrease heterosis over superior (heterobeltosis), mid parents and standard checks of value for thirteen important characters were calculated and has been presented in Table No. 3.

Table 3: Percent heterosis in maize for thirteen quantitative characters in different crosses.

Sr. No.	Hybrids	Days to 50 % Tasseling				Days to 50 % silking			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
1	673-2 X N-8203-1	1.71	0.00	2.30	4.71**	1.69	-1.63	2.84*	4.62**
2	673-2 X N-8215-1	1.12	1.12	3.45**	5.88**	2.21*	0.54	5.11**	6.94**
3	673-2 X 644-1	1.69	1.12	3.45**	5.88**	1.67	-0.54	3.98**	5.78**
4	673-2 X N-8213-48	2.25	2.25	4.60**	7.06**	2.21*	0.54	5.11**	6.94**
5	673-2 X N-8215-4	2.26	1.69	4.02**	6.47**	1.11	-1.09	3.41**	5.20**
6	Hyd-08R-8214-43 X N-8203-1	-0.57	-4.40**	0.00	2.35	0.00	-3.78**	1.14	2.89*
7	Hyd-08R-8214-43 X N-8215-1	0.56	-1.65	2.87*	5.29**	0.55	-1.62	3.41**	5.20**
8	Hyd-08R-8214-43 X 644-1	-1.13	-3.85**	0.57	2.94*	0.00	-2.70*	2.27*	4.05**
9	Hyd-08R-8214-43 X N-8213-48	0.00	-2.20	2.30	4.71**	0.55	-1.62	3.41**	5.20**
10	Hyd-08R-8214-43 X N-8215-4	2.26	-0.55	4.02**	6.47**	2.78*	0.00	5.11*	6.94**
11	Hyd-08R-2630-2 X N-8203-1	-1.71	-2.82*	-1.15	1.18	-1.69	-2.78*	-0.57	1.16
12	Hyd-08R-2630-2 X N-8215-1	0.00	-0.56	1.72	4.12**	0.00	-0.55	2.27*	4.05**
13	Hyd-08R-2630-2 X 644-1	-1.13	-1.13	0.57	2.94*	-0.56	-0.56	1.70	3.47**
14	Hyd-08R-2630-2 X N-8213-48	**-3.95****	**-4.49****	-2.30	0.00	-2.78*	-3.31**	-0.57	1.16

Table: 3 Contd.....

Sr. No.	Hybrids	Days to 50 % Tasseling				Days to 50 % silking			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
15	Hyd-08R-2630-2 X N-8215-4	-2.82*	-2.82*	-1.15	1.18	-2.78*	-2.78*	-0.57	1.16
16	N-8211-35 X N-8203-1	0.00	-1.13	0.57	2.94*	0.56	-0.56	1.70	3.47**
17	N-8211-35 X N-8215-1	0.00	-0.56	1.72	4.12**	0.00	-0.55	2.27*	4.05**
18	N-8211-35 X 644-1	**-3.95****	-3.95**	-2.30	0.00	**-3.89****	**-3.89****	-1.70	0.00
19	N-8211-35 X N-8213-48	-1.69	-2.25	0.00	2.35	-2.22*	-2.76*	0.00	1.73
20	N-8211-35 X N-8215-4	-2.26	-2.26	-0.57	1.76	-2.22*	-2.22*	0.00	1.73
21	679-1 X N-8203-1	1.14	-4.32**	1.72	4.12**	2.25*	-3.19**	3.41**	5.20**
22	679-1 X N-8215-1	2.25	-1.62	4.60**	7.06**	3.87**	0.00	6.82**	8.67**
23	679-1 X 644-1	1.69	-2.70*	3.45**	5.88**	2.22*	-2.13*	4.55**	6.36**
24	679-1 X N-8213-48	1.69	-2.16	4.02**	6.47**	1.66	-2.13*	4.55**	6.36**
25	679-1 X N-8215-4	0.56	-3.78**	2.30	4.71**	0.56	-3.72**	2.84*	4.62**
26	2372-1 X N-8203-1	-2.29	-3.39**	-1.72	0.59	-1.69	-2.78*	-0.57	1.16
27	2372-1 X N-8215-1	0.00	-0.56	1.72	4.12**	0.56	0.00	2.84*	4.62**
28	2372-1 X 644-1	0.00	0.00	1.72	4.12**	0.00	0.00	2.27*	4.05**
29	2372-1 X N-8213-48	-2.26	-2.81*	-0.57	1.76	-2.22*	-2.76*	0.00	1.73
30	2372-1 X N-8215-4	-1.69	-1.69	0.00	2.35	-2.22*	-2.22*	0.00	1.73

Table: 3 Contd…..

Sr. No.	Hybrids	Days to 50 % Tasseling				Days to 50 % silking			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
31	2392-2 X N-8203-1	0.57	-1.68	1.15	3.53**	1.12	-1.10	2.27*	4.05**
32	2392-2 X N-8215-1	1.69	1.12	4.02**	6.47**	1.66	1.10	4.55**	6.36**
33	2392-2 X 644-1	1.69	0.56	3.45**	5.88**	2.22*	1.10	4.55**	6.36**
34	2392-2 X N-8213-48	2.25	1.68	4.60**	7.06**	2.21*	1.65	5.11**	6.94**
35	2392-2 X N-8215-4	-1.13	-2.23	0.57	2.94*	-1.11	-2.20*	1.14	2.89*
36	Hyd-08R-8214-31 X N-8203-1	-0.57	-2.79*	0.00	2.35	0.56	-2.72*	1.70	3.47**
37	Hyd-08R-8214-31 X N-8215-1	-0.56	-1.12	1.72	4.12**	-0.55	-2.17*	2.27*	4.05**
38	Hyd-08R-8214-31 X 644-1	1.13	0.00	2.87*	5.29**	1.11	-1.09	3.41**	5.20**
39	Hyd-08R-8214-31 X N-8213-48	1.12	0.56	3.45**	5.88**	2.21*	0.54	5.11**	6.94**
40	Hyd-08R-8214-31 X N-8215-4	-1.13	-2.23	0.57	2.94*	0.00	-2.17*	2.27*	4.05**
	S.E.(±)	0.60	0.70			0.55	0.64		
	CD at 5%	1.21	1.39			1.11	1.28		
	CD at 1%	1.60	1.85			1.47	1.70		

*,** indicates at 5% and 1% level of significant, respectively.
(Standard Checks: - SC 1: Rajarshi; SC 2: Bio-9637)

Table: 3 Contd.....

Sr. No.	Hybrids	Days to Maturity				Plant height (cm)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
1	673-2 X N-8203-1	1.82*	-1.41	2.19*	1.82*	17.04**	15.68**	-4.53**	-2.12*
2	673-2 X N-8215-1	2.91**	-1.05	3.28**	2.91**	13.98**	12.73**	-4.89**	-2.49*
3	673-2 X 644-1	4.73**	1.77*	5.11**	4.73**	2.77**	1.87	-15.93**	-13.81**
4	673-2 X N-8213-48	4.36**	0.00	4.74**	4.36**	6.92**	2.03	-7.33**	-4.98**
5	673-2 X N-8215-4	2.18*	-3.44**	2.55**	2.18*	-0.51	-7.81**	-10.84**	-8.59**
6	Hyd-08R-8214-43 X N-8203-1	-1.41	-3.11**	2.19*	1.82*	19.63**	16.16**	-0.59	1.92
7	Hyd-08R-8214-43 X N-8215-1	3.50**	2.42**	8.03**	7.64**	-2.07*	-2.76*	-16.79**	-14.69**
8	Hyd-08R-8214-43 X 644-1	-1.06	-3.11**	2.19*	1.82*	3.06**	0.35	-14.13**	-11.96**
9	Hyd-08R-8214-43 X N-8213-48	-1.39	-2.08*	3.28**	2.91**	-4.77**	-7.52**	-16.00	-13.88**
10	Hyd-08R-8214-43 X N-8215-4	**-37.37****	**-37.80****	**-33.94****	**-34.18****	-6.94**	-12.30**	-15.18**	-13.03**
11	Hyd-08R-2630-2 X N-8203-1	-3.52**	-4.86**	0.00	-0.36	**28.91****	**26.87****	**5.62****	**8.29****
12	Hyd-08R-2630-2 X N-8215-1	-1.75*	-2.43**	2.55**	2.18*	19.76**	18.96**	0.36	2.90**
13	Hyd-08R-2630-2 X 644-1	1.06	-0.69	4.38**	4.00**	16.47**	14.96**	-4.30**	-1.89
14	Hyd-08R-2630-2 X N-8213-48	-4.18**	-4.51**	0.36	0.00	8.17**	3.65**	-5.85**	-3.47**
15	Hyd-08R-2630-2 X N-8215-4	-3.13**	-4.12**	1.82*	1.45	15.85**	7.78**	4.24**	6.87**
16	N-8211-35 X N-8203-1	-1.41	-5.41**	2.19*	1.82*	13.01**	11.01**	-7.23**	-4.88**

Table: 3 Contd.....

Sr. No.	Hybrids	Days to Maturity				Plant height (cm)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
17	N-8211-35 X N-8215-1	-0.35	-3.72**	4.01**	3.64**	11.78**	11.25**	-6.14**	-3.77**
18	N-8211-35 X 644-1	-3.89**	-8.11**	-0.73	-1.09	12.41**	10.73**	-7.46**	-5.12**
19	N-8211-35 X N-8213-48	-6.62**	-9.46**	-2.19*	-2.55**	-2.17*	-6.08**	-14.68**	-12.53**
20	N-8211-35 X N-8215-4	-5.50**	-7.09**	0.36	0.00	2.55**	-4.42**	-7.56**	-5.22**
21	679-1 X N-8203-1	1.41	-2.04*	5.11**	4.73**	9.85**	6.95**	-8.97**	-6.67**
22	679-1 X N-8215-1	-0.70	-3.40**	3.65**	3.27**	3.47**	3.01**	-12.32**	-10.10**
23	679-1 X 644-1	3.89**	0.00	7.30**	6.91**	11.84**	9.19**	-7.06	-4.72**
24	679-1 X N-8213-48	1.74*	-0.68	6.57**	6.18**	-5.97**	-8.93**	-17.28**	-15.19**
25	679-1 X N-8215-4	1.72*	0.68	8.03**	7.64**	-1.21	-7.13**	-10.18**	-7.92**
26	2372-1 X N-8203-1	-2.82**	-3.16**	0.73	0.36	24.55**	24.45**	0.49	3.03**
27	2372-1 X N-8215-1	-1.05	-1.40	2.92**	2.55**	24.79**	22.12**	3.02**	5.62**
28	2372-1 X 644-1	0.71	0.00	4.01**	3.64**	24.16**	23.91**	0.46	3.00**
29	2372-1 X N-8213-48	-2.46**	-3.14**	1.46	1.09	14.61**	8.25**	-1.68	0.81
30	2372-1 X N-8215-4	-1.05	-3.09**	2.92**	2.55**	7.72**	-1.17	-4.42**	-2.00*
31	2392-2 X N-8203-1	0.00	-3.07**	3.65**	3.27**	25.94**	24.86**	0.66	3.20**
32	2392-2 X N-8215-1	1.05	-1.37	5.47**	5.09**	2.97**	-0.16	-15.77	-13.64**

Table: 3 Contd.....

Sr. No.	Hybrids	Days to Maturity				Plant height (cm)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
33	2392-2 X 644-1	0.35	-3.07**	3.65**	3.27**	5.94**	4.74**	-15.08**	-12.93**
34	2392-2 X N-8213-48	-1.05	-3.07**	3.65**	3.27**	5.27**	-1.45	-10.48**	-8.22**
35	2392-2 X N-8215-4	-6.87**	-7.51**	-1.09	-1.45	17.77**	7.13**	3.61**	6.23**
36	Hyd-08R-8214-31 X N-8203-1	-1.76*	-3.79**	1.82*	1.45	12.42**	12.12**	-9.13**	-6.84**
37	Hyd-08R-8214-31 X N-8215-1	-0.35	-1.72*	4.01**	3.64**	-0.26	-2.22	-17.51**	-15.43**
38	Hyd-08R-8214-31 X 644-1	3.53**	1.03	6.93**	6.55**	11.37**	11.35**	-9.72**	-7.44**
39	Hyd-08R-8214-31 X N-8213-48	1.39	0.34	6.20**	5.82**	-5.05**	-10.16**	-18.40**	-16.34**
40	Hyd-08R-8214-31 X N-8215-4	-3.45**	-3.78**	2.19*	1.82*	-5.49**	-13.15**	-16.00**	-13.88**
	S.E.(±)	0.69	0.79			1.68	1.94		
	CD at 5%	1.37	1.58			3.35	3.87		
	CD at 1%	1.82	2.10			4.44	5.13		

*,** indicates at 5% and 1% level of significant, respectively.
(Standard Checks: - SC 1: Rajarshi; SC 2: Bio-9637)

Table: 3 Contd…..

Sr. No.	Hybrids	Earhead height (cm)				Ear length (cm)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
1	673-2 X N-8203-1	35.95**	21.60**	19.76**	4.28	5.08**	4.78*	-2.49	-6.64**
2	673-2 X N-8215-1	36.21**	20.63**	18.81**	3.46	16.80**	12.31**	3.91	-0.51
3	673-2 X 644-1	30.00**	12.09**	10.40**	-3.87	12.20**	9.52**	6.41**	1.87
4	673-2 X N-8213-48	10.15**	-9.83**	8.49**	-5.53*	-5.20**	-8.27**	-9.25**	-13.12**
5	673-2 X N-8215-4	23.50**	11.36**	9.68**	-4.49	3.37	0.38	-7.12**	-11.07**
6	Hyd-08R-8214-43 X N-8203-1	44.73**	38.47**	21.98**	6.22*	-3.91*	-4.18	-10.32**	-14.14**
7	Hyd-08R-8214-43 X N-8215-1	10.36**	6.64	-6.98*	-19.00**	-16.10**	-19.77**	-24.91**	-28.11**
8	Hyd-08R-8214-43 X 644-1	18.36**	17.48**	-0.24	-13.13**	-4.48*	-6.23**	-8.90**	-12.78**
9	Hyd-08R-8214-43 X N-8213-48	14.31*	-19.92**	-3.65	-16.10**	-4.81*	-7.37**	-8.36**	-12.27**
10	Hyd-08R-8214-43 X N-8215-4	2.64	-2.59	-13.49**	-24.67**	4.72*	1.14	-5.34**	-9.37**
11	Hyd-08R-2630-2 X N-8203-1	73.12**	49.41**	31.63**	14.62**	18.38**	16.73**	11.74**	6.98**
12	Hyd-08R-2630-2 X N-8215-1	52.82**	33.21**	16.19**	1.17	19.45**	13.01**	8.19**	3.58
13	Hyd-08R-2630-2 X 644-1	57.10**	40.65**	19.44**	4.01	2.58	1.83	-1.07	-5.28**
14	Hyd-08R-2630-2 X N-8213-48	58.35**	0.07	20.40**	4.84	2.38	0.72	-0.36	-4.60*

Table: 3 Contd.....

Sr. No.	Hybrids	Earhead height (cm)				Ear length (cm)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
15	Hyd-08R-2630-2 X N-8215-4	49.37**	27.88**	13.57**	-1.11	16.34**	11.15**	6.41**	1.87
16	N-8211-35 X N-8203-1	36.40**	20.18**	5.87	-7.81**	4.94*	-0.57	-7.47**	-11.41**
17	N-8211-35 X N-8215-1	41.00**	25.48**	9.44**	-4.70	6.75**	5.42*	-9.96**	-13.80**
18	N-8211-35 X 644-1	21.98**	11.50**	-5.32	-17.55**	-1.18	-8.24**	-10.85**	-14.65**
19	N-8211-35 X N-8213-48	33.84**	-13.65**	3.89	-9.54**	-0.78	-8.63**	-9.61**	-13.46**
20	N-8211-35 X N-8215-4	42.02**	24.13**	10.24**	-4.01	1.04	-1.22	-13.88**	-17.55**
21	679-1 X N-8203-1	33.06**	29.33**	17.22**	2.07	11.33**	8.03**	0.53	-3.75
22	679-1 X N-8215-1	21.02**	16.46**	5.56	-8.09**	17.70**	16.26**	1.78	-2.56
23	679-1 X 644-1	24.77**	16.90**	5.95	-7.74**	-3.28	-8.06**	-10.68**	-14.48**
24	679-1 X N-8213-48	14.80**	-13.52**	4.05	-9.40**	-1.53	-7.19**	-8.19**	-12.10**
25	679-1 X N-8215-4	20.73**	18.30**	7.22*	-6.63*	3.87	3.66	-9.25**	-13.12**
26	2372-1 X N-8203-1	33.43**	26.94**	11.83**	-2.63	0.09	-1.84	-4.98**	-9.03**
27	2372-1 X N-8215-1	46.21**	40.49**	22.54**	6.70*	10.55**	4.04	0.71	-3.58
28	2372-1 X 644-1	44.89**	42.99**	21.43**	5.74*	-0.55	-0.73	-3.56	-7.67**
29	2372-1 X N-8213-48	32.39**	-7.78**	10.95**	-3.39	-0.73	-1.80	-2.85	-6.98**
30	2372-1 X N-8215-4	33.90**	26.36**	12.22**	-2.28	11.80**	6.25**	2.85	-1.53

Table: 3 Contd.....

Sr. No.	Hybrids	Earhead height (cm)				Ear length (cm)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
31	2392-2 X N-8203-1	20.45**	17.59**	6.11*	-7.60**	11.32**	10.80**	4.09*	-0.34
32	2392-2 X N-8215-1	15.65**	11.79**	0.87	-12.16**	14.29**	9.09**	2.49	-1.87
33	2392-2 X 644-1	20.09**	13.02**	1.98	-11.20**	5.59**	3.85	0.89	-3.41
34	2392-2 X N-8213-48	5.72	-20.71**	-4.60	-16.93**	2.95	0.36	-0.71	-4.94*
35	2392-2 X N-8215-4	11.62**	9.85**	-0.87	-13.68**	23.77**	19.32**	12.10**	7.33**
36	Hyd-08R-8214-31 X N-8203-1	26.34**	23.60**	8.89**	-5.18	4.51*	0.71	1.07	-3.24
37	Hyd-08R-8214-31 X N-8215-1	17.59**	16.20**	1.35	-11.75**	-8.81**	-15.60**	-15.30**	-18.91**
38	Hyd-08R-8214-31 X 644-1	8.13*	6.54	-8.17**	-20.04**	-15.86**	-17.20**	-16.90**	-20.44**
39	Hyd-08R-8214-31 X N-8213-48	13.49**	-18.70**	-2.18	-14.82**	-7.86**	-8.51**	-8.19**	-12.10**
40	Hyd-08R-8214-31 X N-8215-4	18.97**	15.46**	2.54	-10.71**	-0.57	-7.09**	-6.76**	-10.73**
	S.E.(±)	2.19	2.53			0.32	0.37		
	CD at 5%	4.37	5.04			0.64	0.75		
	CD at 1%	5.79	6.69			0.86	0.99		

*,** indicates at 5% and 1% level of significant, respectively.
(Standard Checks: - SC 1: Rajarshi; SC 2: Bio-9637)

Table: 3 Contd.....

Sr. No.	Hybrids	Ear circumference (cm)				Number of kernel rows per cob			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
1	673-2 X N-8203-1	7.80**	7.31**	-1.26	-3.29*	-6.67**	-12.50**	-12.50**	-12.50**
2	673-2 X N-8215-1	-1.33	-5.11**	-6.30**	-8.23**	0.00	0.00	-12.50**	-12.50**
3	673-2 X 644-1	7.87**	7.37**	-2.10	-4.12*	-20.00**	-25.00**	-25.00**	-25.00**
4	673-2 X N-8213-48	4.61**	2.20	-2.31	-4.32*	14.29**	14.29**	0.00	0.00
5	673-2 X N-8215-4	4.84**	2.42	-2.10	-4.12*	6.67**	0.00	0.00	0.00
6	Hyd-08R-8214-43 X N-8203-1	**11.01****	**10.50****	1.68	-0.41	0.00	0.00	0.00	0.00
7	Hyd-08R-8214-43 X N-8215-1	-3.32*	-7.02**	-8.19**	-10.08**	-6.67**	-12.50**	-12.50**	-12.50**
8	Hyd-08R-8214-43 X 644-1	7.87**	7.37**	-2.10	-4.12*	0.00	0.00	0.00	0.00
9	Hyd-08R-8214-43 X N-8213-48	5.96**	3.52*	-1.05	-3.09	6.67**	0.00	0.00	0.00
10	Hyd-08R-8214-43 X N-8215-4	3.71*	1.32	-3.15	-5.14**	0.00	0.00	0.00	0.00
11	Hyd-08R-2630-2 X N-8203-1	1.56	-0.87	-4.20*	-6.17**	-12.50**	-12.50**	-12.50**	-12.50**
12	Hyd-08R-2630-2 X N-8215-1	-7.10**	-8.09**	-9.24**	-11.11**	6.67**	0.00	0.00	0.00
13	Hyd-08R-2630-2 X 644-1	0.45	-2.83	-6.09**	-8.02**	-12.50**	-12.50**	-12.50**	-12.50**
14	Hyd-08R-2630-2 X N-8213-48	-6.45**	-6.96**	-10.08**	-11.93**	6.67**	0.00	0.00	0.00

Table: 3 Contd.....

Sr. No.	Hybrids	Ear circumference (cm)				Number of kernel rows per cob			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
15	Hyd-08R-2630-2 X N-8215-4	-1.20	-1.74	-5.04**	-7.00**	-12.50**	-12.50**	-12.50**	-12.50**
16	N-8211-35 X N-8203-1	3.95*	2.05	-6.09**	-8.02**	6.67**	-12.50**	-12.50**	-12.50**
17	N-8211-35 X N-8215-1	4.71**	-0.64	-1.89	-3.91*	**28.57****	**28.57****	**12.50****	**12.50****
18	N-8211-35 X 644-1	-0.70	-1.63	-11.13**	-12.96**	6.67**	0.00	0.00	0.00
19	N-8211-35 X N-8213-48	-1.03	-4.62**	-8.82**	-10.70**	14.29**	14.29**	0.00	0.00
20	N-8211-35 X N-8215-4	1.71	-1.98	-6.30**	-8.23**	6.67**	0.00	0.00	0.00
21	679-1 X N-8203-1	1.55	-1.50	-3.57*	-5.56**	0.00	0.00	0.00	0.00
22	679-1 X N-8215-1	-0.85	-1.28	-2.52	-4.53**	6.67**	0.00	0.00	0.00
23	679-1 X 644-1	-3.57*	-7.30**	-9.24**	-11.11**	0.00	0.00	0.00	0.00
24	679-1 X N-8213-48	-5.10**	-6.22**	-8.19**	-10.08**	20.00**	12.50**	**12.50****	**12.50****
25	679-1 X N-8215-4	6.84**	5.58**	**3.36***	**1.23**	12.50**	12.50**	**12.50****	**12.50****
26	2372-1 X N-8203-1	1.62	0.00	-7.98**	-9.88**	-6.67**	-12.50**	-12.50**	-12.50**
27	2372-1 X N-8215-1	-2.24	-7.02**	-8.19**	-10.08**	0.00	0.00	-12.50**	-12.50**
28	2372-1 X 644-1	2.11	1.40	-8.40**	-10.29**	-6.67**	-12.50**	-12.50**	-12.50**
29	2372-1 X N-8213-48	5.12**	1.54	-2.94	-4.94**	0.00	0.00	-12.50**	-12.50**

Table: 3 Contd.....

Sr. No.	Hybrids	Ear circumference (cm)				Number of kernel rows per cob			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
30	2372-1 X N-8215-4	3.07	-0.44	-4.83**	-6.79**	6.67**	0.00	0.00	0.00
31	2392-2 X N-8203-1	-1.76	-5.11**	-6.30**	-8.23**	6.67**	0.00	0.00	0.00
32	2392-2 X N-8215-1	-5.11**	-5.11**	-6.30**	-8.23**	0.00	0.00	-12.50**	-12.50**
33	2392-2 X 644-1	-3.56*	-7.66**	-8.82**	-10.70**	-6.67**	-12.50**	-12.50**	-12.50**
34	2392-2 X N-8213-48	-1.84	-3.40*	-4.62**	-6.58**	14.29**	14.29**	0.00	0.00
35	2392-2 X N-8215-4	-8.32**	-9.79**	-10.92**	-12.76**	-6.67**	-12.50**	-12.50**	-12.50**
36	Hyd-08R-8214-31 X N-8203-1	0.44	-3.38*	-3.78*	-5.76**	-20.00**	-25.00**	-25.00**	-25.00**
37	Hyd-08R-8214-31 X N-8215-1	-7.84**	-8.23**	-8.61**	-10.49**	0.00	0.00	-12.50**	-12.50**
38	Hyd-08R-8214-31 X 644-1	-5.75**	-10.13**	-10.50**	-12.35**	-20.00**	-25.00**	-25.00**	-25.00**
39	Hyd-08R-8214-31 X N-8213-48	-3.12*	-5.06**	-5.46**	-7.41**	0.00	0.00	-12.50**	-12.50**
40	Hyd-08R-8214-31 X N-8215-4	-0.11	-2.11	-2.52	-4.53**	6.67**	0.00	0.00	0.00
	S.E.(±)	0.22	0.26			0.33	0.38		
	CD at 5%	0.45	0.52			0.66	0.77		
	CD at 1%	0.60	0.69			0.88	1.02		

*,** indicates at 5% and 1% level of significant, respectively.
(Standard Checks: - SC 1: Rajarshi; SC 2: Bio-9637)

Table: 3 Contd.....

Sr. No.	Hybrids	Number kernels per row				100 grain weight (g)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
1	673-2 X N-8203-1	-1.68	-4.97	-8.72**	-16.54**	16.61**	5.09	0.48	-3.69
2	673-2 X N-8215-1	23.11**	22.55**	10.86**	1.35	-4.77	-13.50**	-17.30**	-20.73**
3	673-2 X 644-1	5.55	2.97	-2.96**	-11.28**	22.19**	10.97*	6.10	1.70
4	673-2 X N-8213-48	-9.06**	-14.88**	-12.50**	-20.00**	4.64	-7.83	-11.87**	-15.53**
5	673-2 X N-8215-4	15.28**	12.37**	6.09*	-3.01	-25.33**	-34.37**	-37.25**	-39.86**
6	Hyd-08R-8214-43 X N-8203-1	9.04**	7.36*	3.13	-5.71*	24.74**	21.39**	-6.87	-10.73**
7	Hyd-08R-8214-43 X N-8215-1	-21.51**	-22.61**	-27.96**	-34.14**	-0.78	-4.26	-25.25**	-28.35**
8	Hyd-08R-8214-43 X 644-1	22.56**	21.82**	14.80**	4.96	9.95*	6.11	-17.18**	-20.62**
9	Hyd-08R-8214-43 X N-8213-48	9.82**	4.64	7.57*	-1.65	2.46	2.30	-25.50**	-28.59**
10	Hyd-08R-8214-43 X N-8215-4	0.88	0.17	-5.43	-13.53**	6.77	6.65	-22.57**	-25.78**
11	Hyd-08R-2630-2 X N-8203-1	-2.31	-5.59	-2.80	-11.13**	7.81	-4.58	-4.95	-8.89*
12	Hyd-08R-2630-2 X N-8215-1	3.74	-2.56	0.33	-8.27**	18.14**	5.37	4.96	0.61
13	Hyd-08R-2630-2 X 644-1	8.26**	3.67	6.74*	-2.41	4.34	-6.95	-7.31	-11.16**
14	Hyd-08R-2630-2 X N-8213-48	-10.47**	-10.54**	-7.89	-15.79**	15.53**	0.00	-0.38	-4.52
15	Hyd-08R-2630-2 X N-8215-4	6.67*	2.24	5.26	-3.76	-13.55**	-25.34**	-25.63**	-28.72**

Table: 3 Contd.....

Sr. No.	Hybrids	Number kernels per row				100 grain weight (g)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
16	N-8211-35 X N-8203-1	13.81**	5.82	1.64	-7.07*	13.75**	4.06	-20.17**	-23.48**
17	N-8211-35 X N-8215-1	26.05**	20.55**	9.05**	-0.30	-4.67	-13.48*	-32.44**	-35.25**
18	N-8211-35 X 644-1	20.74**	13.26**	6.74*	-2.41	7.96	-2.00	-23.51**	-26.69**
19	N-8211-35 X N-8213-48	20.50**	8.64**	11.68**	2.11	33.77**	25.34**	-8.72*	-12.50**
20	N-8211-35 X N-8215-4	15.80**	8.54**	2.47	-6.32*	5.16	-1.22	-28.44**	-31.41**
21	679-1 X N-8203-1	25.07**	15.75**	11.18**	1.65	28.95**	28.48**	-0.65	-4.78
22	679-1 X N-8215-1	2.20	-2.73	-12.01**	-19.55**	33.09**	32.48**	3.44	-0.85
23	679-1 X 644-1	**32.34****	23.56**	**16.45****	**6.47***	-2.61	-3.03	-24.32**	-27.46**
24	679-1 X N-8213-48	-0.71	-10.88**	-8.39**	-16.24**	5.48	2.39	-20.78**	-24.07**
25	679-1 X N-8215-4	21.76**	13.59**	7.24*	-1.95	10.66*	7.14	-17.11**	-20.55**
26	2372-1 X N-8203-1	1.80	-2.91	-6.74*	-14.74**	15.47**	-0.79	5.95	1.55
27	2372-1 X N-8215-1	22.87**	20.64**	9.13**	-0.23	14.95**	-0.50	6.25	1.84
28	2372-1 X 644-1	7.89**	3.84	-2.14	-10.53**	3.50	-10.43**	-4.35	-8.32*
29	2372-1 X N-8213-48	-1.30	-8.80**	-6.25*	-14.29**	4.08	-12.47**	-6.52	-10.40**
30	2372-1 X N-8215-4	12.14**	7.84*	1.81	-6.92*	-14.70**	-28.41**	-23.55**	-26.72**

Table: 3 Contd.....

Sr. No.	Hybrids	Number kernels per row				100 grain weight (g)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
31	2392-2 X N-8203-1	19.72**	15.92**	11.35**	1.80	11.96*	5.67	-18.93**	-22.30**
32	2392-2 X N-8215-1	27.07**	**26.73****	14.64**	4.81	22.55**	14.71**	-10.43*	-14.15**
33	2392-2 X 644-1	2.50	0.17	-5.59	-13.68**	8.26	1.36	-20.90**	-24.18**
34	2392-2 X N-8213-48	5.29	-1.28	1.48	-7.22*	9.39	5.84	-22.92**	-26.12**
35	2392-2 X N-8215-4	20.25**	17.42**	10.86**	1.35	**39.35****	**35.17****	-2.08	-6.14
36	Hyd-08R-8214-31 X N-8203-1	-2.90	-5.31	-9.05**	-16.84**	12.37**	-2.94	2.35	-1.90
37	Hyd-08R-8214-31 X N-8215-1	-16.20**	-16.58**	-23.85**	-30.38**	14.66**	-0.22	5.21	0.85
38	Hyd-08R-8214-31 X 644-1	-12.94**	-14.31**	-19.24**	-26.17**	7.63	-6.35	-1.25	-5.35
39	Hyd-08R-8214-31 X N-8213-48	4.41	-1.44	1.32	-7.37**	15.70**	-2.19	3.14	-1.14
40	Hyd-08R-8214-31 X N-8215-4	2.39	0.70	-4.93	-13.08**	6.98	-9.76*	-4.85	-8.80*
	S.E.(±)	1.05	1.22			1.22	1.41		
	CD at 5%	2.10	2.42			2.43	2.80		
	CD at 1%	2.78	3.22			3.22	3.72		

*,** indicates at 5% and 1% level of significant, respectively.
(Standard Checks: - SC 1: Rajarshi; SC 2: Bio-9637)

Table: 3 Contd.....

Sr. No.	Hybrids	Shelling (%)				Grain yield Per plant (g)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
1	673-2 X N-8203-1	6.96**	2.81**	1.87	**7.24****	29.44**	11.68**	4.13	14.06**
2	673-2 X N-8215-1	4.20**	0.60	-0.32	4.93**	8.93**	4.75	-2.34	6.97*
3	673-2 X 644-1	-1.82*	-2.89**	-3.77**	1.30	11.14**	-1.69	-8.34**	0.40
4	673-2 X N-8213-48	1.96*	-1.91	-2.80**	2.32*	7.48*	-5.34	-11.74**	-3.33
5	673-2 X N-8215-4	5.23**	0.95	0.03	5.30**	26.10**	17.95**	9.97**	20.46**
6	Hyd-08R-8214-43 X N-8203-1	2.45**	-1.39	-2.59**	2.55*	1.82	-10.63**	-19.97**	-12.34**
7	Hyd-08R-8214-43 X N-8215-1	4.87**	1.39	0.16	5.45**	-10.25**	-11.99**	-21.19**	-13.67**
8	Hyd-08R-8214-43 X 644-1	-0.04	-0.97	-2.17*	2.99**	11.30**	0.22	-10.26**	-1.70
9	Hyd-08R-8214-43 X N-8213-48	2.88**	0.88	- 2.09*	3.08**	7.60*	-3.55	-13.63**	-5.39
10	Hyd-08R-8214-43 X N-8215-4	0.67	-3.28**	-4.46**	0.58	-11.14**	-15.28**	-24.14**	-16.90**
11	Hyd-08R-2630-2 X N-8203-1	6.69**	4.02**	0.07	5.35**	50.84**	49.27**	3.13	12.96**
12	Hyd-08R-2630-2 X N-8215-1	4.42**	2.27*	-1.62	3.57**	34.88**	21.57**	4.65	14.63**
13	Hyd-08R-2630-2 X 644-1	0.51	0.13	-2.94**	2.18*	21.01**	18.79**	-14.81**	-6.69*
14	Hyd-08R-2630-2 X N-8213-48	2.89**	0.41	-3.41**	1.69	28.08**	26.36**	-10.29**	-1.74

Table: 3 Contd.....

Sr. No.	Hybrids	Shelling (%)				Grain yield Per plant (g)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
15	Hyd-08R-2630-2 X N-8215-4	4.83**	2.01	-1.87	3.31**	22.81**	13.66**	-7.72**	1.08
16	N-8211-35 X N-8203-1	-2.55**	-7.36**	-6.08**	-1.13	-12.81**	-24.18**	-30.61**	-23.99**
17	N-8211-35 X N-8215-1	-0.87	-5.35**	-4.04**	1.02	-11.67**	-14.30**	-21.57**	-14.09**
18	N-8211-35 X 644-1	-0.12	-2.31*	-0.96	4.26**	0.85	-10.07**	-17.69**	-9.84**
19	N-8211-35 X N-8213-48	1.15	-3.74**	-2.41*	2.73**	13.09**	0.40	-8.11**	0.65
20	N-8211-35 X N-8215-4	2.31*	-2.91**	-1.57	3.62**	-12.35**	-17.29**	-24.31**	-17.09**
21	679-1 X N-8203-1	7.25**	5.23**	-0.07	5.20**	30.56**	16.35**	0.61	10.21**
22	679-1 X N-8215-1	**8.33****	**6.77****	1.40	6.74**	**51.52****	**51.17****	**30.73****	**43.19****
23	679-1 X 644-1	3.49**	2.44*	-0.70	4.54**	20.75**	10.44*	-4.50	4.61
24	679-1 X N-8213-48	7.34**	5.42**	0.11	5.39**	25.34**	14.12**	-1.31	8.10**
25	679-1 X N-8215-4	4.67**	2.50*	-2.66**	2.47*	14.83**	11.32**	-3.74	5.44
26	2372-1 X N-8203-1	2.25*	-1.79	-2.55*	2.58*	4.84	-10.79**	-14.00**	-5.80
27	2372-1 X N-8215-1	0.17	-3.36**	-4.11**	0.95	-8.24**	-13.15**	-16.27**	-8.29**
28	2372-1 X 644-1	-2.41**	-3.54**	-4.29**	0.76	-6.25*	-18.25**	-21.19**	-13.68**
29	2372-1 X N-8213-48	0.68	-3.20**	-3.96**	1.11	7.92**	-6.30*	-9.67**	-1.06

Table: 3 Contd.....

Sr. No.	Hybrids	Shelling (%)				Grain yield Per plant (g)			
		MP	BP	SC 1	SC 2	MP	BP	SC 1	SC 2
30	2372-1 X N-8215-4	5.95**	1.57	0.78	6.10**	12.57**	3.68	-0.04	9.49**
31	2392-2 X N-8203-1	4.66**	3.10**	-2.89**	2.24*	5.66	-5.33	-19.12**	-11.41**
32	2392-2 X N-8215-1	4.62**	3.53**	-2.48*	2.66*	3.92	3.52	-10.89**	-2.39
33	2392-2 X 644-1	-0.54	-1.94	-4.94**	0.07	-17.53**	-24.16**	-35.21**	-29.03**
34	2392-2 X N-8213-48	5.52**	4.05**	-1.99*	3.18**	15.25**	5.51	-9.86**	-1.26
35	2392-2 X N-8215-4	3.88**	2.13*	-3.80**	1.28	-4.09	-6.47	-20.10**	-12.47**
36	Hyd-08R-8214-31 X N-8203-1	3.76**	2.76*	-4.24**	0.81	19.06**	5.92	-8.04**	0.73
37	Hyd-08R-8214-31 X N-8215-1	-0.18	-0.69	-7.46**	-2.58*	-22.78**	-23.11**	-33.24**	-26.88**
38	Hyd-08R-8214-31 X 644-1	2.41**	0.43	-2.64**	2.49*	-3.69	-12.07**	-23.66**	-16.38**
39	Hyd-08R-8214-31 X N-8213-48	5.04**	4.13**	-2.97**	2.15*	13.74**	3.38	-10.25**	-1.69
40	Hyd-08R-8214-31 X N-8215-4	3.17**	1.98	-4.97**	0.04	4.76	1.37	-11.99**	-3.60
	S.E.(±)	0.73	0.85			3.94	4.55		
	CD at 5%	1.46	1.69			7.85	9.07		
	CD at 1%	1.94	2.25			10.42	12.03		

*,** indicates at 5% and 1% level of significant, respectively.
(Standard Checks: - SC 1: Rajarshi; SC 2: Bio-9637)

Table: 3 Contd.....

Sr. No.	Hybrids	Starch content (%)			
		MP	BP	SC 1	SC 2
1	673-2 X N-8203-1	-0.69	-2.69	0.59	-3.90*
2	673-2 X N-8215-1	2.55	2.45	1.63	-2.91
3	673-2 X 644-1	2.44	2.21	1.40	-3.13
4	673-2 X N-8213-48	2.62	1.90	2.53	-2.05
5	673-2 X N-8215-4	-1.21	-3.67	0.57	-3.92*
6	Hyd-08R-8214-43 X N-8203-1	-1.75	-2.44	0.84	-3.66
7	Hyd-08R-8214-43 X N-8215-1	-0.06	-1.49	0.40	-4.09*
8	Hyd-08R-8214-43 X 644-1	1.54	-0.03	1.88	-2.67
9	Hyd-08R-8214-43 X N-8213-48	0.33	-0.30	1.60	-2.93
10	Hyd-08R-8214-43 X N-8215-4	-0.57	-1.76	2.57	-2.01
11	Hyd-08R-2630-2 X N-8203-1	2.05	-1.04	2.29	-2.28
12	Hyd-08R-2630-2 X N-8215-1	3.75*	2.76	1.73	-2.81
13	Hyd-08R-2630-2 X 644-1	**6.10****	**5.21***	3.91*	-0.73
14	Hyd-08R-2630-2 X N-8213-48	1.37	-0.40	0.22	-4.25*

Table: 3 Contd.....

Sr. No.	Hybrids	Starch content (%)			
		MP	BP	SC 1	SC 2
15	Hyd-08R-2630-2 X N-8215-4	0.97	-2.56	1.73	-2.81
16	N-8211-35 X N-8203-1	-1.19	-1.29	2.03	-2.52
17	N-8211-35 X N-8215-1	1.42	-0.62	2.51	-2.06
18	N-8211-35 X 644-1	-1.74	-3.83*	-0.80	-5.23**
19	N-8211-35 X N-8213-48	2.32	1.06	4.25*	-0.41
20	N-8211-35 X N-8215-4	2.09	1.47	5.95**	1.22
21	679-1 X N-8203-1	-1.12	-1.70	2.82	-1.77
22	679-1 X N-8215-1	1.85	-0.88	3.69	-0.94
23	679-1 X 644-1	5.52**	2.58	**7.30****	2.51
24	679-1 X N-8213-48	-0.48	-2.38	2.12	-2.44
25	679-1 X N-8215-4	-1.81	-1.91	2.61	-1.97
26	2372-1 X N-8203-1	-0.05	-0.65	2.69	-1.90
27	2372-1 X N-8215-1	0.18	-1.34	0.74	-3.76*
28	2372-1 X 644-1	1.14	-0.52	1.58	-2.95
29	2372-1 X N-8213-48	0.21	-0.52	1.58	-2.96

Table: 3 Contd.....

Sr. No.	Hybrids	Starch content (%)			
		MP	BP	SC 1	SC 2
30	2372-1 X N-8215-4	-0.13	-1.23	3.13	-1.48
31	2392-2 X N-8203-1	1.51	-1.73	1.58	-2.95
32	2392-2 X N-8215-1	2.71	1.56	0.54	-3.95*
33	2392-2 X 644-1	0.91	-0.10	-1.33	-5.74**
34	2392-2 X N-8213-48	-0.08	-1.99	-1.38	-5.79**
35	2392-2 X N-8215-4	1.65	-2.07	2.25	-2.32
36	Hyd-08R-8214-31 X N-8203-1	0.10	-1.16	2.17	-2.39
37	Hyd-08R-8214-31 X N-8215-1	4.20*	3.29	4.09*	-0.56
38	Hyd-08R-8214-31 X 644-1	2.12	1.11	1.89	-2.66
39	Hyd-08R-8214-31 X N-8213-48	1.12	1.05	1.83	-2.72
40	Hyd-08R-8214-31 X N-8215-4	-0.34	-2.08	2.24	-2.33
	S.E.(±)	1.15	1.33		
	CD at 5%	2.29	2.65		
	CD at 1%	3.04	3.51		

*,** indicates at 5% and 1% level of significant, respectively.
(Standard Checks: - SC 1: Rajarshi; SC 2: Bio-9637)

4.3.1 Days to 50% tasseling:

Since, earliness in the pollen shed is highly desirable in the hybrids showing negative heterotic effects are of immense valve in breeding.

The range of heterosis for days to 50 % tasseling was -3.95 to 2.26% over mid parent, -4.49 to 2.25% over better parent, -2.30 to 4.60% over standard check Rajarshi, and 0.59 to 7.06% over check Bio-9637.

The crosses N-8211-35 X 644-1, Hyd-08R-2630-2 X N-8213-48 (-3.95%) and Hyd-08R-2630-2 X N-8215-4 (-2.82%) showed highest significant negative heterosis over mid parent. While the crosses Hyd-08R-2630-2 X N-8213-48 (-4.49), Hyd-08R-8214-43 X N-8203-1 (-4.40) and 679-1 X N-8203-1 (-4.32%) showed highest significant negative heterosis over its better parent.

Among the forty crosses, three and twelve hybrids over mid parent and better parent exhibited significant negative heterosis respectively. Whereas, none of the cross exhibited significant negative heterosis over commercial check Rajarshi and Bio-9637.

4.3.2 Day to 50% silking:

Since, earliness to 50% silk emergence is highly desirable in maize. The hybrids exhibiting negative heterotic effects for this trait are considered as superior.

Among the crosses, range of heterosis for 50% silk emergence was observed from -3.89 to 3.87% over mid parents;

-3.89 to 1.65% over better parent, -1.70 to 6.82% over check Rajarshi and 1.16 to 8.67% over check Bio-9637.

The higher percentage of negative heterosis were recorded in crosses N-8211-35 X 644-1 (-3.89%), Hyd-08R-2630-2 X N-8213-48 (-2.78%), Hyd-08R-2630-2 X N-8215-4 (-2.78); N-8211-35 X N-8215-4, 2372-1 X N-8213-48, N-8211-35 X N-8213-48 and 2372-1 X N-8215-4 (-2.22%) over mid parents. As regards over better parents the crosses N-8211-35 X 644-1 (-3.89%); Hyd-08R-8214-43 X N-8203-1 (-3.78%), 679-1 X N-8215-4 (-3.72%), Hyd-08R-2630-2 X N-8213-48 (-3.31) and 679-1 X N-8203-1 (-3.19%) exhibited higher magnitude of heterosis.

Among the forty crosses, seven crosses over mid parent and nineteen crosses over better parent exhibited significant negative heterosis. While none of these crosses were showed significant negative heterosis over check Rajarshi and Bio-9637.

4.3.3 Day to maturity:

Earliness in maturity is considered desirable character. The crosses exhibiting negative heterotic effects for this trait of immense value in breeding.

The range of heterosis was from -37.37 to 4.73% over mid parent, -37.80% to 2.42% over better parent, -33.94 to 8.03 over the check Rajarshi and -34.18 to 7.64% over check Bio-9637.

The higher magnitude of heterosis was recorded in the crosses Hyd-08R-8214-43 X N-8215-4 (-37.37%); 2392-2 X N-8215-4 (-6.87%); N-8211-35 X N-8213-48 (-6.62%); N-8211-35 X

N-8215-4 (-5.50%) over mid parent. As regards the heterosis over better parents, the crosses Hyd-08R-8214-43 X N-8215-4 (-37.80%); N-8211-35 X N-8213-48 (-9.46%); N-8211-35 X 644-1 (-8.11%); 2392-2 X N-8215-4 (-7.51%) and N-8211-35 X N-8215-4 (-7.09%) recorded higher magnitude of the crosses.

Of the forty crosses, thirteen, twenty six, crosses over mid parent and better parent respectively. Each of two crosses exhibited significant negative heterosis over standard check Rajarshi and Bio-9637.

4.3.4 Plant height (cm):

The range of heterosis for plant height was -6.94 to 28.19 over mid parent, -13.15 to 26.87% over better parent, -18.40 to 5.62% over check Rajarshi and -16.34 to 8.29% over check Bio-9637.

The crosses Hyd-08R-2630-2 X N-8203-1 (28.91%), 2392-2 X N-8203-1 (25.94%), 2372-1 X N-8215-1 (24.79%), 2372-1 X N-8203-1 (24.55%), 2372-1 X 644-1 (24.16%) recorded highest significant positive heterosis over mid parent; over the better parents, the crosses Hyd-08R-2630-2 X N-8203-1 (26.87%), 2392-2 X N-8203-1 (24.86%) and 2372-1 X N-8203-1 (24.45%) showed higher magnitude of significant positive heterosis. The crosses Hyd-08R-2630-2 X N-8203-1 (5.62%) and Hyd-08R-2630-2 X N-8215-4 (4.24%) over check Rajarshi and Hyd-08R-2630-2 X N-8203-1 (8.29%), Hyd-08R-2630-2 X N-8215-4 (6.87%), 2372-2 X N-8215-4 (6.23%) over check Bio-9637 showed highest significant positive heterosis for plant height.

Among the forty crosses, thirty and twenty three crosses showed significant positive heterosis over mid and better parent, respectively. While four and eight crosses exhibited significant positive heterosis over check Rajarshi and check Bio-9637, respectively.

4.3.5 Earhead height:

The earhead placement at lower side on the stem is desirable for lodging tolerance in maize. The crosses exhibiting negative heterotic effects for this trait are considered superior.

Over mid parent, better parents, check Rajarshi and Bio-9637, the range of the heterosis for earhead height was -2.64 to 58.35%, -20.71 to 49.41%, -13.49 to 31.63% and -24.67 to 14.62 respectively.

The crosses of 2392-2 X N-8213-48 (-20.71%), Hyd-08R-8214-43 X N-8213-48 (-19.92%), Hyd-08R-8214-31 X N-8213-48 (-18.70%), N-8211-35 X N-8213-48 (-13.65); 679-1 X N-8213-48 (-13.52); 673-2 X N-8213-48 (-9.43) and 2372-1 X N-8213-48 (-7.78%) over better parent; Hyd-08R-8214-43 X N-8215-4 (-13.49) and Hyd-08R-8214-31 X 644-1 (-8.17%) over the check Rajarshi exhibited the significant negative heterosis over check Bio-9637, the higher percentage of negative heterosis was predominant in Hyd-08R-8215-4 X N-8214-4 (-24.67%), Hyd-08R-8214-31 X 644-1 (-20.04%) and Hyd-08R-8214-43 X N-8215-1 (-19.00%)

Of the forty crosses, seven, three, twenty one crosses showed significant negative heterosis over better parent; check Rajarshi and Bio-9637.

4.3.6 Ear length:

The extent of heterosis for ear length was ranging from (-16.10 to 23.77%) over mid parent, (-19.77 to 19.32%) over better parent, (-24.10 to 12.10%) over check Rajarshi, (-28.11 to 7.33%) over check Bio-9637.

Out of forty hybrids, eighteen and thirteen hybrids exhibited significant positive heterosis over mid and better parent respectively. While six hybrids over check Rajarshi and two hybrids over Bio-9637 showed highest significant positive heterosis for ear length.

The crosses 2392-2 X N-8215-4 (23.77%), Hyd-08R-2630-2 X N-8215-1 (19.45%) and Hyd-08R-2630-2 X N-8203-1 (18.38%) over mid parents. 2392-2 X N-8215-4 (19.32%), Hyd-08R-2630-2 X N-8203-1 (16.73%) and 679-1 N-8215-1 (16.26%) over better parent. 2392-2 X N-8215-4 (12.10%), 2392-2 X N-8203-1 (11.74%), Hyd-08R-2630-2 X N-8215-1 (8.91%) over check Rajarshi and the hybrids 2392-2 X N-8215-4 (7.33%) and Hyd-08R-2630-2 X N-8203-1 (6.98%) over check Bio-9637 showed significant positive heterosis.

4.3.7 Ear circumference (cm):

For ear circumference out of forty crosses twelve, six and one hybrid showed significant positive heterosis over mid parent, over better parent and check Rajarshi

The heterosis was ranging from -8.32 to 11.01% over mid parents, -10.13 to 10.50% over better parents, -11.13 to 3.36 over check Rajarshi and -12.96 to 1.23 over check Bio-9637.

Of the forty hybrids, the higher magnitude of heterosis was noted in Hyd-08R-8214-43 X N-8203-1 (11.01%), 673-2 X 644-1 (7.87%), Hyd-08R-8214-43 X 644-1 (7.84%) and 679-1 X N-8215-4 (6.84%). The crosses Hyd-08R-8214-43 X N-8203-1 (10.50%), 673-2 X 644-1 (7.37%), Hyd-08R-8214-43 X 644-1 (7.37%), 673-2 X N-8203-1 (7.31%) showed highest positive heterosis over better parents. Single hybrid 679-1 X N-8215-4 (3.36%) showed significant positive heterosis over check Rajarshi.

4.3.8 Number of kernel rows per cob:

The extent of heterosis for number of kernel rows per cob was ranged from -20.00 to 28.57% over mid parent; -25.00 to 28.57% over better parent, -25.00 to 12.50% over check Rajarshi and -25.00 to 12.50% over check Bio-9637.

The crosses N-8211-35 X N-8215-1 (28.57%), 679-1 X N-8213-48 (20.00%), N-8211-35 X N-8213-48, 2392-2 X N-8213-48 (14.29); 679-1 X N-8215-4 (12.51%) exhibited significant heterosis over mid parent. The higher significant magnitude of positive heterosis over better parents was noted in N-8211-35 X N-8215-1 (28.57%); 673-2 X N-8213-48, N-8211-35 X N-8213-4, 2392-2 X N-8213-48 (14.29%); 679-1 X N-8213-48 and 679-1 X N-8215-4 (12.50%), the hybrids N-8211-35 X N-8215-1, 679-1 X N-8213-48; 679-1 X N-8215-4 (12.50%) over both check Rajarshi and Bio-9637.

The cross 673-2 X 644-1 (25.00%) Rajarshi recorded the significant positive heterosis.

Among forty hybrids, sixteen, six showed significant positive heterosis over mid parent and better parent respectively. While each of three crosses showed significant positive heterosis over Rajarshi and Bio-9637.

4.3.9 Number of kernels per row:

For number of kernel per row the magnitude of heterosis was ranging -21.51 to 32.34% over mid parent, -22.61 to 26.73% over better parent, -27.96 to 16.45% over check Rajarshi and -34.14 to 6.47 over check Bio-9637.

Among the forty hybrids twenty one, sixteen, fifteen and one hybrids exhibited significantly positive heterosis over mid parent better parent, Rajarshi and Bio-9637, respectively.

Out of forty hybrids the heterotic effects was more prounced in 679-1 X 644-1 (32.34%), 2392-2 X N-8215-1 (27.07%), N-8211-35 X N-8215-1 (26.05%), 679-1 X N-8203-1 (25.07%) and 673-2 X N-8215-1 (23.11%) over mid parent. The hybrid 2392-2 X N-8215-1 (26.73%) showed the highest significant positive heterosis over better parent followed by hybrid 679-1 X N-8215-1 (23.56%), 673-2 X N-8215-1(22.55%), Hyd-08R-8214-43 X 644-1 (21.82%) and 2372-1 X N-8215-1 (20.64%). The higher magnitude of significant heterosis over check Rajarshi was recorded by the hybrids 679-1 X 644-1 (16.45%), Hyd-08R-8214-43 X 644-1 (14.80%) and 2392-2 X N-

8215-1 (14.64%). While single hybrid 679-1 X 644-1 (6.47%) showed significant positive heterosis over check Bio-9637.

4.3.10 100 Grain weight (g):

Nineteen crosses exhibited significant positive heterosis over mid parental values for 100 grains weight. The range of heterosis was -25.33 to 39.35. The crosses 2392-2 X N-8215-4 (39.35%); N-8211-35 X N-8213-48 (33.77%); 679-1 X N-8215-1 (33.09%); 679-1 X N-8203-1 (28.95%) and Hyd-08R-8214-43 X N-8203-1 (24.74%) recorded highest significant positive heterosis over mid parents.

The significant and positive heterosis was observed in seven crosses over better parents and the range among all the hybrids was from -34.37 to 35.17. The higher percentage of such heterosis were recorded in 2392-2 X N-8215-4 (35.17%); 679-1 X N-8215-1 (32.48%); 679-1 X N-8203-1 (28.48%) and N-8211-35 X N-8213-48 (25.34).

While none of the hybrids exhibited significant positive heterosis over both check Rajarshi and Bio-9637 for 100 grain weight.

4.3.11 Shelling percentage:

The range of heterosis for shelling percentage over mid parents was -2.55 to 8.33. The significant and positive heterosis was showed in twenty seven crosses. The higher magnitude of heterotic effects were noticed in 679-1 X N-8215-1 (8.33%); 679-1 X N-8213-48 (7.34%), 679-1 X N-8203-1 (7.25%), 673-2 X N-8203-1 (6.96%) and Hyd-08R-2630-2 X N-8203-1 (6.69%).

Over better parents the range of heterosis was from -7.36 to 6.77 and fourteen crosses exhibited significant positive heterosis. The heterotic effects were more pounced in 679-1 X N-8215-1 (6.77%), 679-1 X N-8213-48 (5.42%), 679-1 X N-8203-1 (5.23%) and Hyd-08R-8214-31 X N-8213-48 (4.13%).

None of the forty hybrids showed positive and significant heterosis over the check Rajarshi. However twenty seven crosses showed positive significant heterosis over the check Bio-9637. The combinations 673-2 X N-8203-1 (7.24%); 679-1 X N-8215-1 (6.74%); 2372-1 X N-8215-4 (6.10%) and Hyd-08R-8214-43 X N-8215-1 (5.45%) recorded the higher magnitude of significant positive heterosis over Bio-9637.

4.3.12 Grain yield per plant:

For grain yield per plant the percentage of positive heterosis over both mid and better parents were high. The range of heterosis over mid parents -22.78 to 51.52%. While it was -24.18 to 51.17% over better parents. Of the twenty three crosses showing positive heterosis over mid parents. The magnitude were higher in 679-1 X N-8215-1 (51.52%), Hyd-08R-2630-2 X N-8203-1 (50.84%); Hyd-08R-2630-2 X N-8215-1 (34.88%), 679-1 X N-8203-1 (30.56%) and 673-2 X N-8203-1 (29.44%)

When the heterosis based on better parents was considered, it was observed that twelve crosses exhibited significant positive heterosis. The heterotic effects in 679-1 X N-8215-1 (51.17%); Hyd-08R-2630-2 X N-8203-1 (49.27%); Hyd-08R-2630-2 X N-8213-48 (26.36%) and Hyd-08R-2630-2 X N-8215-1 (21.57%) were of greater magnitude.

Two magnitude 679-1 X N-8215-1 (30.73%) and 673-2 X N-8215-4 (9.97%) showed positive and significant heterosis over check Rajarshi. Of the nine hybrids showing positive significant heterosis over check Bio-9637. The higher magnitude of such heterosis was observed in 679-1 X N-8215-1 (43.19%), 673-2 X N-8215-4 (20.46%); Hyd-08R-2630-2 X N-8215-1 (14.63%) and 673-2 X N-8203-1 (14.06%).

4.3.13 Starch content:

The magnitude of positive heterosis for starch content over mid parents, better parent and the checks were very low. The range of heterosis over mid parents was -1.81 to 6.10%; -3.83 to 5.21 % over better parents, -1.38 to 7.30% over check Rajarshi and -5.79 to 2.51 over Bio-9637.

The four crosses *viz*; Hyd-08R-2630-2 X 644- 1 (6.10%); 679-1 X 644-1 (5.52%); Hyd-08R-8214-31 X N-8215-1 (4.20%) and Hyd-08R-2630-2 X N-8215-1 (3.75%) showed significant positive heterosis over mid parents. Only one hybrid Hyd-08R-2630-2 X 644-1 (5.21%) recorded significant positive heterosis over better parent. Five crosses exhibited significant positive heterosis over check Rajarshi and the higher magnitude of such heterosis were noticed in 679-1 X 644-1 (7.30%); N-8211-35 X N-8215-4 (5.95%), N-8211-35 X N-8213-48 (4.25%), Hyd-08R-8214-31 X N-8215-1 (4.09%), Hyd-08R-2630-2 X 644-1. None of the hybrids showed significant positive heterosis over the check Bio-9637.

Table: 4. Analysis of variance for combining ability.

SN	Source of Variation	DF	Days to 50% tasseling	Days to 50% sillking	Days to maturity	Plant height (cm)	Earhead height (cm)	Ear length (cm)	Ear circumferance (cm)	Number of kernel rows per cob	Number of kernel per row	100 grain weight (g)	Shelling percentage	Grain yield per plant (g)	Starch content (%)
1	Female	7	12.26**	13.81**	104.98	1686.72**	652.84**	20.92**	1.44	15.72**	77.71	110.18*	19.24	3472.89**	7.18
2	Male	4	6.346*	6.396*	136.61	991.19*	337.546**	3.620	1.344	11.55*	20.33	89.45	1.348	707.89	1.62
3	Female X Male	28	1.579**	1.624**	94.68**	263.07**	76.48**	3.43**	0.719**	3.83**	53.14**	36.59**	8.284**	771.56**	3.43
4	Error	78	0.659	0.497	0.755	6.2	11.39	0.24	0.112	0.30	2.634	3.24	1.12	39.44	2.54
5	δ^2 g.c.a. for lines		0.768**	0.879**	6.936	112.07**	42.88**	1.387**	0.089**	1.033**	5.032	7.146*	1.21	229.44**	0.301
6	δ^2 g.c.a. tester		0.234*	0.240*	5.652	41.06*	13.66**	0.142	0.052*	0.472*	0.754	3.603	0.011	28.19	-0.043
7	δ^2s.c.a. for L x T		0.280**	0.333**	31.24**	85.79**	22.28**	1.075**	0.205**	1.203**	16.972**	11.20**	2.39**	246.80**	0.255*

*, ** indicates at 5% and 1%level of significant, respectively.

4.4 Analysis of variance for combining ability:

The details of analysis of variance for combining ability for thirteen different characters have been presented in Table 4 and described in brief as given below.

4.4.1 Variance due to females:

The variances due to females were significant for days to 50% tasseling, days to 50% silking, plant height, earhead height, ear length, number of kernel rows per cob, 100 grain weight and grain yield per plant. The variance due to females for rest of characters were non significant.

4.4.2 Variance due to males:

The variances for combining ability due to males were found to be significant for days to 50% tasseling, days to 50% silking, plant height, earhead height, number of kernel rows per cob. The variances due to males were non-significant for rest of characters.

4.4.3 Variance due to female X male interaction:

The variance due of female X male interaction was observed to be significant for all character studied except starch content.

The magnitudes of variances due to females were greater than those due to male and females X male interaction for all the character studied except for day to maturity. For days to maturity the magnitude were higher than females X males interaction.

Due to males, the values of variances were higher than those due to female X male interaction for all the characters except number of Kernel per row, shelling percentage, grain yield per plant and starch content.

4.5 G.C.A. and S. C. A. effect for parents and their crosses:

The estimates of general combining ability effects of females and male and specific combining ability effects for the hybrid were presented in Table 5 and 6, respectively and have explained brief as given below.

4.5.1 Days to 50% tasseling:

For days to 50% tasseling, females, *viz*; Hyd-08R-2630-2, N-8211-35, 2372-1 and males N-8203-1 and N-8215-4 showed significant negative g.c.a. effects. While significant positive g.c.a effects were exhibited by the female 673-2, Hyd-08R-8214-43, 679-1, 2392-1 and the male parents N-8215-1 and N-8213-48.

Out of the crosses, two and three hybrids showed significant positive and negative s.c.a. combinations, respectively. The magnitude of the negative s.c.a. effects were higher in N-8211-35 X 644-1 (-1.33), Hyd-08R-2630-2 X N-8213-48 (-1.30) and 2392-2 X N-8215-4 (-1.042). While that of positive s.c.a effects in Hyd-08R-8214-43 X N-8215-4 and N-8211-35 X N-8203-1 crosses.

4.5.2 Days to 50% silking:

Out of eight females, three showed significant negative and five showed significant positive g.c.a. effects respectively for days to 50 % silking. Hyd-08R-2630-2; N-8211-35 and 2372-1 showed higher magnitude of the negative g.c.a. effects, While 679-1, 673-2, 2392-2, Hyd-08R-8214-43, Hyd-08R-8214-31 had higher values of positive significant g.c.a. effects.

Out of five male; N-8203-1 and N-8215-4 showed significant negative g.c.a. effects. While N-8215-1 showed significant positive g.c.a. effects.

As regards s.c.a. effects three crosses for each showed significant negative and positive s.c.a. effects, respectively. The higher value of negative s.c.a. effects were found in N-8211-35 X 644-1, Hyd-08R-8214-31 X N-8215-1, 2392-2 X N-8215-4. While positive s.c.a effects were recorded in Hyd-08R-8214-43 X N-8215-4; N-8211-35 X N-8203-1 and Hyd-08R-8214-31 X N-8213-48.

4.5.3 Day to maturity:

The female parents, Hyd-08R-8214-43, N-8211-35, Hyd-08R-2630-2 had significant negative g.c.a effect. While 673-2; 679-1, 2392-2 and Hyd-08R-8214-31 had significant positive g.c.a. effects for earliness.

Among the males, N-8215-4 showed significant negative and N-8215-1; 644-1 and N-8213-48 showed significant positive g.c.a. effect.

Among the forty crosses, fourteen and thirteen showed significant negative and positive s.c.a. effects, respectively. The crosses Hyd-08R-8214-43 X N-8215-4, 679-1 X N-8215-1, N-8211-35 X N-8213-48 exhibited higher values of negative s.c.a. effects. While Hyd-08R-8214-43 X N-8215-1; 679-1 X N-8215-

and Hyd-08R-8214-43 X N-8213-48 and Hyd-08R-8214-43 X N-8203-1 showed such values of positive s.c.a. effects.

4.5.4 Plant height (cm):

The female Hyd-08R-2630-2 and 2372-1 had significant positive, while Hyd-08R-8214-31; Hyd-08R-8214-43; 679-1, 673-2 and N-8211-35 showed significant negative g.c.a. effect for plant height.

The male parents, N-8203-1 and N-8215-4 recorded significant positive g.c.a. effects for plant height. While significant negative g.c.a. effects were recorded by N-8213-4, 644-1 and N-8215-1.

Among the forty crosses, thirteen and sixteen showed significant positive and negative s.c.a. effects respectively. The crosses 2392-2 X N-8215-4; Hyd-08R-8214-43 X N-8203-1, Hyd-08R-8214-31 X 644-1, 679-1 X 644-1 and 673-2 X N-8213-48 showed higher value of significant positive s.c.a. effects. While 2392-2 X N-8215-1, 2392-2 X 644-1 and 673-2 X 644-1 showed significant negative s.c.a. effects.

4.5.5 Earhead height (cm):

Out of eight females, for earhead height the females Hyd-08R-8214-43, Hyd-08R-8214-31, 2392-2, N-8211-35 while Hyd-08R-2630-2, 2372-1 and 673-2 had significant positive g.c.a. effects.

Among the male, three and one showed significant negative and positive g.c.a effects, respectively. The higher value of negative g.c.a effects were noted in N-8213-48, N-8215-4 and 644-1.

Table: 5. The estimates of the general combining ability effects for thirteen characters in Maize.

SN	Parents	Day to 50% tasseling	Days to 50% sillking	Days to maturity	Plant height (cm)	Earhead height (cm)	Ear length (cm)	Ear circumference (cm)	Number of kernel rows per cob	Number of kernel per row	100 grain weight (g)	Shelling percentage	Grain yield per plant (g)	Starch content (%)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Females													
1	673-2	1.13**	0.942**	1.175**	-1.68**	4.66**	0.402**	0.411**	-0.65 0**	-0.64**	-0.19**	1.212**	15.58**	-0.446**
2	Hyd-08R-8214-43	0.20*	0.342**	**-5.425****	-9.461**	**-7.015****	-1.44**	**0.451****	0.55**	-0.694**	-2.796**	0.137	-10.94**	-0.368**
3	Hyd-08R-2630-2	**-1.20****	**-1.192****	-0.425**	**16.00****	10.39**	**1.65****	-0.243**	-0.250**	0.079	1.643**	0.379*	10.09**	-0.014**
4	N-8211-35	-1.00**	**-1.192****	-1.425**	-1.50**	-2.56**	-1.218**	-0.22**	0.950**	2.50**	-3.899**	-0.551**	-15.24**	0.537
5	679-1	0.93**	1.142**	3.508**	-6.67**	0.105	-0.245**	0.218*	**1.750****	1.119**	-0.167**	**1.752****	**25.46****	**1.162***
6	2372-1	-0.800**	-0.925**	0.108	15.11**	6.652**	0.428**	-0.169*	-0.65 0**	-0.394**	2.411**	-0.385**	-1.75**	-0.038**
7	2392-2	0.667**	0.608**	0.708**	0.93	-6.028**	1.42**	-0.316**	-0.250*	**2.599****	-1.26**	-0.730**	-12.90**	-1.134**

Table: 5 Contd.....

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
8	Hyd-08R-8214-31	0.067	0.275*	1.77**	-12.74**	-6.208**	-1.005**	-0.123**	-1.45**	-4.574**	**4.269 ****	-1.814**	-10.29**	0.302
	SE	0.22	0.20	0.25	0.61	0.80	0.11	0.08	0.12	0.38	0.44	0.26	1.44	0.42
	CD 5%	0.44	0.40	0.50	1.22	1.59	0.23	0.16	0.24	0.76	0.88	0.53	2.86	0.83
	CD 1%	0.58	0.53	0.66	1.62	2.11	0.31	0.21	0.32	1.01	1.17	0.71	3.80	1.11

*, ** indicates at 5% and 1%level of significant, respectively.

Table: 5 Contd.....

SN	Parents	Days to 50% tasseling	Days to 50% sillking	Days to maturity	Plant height (cm)	Earhead height (cm)	Ear length (cm)	Ear circumference (cm)	Number of kernel rows per cob	Number of kernel per row	100 grain weight (g)	Shelling percentage	Grain yield per plant (g)	Starch content (%)
	Males													
1	N-8203-1	**-0.725****	**-0.583****	-0.050	**9.97****	6.331**	**0.53****	**0.233****	-0.55**	-0.054	**2.097****	**0.284***	1.11	-0.083**
2	N-8215-1	0.650**	0.70**	1.783**	-1.78**	0.502	-0.053	-0.159*	-0.050	-1.058**	1.112**	0.066	**3.93** *	-0.056**
3	644-1	0.067	0.083	1.658**	-2.596**	-1.84**	-0.324**	-0.301**	-0.80**	0.696*****	-0.065	-0.365**	-9.501**	-0.014**
4	N-8213-48	2.33**	0.208	0.658**	-7.279**	**-2.69****	-0.391**	-0.005	**0.70****	-0.712*	-1.01	-0.047**	2.96*	-0.277**
5	N-8215-4	-0.225**	-0.417**	**-4.050****	1.692**	-2.29**	0.230*	**0.233****	**0.70****	**1.129****	-3.043**	0.062	1.48	0.430
	SE	0.17	0.16	0.19	0.48	0.63	0.094	0.065	0.09	0.30	0.35	0.21	1.13	0.33
	CD 5%	0.34	0.32	0.39	0.96	1.26	0.187	0.13	0.19	0.60	0.70	0.42	2.26	0.66
	CD 1%	0.46	0.42	0.52	1.28	1.67	0.248	0.17	0.25	0.80	0.93	0.56	3.00	0.87

*,** indicates at 5% and 1%level of significant, respectively.

Table: 6. Estimates of specific combining ability effects for crosses in Maize.

S N	Crosses	Days to 50% tasseling	Days to 50% sillking	Days to maturity	Plant height (cm)	Earhead height (cm)	Ear length (cm)	Ear circumference (cm)	Number of kernel rows per cob	Number of kernel per row	100 grain weight (g)	Shelling percentage	Grain yield per plant (g)	Starch content (%)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	673-2 X N-8203-1	-0.008	-0.15	-1.217*	-1.504	-1.011	-0.685**	0.014	0.150	-2.893**	2.216*	2.223**	8.383*	0.431
2	673-2 X N-8215-1	-0.717	-0.108	-2.050**	9.521**	4.018*	1.107**	-0.394*	-0.350	**6.045****	-2.959**	0.526	-5.042	0.251
3	673-2 X 644-1	-0.133	-0.150	-0.258	-12.07**	-0.707	**1.84****	0.414*	-1.600**	-1.309	6.325**	-2.062**	-1.447	0.049
4	673-2 X N-8213-48	0.367	0.392	0.408	10.07**	-1.453	-1.023**	0.085	0.900**	-3.767**	0.134	-1.530*	-19.49**	1.085
5	673-2 X N-8215-4	0.492	0.017	3.117**	-6.025**	-0.848	-1.243**	-0.119	0.900**	1.924*	-5.717**	0.837	17.59**	-0.954
6	Hyd-08R-8214-43 X N-8203-1	-0.408	-0.550	5.383**	14.269**	12.53**	-0.30	0.441*	0.950**	1.961*	2.278*	-0.599	-4.613	-0.335
7	Hyd-08R-8214-43 X N-8215-1	-0.117	-0.508	8.883**	-6.839**	-5.968**	-2.44**	-0.734**	-1.550**	-9.635**	-3.112**	2.028**	-9.431**	-0.66
8	Hyd-08R-8214-43 X 644-1	-0.867	-0.550	3.675**	-0.631	2.040	0.824**	0.374*	1.200**	5.944**	0.859	0.413	21.93**	0.302
9	Hyd-08R-8214-43 X N-8213-48	-0.033	-0.008	5.675**	0.252	0.028	0.991**	0.245	-0.300	4.419**	-1.986	0.172	3.939	0.375
10	Hyd-08R-8214-43 X N-8215-4	1.425**	1.617**	**-23.61****	-7.052**	-8.635**	0.937**	-0.326	-0.300	-2.689**	1.970	-2.014**	-11.82**	0.325
11	Hyd-08R-2630-2 X N-8203-1	0.325	-0.017	-1.617**	1.402	3.22	0.728**	0.201	-0.250	-1.213	-1.502	1.485*	12.23**	0.294
12	Hyd-08R-2630-2 X N-8215-1	0.617	0.358	-1.117	2.494	-3.908*	0.653*	-0.208	1.250**	1.058	2.916**	0.226	11.90**	-0.110

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
13	Hyd-08R-2630-2 X 644-1	0.533	0.650	0.675	-6.16**	1.16	-0.809**	0.434*	0	1.904*	-0.160	-0.499	-6.576*	1.331
14	Hyd-08R-2630-2 X N-8213-48	-1.300*	-0.808	-1.99**	-4.614**	2.82	-0.609*	-0.495**	0.500	-2.621**	2.276*	-1.227*	-11.627**	-0.919
15	Hyd-08R-2630-2 X N-8215-4	-0.175	-0.183	4.05**	6.882**	-3.30	0.037	0.068	-1.500**	0.871	-3.529**	0.014	-5.931	-0.596
16	N-8211-35 X N-8203-1	1.125*	1.317**	1.38*	-7.157**	-5.45**	0.002	-0.113	-1.450**	-1.839*	-1.235	-2.968**	-17.76**	-0.431
17	N-8211-35 X N-8215-1	0.417	0.358	1.21*	6.801**	3.37	0.127	**0.946****	**2.050****	2.165*	-4.503**	-0.967	-5.756	-0.131
18	N-8211-35 X 644-1	**-1.33****	**-1.35 ****	-2.99**	4.942**	-6.68**	0.231	-0.379*	0.800**	-0.523	-0.232	2.161**	14.03**	-2.427*
19	N-8211-35 X N-8213-48	-0.167	-0.475	-3.32**	-5.041**	1.90	0.531*	-0.308	-0.700*	2.886*	4.931**	0.573	17.289**	1.269
20	N-8211-35 X N-8215-4	-0.042	0.15	3.71**	0.455	6.845**	-0.890**	-0.146	-0.700*	-2.689**	1.039	1.201*	-7.802*	1.720
21	679-1 X N-8203-1	-0.142	-0.017	-0.883	-5.51**	1.41	0.528	-0.159	-0.250	3.414**	1.793	-0.008	-7.260*	-0.519
22	679-1 X N-8215-1	0.150	0.692	-4.050**	-0.559	-2.55	1.353**	0.399*	-0.750**	-4.982**	4.199**	1.493*	**39.315****	0.043
23	679-1 X 644-1	0.067	-0.017	-0.592	10.91**	0.12	-0.709**	-0.526**	0	4.79**	-4.244**	0.091	-5.023	**2.428***
24	679-1 X N-8213-48	0.233	-0.142	-0.258	-5.134**	-0.62	-0.17	-0.655**	0.500	-3.86**	-2.982**	0.480	-12.267**	-0.806
25	679-1 X N-8215-4	-0.308	-0.517	5.783**	0.295	1.64	-0.997**	**0.941****	0.500	0.631	1.234	-2.056**	-14.76**	-1.176
26	2372-1 X N-8203-1	-0.408	-0.283	-1.487*	-8.11**	**-9.66****	-1.178**	-0.472*	0.150	-2.33**	1.503	-0.047	-4.012	0.591
27	2372-1 X N-8215-1	0.217	0.425	-1.31*	8.781**	5.16**	0.48	-0.114	-0.350	-5.098**	2.595*	-1.193	-10.55**	-0.762
28	2372-1 X 644-1	0.800	0.717	-0.192	4.389**	6.57**	-0.049	-0.006	0.400	-1.223	0.099	-0.915	-5.189	-0.232

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
29	2372-1 X N-8213-48	-0.700	-0.742	-1.525**	4.739**	-1.372	0.151	0.569**	-1.100**	-1.481	-0.619	-0.943	1.247	0.028
30	2372-1 X N-8215-4	0.092	-0.117	4.517**	-9.798**	-0.702	0.597*	0.027	0.900**	-0.056	-3.574**	**3.098****	18.51**	0.375
31	2392-2 X N-8203-1	-0.208	-0.15	0.583	6.402**	-1.784	-0.478	-0.059	1.750**	2.001*	-3.443**	0.008	-1.261	0.934
32	2392-2 X N-8215-1	0.083	-0.108	0.417	-15.17**	0.355	-0.187	0.33	-0.750**	4.338**	0.489	0.579	9.427**	0.200
33	2392-2 X 644-1	0.333	0.517	-1.125*	-12.964**	2.920	-0.216	0.074	0	-5.616**	-1.960	-1.146	-17.025**	-1.119
34	2392-2 X N-8213-48	0.833	0.725	-0.125	1.053	-1.759	-0.449	0.445*	0.500	-1.34	-2.624*	1.126	12.085**	-0.889
35	2392-2 X N-8215-4	-1.042*	-0.983*	0.250	**20.68****	0.978	1.330**	-0.793**	-1.500**	0.618	**7.537****	-0.567	-3.226	0.874
36	Hyd-08R-8214-31 X N-8203-1	-0.275	-0.150	-2.150**	0.216	0.729	1.388**	0.147	-1.050**	0.908	-1.603	-0.098	14.294**	-0.102
37	Hyd-08R-8214-31 X N-8215-1	-0.650	-1.108*	-1.983**	-5.026**	0.225	-1.087**	-0.227	0.450	-4.088**	0.376	-2.694**	-29.858**	1.174
38	Hyd-08R-8214-31 X 644-1	0.600	0.183	0.808	11.583**	-5.433**	-1.116**	-0.386*	-0.800**	-3.976**	-0.687	1.955**	-0.703	-0.362
39	Hyd-08R-8214-31 X N-8213-48	0.767	1.058*	1.142*	-1.334	0.454	0.584*	0.118	-0.300	5.766**	0.869	1.35*	8.826**	-0.142
40	Hyd-08R-8214-31 X N-8215-4	-0.442	0.017	2.183**	-5.438**	4.025*	0.230	0.348	1.700**	1.391	1.044	-0.513	7.442*	-0.568
	SE	0.49	0.45	0.56	1.37	1.79	0.26	0.18	0.27	0.86	0.99	0.60	3.22	0.94
	CD 5%	0.98	0.90	1.12	2.73	3.56	0.53	0.37	0.54	1.71	1.98	1.19	6.41	1.87
	CD1%	1.31	1.20	1.48	3.63	4.73	0.70	0.49	0.72	2.27	2.63	1.59	8.51	2.48

*, ** indicates at 5% and 1%level of significant, respectively.

While such values of positive g.c.a. effects were recorded in N-8203-1 for this character.

Out of forty crosses six and seven crosses showed significant positive and negative s.c.a. effects, respectively. The crosses Hyd-08R-8214-43 X N-8203-1, N-8211-35 X N-8215-4, 2372-1 X 644-1 and 2372-1 X N-8215-1 exhibited higher positive s.c.a. effects, whereas the crosses 2372-1 X N-8203-1, Hyd-08R-8214-43 X N-8215-4, N-8211-35 X 644-1, Hyd-08R-8214-43 X N-8215-1, N-8211-35 X N-8203-1, Hyd-08R-8214-31 X 644-1, Hyd-08R-2630-2 X N-8215-1 showed highest significant negative s.c.a. effects.

4.5.6 Ear length (cm):

Among the eight females, Hyd-08R-2630-2, 2392-2, 673-2 and 2372-1 had significant positive g.c.a. effects for ear length. While Hyd-08R-8214-43, N-8211-35, 679-1, Hyd-08R-8214-31 had significant negative g.c.a. effects.

The male parents, N-8203-1 and N-8215-4 exhibited the significant positive g.c.a. effects, whereas 644-1 and N-8213-48 had significant negative gca effects.

Out of forty crosses, thirteen and twelve crosses showed significant positive and negative s.c.a. effect, respectively. The higher values of positive significant s.c.a. effects were noted in 673-2 X 644-1, Hyd-08R-8214-31 X N-8203-1,679-1 X N-8215-1 and 2392-2 X N-8215-4. While such values of negative s.c.a effects were found in Hyd-08R-8214-43 X N-8215-1; 673-2 X N-8215-4 and 2372-1 X N-8203-1.

4.5.7 Ear circumference (cm):

Three females parents *viz*; Hyd-08R-8214-43, 673-2 and 679-1 showed significant positive g.c.a. effects for ear circumference. Whereas five female parents showed significant negative g.c.a. effects.

Among the males N-8203-1 and N-8215-4 had significant positive g.c.a. effects, whereas 644-1 and N-8215-1 showed highly significant negative g.c.a. effects.

Of the forty crosses, each of nine crosses showed significant positive and negative s.c.a. effects, respectively. The crosses N-8211-35 X N-8215-1; 679-1 X 8215-4 and 2372-1 X N-8213-48 exhibited higher values of positive s.c.a. effects. Such values of negative s.c.a. were noted in 2392-2 X N-8215-4 and Hyd-08R-8214-43 X N-8215-1.

4.5.8 Number of kernel rows per cob:

For number of kernel rows per cob, three and five females showed significant positive and negative g.c.a. effects, respectively. The female parents 679-1, N-8211-35 and Hyd-08R-8214-43 had significant positive g.c.a. effects. Whereas higher values of significant negative g.c.a. effects were found in Hyd-08R-8214-31, 673-2 and 2372-1.

Out of five males, two *viz*; N-8213-48 and N-8215-4 showed significant positive g.c.a. effects, whereas significant negative g.c.a. effects were found in 644-1 and N-8203-1.

Out of forty crosses, ten and twelve showed significant positive and negative s.c.a. effects respectively. The crosses

N-8211-35 X N-8215-1, 2392-2 X N-8203-1 and Hyd-08R-8214-31 X N-8215-4 had higher positive s.c.a. effects, whereas such values of negative s.c.a. effects were found in 673-2 X 644-1; Hyd-08R-8214-43 X N-8215-1; Hyd-08R-2630-2 X N-8215-4 and 2392-2 X N-8215-4.

4.5.9 Number of kernels per row:

The female parents 2392-2, N-8211-35 and 679 -1 had significant positive g.c.a. effects. Whereas the females parents Hyd-08R-8214-31,673-2, Hyd-08R-8214-43 and 2372-1 had significant negative g.c.a. effects for number of kernels per row

Among the male, 644-1 and N-8215-4 showed significant positive g.c.a. effects, whereas the male parent N-8215 -1 and N-8213-48 showed showed significant negative g.c.a effects.

Among the crosses, thirteen and fourteen showed significant positive and negative s.c.a. effects, respectively. The crosses 673-2 X N-8215-1, Hyd-08R-8214-43 x 644-1, Hyd-08R-8214-31 X N-8213-48 and 679-1 X 644-1 showed higher values of significant positive s.c.a effects.

4.5.10 100 grain weight (g):

For 100 grain weight the three females parents *viz*; Hyd-08R-8214-31, 2372-1 and Hyd-08R-2630-2 showed the significant positive g.c.a. effects. While N-8211-35, Hyd-08R-8214-43, 673-2, 679-1 and 2392-2 showed significant negative g.c.a. effects.

Of the male parents two and one showed the significant positive and negative g.c.a. effects, respectively. N-8203-1 and

N-8215-1 showed significant positive g.c.a. effects, while N-8215-4 showed significant g.c.a effects.

As regards the s.c.a. effects, nine and ten crosses showed significant positive and negative s.c.a. effects respectively. The crosses 2392-2 X N-8215-4, 673-2 X 644-1, N-8211-35 X N-8213-48 and 679-1 X N-8215-1 had higher values of significant positive s.c.a. effects. The higher magnitude of negative s.c.a. effects were recorded in 673-2 X N-8215-4; N-8211-35 X N-8215-1; 679-1 X 644-1 and 2372-1 X N-8215-4 crosses.

4.5.11 Shelling percentage:

For shelling percentage, three and four females showed significant positive and negative g.c.a. effects respectively. The females 679-1, 673-2 and Hyd-08R-2630-2 had significant positive g.c.a. effects. While Hyd-08R-8214-31, 2392-2, N-8211-35 and 2372-1 had significant negative g.c.a. effects.

Among the male parents N-8203-1 showed significant positive and 644-1, N-8213-48 showed negative g.c.a. effects for shelling percentage.

Of the forty crosses, nine and seven showed significant positive and negative s.c.a. effects. The higher magnitude in former were observed in 2372-1 X N-8215-4, 673-2 X N-8203-1, N-8211-35 X 644-1 and Hyd-08R-8214-43 X N-8215-1 and that of latter in N-8211-35 X N-8203-1, Hyd-08R-8214-31 X N-8215-1; 673-2 X 644-1 and 679-1 X N-8215-4.

4.5.12 Grain yield per plant:

Three exhibited significant positive g.c.a. effects for grain yield per plant. The females 679-1, 673-2 and Hyd-08R-2630-2 had significant positive g.c.a. effects.

Two male parents N-8215-1 and N-8213-48 had significant positive g.c.a. effects for grain yield.

Among the forty crosses, fourteen expressed significant positive s.c.a. effects. The crosses 679-1 X N-8215-1, Hyd-08R-8214-43 X 644-1, 2372-1 x N-8215-4, 673-2 X N-8215-4 and N-8211-35 X N-8213-48 showed higher values of significant positive s.c.a. effects.

4.5.1.13 Starch Content:

One and five female parents showed significant positive and negative g.c.a. respectively. In former case the females was 679-1 and in latter case female 2392-2, 673-2, 2372-1, Hyd-08R-8214-43 and Hyd-08R-2630-2.

Among the male, N-8213-48, N-8203-1, N-8215-1 and 644-1 had showed significant negative g. c .a. effects, while none of these male parents showed positive g.c.a. effects.

Among the forty crosses 679-1 X 644-1 and N-8211-35 X 644-1 showed significant positive and negative s.c.a. effect for starch content.

4.6 Gene action and Heritability

The value of the estimates of g.c.a. and s.c.a. variance, their A : D ratios and percentages of the heritability are presented in Table 7.

The variance due to g.c.a. effects were higher for grain yield per plant, earhead height and plant height, while the values of variance due to s.c.a effects were higher for grain yield per plant, earhead height and days to maturity than the rest of the characters.

While comprising the g.c.a. and s.c.a. variance for individual character, the value of s.c.a. variance were higher than those of g.c.a. variance for all the characters except days to 50% tasseling and silking and earhead height.

Estimation of dominance variances (δ^2 D) were higher than the additive variance (δ^2 A) for days to maturity, ear circumference, number of kernel per row, 100 grain weight, shelling percentage, grain yield per plant and starch content. The A : D ratio was lesser than the unity for these characters indicating predominance of non-additive gene action.

Table 7. Gene action and heritability for 13 differents characters in Maize.

parameter	Days to 50% Tasseling	Days to 50% Silking	Days to Maturity	Earhead height (cm)	Plant height (cm)	Ear lenght (cm)	Ear circumference (cm)	Number of kernel rows/cob	Number of kernels/row	100 grain weight (g)	Shelling (%)	Grain yield/plant (g)	Starch content (%)
σ^2 gca	0.43	0.48	6.14	24.90	68.37	0.61	0.06	0.68	2.40	4.96	0.47	105.60	0.089
σ^2 sca	0.28	0.33	31.24	22.28	85.79	1.07	0.20	1.20	16.97	11.20	2.39	246.80	0.25
σ^2 A	0.87	0.97	12.29	49.80	136.74	1.23	0.13	1.37	4.79	9.93	0.94	211.20	0.17
σ^2 D	0.28	0.33	31.24	22.28	85.79	1.07	0.20	1.20	16.97	11.20	2.39	246.80	0.25
σ^2 e	0.24	0.20	0.31	3.21	1.89	0.07	0.035	0.075	0.744	0.99	0.36	10.38	0.88
h^2 (ns) %	65.53	64.23	28.02	66.13	60.92	51.90	35.56	51.82	21.31	44.87	25.48	45.09	13.51
σ^2g.c.a/ σ^2 s.c.a.	1.57	1.46	0.19	1.11	0.797	0.575	0.323	0.57	0.14	0.44	0.19	0.428	0.35
Nature of gene action	Additive	Additive	Non-additive	Additive	Non-additive	Non-additive	Non-additive	Non-additive	Non-additive	Non-additive	Non-additive	Non-additive	Non-additive

Out of the thirteen character studied the value of heritability estimate were high for plant height (66.13%), days to 50% tasseling (65.53%), days to 50% silking (64.23%) and earhead height (60.92%.). The heritability values were medium for ear length (51.90%), number kernel rows per cob (51.82%), grain yield per plant (45.09%), 100 grain weight (44.87%), and ear circumference (35.56%). While value of the rest of the characters between 13.51 to 28.02 percent which were low.

4.7 Percentage contribution of females, males and females X males interaction to the hybrid sum of square.

Percentage contribution of males, females and females X males to the sum of square of hybrids are presented in Table 8.

The contribution of females parents was ranged between 57.64 (days to 50% silking) to 18.68 percent (days to maturity). The contribution of males parents was ranged from 17.51 (Number of kernels rows per cob) to 1.44 percent (shelling percentage).

The percentages of contribution by female parent to the hybrids were higher for all the characters than those by male parents. The contribution due females x males was ranged between 70.41 (Number of kernel per row) to 26.56 percent (earhead height).

Table 8. Percentage contribution of females, males and females X male interaction to sum of square of hybrids.

S N	Characters	Females (%)	Males (%)	Hybrid
1	Days to 50% tasseling	55.23	16.32	28.44
2	Days to 50% sillking	57.64	15.24	27.10
3	Days to maturity	18.68	13.89	67.41
4	Ear head height (cm)	56.68	16.74	26.56
5	Plant height (cm)	51.02	17.13	31.83
6	Ear length (cm)	56.94	5.62	37.42
7	Ear circumference (cm)	28.38	15.09	56.52
8	Number of Kernel rows / cob	41.75	17.51	40.72
9	Number Kernels / row	25.73	3.84	70.41
10	100 grain weight (g)	35.81	16.61	47.57
11	Shelling percentage	36.20	1.44	62.34
12	Grain yield per plant (g)	49.87	5.80	44.31
13	Starch content (%)	32.90	4.26	62.83

Table 9: Grain colour and shape (Quality characters)

Sr. No.	Genotypes	Grain colour	Grain shape
	Females		
1	673-2	Orange yellow	Flint
2	Hyd-08R-8214-43	Orange yellow	Flint
3	Hyd-08R-2630-2	Yellow	Flint
4	N-8211-35	Yellow	Flint
5	679-1	Yellow	Flint
6	2372-1	Orange	Dent
7	2392-2	Orange yellow	Flint
8	Hyd-08R-8214-31	Yellow	Flint
	Males		
1	N-8203-1	Yellow	Flint
2	N-8215-1	Orange yellow	Dent
3	644-1	Yellow	Dent
4	N-8213-48	Orange	Flint
5	N-8215-4	Orange yellow	Flint
	Hybrids		
1	673-2 X N-8203-1	Orange	Dent
2	673-2 X N-8215-1	Orange	Semi-flint
3	673-2 X 644-1	Yellow	Flint
4	673-2 X N-8213-48	Orange yellow	Flint
5	673-2 X N-8215-4	Orange yellow	Flint
6	Hyd-08R-8214-43 X N-8203-1	Yellow	Dent
7	Hyd-08R-8214-43 X N-8215-1	Yellow	Dent
8	Hyd-08R-8214-43 X 644-1	Yellow	Dent
9	Hyd-08R-8214-43 X N-8213-48	Yellow	Dent
10	Hyd-08R-8214-43 X N-8215-4	Yellow	Dent
11	Hyd-08R-2630-2 X N-8203-1	Orange yellow	Dent
12	Hyd-08R-2630-2 X N-8215-1	Yellow	Flint

Table: 9 Contd.....

13	Hyd-08R-2630-2 X 644-1	Orange	Flint
14	Hyd-08R-2630-2 X N-8213-48	Orange yellow	Dent
15	Hyd-08R-2630-2 X N-8215-4	Orange yellow	Semi flint
16	N-8211-35 X N-8203-1	Yellow	Flint
17	N-8211-35 X N-8215-1	Orange	Flint
18	N-8211-35 X 644-1	Orange	Dent
19	N-8211-35 X N-8213-48	Orange yellow	Dent
20	N-8211-35 X N-8215-4	Orange yellow	Flint
21	679-1 X N-8203-1	Orange yellow	Dent
22	679-1 X N-8215-1	Yellow	Dent
23	679-1 X 644-1	Yellow	Dent
24	679-1 X N-8213-48	Orange yellow	Flint
25	679-1 X N-8215-4	Yellow	Dent
26	2372-1 X N-8203-1	Yellow orange	Dent
27	2372-1 X N-8215-1	Yellow	Flint
28	2372-1 X 644-1	Orange yellow	Flint
29	2372-1 X N-8213-48	Orange yellow	Flint
30	2372-1 X N-8215-4	Orange yellow	Semi flint
31	2392-2 X N-8203-1	Yellow	Dent
32	2392-2 X N-8215-1	Orange yellow	Flint
33	2392-2 X 644-1	Orange	Flint
34	2392-2 X N-8213-48	Yellow	Flint
35	2392-2 X N-8215-4	Orange yellow	Flint
36	Hyd-08R-8214-31 X N-8203-1	Yellow	Dent
37	Hyd-08R-8214-31 X N-8215-1	Yellow	Dent
38	Hyd-08R-8214-31 X 644-1	Yellow	Flint
39	Hyd-08R-8214-31 X N-8213-48	Orange yellow	Dent
40	Hyd-08R-8214-31 X N-8215-4	Yellow	Flint
	Check		
1	Rajarshi	Orange yellow	Semident
2	Bio-9637	Orange yellow	Flint

5. DISCUSSION

In the cross pollinated crop like maize, the breeder is interested to develop heterozygous population in the form of hybrids or synthetic by combining promising inbred lines. Through the performance of parents themselves give some indications regarding their usefulness, their long term potentialities are the least known at beginning of the programme. The combining ability analysis assesses the utility value of the crosses and the parents. The utility of line x tester design (Kempthorne 1957) in deciding about the relative capability of number of female and male parents to produce desirable hybrids is well known.

The general combining ability is defined as the average performance of line in a series of crosses and the specific combining ability is used to refer those case in which certain combination perform relatively better or worse than would be expected on the basis or the average performance of line involved (Sprague and Tatum, 1942). Development of single crosses hybrids led a major step in increasing yield levels of this crop. The increase in the production per unit area and per unit time is the basic aim in breeding field crops.

The available literature on maize indicated the possibility of exploiting heterosis for realizing higher yield potentially being monoecious in nature it provides an ample scope to exploit heterosis commercially.

The yield is the complex character dependent on several other component characters. The knowledge of variation and nature of combining ability of inbreds for grain yield its attributes is of immense importance to the breeder in planning heterosis or recombination breeding programme.

Considering the usefulness of line X tester design in assessing the performance of larger number of genotypes, the present investigation were aimed at studying the heterosis and combining ability for grain yield contributing attributes of different inbreds. The results obtained in the present investigations have been discussed in brief as under.

5.1 Mean performance and analysis of variance:

The data on mean performance of the parents are presented in Table 1. from this table it was noticed that each of the females and males used in present investigation had some desirable attributes for days to 50% tasseling and silking Hyd-08R-2630-2, N-8211-35, 2372-1 and male N-8203-1 were found to be superior, for days to maturity female 673-2 and male 644-1, for plant height female Hyd-08R-8214-43 and male N-8215-4, for earhead height female Hyd-08R-2630-2 and male 644-1, for ear length female Hyd-08R-8214-31 and male N-8213-48, for ear circumference female Hyd-08R-8214-31 and male N-8215-1, for number of kernels rows per cob female Hyd-08R-8214-43, Hyd-08R-2630-2, 679-1 and males N-8203-1, 644-1 and N-8215-4, for number of kernels per row female Hyd-08R-2630-2 and male N-8213-48, for 100 grain weight female Hyd-08R-8214-31 and male N-8215-1, for shelling percentage female N-8211-35 and 644-1, for grain yield per plant females 2372-1 and male

N-8215-1 and for starch content female 679-1 and male N-8215-4 were found to be superior.

On the basis of *per se* performance of the crosses for days to 50% tasseling Hyd-08R-2630-2 X N-8213-48 and N-8211-35 X 644-1 (56.66), for days to 50% silking N-8211-35 X 644-1 (57.66), for days to maturity Hyd-08R-8214-43 X N-8215-4, 2392-2 X N-8215-4 (90.33), for plant height Hyd-08R-2630-2 X N-8203-1 (214.33 cm), for earhead height Hyd-08R-8214-43 X N-8215-4 (72.66 cm), for ear length 2392-2 X N-8215-4 (21.00 cm), for ear circumference 679-1 X N-8215-4 (16.40 cm), for number of kernels rows per cob N-8211-35 X N-8215-1 (18.00), 679-1 X N-8213-48, 679-1 X N-8215-4, for number of kernels per row 679-1 X 644-1 (47.20), for 100 grain weight 2372-1 X N-8215-1 (36.81g), for shelling percentage 673-2 X N-8203-1 (89.20%), for grain yield per plant 679-1 X N-8215-1 (214.42g) and for starch content 679-1 X 644-1 (73.00%) were found superior.

5.2 Analysis of variance:

The data presented in Table 2. showed that the variance due to parents Vs. hybrids which may be considered as measure of heterosis were highly significant for all the characters except ear circumference and number of kernel rows per cob.

The variance due to females and males were highly significant for all the characters except days to 50% tasseling, days to 50% silking and 100 grain weight in case of males. The variance due to female Vs. male were highly significant for all the characters excepts ear length, ear circumference and starch content. As regards the crosses the differences were highly significant for all character under study except starch content.

The non-significant differences for the particular characters shows the less variability for those characters.

5.3 Heterosis:

The utilization of heterosis in breeding hybrids varieties has opened the new vistas to boost up the crop yield in major cross pollinated species. The heterosis breeding in maize has made tremendous impact and a number of high yielding hybrids have been released for general cultivation. The single cross hybrids technology in maize is the key to realize desired success that has the potential to open up the new vistas.

The heterosis for grain yield and its attributes studied in the forty crosses and presented in below (Table 3.)

From Table 3. It can be seen that an appreciable amount of heterosis over mid, better and superior parents except days to 50% tasseling, days to 50% silking, shelling percentage and starch content. The range of the percentages of heterosis recorded for different character has been presented in Table 10.

For days to 50% tasseling, three and twelve hybrids showed significant negative relative heterosis and heterbeltiosis, respectively. (Table. 3 and 10.) which is desired for earliness. None of these hybrids recorded significant negative heterosis over check Rajarshi and Bio-9637. The hybrids N-8211-35 X 644-1, Hyd-08R-2630-2 X N-8213-48, Hyd-08R-8214-43 X N-8215-4 and Hyd-08R-2630-2 X N-8213-48, Hyd-08R-8213-43 X N-8203-

1 were earlier (over BP -2.70 to -4.49; and MP -2.82 to -3.95). The negative heterosis for days to tasseling was also previously reported by Hassaballa *et al.,* (1980), Singh *et al.,* (1998), Saindass and Pawan Aroro (1999), Chattopadhyay and Dhiman (2005).

For days to 50% silking, the seven and nineteen hybrids showed significant negative relative heterosis and heterobeltiosis, respectively. The magnitude of heterosis for days to 50% silking was between (-2.22 to -3.89) in the former set of crosses, while it was between (-2.13 to -3.89) in the latter. Among all hybrids N-8211-35 X 644-1, Hyd-08R-2630-2 X N-8213-48 and Hyd-08R-2630-2 X N-8215-4, N-8211-35 X N-8215-4, 2372-1 X N-8213-48, 2372-1 X N-8215-4, 679-1 X N-8203-1 were early then mid and better parents, respectively. The negative heterosis for day to 50% silking was also observed by Shrivastava and Singh (2003), Chattopadhyay and Dhiman (2005) and Manpreet *et al.,* (2007).

Thirteen and twenty six hybrids recorded significant relative heterosis and hetrobeltiosis respectively for days to maturity over BP (1.72 to -37.80) and over MP (1.75 to -37.37). The crosses Hyd-08R-8214-43 X N-8215-4 and N-8211-35 X N-8213-48 showed significant negative heterosis over check Rajarshi and Bio-9637 and were earlier.

These two hybrids can be exploited and further tested in various trials for the development of early hybrids.

Table 10: The range of heterosis and number of hybrids showing significant heterosis.

Sr. No .	Characters	Heterosis (%) over MP		Heterosis (%) over BP		Standard heterosis over Rajarshi (%)		Standard heterosis over Bio-9637 (%)	
		Range(%)	Number of significant hybrids	Range	Number of significant hybrids	Range (%)	Number of significant hybrids	Range (%)	Number of significant hybrids
1	Days to 50% Tasseling	-3.95 to 2.26	3	-4.49 to 2.25	12	-2.30 to 4.60	0	0.59 to 7.06	0
2	Days to 50% Silking	-3.89 to 3.87	7	-3.89 to 1.65	19	-1.70 to 6.82	0	1.16 to 8.67	0
3	Days to Maturity	-37.37 to 4.73	13	-37.80 to 2.42	26	-33.94 to 8.03	2	-34.18 to 7.64	2
4	Plant height (cm)	-6.94 to 28.91	30	-13.15 to 26.87	23	-18.40 to 5.62	4	-16.34 to 8.29	8
5	Earhead height (cm)	-2.64 to 58.35	0	-20.71 to 49.41	7	-13.49 to 31.63	3	-24.67 to 14.62	21
6	Ear length (cm)	-16.10 to 23.77	18	-19.77 to 19.32	13	-24.10 to12.10	6	-28.11 to 7.33	2
7	Ear circumference (cm)	-8.32 to 11.01	12	-10.13 to 10.50	6	-11.13 to 3.36	1	-12.96 to 1.23	0
8	No. of kernel rows per cob	-20.00 to 28.57	16	-25.00 to 28.57	6	-25.00 to 12.50	3	-25.00 to 12.50	3
9	No.of kernels per row	-21.51 to 32.34	21	-22.61 to 26.73	16	-27.96 to 16.45	15	-34.14 to 6.47	1
10	100-Grain weight (g)	-25.33 to 39.35	19	-34.37 to 35.17	7	-37.25 to 6.25	0	-39.86 to 1.84	0
11	Shelling %	-2.55 to 8.33	27	-7.36 to 6.77	14	-7.46 to 1.87	0	-2.58 to 7.24	27
12	Grain yield per plant (g)	-22.78 to 51.52	23	-24.18 to 51.17	12	-35.21 to 30.73	2	-29.03 to 43.19	9
13	Starch content (%)	-1.81 to 6.10	4	-3.83 to 5.21	1	-1.38 to 7.30	5	-5.79 to 2.51	0

Table 11. Promising crosses for grain yield per plant.

Sr. No.	Crosses	Mean grain yield plant	Heterosis over		s.c.a. effects
			BP (%)	MP (%)	
1	679-1 X N-8215-1	214.42	51.17	51.52	39.31
2	673-2 X N-8215-4	180.37	17.95	26.10	17.59
3	Hyd-08R-2630-2 X N-8215-1	171.64	21.57	34.88	11.90
4	673-2 X N-8203-1	170.78	11.68	29.44	8.38
5	Hyd-08R-2630-2 X N-8203-1	169.15	49.27	50.84	12.23
6	679-1 X N-8203-1	165.02	16.35	30.56	-7.26
	Rajarshi	164.00			
7	2372-1 X N-8215-4	163.94	3.68	12.57	18.51
8	679-1 N-8213-48	161.86	14.12	25.34	-12.26
9	673-2 X N-8215-1	160.18	4.75	8.93	-5.04
	Bio-9637	149.74			

The expression of negative heterosis for this trait was also reported by Kalsy and Sharma (1970), Murthy *et al.,* (1991), Sain Dass and Pawan Arora (1999), Chattopadhyay and Dhiman (2005) and A.K.M.M. Alard *et al.,* (2008).

In respect of plant height, thirty and twenty three hybrids exhibited the significant with positive relative heterosis and heterobeltiosis, respectively with the range of 2.55 to 28.91% in former case, while 3.01 to 26.87% in latter.

The hybrids Hyd-08R-2630-2 X N-8203-1, Hyd-08R-2630-2 X N-8215-4 were taller than the check Rajarshi and Bio-9637. The hybrids Hyd-08R-2630-2 X N-8203-1, 2392-2 X N-8203-1, 2372-1 X N-8215-1, 2372-1 X N-8203-1, 2372-1 X 644-1 and Hyd-08R-2630-2 X N-8203-1, 2392-2 X N-8203-1, 2372-1 X N-8203-1 also showed significant positive heterosis over mid parent and better parent. The positive and significant heterosis for plant height was previously observed by Ganguli *et al.,* (1989) reported positive heterosis over better parent Beck *et al.,* (1990), Vasal *et al.,* (1992), Reddy and Agarwal (1992), Alvarez *et al.,* (1993) and Farhan Ali *et al.,* (2012).

The negative heterosis is considered desirable for earhead height. The significant negative heterosis over better parents (-7.78 to -20.71%) for earhead height was noticed in seven crosses over better parents, respectively. While three and twenty one hybrids showed the significant negative heterosis over check Rajarshi and Bio-9637, respectively. Manpreet *et al.,* (2007) and Farhan Ali *et al.,* (2012) also reported negative heterosis for earhead height.

Of the forty crosses eighteen produced significant positive heeterosis (4.51 to 23.77 %) over the mid parents and thirteen over better parents (4.78 to 19.32%) for ear length. The expressions of positive heterosis in most of the crosses revealed dominance of longer earhead in general.

The crosses involving 2392-2; Hyd-08R-2630-2 and 679-1 as female parents and N-8215-4, N-8215-1 and N-8203-1 as male parents produced longer ear heads. The crosses Hyd-08R-2630-2 X N-8203-1 (11.74%) over check Rajarshi and the hybrid 2392-2 X N-8215-4 (7.33%) and Hyd-08R-2630-2 X N-8203-1 (6.98%) over check Bio-9637 showed significant positive heterosis. Verma and Singh (1980), Debnath (1987), Farhan Ali *et al.,* (2012) found positive significant heterosis over better and mid parents for earhead length.

For ear circumference, twelve, six and one hybrid showed significant relative heterosis (3.71 to 11.01%), heterobeltiosis (3.52 to 10.50%) and 3.36% heterosis over check Rajarshi. The higher magnitude of significant positive heterosis was observed in, Hyd-08R-8214-43 X N-8203-1 followed by 673-2 X 644-1 and Hyd-08R-8214-43 X 644-1 over mid parent and Hyd-08R-8214-43 X N-8203-1, 673-2 X 644-1 and Hyd-08R-8214-43 X 644-1, 673-2 X N-8203-1 over better parents. The hybrid 679-1 X N-8215-4 produced more ear circumference than the check Rajarshi was highest positive. The positive heterosis for ear circumference was also reported previously by Saleh *et al.,* (2002), Amer *et al.,* (2004), Manpreet et al., (2007) and Vijayabharathi, A. *et al.,* (2009).

In respects of number of kernels rows per cob positive heterosis over mid parents, better parents and both checks was observed on sixteen, six, three and three crosses, respectively. The range of significant positive heterosis over mid parents was from (6.67 to 28.57%) over better parents from (12.50 to 28.57%) and 12.50 over check Rajarshi and Bio-9637. The crosses N-8211-35 X N-8215-1, 679-1 X N-8213-48 and 679-1 X N-8215-4 were heterotic over both the check Rajarshi and Bio-9637. Similarly Mukharjee *et al.*, (1974), Beck *et al.*, (1990), Sharma and Bhalla (1993), Gupta *et al.*, (1994), Netaji *et al.*, (2000), Geetha and Jayaraman (2001), Saleh *et al.,* (2002), Premlatha *et al.,* (2011), Sundarajan and Senthil Kumar (2011) reported previously the positive heterosis for number of kernels rows per cob.

As regards the significant positive heterosis for number of kernels per row, twenty one, sixteen, fifteen and one hybrids showed the higher values over mid parents, better parents; check Rajarshi and Bio-9637, respectively. The range of parentage of heterosis was between 6.67 (Hyd-08R-2630-2 X N-8215-4) to 32.34% (679-1 X 644-1) over mid parents; 7.36 (Hyd-08R-8214-43 X N-8203-1) to 26.73% (2392-2 X N-8215-1) over better parents; 6.09 (673-2 X N-8215-4) to 16.45% (679-1 X 644-1) over Rajarshi and 6.47% (679-1 X 644-1) over Bio-9637. These findings were in confirmation with Appudurai and Nagarajun (1975), Ganguli *et al.*, (1986), Yurankova *et al.*, (1986), Presolska and Kamara (1991), De (1996), Rao *et al.*, (1996), Geetha and Jayaraman (2001), Saad Imran Malik *et al.*, (2004) and Vijayabharathi, A. *et al.,* (2009).

Of the forty crosses nineteen produced significant and positive heterosis (9.95 to 39.35%) over mid parents seven over better parents (10.97 to 35.17%) for 100 grain weight. None of these crosses excelled the performance of the checks. The heterotic crosses over mid parents were 2392-2 X N-8215-4; N-8211-35 X N-8213-48 and 679-1 X N-8215-1. While 2392-2 X N-8215-4, 679-1 X N-8215-1 and 679-1 X N-8203-1 over better parents. Similar trend of heterotic in this character was reported by Salillari and Hoxa (1998), Netaji *et al.*, (2000) and Vijayabharathi *et al.,* (2009).

These data indicates the need of giving due weightages to the parents showing substantial heterosis for 100 grain weight in different crosses for exploiting hybrid vigour for grain yield per plant.

For shelling percentage, twenty seven over mid parents (2.25 to 8.33%); fourteen over better parents (2.13 to 6.77%); and twenty seven hybrids over Bio-9637 (2.15 to 7.24) showed significant positive heterosis. The hybrids 679-1 X N-8215-1, 679-1 X N-8213-48, 679-1 X N-8203-1 over mid parents, 679-1 X N-8215-1, 679-1 X N-8213-48, 679-1 X N-8203-1 over better Parents and 673-2 X N-8203-1, 679-1 X N-8215-1, 2372-1 X N-8215-4 over check Bio-9637 exhibited high heterotic effects.

In the previous studies conducted by Muthiah (1989), Saleh *et al.,* (2002), Oja *et al.,* (2007) and Vijayabharathi, A. *et al.*, (2009) same trend of heterosis for shelling percentage was also observed.

The significant positive heterosis over mid parents (7.48 to 51.52%); over better parents (10.44 to 51.17%); over check Rajarshi (9.97 to 30.73%) and over another check Bio-9637 (6.97 to 43.19%) for grain yield per plant was noticed in twenty three; twelve, two. and nine hybrids, respectively. The data revealed that in most of the crosses higher grain yield per plant was found to be dominant trait. In general crosses involving 673-2, Hyd-08R-2630-2 and 679-1, 2372-1 as female parents and N-8203-1, N-8215-4, N-8215-1, 644-1 and N-8213-48 as male parents produced very high heterotic effects in respect of this trait (Table 11). Murthy *et al.,* (1981), Pal and Pradhan (1994), Dass (1997), Joshi *et al.,* (1998), Mahantesh (2006) and Shashidhara C. K. (2009) also recorded significant positive heterosis for grain yield per plant. These crosses had also higher mean values than the high yielding parents and the standard checks Rajarshi and Bio-9637. These crosses may be useful for replacing some of the present maize hybrids.

These crosses having high heterotic effect also higher grain yield could be tested at different location for testing their yield performance under different environmental condition. While selecting a particular hybrid, it is therefore necessary to consider the *per se* performance in addition to its heterotic effects for grain yield. The heterotic effects for grain yield in the crosses was found to be mostly influence by heterosis for either one or more of the yield contributing characters like plant height, ear head height, ear length, number of kernels per row, 100 grain weight and shelling percentage.

For starch content very few crosses showed significant positive and the magnitude of heterosis observed were low. Out of forty crosses four over mid parent (3.75 to 6.10%); one over better parent (5.21) and five over check Rajarshi (3.91 to 7.30%) exhibited significant positive heteroisis. The higher values were noticed in the crosses Hyd-08R-2630-2 X 644-1, 679-1 X 644-1, Hyd-08R-8214-31 X N-8215-1 and Hyd-08R-2630-2 X N-8215-1 over mid parent; Hyd-08R-2630-2 X 644-1 over better parent and 679-1 X 644-1, N-8211-35 x N-8215-4, N-8211-35 X N-8213-48, Hyd-08R-8214-31 X N-8215-1, Hyd-08R-2630-2 X 644-1 over the check Rajarshi. Such type of higher values of heterosis was reported by Dubey *et al.,* (2001), Idikut L. *et al.,* (2009) and Vijayabharathi A. *et al.,* (2009).

5.4 Analysis of variance for combining ability:

The analysis of variance for combining ability as presented in Table 4. indicated the existence of significant differences for combining ability effects among the females for all the characters except days to maturity, ear circumference, number of kernels per row, shelling percentage and starch content. The magnitudes of g.c.a. variances due to females were much higher than those due to males and s.c.a variance due to females X male interaction for all the character except days to maturity Hassaballa *et al.,* (1980); Sanghi *et al.*, (1982), Vasal *et al.*, (1992), EI-Hosary *et al.*, (1994) and Altinbos (1995) in their studies also noted higher magnitude of g.c.a. effects for days to 50% tasseling and 50% silking and earhead height.

The differences among the males were significant for days to 50% tasseling and 50% silking, plant height, earhead height and number of kernels rows per cob and the magnitude of the variances due to g.c.a. of males were comparatively higher than those of s.c.a. for almost all the character except number of kernels per row, shelling percentage, grain yield per plant and starch content. These observations reveal the importance of general combining ability effects for grain yield per plant and its most of the componental characters.

5.5 General combining ability effects:

For days to 50% tasseling, the higher values of g.c.a. effects in desired direction suggested that the females Hyd-08R-2630-2, N-8211-35, 2372-1 were good general combiner and exhibited earliness in developing tassel, while among the males N-8203-1 and N-8215-4 exhibited earliness in tasseling.

The females N-8211-35, Hyd-08R-2630-2 and 2372-1 and the males N-8203-1 and N-8215-4 were good general combiner. for days to 50% silking which had showed earliness in silking.

For days to maturity, the females Hyd-08R-8214-43, N-8211-35, Hyd-08R-2630-2 and male N-8215-4 were good general combiner. They exhibited significant negative values of g.c.a. effects suggesting their earliness in maturity.

The females Hyd-08R-2630-2 and 2372-1 and male N-8203-1 and N-8215-4 were good general combiner for plant height.

For earhead height, the g.c.a. effects studies revealed that four female and three male expressed significant negative g.c.a. effects and those are the higher values of significant negative g.c.a. effects for earhead height were reported by females Hyd-08R-8214-43, 2392-2, Hyd-08R-8214-31, N-8211-35 and males N-8213-48, N-8215-4 and 644-1 indicating the good general combining ability for this character.

The female Hyd-08R-2630-2, 2392-2, 2372-1, 673-2 and the male N-8215-4 and N-8203-1 were found good general combiner for ear length.

For ear circumference, the higher values of significant positive g.c.a. effects were showed by the females Hyd-08R-8214-43, 673-1 and 679-1 and the males N-8203-1 and N-8215-4 were found to be good general combiner for this trait.

The female 679-1, N-8211-35 and Hyd-08R-8214-43 and the males N-8213-48 and N-8215-4 were found to be the best general combiners for number of kernels rows per cob.

The higher magnitudes of significant positive general combining ability effects were recorded by the females 2392-2, N-8211-35 and 679-1 and the males 644-1 and N-8215-4 suggesting their good general combining ability for number of kernels per row.

For 100 grain weight, the females Hyd-08R-8214-34, 2372-1, Hyd-08R-2630-2 and male N-8203-1 and N-8215-1 were found to be good general combiner for this trait.

The female parents 679-1, 673-2, Hyd-08R-2630-2 and male N-8203-1 was found to be good general combiners for shelling percentage.

For grain yield per plant, the females 679-1, Hyd-08R-2630-2, 673-2 and males N-8215-1, N-8213-48 were found to be good general combiners.

The female 679-1 was found to be the best general combiner for starch content. While rest of the females and males were found average or poor general combiner.

The female and male parents showing very high general combining ability effects for grain yield per plant were also the best general combiner for one or more yield controlling characters. Among the females Hyd-08R-2630-2 was found to be the best general combiner for eight character, female 679-1 and N-8211-35 for six characters, 2372-1 for five character, 673-2 and Hyd-08R-8214-43 for four character; 2392-2 for three character and Hyd-08R-8214-31 for two characters (Table.13)

Among the male N-8215-4 was found to be the best general combiner for nine characters, N-8203-1 for six characters, N-8213-48 for three characters, N-8215-1 and 644-1 for two characters.

None of the parents however showed consistently high general combining ability effects for all the character therefore it is difficult to select a parent which is best general combiner for all characters. The female and male parents which exhibited high general combining ability effects for more than one character in addition of grain yield are given in Table 13.

Incidentally, it can be seen that the crosses which expressed very high heterotic effects; the eighter one or both the parents of these crosses exhibited high general combining ability for grain yield per plant and other character. From these finding, it is apparent that high general combining ability effects for grain yield could be attributed to the high general combining ability effects for one or more yield attributing traits. The female parents, 673-2, Hyd-08R-2630-2 and 679-1 and the male parents N-8215-1 and N-8213-48 are therefore worth considering as they are better combinations for grain yield per plant and more yield attributing characters and hence could be used to exploit hybrid vigour or involved in crossing programme so as to combine desirable yield attributing traits. The recombinants could form a base material for development of new inbred lines or synthetic populations.

5.6 Specific combining ability effects for hybrids:

For days to 50% tasseling, out of forty crosses, two hybrids showed significant positive effects. While three showed significant negative s.c.a. effects. The higher magnitude of negative s.c.a. effects were noted in N-8211-35 X 644-1, Hyd-08R-2630-2 X N-8213-48 and 2392-2 X N-8215-4. These combinations were between high X average, highly poor and poor X average general combiners.

Out of forty crosses, three crosses each showed significant negative and positive s.c.a. effects for days to 50 % silking. The hybrids N-8211-35 X 644-1, Hyd-08R-8214-31 X N-8215-1 and 2392-2 X N-8215-4 showed significant negative s.c.a. effects.

These hybrids were derived from high average; average X poor and poor X high general combiners.

Fourteen and thirteen crosses showed significant negative and positive s.c.a. effects for days to maturity. The higher magnitude of significant negative s.c.a. effects were recorded in Hyd-08R-8214-43 X N-8215-4, 679-1 X N-8215-1 and N-8211-35 X N-8213-48. These crosses were derived from high X high, poor X poor and high X poor general combiners were showed good specific combiner.

Among the forty hybrids, thirteen showed significant positive and sixteen showed significant negative s.c.a. effects for plant height.

The crosses 2392-2 X N-8215-4, Hyd-08R-8214-43 X N-8203-1, Hyd-08R-8214-31 X 644-1, 679-1 X 644-1 and 673-2 X N-8213-48 showed the high values of positive s.c.a. effects. The first cross was derived from average X high; second from poor X high and last three from poor X poor general combiners.

For earhead height, six and seven hybrids showed significant positive and negative s.c.a. effects, respectively. The crosses 2372-1 X N-8203-1; Hyd-08R-8214-43 X N-8215-4 and N-8211-35 X 644-1 showed high values of significant negative s.c.a. effects. The first hybrid was derived from poor X poor, while the latter two were derived from high X high general combiners.

Out of forty crosses, thirteen and twelve showed significant positive and negative s.c.a. effects respectively for ear length. The higher magnitudes of significant positive s.c.a. effects was noticed in 673-2 X 644-1, Hyd-08R-8214-31 X N-8203-1 and 679-1 X N-8215-1. These combinations involved the parents having high X poor; poor X high and poor X average general combining ability (Table 5).

The nine combination *viz.* N-8211-35 X N-8215-1, 679-1 X N-8215-4, 2372-1 X N-8213-48, Hyd-08R-8214-43 X N-8203-1, 2392-2 X N-8213-48, Hyd-08R-2630-2 X 644-1, 673-2 X 644-1, 679-1 X N-8215-1, Hyd-08R-8214-43 X 644-1 showed significant positive s.c.a. effects for ear circumference. These crosses involved the parents having high, average and poor general combining ability.

For number of kernels rows per cob, ten hybrids showed significant positive s.c.a. effects and hybrids N-8211-35 X N-8215-1, 2392-2 X N-8203-1 and Hyd-08R-8214-31 X N-8215-4 are found the best specific combinations. These crosses were derived from high X average, poor X poor and poor X high general combiners.

Thirteen and fourteen crosses produced significant positive and negative s.c.a. effects, respectively for number of kernel per row. The hybrids 673-2 X N-8215-1, Hyd-08R-8214-43 X 644-1, Hyd-08R-8214-31 X N-8213-48 and 679-1 X 644-1 exhibited highest significant positive s.c.a. effects. These hybrids were between either poor X poor; average X poor or average X high general combiners.

For 100 grain weight, nine hybrids showed positive significant s.c.a. effects. The high magnitude of significant positive s.c.a. effects were noticed in 2392-2 X N-8215-4, 673-2 X 644-1, N-8211-35 X N-8213-48 and 679-1 X N-8215-1. The female parents 2392-2, N-8211-35 were poor general combiner and 673-2, 679-1 were average general combiners. While the male N-8215-4 was poor; 644-1 (average) and N-8215-1 was high general combiner. Nine and seven hybrids showed significant positive and negative s.c.a. effects for shelling percentage. The highest significant positive s.c.a. effects were recorded by 2372-1 X N-8215-4, 673-2 X N-8203-1, N-8211-35 X 644-1 and Hyd-08R-8214-43 X N-8215-1. These crosses were derived from poor X average, average X average and high X average general combiners.

Out of forty crosses, fourteen and thirteen showed significant positive and negative s.c.a. effects, respectively for grain yield per plant. The hybrids 679-1 X N-8215-1, Hyd-08R-8214-43 X 644-1, 2372-1 X N-8215-4, 673-2 X N-8215-4 and N-8211-35 X N-8213-48 showed higher magnitude of significant positive s.c.a. effects.

The crosses were derived from high X high, poor X poor, average X average, high X average and poor X high general combiners. The crosses showing significant positive s.c.a effects for grain yield per plant also shows significant positive s.c.a. effects for some other characters. But there was not particular trend observed. These crosses doesn’t showed similar trend of significant positive or negative s.c.a. effects with rest of the characters.

From the above observations on specific combining ability of different crosses, it was observed that none of the crosses exhibited significant positive effects for all characters. In general it appears that the crosses showing high values of s.c.a. effects were derived from poor average and high general combiner for all the characters suggesting the importance of both g.c.a. and s.c.a. effects for inheritance of these characters. Zambezi *et al.*, (1986), Turgut *et al.*, (1995), Sain Dass *et al.*, (1992), Pal and Pradhan (1994), Preciado *et al.*, (1997), Aly (1999), Habtamu (2000) and Premlatha and Kalamani (2010) also observed the importance of both g.c.a. and s.c.a. effects for grain yield per plant and some other characters.

If we consider results of *per se* performance heterosis and combining ability together, it is interesting to note that not all the crosses showing high *per se* and heterosis for grain yield per plant showed high values of s.c.a. effects for this trait (Table.11.)

Further the crosses which showed very high s.c.a. effects did not always exhibit very high magnitude of heterosis and *per se* performance for example the crosses Hyd-08R-8214-43 X 644-1 (21.93), N-8211-35 X N-8213-48 (17.28), 2392-2 X N-8213-48 (12.08) and Hyd-08R-8214-31 X N-8203-1 (14.29) had high s.c.a. effects but their respective heterosis over better parents were 0.22,0.40; 5.51 and 5.92, respectively (Table 3 and 6.). The mean grain yield per plant of theses crosses were also less (Table 1.). These facts suggest that while selecting a specific combination for exploiting hybrid for grain yield, due consideration also needs to be given to the *per se* performance of that crosses.

Considering the *per se* performance, heterosis effects and s.c.a. effects, the combination which could be selected for exploiting hybrid vigour were 679-1 X N-8215-1, 673-2 X N-8215-4, Hyd-08R-2630-2 X N-8215-1, 673-2 X N-8203-1 and 2372-1 X N-8215-4 (Table 11). These crosses can be tested at different location for their stability in grain yield.

For starch content, single 679-1 X 644-1 showed the higher magnitude of positive s.c.a. effects and involved the parents having high X average general combining ability effects.

5.7 Gene action and heritability:

The information an nature and relative magnitude of gene action controlling a particular character is of immense importance in the development of efficient breeding programme in crop species which are amenable to commercial production of F_1s hybrid seed and also to develop synthetics, composites or varieties having desirable character. In the present investigation gene action and heritability was studied for the thirteen different characters and has been discussed in brief.

Significance of g.c.a. for all the characters except days to maturity, ear circumference, number of kernel per row, shelling percentage and starch content indicated the influence of the additive gene action in the expression of these characters. However significance of s.c.a. for all the characters except starch content indicated also influences of non-additive gene in the expression of these characters. The highest magnitude of g.c.a. variance was recorded for grain yield per plant followed by plant height, earhead height, days to maturity and 100 grain weight.

Table 12: Number of parents and hybrids which showed significant gca & sca effects.

Sr. No.	Characters	Number of parents with g.c.a. effect				Number of hybrids with s.c.a. effect	
		Number of significant parents				Range	Number of significant hybrids
		Range	Females	Range	Males		
1	Days to 50% tasseling	-1.20 to 1.13	3	-0.72 to 2.33	2	-1.33 to 1.42	3
2	Days to 50% Silking	-1.192 to 0.94	3	-0.58 to 0.70	2	-1.35 to 1.61	3
3	Days to Maturity	-5.42 to 3.50	3	-4.05 to 1.78	1	-23.61 to 8.88	14
4	Plant height (cm)	-12.74 to 16.00	2	-7.27 to 9.97	2	-15.17 to 20.68	13
5	Earhead height (cm)	-7.015 to 10.39	4	-2.69 to 6.33	3	-9.66 to 12.53	7
6	Ear length (cm)	-1.44 to 1.65	4	-0.39 to 0.53	2	-2.44 to 1.84	13
7	Ear circumference (cm)	-0.31 to 0.45	3	-0.30 to 0.23	2	-0.79 to 0.946	9
8	No. of kernel rows/cob	-1.45 to 1.75	3	-0.80 to 0.70	2	-1.60 to 2.05	10
9	No.of kernels/row	-4.57 to 2.59	3	-1.05 to 1.12	2	-9.63 to 6.04	13
10	100 grain weight (g)	-3.89 to 4.26	3	-3.04 to 2.09	2	-5.71 to 7.53	9
11	Shelling %	-1.81 to 1.75	3	-0.36 to 0.066	1	-2.96 to 3.09	9
12	Grain yield/plant (g)	-15.24 to 25.46	3	-9.50 to 3.93	2	-29.85 to 39.31	14
13	Starch content (%)	-1.13 to 1.16	1	-0.27 to 0.43	0	-2.42 to 2.45	1

Table 13: Parents showing high GCA for different characters.

Sr. No.	Parent	No. of characters	Name of characters
	Females		
1	673-2	4	ear length, ear circumference, shelling percentage, grain yield per plant
2	Hyd-08R-8214-43	4	Days to maturity, earhead height, ear circumference and No.of Kernel rows/cob
3	Hyd-08R-2630-2	8	days to 50% tasseling, days to 50% silking, days to maturity, plant height, ear length, 100 grain weight, shelling percentage, grain yield per plant
4	N-8211-35	6	Days to 50% tasseling, days to 50% silking, days to maturity, earhead height, No. of kernel rows per cob and No. of kernels per row.
5	679-1	6	Ear circumference, no of kernel rows per cob and no. of kernels per row. Shelling percentage, grain yield per plant, starch percentage.
6	2372-1	5	Days to 50% tasseling, days to silking, plant height, ear length, 100 grain weight.
7	2392-2	3	Earhead height, ear length, No. of kernels per row.
8	Hyd-08R-8214-31	2	Earhead height, 100 grain weight.
	Males		
1	N-8203-1	6	Days to 50% tasseling, days to 50% silking, plant height, ear length ear circumference, 100 grain weight.
2	N-8215-1	2	100 grain weight, Grain yield per plant
3	644-1	2	Earhead height, No. of kernel per row
4	N-8213-48	3	Earhead height, Number of kernel per/cob, grain yield per plant.
5	N-8215-4	9	Days to 50% tassseling, days to 50% silking, plant height, days to maturity, ear head height, ear length, ear circumference, No. of kernel per/ cob, No. of kernel per row

For the same characters s.c.a. variance were also high considering the ratio of variance due to g.c.a. and s.c.a. the values of the ratio were less than unity for all the characters except days to 50% tasseling and 50% silking and earhead height indicating the perdominance of non-additive gene action as s.c.a. is attributed primarily to deviation from additive scheme caused by dominance and epitasis, while g.c.a. is associated with genes which are additive in nature.

Predominance of additive genetic effects for days to 50 % tasseling was also reported by Hassaballa *et al.*, (1980), Mathur and Bhatnagar (1995), Gul *et al.*, (1998), San-Vicente *et al.*, (1998), Paul and Debnath (1999) and Surayaprakash and Ganguli (2004). For days to 50 % silking additive gene action was previously reported by Singh *et al.*, (1983), Vasal *et al.*, (1992), EI-Hosary *et al.*, (1994), Mathur *et al.*, (1998), Talleei and Kochaksarari (1999), Nigussie and Zelleke (2001), Ashish and Singh (2003), Devi and Pradhan (2004) and Kumar (2008). In previous studies of Nawar (1980), Pal *et al.,* (1986), Shahi and Singh (1986), Zambezi *et al.*, (1986), Mahajan and Khehra (1991), EI-Hosary *et al.*, (1994), Altinbos (1995) and Paul *et al.,* (1999) for earhead height were also reported which are in conformity of the present investigation.

The ratio of variances due to g.c.a. and s.c.a. the values of the ratio were less than one for days to maturity, plant height, ear lemgth, ear circumference, number of kernel rows per cob, number of kernel row, 100 grain weight, shelling percentage, grain yield per plant and starch content indicating the predominance of non- additive gene action for these characters.

For days to maturity non-additive gene action was reported by Satyanarayana *et al.*, (1994), Paul and Debnath (1999), Alam *et al.,* (2008). While for plant height, influence of non-additive genetic effects were noted by Herbert and Gallis (1986), EI-Hosary *et al.,* (1994), Dehghanapour *et al.*, (1997), Petrovic (1998), Rana and Vinod (2001), Suryaprakash and Ganguli (2004) and Jayakumar and Sundaram (2007).

Importance of non-additive gene action for ear length was noted by Ali and Topera (1986) and Khristova *et al.*, (1995), while Shen and Lai (1987), Debnath and Sarkar (1990), Singh (1996) and Li-jizhu *et al.,* (2004), Katna *et al.*, (2005), Neha-Singhal *et al.*, (2006) reported the importance of both additive and non-additive gene effects.

For ear circumference, predominance of non-additive gene action was recorded by Bhall and Khehra (1980), EI-Hosary *et al.*, (1994), Sinobas and Moteagudo, Kumar *et al.*, (1998) and Rana and vinod kumar (2001), Devi and Pradhan (2004), Rakesh Kumar *et al.*, (2005) and Jayakumar and Sundaram (2007).

For number of kernel rows per cob, importance of non-additive gene action was reported by Cross (1990), Pal and Pradhan (1994), Singh (1996), Kumar *et al.*, (1998), Mathur (1998), Geetha and Jayaraman (2001), Kobdal *et al.*, (2003), Li-Jizhu *et al* ., (2004) and Devi (2007).

The influence of non- additive gene action in the expression of number of kernel per row was noted by Muthiah *et al.*, (1980), Satyanarayana *et al.*, (1990), Pal and Pradhan (1994), Dehghanapour *et al.*, (1997), Rakesh kumar *et al.*, (2005). Ali

Akheel Wannows *et al.*, (2010) therefore heterosis breeding may be rewarding.

Dehghanapour *et al.*, (1997), Satyanarayana *et al.*, (1990), Anuradha *et al.*, (1993), Suneetha *et al.*, (2000), Shrivastava and Singh (2003), Manpreet *et al.,* (2007) and Vijayabharathi, A. *et al.,* (2009) indicated the importance of non-additive gene action for 100 grain weight.

For shelling percentage, non-additive gene action was reported by Muthiah (1989), Saleh *et al.,* (2002) and Vijayabharathi, A. *et al.,* (2009).

The influence of non-additive gene action in the expression of grain yield per plant was reported by Pal and Duara (1991), Mohammad (1993), Damborsky *et al.*, (1994), Pal and Pradhan (1994), Satyanaryana (1994), Crossa *et al.,*(1990), Zheng-Zuping (1995), Debnath and Sarkar (1990), Manpreet *et al.,* (2007), Dubey *et al.,* (2009) and Vijayabharathi A. *et al.,* (2009); while for starch content such genetic effects were reported by Satyanarayan *et al.,* (1994), Joshi (1998) and Has, V. (1999).

Since both non-additive and additive components of genetic variance are important for most of the agronomic character and as the former being higher in magnitude, the emphasis on exploiting hybrid vigour would be appropriate. The crosses among the parents having high mean and high g.c.a. for grain yield and other characters could also be planned. This will provide an opportunity to develop inbred possessing different desirable yield components through selection in segregating generation.

Heritability:

Heritability specifies the proportion of the total variability that is due to genetic causes, or the ratio of genotypic variance to total variance. It is good index of the transmission of character from parents to their offspring.

The heritability in narrow sence was high for plant height (66.13%), days to 50% tasseling (65.53%), days to 50% silking (64.23%) and earhead height (60.92%.), while medium for ear length (51.90%), number kernel rows per cob (51.82%), grain yield per plant (45.09%), 100 grain weight (44.87%), and ear circumference (35.56%). The low heritability values of were recorded for starch content (13.51%), number of kernel per row (21.31%), shelling percentage (25.48%) and days to maturity (28.02%)

The heritability values were high for days to 50% tasseling and 50% silking in the studies conducted by Singh *et al.*, (1989), for earhead height by Mohammad and Mohammad (2002) and for plant height by Yassein (1999).

Moderate values of heritability for ear length were recorded by Yassein (1999), for number of kernels rows per cob by Geetha (1997); Yassein (1999) and Mohammad and Mohammad (2002), for ear circumference by Amer and Mosa (2004), for grain yield per plant by Satyanarayana (1994); Saleh *et al.*, (2002) and Amer and Mosa (2004); for 100 grain weight by Yassein (1999).

Lower values of heritability were recorded for number of kernels per row by Amer and Mosa (2004) and Abolhamid Rezaei *et al.*, (2004).

Among the characters studied selection would comparatively be effective for the traits showing high and medium heritability.

5.8 Percentage contribution of female, males and females X males to the hybrid s.s.

Percentage contribution of female, males and females X males to the sum of square of hybrids are presented in Table 8.

It was observed from the data that the males had contributed less to the s.s. of hybrids for all the character as compared to the females and female X males interaction.

The contribution of females was the highest for days to 50% tasseling, days to 50% silking, earhead height, plant height, ear length, number of kernel rows per cob and grain yield per plant as compared to the males and females X males interaction.

The contribution of interaction (females X males) was greater than parents for days to maturity, ear circumference, number of kernels per row, 100 grain weight, shelling percentage and starch content.

6. Summary and conclusion

The present investigation on Line x tester analysis in maize (*Zea mays* L.)" was carried out during rabi 2010 at Maize Improvement Project Kasba Bawda, Kolhapur and Post Graduate Reasearch Farm, College of Agriculture, Kolhapur during Kharif-2011, with the following objectives.

i) To estimate heterosis for grain yield and its components ii) To estimate the gca and sca effects iii) To estimates the gene effects for grain yield and its component iv) To estimates heritability for different characters v) To isolate promising inbred lines for exploiting hybrid vigour.

The experimental material was consisted of eight females parents *viz*; 673-2, Hyd-08R-8214-43, Hyd-08R-2630-2, N-8211-35, 679-1, 2372-1, 2392-2, Hyd-08R-8214-31 and five male parents *viz*; N-8203-1, N-8215-1, 644-1, N-8213-48 and N-8215-4. The crosses among the females and males were effected in line x tester (8 x 5) design during rabi-2010. The resulting 40 F_1s were evaluated along with the thirteen parents and two checks (Rajarshi and Bio-9637) in Randomized Block Design with three replication during the *Kharif*-2011. The sowing was done at 75 X 20 cm distance and the length of the plot was 4.00 m. The observation on five random selected plants in each replication were recorded for thirteen characters *viz*; days for 50% tasseling, days to 50% silking, days to maturity, plant height, earhead height, ear length, ear circumference, number of kernel rows per cob, number of kernels per row, 100 grain weight, shelling percentage, grain yield per plant, starch content.

The analysis for combining ability was done by following the procedure given by Kempthorne (1957). Analysis of variance indicated the presence of significant difference among parents, hybrids and checks for all traits indicating the existence of genetic variability in material.

Among the females 673-2 was superior for early maturity; Hyd-08R-8214-43 for plant height and number of kernel rows per cob; Hyd-08R-2630-2 for early tasseling and silking; less earhead height, ear circumference, number of kernels per row; N-8211-35 for early tasseling and silking, shelling percentage; 679-1 for plant height, ear circumference, number of kernel rows per cob, starch content; 2372-1 early tasseling and silking, 100 grain weight, grain yield per plant and Hyd-08R-8214-31 for ear length and ear circumference.

As regards the males; N-8203-1 was superior for early tasseling and silking, number of kernel rows per cob; N-8215-1 for ear circumference, 100 grain weight, grain yield per plant; 644-1 for early maturity, earhead height, number of kernel rows per cob, shelling percentage; N-8213-48 for ear length, number of kernels per row and N-8215-4 for plant height number of kernel rows per cob, starch content.

Twelve, nineteen, twenty six and seven crosses showed significant negative heterosis for days to 50% tasseling, days to 50% silking, days to maturity and earhead height, respectively. Whereas the significant and positive heterosis was exhibited by thirty crosses for plant height, eighteen for ear length, twelve for ear circumference, sixteen for number of kernels per cob, twenty one for number of kernels per row; nineteen for 100 grain weight, twenty seven for shelling percentage, twenty three for grain yield per plant and four starch content.

As compared to the check, two hybrids each for days to maturity; three and twenty one for earhead height showed significant negative heterosis over the checks Rajarshi and Bio-9637 respectively. However four and eight crosses for plant height; six and two for ear length, three each for number of kernel per cob; fifteen and one for number of kernels per row, two and nine for grain yield per plant recorded significant positive heterosis over Rajarshi and Bio-9637, respectively. Twenty seven hybrids over Bio-9637 and one and five over Rajarshi exhibited such type of heterosis for shelling percentage, ear circumference and starch content, respectively.

The heterosis for grain yield in hybrids was founds to be mainly influenced by earhead height, plant height, ear circumference and 100 grain weight. The outstanding crosses were 679 X N-8215-1; 673-2 X N-8215-4; Hyd-08R-2630-2 X N-8215-1; 673-2 X N-8203-1; Hyd-08R-2630-2 X N-8203-1, 679-1 X N-8203-1 and 679-1 X N-8213-48; which could be further tested.

As regards general combining ability effects the female parents 679-1, 673-2, Hyd-08R-2630-2 and male N-8215-1 and N-8213-48 were best general combiner for grain yield per plant. Similarly for shelling percentage female 679-1, 673-2, Hyd-08R-2630-2 and male N-8203-1, for 100 grain weight female Hyd-08R-8214-31, 2372-1, Hyd-08R-2630-2 and male N-8203-1 and N-8215-1, for number of kernels per row female 2392-2, N-8211-35, 679-1 and male N-8215-4 and 644-1, for number of kernels rows per cob female parents 679-1, N-8211-35, Hyd-08R-8214-43 and male N-8213-48, N-8215-4, for ear circumference females Hyd-08R-8214-43, 673-2 and 679-2 and male N-8203-1, N-8215-4, for ear length females Hyd-08R-2630-2, 2392-2, 2372-1, 673-2 and male N-8203-1 and N-8215-4, for earhead height female Hyd-08R-8214-43, 2392-2, Hyd-08R-8214-31, N-8211-35 and male N-8213-48, N-8215-4, 644-1, for plant height female Hyd-08R-2630-2, 2372-1 and male N-8203-1, N-8215-4, for days to maturity female Hyd-08R-8214-43, N-8211-35, Hyd-08R-2630-2 and male N-8215-4, for days to 50% silking female Hyd-08R-2630-2, N-8211-35, 2372-1 and male N-8203-1, N-8215-4, for 50% tasseling female Hyd-08R-2630-2, N-8211-35, 2372-1 and male N-8203-1, N-8215-4 and for starch content female679-1 were found the best general combiner.

The promising combinations for grain yield per plant were 679-1 X N-8215-1, Hyd-08R-8215-43 X 644-1, 2372-1 X N-8215-4, 673-2 X N-8215-4 and N-8211-35 X N-8213-48. Similarly for shelling percentage 2372-1 X N-8215-4, 673-2 X N-8203-1, N-8211-35 X 644-1, Hyd-08R-8214-43 X N-8215-1, for 100 grain weight 2392-2 X N-8215-4, 673-2 X 644-1, N-8211-35 X N-8213-48, 679-1 X N-8215-1, for number of kernels per row 673-2 X N-8215-1, Hyd-08R-8214-43 X 644-1, Hyd-08R-8214-31 X N-8213-48, 679-1 X 644-1, for number of kernels rows per cob N-8211-35 X N-8215-1, 2392-2 X N-8203-1 and Hyd-08R-8214-31 X N-8215-4, for ear circumference N-8211-35 X N-8215-1, 679-1 X N-8215-4 and 2372-1 X N-8213-48, for ear length 673-2 X 644-1, Hyd-08R-8214-31 X N-8203-1 and 679-1 X N-8215-1, for earhead height 2372-1 X N-8203-1, Hyd-08R-8214-43 X N-8215-4 and N-8211-35 X 644-1, for plant height 2392-2 X N-8215-4, Hyd-08R-8214-43 X N-8203-1, Hyd-08R-8214-31 X

644-1, 679-1 X 644-1 and 673-2 X N-8213-48, for days to maturity Hyd-08R-8214-43 X N-8215-4, 679-1 X N-8215-1, N-8211-35 X N-8213-48, for days to 50% silking N-8211-35 X 644-1, Hyd-08R-8214-31 X N-8215-1 and 2392-2 X N-8215-4, for days to 50% tasseling N-8211-35 X 644-1, Hyd-08R-2630-2 X N-8213-48, 2392-2 X N-8215-4, for starch content 679-1 X 644-1 were the best specific combinations.

From the studies on specific combining ability of different crosses in general, it appears that significant positive s.c.a. effects for grain yield could be attributed to the significant positive s.c.a. effects for one or more of the yield components like ear length, number of kernels rows per cob, number of kernels per row and 100 grain weight.

The data on heterosis and combining ability indicated that the significant of s.c.a. effects or its magnitude cannot always related with the significance or magnitude of heterosis. Both g.c.a. and s.c.a. effects were found to play an important role in the expression of heterosis for grain yield and other traits. The data on gene action has also indicated the importance of both additive and non-additive gene action with predominance of latter for all the traits except days to 50% tasseling and silking and earhead height.

The contribution of females to the sum of square of hybrids was more than males for all the characters. However the contribution of females X males interaction was more than the females for days to maturity, ear circumference, number of kernels per row, 100 grain Weight, shelling percentage and starch content.

Conclusion:

Among parent, females 679-1, 673-2, Hyd-08R-2630-2, 2372-1 and males N-8215-1, N-8213-48, N-8215-4, N-8203-1 were found best general combiner for grain yield.

On the basis of *Per se* performance, heterosis percentage and s.c.a effects the crosses which out yielded the standard check Rajarshi and could be considered for exploiting hybrid vigour were 679-1 X N-8215-1, 673-2 X N-8215-4, Hyd-08R-2630-2 X N-8215-1, 673-2 X N-8203-1, Hyd-08R-2630-2 X N-8203-1, and 679-1 X N-8203-1. In addition to these, the crosses 2372-1 X N-8215-4, 679-1 X N-8213-48 and 673-2 X N-8215-1 out yielded the check Bio-9637. The Single hybrid 679-1 X 644-1 was found best for starch content.

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8. VITA

THOTE AJIT SHIVAJI

A Candidate for the degree of

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Title of thesis	:	Line X tester analysis in Maize (*Zea mays* L.)
Major field	:	Genetics and Plant Breeding

Biographical Information

Personal	:	Born on 23rd August 1988 at Jamb (Bk.) Tal. Mukhed, Dist. Nanded, (MS). Son of Shri. Thote Shivaji Vishwanath and Sou. Thote Mangal Shivaji
Educational	:	Secondary school at Vivekanand High school, Hadgaon, Tal. Hadgaon, Dist. Nanded
	:	Higher secondary school at Neeti Niketan, Junior College, Jamb (Bk.), Tal. Mukhed, Dist. Nanded
	:	Received Bachelor of Science (Agriculture) degree from Aditya Agriculture College Beed, under Marathwada Agriculture University Parbhani.
Permanent add.	:	C/o Swayamdip Niwas, Vyanketesh Nagar Mukhed Tal. Mukhed, Dist. Nanded (M.S.)
E-mail id.	:	ajit_thote@yahoo.com