# EVALUATION OF NEWLY DEVELOPED INBRED LINES FOR GENERAL COMBINING ABILITY IN MAIZE (*Zea mays* L.)

**THESIS**

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**Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola**
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**By**
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## DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the Thesis entitled **"EVALUATION OF NEWLY DEVELOPED INBRED LINES FOR GENERAL COMBINING ABILITY IN MAIZE (*Zea mays* L.)"** or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or scientific organization. The source of material used and all assistance received during the course of investigation have been duly acknowledged.

Udasi

Place: Nagpur (Udasi Raviraj Naresh)

Date: 07/05/2011 Enrolment No. DD/672

## CERTIFICATE

This is to certify that thesis entitled **"EVALUATION OF NEWLY DEVELOPED INBRED LINES FOR GENERAL COMBINING ABILITY IN MAIZE (*Zea mays* L.)"** submitted in partial fulfilment of the requirement for the degree of **"Master of Science in Agriculture (Agricultural Botany)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Udasi Raviraj Naresh** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

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## (B) Abbreviations

| | | |
|---|---|---|
| C.D. | : | Critical difference |
| cm | : | Centimeter |
| d.f. | : | Degrees of freedom |
| *et al.* | : | et alia (and associates) |
| g | : | Grams |
| GCA/gca | : | General Combining Ability |
| Kg/ha | : | Kilogram per hectare |
| L. ha | : | Lakh hectare |
| MT | : | Metric tonnes |
| q/ha | : | Quintal/ hectare |
| S.E. $\pm$ | : | Standard Error |
| SCA/sca | : | Specific Combining Ability |

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## ABSTRACT

Thirty nine $F_1$ top crosses obtained by crossing thirty nine inbreds and one tester PKVM-Shatak as check in a top cross fashion were used to assess the general combining ability of inbreds and to select good combiner inbreds for single cross hybrid production. These parents and top crosses were grown in randomized complete block design replicated twice and observations on days to 50% tasseling, days to 50% silking, days to maturity, plant height (cm), cob length (cm), cob girth (cm), number of grains $cob^{-1}$, 100 grain weight (g) and grain yield $plant^{-1}$ (g) were recorded. Considerable variability existed among the genotypes, parents, parents vs. top crosses for all the characters studied. Top crosses had considerable variability among them for all the characters studied except days to 50% silking and days to maturity. The gca effects showed wide variation in the level of significance for different characters. The inbreds NM-0988, NM-0914, NM-0978, NM-0990, NM-0969, NM-0971, NM-0919 and NM-0926 were identified as good general combiner for yield and yield contributing characters. Therefore diallel mating between these eight inbreds was suggested to get superior single cross. NM-0984 was identified as superior inbred for early days to 50% tasseling.

# Chapter - I
# INTRODUCTION

## 1.1 Background information

Maize (*Zea mays* L.), (2n=20) is one of the most important cereal and staple food crop of the world. It is globally the top ranking cereal in productivity. It has greater adaptability and grown throughout the world over a wide range of climatic conditions. It belongs to family Gramineae and sub family Panicoideae. Maize is more useful as compared to other cereals; therefore it is called as "Queen of Cereals". The most probable origin of Maize is South America (Singh, 2006). The area under this crop in the world is 148.48 million hectares with a grain production of 699.32 million tones (Anonymous, 2009a). The cultivation of Maize is predominant in United States of America, China, Brazil, Mexico, India, Indonesia, Russia, Canada and Italy. In India its cultivation is mainly confined to the states of Andhra Pradesh, Rajasthan, Madhya Pradesh, Bihar, Uttar Pradesh, Karnataka, Gujarat and Maharashtra, but it is also grown in small pockets in other states. In India Maize is cultivated in 8.19 million ha. with total production of 19.29 million tones and average productivity of 2355 kg $ha^{-1}$ (Anonymous, 2009a). The area under Maize in Maharashtra is 5.50 lakh ha. with a production of 13.23 lakh tones and productivity is 2405 kg $ha^{-1}$. In Vidarbha, the Maize is grown on 62,100 ha. with a production of 1,83,000 tones and productivity is 3025 kg $ha^{-1}$. It is mostly cultivated in Buldhana, Akola, Amaravati and Gadchiroli district. It is grown in *Kharif* under rainfed condition and in rabi/summer under irrigated conditions.

Maize is considered as a tropical crop and is grown in wide range of climatic conditions. About 85% of the total acreage under

maize is grown during monsoon because of the fact that the crop stops growing if the night temperature falls below 15.6°C or 60°F. The day length requirement for flowering is controlled genetically and regulated by phytochrome system.

Maize kernel contains about 70-75% starch, 8-11% proteins, 3-18% oil and other carbohydrates 1-3%. Maize is having either dent or flint type of endosperm. In both of these types amylase makes up 25 to 30% of the starch and amylopectin makes up 70 to 75%. Waxy maize contains 100% amylopectin as starch. Moreover, it also contains ash 1.3%, vitamins, viz., Provitamin A, E, thiamine and riboflavin.

Maize has more importance in "Human Nutrition". It is used for preparing different dishes, popcorn, for bread preparation, and curry etc. Beside these, it has various industrial uses, viz., for preparation of starch and alcohol. Its stem is used for paper making; its starch is used in paper lamination and also in textile. Based on the physical properties of the cob when ground to powder are used as fillers for explosives in the manufacture of plastics, glues, adhesives, vinegar, resin and artificial leather and as diluents and carrier in the formulation of insecticides and pesticides. Based on the chemical properties the processed cobs find their use in the manufacture of fermentable sugars, solvents, liquid fuels, charcoal gas and other chemicals by destructive distillation. The water in which the maize grains are soaked for the manufacture of glucose is used for growing penicillin moulds.

It is also an important source of fodder for cattle. Silage is prepared from green maize plants. Maize also serves as poultry and piggery feed.

### 1.2 Importance of study

Maize being highly cross pollinated crop, development of hybrids are preferred rather than developing varieties. For exploitation of heterosis, availability of good inbred lines is the prerequisite. Not all the line in hybrid combinations will be superior to the original open pollinated varieties. Variation among double cross hybrids showed that only certain combinations of inbred lines give satisfactory double cross hybrids.

The *per se* performance of parents themselves does not always gives a correct indication of their breeding potential. It is therefore, important to study the combining ability of parents which when crossed gives high level of heterosis. This information concerning to breeding behaviour of parents is of prime importance in planning the breeding programme.

Selection of parents for crossing is the first and most important task to evolve superior hybrid or strains. The selection of parents for hybridization is difficult task, as yield is a complex character involving number of components, each of which are polygenically controlled, and hence sensitive to environmental fluctuations. The initial selection of suitable parents is stated to be of immense importance by all workers for utilization of heterosis to its maximum extent.

Top cross, poly cross, diallel and line x tester are the different biometrical approaches which have helped the breeder to choose appropriate parents to be included in the hybridization programme. Preliminary screening technique suggested by Davis (1927) and Jenkins and Brunson (1932) showed that crossing lines with a common tester (top cross) was effective for discarding lines that did not have satisfactory performance in hybrids. Many lines could be discarded on the basis of preliminary top cross performance

information. Often a sizable number of lines that had potential for use in hybrids still are available. Even if 20 lines are available for testing in hybrids, 190 different single crosses and 14,535 different double crosses are possible. Jenkins (1934) developed and tested four methods for predicting double cross hybrids from use of single cross hybrid data. The top cross (inbred x open pollinated variety) method proved to be efficient in testing of inbred lines for combining ability because with its use, it was possible to identify more promising inbred lines by making fewer numbers of crosses than are required for making all possible single crosses. Therefore, top cross test for preliminary screening of line and prediction method for reducing the number of double cross hybrid for testing were widely used and contributed greatly to the efficiency of maize breeding.

Considering the importance of Maize from nutritional and productional point of view, Maize has much importance with expectation of higher yield. Maize being a versatile crop, in order to harness its yield potential several genetic and agro-technique improvement strategies have been suggested in the past and present viz., open pollinated varieties (OPVs), composites, double top cross, double cross, three way crosses, four way crosses etc., since none of these strategies were able to harness full heterotic potential finally, single cross technology have been advocated. The impact of single cross hybrid technology was clearly visible in USA, China, Canada and many other countries. After shifting to single cross hybrid technology (2006-2008), in India has witnessed 30% increase in production and 27% increase in productivity within two years with the coverage of 20% area under single cross hybrid. There is also 15% annual increase in production and more than 12% increase in productivity (Anonymous, 2009b). This is the visible impact of single cross hybrid technology. For the development of high yielding single cross hybrids, development of

vigorous, genetically diverse inbred lines that have good performance *per se* as well as in cross combinations. The potential of the hybrids thus depends on the inbreds used in their development. It therefore becomes essential to first evaluate the potential of the available inbreds at our research centre, so that good inbreds can be identified then be used in the development of new hybrids. Hence, this research work was taken up with the following objectives.

### 1.3 Objectives of study

The present study was conducted with following objectives:

1. To study the general combining ability of inbred lines.
2. To identify superior inbreds for hybrid breeding programme.

### 1.4 Scope and limitations

This study has a wide scope as it will help in developing new hybrids of maize with high yield and additional traits for farmer's cultivation. In this study we will be evaluating the available inbreds and on the basis of *per se* and gca superior inbreds will be identified. These identified inbreds can then be involved in the development of single cross or double cross hybrid for commercial cultivation.

The limitations in the implementation and the success of this study are as follows:

1. Synchronization of flowering in male and female parents.
2. Percentage of grain set after crossing.
3. Protecting the crossed cobs till harvest from getting lost due to various sources.

### 1.5 Hypothesis

The information derived from this research work will help in identifying superior inbred lines for hybrid development in Maize.

## Chapter - II
## REVIEW OF LITERATURE

The concept of combining ability was introduced by Sprague and Tatum, 1942. Combining ability is defined as the performance of a line in several hybrid combinations i.e. ability of genotype to transmit the desirable traits to the progeny. The concept of combining ability and its importance in breeding has been evolved preliminarily through fundamental research on corn (Sprague and Tatum, 1942).

The general combining ability (GCA) is defined as the average performance of a genotype in a series of cross combination. General combining ability is attributed to additive effect of gene interaction (Falconer, 1960). On the other hand Griffing's (1956) was of the opinion that GCA is due to both additive and additive × additive gene interaction.

Various methods have been developed to estimate the general and specific combining ability and they are-

1. Top cross analysis (Davis, 1927)
2. Poly cross analysis (Tysdal *et al.*, 1942)
3. North Carolina Design (Comstock and Robinson, 1952)
4. Diallel analysis: a) By Hayman's graphical approach (1954)
   b) By Griffing's numerical approach (1956)
5. Line × Tester analysis (Kempthorne, 1957)
6. Triple test cross (Kearsey and Jinks, 1968)

The use of top cross analysis provides an efficient method for preliminary evaluation of inbred lines. Davis (1927) used top crosses to estimate combining ability of $S_2$ lines. Lindstorm (1931)

suggested the commercial use of top crosses. The use of top crosses provides an efficient method for preliminary evaluation of inbred lines. They are especially useful for determining combining ability of a large number of lines.

Brief account of research work carried out by previous workers on general combining ability analysis and its use in maize for selecting inbred lines are reviewed below in this chapter.

Dumacheva *et al.* (1976) reported that the satisfactory evaluation of general combining ability by top cross method did not depend on the number of testers or the extent of their heterogeneity, so that new line could be successfully evaluated by producing only the two test hybrids for each of them, using as the second parent a form with high combining ability regardless of its heterogeneity.

Kostyuchenko *et al.* (1976) studied 600 top cross hybrids obtained by using 110 lines and six testers and reported that high general combining ability (GCA) for yield was combined with high variances in specific combining ability (SCA) in the lines YuV158, W70, B55, B46, Oh45, V312, and DE3. High GCA combined with low variances in SCA was found in the lines W33, R221, 3-3, SN41A, B164, ND405, 39, Oh43, YuR55, Wf9, S123, R803, B14 and A632.

An evaluation was made by Sokolov and Kostyuchenko (1978) with 110 lines differing in earliness, using five inbred as tester and the single hybrid Slava (Glory). Over 600 top cross hybrids were studied. The fairly high correlation between the general combining ability of the lines and their specific combining

ability in crosses with individual testers (r = 0.68 to 0.86) indicates that GCA can be successfully evaluated using testers such as Slava and the line A344, which were the most effective in this respect. The efficiency of the testers did not depend on their own yield or GCA.

Abreu and Gonzalez (1981) studied top crosses with a single tester and established that 19 out of 240 lines tested showed high general combining ability for grain yield. They were adapted as foundation lines for the development of hybrid varieties.

Nawar and EL-Hoasary (1984) top crossed five promising inbred maize lines to each of eleven testers. The parents and 55 hybrids were evaluated at two sites in 1982 for yield and seven yield related traits. The lines $C_5$, $C_8$ and $C_{49}$ were the best combiners for grain yield plant$^{-1}$ and the best three testers were DC1, VC sidic7421 and composite 108.

Shuman *et al.* (1984) tested 1038 new lines in top crosses in 1980-81 and 16 were selected and diallel crosses in 1982-83. Nine lines with high combining ability were selected MK-45, MK -216, MK -220, MK-224, MK-227, MK-228, MK-234, MK367 and MK-368. The best crosses for grain yield, length and growth period and moisture content at harvest were MK-224 x W117, MK-224xMK-228 and MK-234 x MK-368.

The gene action and combining ability for important yield components in maize were analyzed by Muthiah *et al.* (1989) using twenty nine lines and five testers. The study revealed the predominant role of dominant and epistatic gene action for plant height, height up to ear, cob length, cob girth, number of row cob$^{-1}$

and number of grains row$^{-1}$. Grain yield was found to be influenced by both additive and non-additive gene action. The inbreds UMI108, 123, 140, 29, 182/1, 53, 54, 450, 242, 262 and 287 were identified as potential source of yield improvement and specific combinations with good gca effect that could be of immediate practical value have been reported.

Five maize inbred lines were top crossed to each of the three testers and significant differences were observed by Hussain and Aziz (1998) among top cross progenies for plant height, ear height, ear length, kernel rows ear$^{-1}$, ear weight and grain yield. Top crosses excelled their respective parents in performance for most of the traits studied. Parents showing high general combining ability (GCA) for a particular trait did not necessarily show high specific combining ability for that trait.

Mathur *et al.* (1998) evaluated seventy eight single cross hybrids involving thirteen diverse inbred lines and three checks of maize (*Zea mays* L.) were evaluated in a simple lattice design (9 × 9 structure) with two replications in two environments viz, normal and stress. Inbreds P1, P2, P3 and P4 were identified as good general combiners for early silking in the present study and can be used as the potential components for improving/developing heterotic pool/population aimed at earliness. Under high plant density and rainfed conditions the inbreds P5, P6, P8, P12 and P13 can be used to develop high yielding white-seeded maize hybrids.

Ten of 13 new white maize inbred lines developed at Gemmeiza Agricultural Research Station, Egypt, were top crossed with the other three in 1995 by Soliman and Sadek (1999). The top crosses were evaluated in the 1996 season at Sids and Sakha

Agricultural research Station for grain yield, days to 50% siking, plant height, ear position and late wilt (*Cephalosporium maydis*) resistance. Mean values for grain yield, days to 50% silking and plant height of all entries were higher at Sakha. Inbred lines Gm.4, Gm.5, Gm.6, Gm.13 and Gm.26 exhibited the highest positive and significant GCA effects for grain yield, whereas the tester inbred line Gm. 30 showed the highest significant GCA estimate for grain yield and late wilt resistance. The top crosses Gm. 26x Gm. 30, Gm. 2 x Gm. 14, Gm. 11 x Gm. 21, Gm. 13x Gm. 21, Gm.1x Gm. 14 and Gm. 3 x Gm. 21 showed high and significant SCA effects for grain yield.

The combining ability of eight inbred lines of maize and their top crosses was evaluated by Amer *et al.* (2002) in Egypt in 2000-01. Line SK-835, GM-4 and Sd-63 recorded the highest positive general combining ability for grain yield and late wilt resistance. The top cross GM-4 × S.C.SK.-1 recorded the highest yield (31.51 ard/fed).

Nine top crosses were developed by Karunaratne (2002) combining one vigorous line with nine families developed from maize populations and evaluated during 1999. Due to high promise shown, steps were taken to develop eighteen further top crosses combining same families with two other inbred lines. Except top cross KTC5, which is a combination of Ki31, the rest of the top crosses which gave the highest grain yields were from combination of inbred Ki42. They revealed that the top crosses developed using inbred Ki42 are better than top crosses developed with other two inbreds Ki32 and Ki31 between the same parents selected. This study reveals that out of three inbred parents, Ki42 had the best

combining ability and it is the most suitable for hybrid development compared to two other lines tested.

Srivastava and Singh (2003) crossed twenty exotic inbred lines of maize to four indigenous elite inbred testers of maize. The eighty test crosses along with their parents were evaluated over three locations viz., Pantnagar, Bulandshahr and Ludhiana, $L_1$, $L_{12}$, $L_{13}$, $L_{17}$ and $L_{20}$ were good general combiners for grain yield, ear length and 1000 kernel weight and 50% silking. The cross combinations $L_6xT_3$, $L_{14}xT_2$ and $L_{15}xT_1$ had high mean and SCA effects for grain yield and its components.

Sofi and Rather (2006) attempted to characterize the genetic architecture of various local and CIMMYT inbred line crosses. The parental lines (15), testers (3) and test crosses (45) were evaluated at two diverse locations of Kashmir valley namely Larnoo and Wadura during 2005. The analysis of variance revealed significant mean squares due to progenies, crosses and parents v/s crosses for all traits. GXE interaction was significant for all traits except ear diameter and 100 - seed weight. They identified various parents and crosses in terms of *per se* performance and GCA and SCA estimates. A number of parental lines and testers were observed by them to posses good general combining ability effects for various traits especially CML-214, CML-244 and CML-240, which not only had good GCA but also entered into specific cross combinations exhibiting superior mean performance and SCA effects for grain yield and related traits.

Bajaj *et al.* (2007) performed the combining ability analysis using top cross method in high quality protein maize (QPM) inbred lines for yield and yield contributing characters in order to assess

the QPM inbred lines for general combining ability (GCA) and to estimate mid parent and standard heterosis. The major interest was to seek out specific set of lines having maximum genetic distance that maximizes expression of heterosis in hybrid combination. Significant positive gca effects for grain yield were revealed by the inbreds $I_3$, $I_4$ and $I_6$. The inbred line $I_7$, $I_{18}$ and $I_{20}$ revealed negative significant gca effects for days to 50% silking which can be utilized for developing early maturing hybrids.

Iqbal *et al.* (2007) aimed to assess the general combining ability effects of parents and specific combining ability effects of hybrids for yield and yield related traits and explore their use in hybrid development. Combining ability analysis using maize (*Zea mays* L.) inbred lines by growing 45 $F_1$'s generated by crossing fifteen lines with three well adopted testers. There was great contribution of lines towards gca variance for all the traits. Inbred lines viz., KDM 334, KDM 342 and KDM 347 were good combiners for yield and yield attributing characters. Testers C6 were high combiner for grain yield, number of kernel rows $ear^{-1}$ and number of kernels $row^{-1}$.

Ten $S_6$ maize inbred lines derived from Giza-2 white population were top crossed to three inbred tester, i.e. Sd-7, Sd-34 and Gz-602 in 2004 season. The 30 resultant top crosses along with SC-10, SC-122 and Sc-129 as check hybrids were evaluated in 2005 at Gemmeiza, Nubaria and Sakha Agricultural Research Stations by Seiam (2007). Differences among crosses of testers were significant only for number of days to 50% silking. Significant differences were also detected among crosses of lines for 50% silking and ear height. Also, significant mean squares were obtained for locations x lines and location x lines x testers for all studied

traits. Grain yield, as an average, of crosses of lines No. 1, 3, 6 and 8 across testers ranged from 27.98 to 31.35 ard/fad and significantly out yielded the highest yielding check SC-10 (26.77 ard/fad). Average grain yield of the crosses of 10 $S_6$ lines across the 3 testers (27.29 ard/fad) was slightly higher than that of the highest yielding check, i.e. SC-10 (26.77 ard/fad) but significantly higher than checks SC-122 and SC 129 (24.91 and 24.24 ard/fad, respectively). Nine top crosses significantly out yielded the check SC-10 and the line 3 was considered the best combiner for grain yield since it had the highest significant and positive GCA effect and also contributed in 3 out of the 5 top yielding top crosses. Regarding days to 50% silking, the overall average of the top crosses showed that they were significantly earlier (60.6 days) than SC 10 (62.4 days) and slightly earlier than SC. 122 and SC. 129. Lines No. 1 and 5 had significant and negative GCA effects, and exhibited earliness in their top crosses with the 3 testers. Average plant height of the crosses of the 10 $S_6$ lines across testers was significantly shorter than that of SC-10. Average plant height of crosses of lines No. 1, 2, 4, 8 and 9 across testers was significantly shorter than SC-10. This is in accordance with their negative GCA effects. Lines 1 and 2 showed significant and negative GCA effects for ear height which is in direction of inducing lower ear heights in their top crosses. Average ear height of top crosses of lines 1, 2 and 5 across the 3 testers was significantly lower than that of SC-10. Lines No. 1, 3, and 6 were suggested for immediate use in the hybrid breeding program.

Combining ability and type of gene action in yellow maize top crosses were estimated by Sharif *et al.* (2007). Ten new yellow inbred lines of maize (Gm.1-Gm10) were top crossed to three testers, i.e. Gm.1021, S.C.52 and Comp21. The 30 top crosses plus

three testers (S.C.155, T.W.C.352 and Gm. Y Pop) were evaluated in 2006 in Gemmeiza and Sids, Egypt. Significant differences were noticed between the two locations for all the traits, except for resistance to late wilt disease (*Cephalosporium maydis*) and ear diameter. Inbred lines Gm.1 and Gm.4 exhibited positive and significant general combining ability (GCA) for grain yield. Inbred lines Gm.1, Gm.5 and Gm.10 showed negative(desirable) GCA effects for less days to 50% silking towards (earliness), Gm.5 and Gm.10 for plant height towards (shortness), Gm.5 for low ear position and resistance to late wilt disease. Tester Gm. 1021 gave significant and desirable GCA effect towards earliness, ear length, 100-kernel weight and grain yield while tester S.C.52 gave significant and desirable GCA effects for ear height, ear diameter and number of rows per ear. Tester Comp 21 gave highly significant GCA effect for plant height and ear height. At least 19 crosses surpassed the 3 controls in yield potentiality, while, the highest mean performance was detected in the cross Gm. × Gm.1021 (45.29 ard/feddan). These crosses were favourable and could be used in maize breeding programmes.

Top cross analysis was used by Mosa (2010) to determine the relative potential of maize inbred lines in a hybrid breeding programme and suggested that choice of tester is important for efficient selection among line for their potential in hybrid. Nine new yellow maize inbred lines were top crossed with three testers. Difference between the top crosses were found to be significant for all character studies i.e. day 50% silking, plant height, ear height, grain yield, ear length, ear diameter, number of rows $ear^{-1}$ and number of kernels $row^{-1}$. The additive genetic effect was most important for controlling the inheritance for all the traits. Best parental inbred lines which revealed desirable GCA effects were

Sk 10 for days to 50% silking, grain yield, ear diameter and number of kernels row$^{-1}$; Sk 5027 for grain yield, ear diameter, number of rows ear$^{-1}$ and number of kernels row$^{-1}$; Sk 5026 for plant height, ear height, grain yield and number of rows ear$^{-1}$; Sk 5002 for days to 50% silking, grain yield and number of rows ear$^{-1}$; and Sk 8001 for plant height and number of rows ear$^{-1}$.

Wali *et al.* (2010) developed eighty seven single cross hybrids of maize by crossing twenty nine newly developed inbreds from the National Yellow Pool with three testers in a line x tester method and evaluated for grain yield and its component traits. The mean of male lines was higher (78.01 g) than the female lines (70.66 g) for grain yield plant$^{-1}$. Among the parental lines (females) the line YP 4 #07.20 was found to be best general combiner.

From the review of work done by various scientist, discussed above it could be concluded that top cross analysis is an effective method for testing the potential of inbred lines for combining ability and hence can be effectively used for identifying superior inbreds for their use in hybrid maize breeding program.

## Chapter - III

# MATERIAL AND METHODS

The research work entitled "Evaluation of newly developed inbred lines for general combining ability in Maize" was conducted during *rabi* 2009-11 at the experimental farm of Agricultural Botany Section, College of Agriculture, Nagpur. The material used and methodology followed in the research work are described below.

### 3.1 Material required

The experimental material comprised of thirty nine inbreds and one tester as listed below.

| Sr. No. | Parents |
|---|---|
| | **Lines (female)** |
| 1 | NM-091 |
| 2 | NM-094 |
| 3 | NM-099 |
| 4 | NM-0914 |
| 5 | NM-0916 |
| 6 | NM-0919 |
| 7 | NM-0926 |
| 8 | NM-0927 |
| 9 | NM-0929 |
| 10 | NM-0934 |
| 11 | NM-0935 |
| 12 | NM-0938 |
| 13 | NM-0943 |
| 14 | NM-0944 |
| 15 | NM-0949 |

| | |
|---|---|
| 16 | NM-0952 |
| 17 | NM-0954 |
| 18 | NM-0961 |
| 19 | NM-0962 |
| 20 | NM-0966 |
| 21 | NM-0967 |
| 22 | NM-0968 |
| 23 | NM-0969 |
| 24 | NM-0970 |
| 25 | NM-0971 |
| 26 | NM-0973 |
| 27 | NM-0974 |
| 28 | NM-0978 |
| 29 | NM-0979 |
| 30 | NM-0980 |
| 31 | NM-0981 |
| 32 | NM-0982 |
| 33 | NM-0983 |
| 34 | NM-0984 |
| 35 | NM-0985 |
| 36 | NM-0987 |
| 37 | NM-0988 |
| 38 | NM-0990 |
| 39 | NM-09-13 |
| | **Tester (male)** |
| 1 | PKVM-Shatak (Check) |

### 3.2 Methods adopted

Thirty nine lines were crossed with one tester by following top cross mating design to produce thirty nine crosses in *rabi* 2009. These thirty nine crosses were grown in Randomized Complete Block Design in two replications with the spacing of 60 cm x 20 cm accommodating 15 plants in each row in *kharif* 2010. The data were recorded on five randomly selected plants from each cross on following six characters except days to 50% tasseling, days to 50% silking and days to maturity which were recorded on plot basis.

#### 3.2.1 Recording of experimental data

**1. Days to 50% tasseling**

The number of days taken by 50% plants to initiate tasseling in each cross from the date of sowing were counted and presented as days to 50% tasseling.

**2. Days to 50% silking**

The number of days taken by 50% plants to initiate silking in each cross from the date of sowing were counted and presented as days to 50% silking.

**3. Days to maturity**

The number of days taken by all the plants in each cross to attain physiological maturity from the date of sowing were counted and presented as days to maturity.

**4. Plant height (cm)**

The plant height was measured in centimeter from bottom to flag leaf of shoot with the help of meter scale on five randomly

selected plants at the time of maturity. The average height of five plants was reported as plant height in centimeter.

**5. Cob length (cm)**

Five cobs from each line were selected randomly and husk (covering) were removed at the time of harvesting and their length were measured with meter scale and average length was calculated in centimeter.

**6. Cob girth (cm)**

Girth of five cobs whose length was already recorded measured with meter scale in centimeter and average girth was calculated.

**7. Number of grains cob$^{-1}$**

Five cobs from each observational plant were picked up, threshed separately and the grains cob$^{-1}$ was counted. The average grains over five plants were recorded as grains cob$^{-1}$.

**8. 100 grain weight (g)**

100 grains were counted from five randomly selected plants and weighed in gram separately on precision electronic balance and mean 100 grain weight plant$^{-1}$ were recorded.

**9. Grain yield plant$^{-1}$ (g)**

The grains obtained from five randomly selected plant were weighed in gram separately on precision electronic balance and mean grain yield were calculated and recorded as grain yield plant$^{-1}$.

**3.3 Statistical analyses**

The data were subjected to the following statistical and biometrical analysis.

1. Top cross analysis as suggested by Davis (1927).
2. Estimation of general combining ability effect of inbred lines as suggested by White and Richmond (1963).

### 3.3.1 Top cross analysis

#### 3.3.1.1 Analysis of variance for the experimental design

Analysis of variance was carried out as per standard method given by Panse and Sukatme (1954) for all the character under study.

The statistical model used for the design was

$Y_{ij} = \mu + g_i + b_j + e_{ij}$

Where,

$Y_{ij}$ = Phenotypic performance of $i^{th}$ genotype over $j^{th}$ replication

$\mu$ = general mean

$g_i$ = the effect of $i^{th}$ genotype

$b_j$ = effect of $j^{th}$ block

$e_{ij}$ = environmental effect

**The analysis of variance based on this model is given below:**

| Source of variation | Degrees of freedom (d.f.) | Mean squares | |
|---|---|---|---|
| | | Observed | Expected |
| Replications | (r-1) | MSr | |
| Genotypes | (g-1) | MSg | $\sigma_e^2 + r\sigma_g^2$ |
| Parents | (p-1) | MSp | |
| Top crosses | (c-1) | MSc | |
| Parents vs. top crosses | 1 | MSplc | |
| Error | (g-1) (r-1) | MSe | $\sigma_e^2$ |

Where

r = Number of replications

g = Number of genotypes

p = Number of parents

c = Number of top crosses

e = error

$\sigma^2$ = Sum of square

The significance of mean square was tested against error variance by using F-test. The standard error of mean for comparing any two progeny means was computed by using error variance of respective characters as follows:

$$S.E._{(m)} \pm = \sqrt{\frac{\sigma_e^2}{r}}$$

The critical difference was computed by multiplying the standard error of difference with't' value at error degree of freedom at p = 0.05 (5%) and p = 0.01 (1%).

### 3.3.2 Estimation of general combining ability effect of inbred lines

The estimation of general combining ability effect was estimated by using top cross method as suggested by Davis (1927) and White and Richmond (1963).

1. Population mean $\mu = \frac{Y...}{itr}$

Where,

Y... = Total of all hybrid combinations

i = Number of inbred lines

t = Number of tester

r = Number of replication

## Chapter – IV
# RESULTS AND DISCUSSION

Maize possesses superb genetic diversity and enormous biological diversity which justifies continuous attention from geneticist and plant breeders. Research efforts in maize is having focus on the development of high yielding single cross hybrid for different agro ecological region of the country, due to the strength of heterosis for high yielding and tackling the problems possessed by biotic and abiotic stresses. This has been duly supported by development of vigorous genetically diverse inbred lines that have good *per se* performance as well as in cross combinations. The major mandate therefore is to evolve and disseminate inbred-hybrid technology. A coordinated emphasis has been laid on various aspects of maize breeding activities in the country viz. development of genetically diverse, productive, inbred lines with good *per se* performance and resistance / tolerance to biotic and abiotic stresses; testing of large number of two parent crosses at a different locations under multilocation programme; easy economical and efficient commercial seed production technology and demonstration specially on the farmers field.

The top cross (inbred x open pollinated variety) method proved to be efficient in testing of inbred lines for combining ability because with its use, it was possible to identify more promising inbred lines by making fewer number of crosses than are required for making all possible single crosses. This helps in selecting more promising inbred lines on the basis of good general combining ability which will then help in identifying particular combinations that will produce the highest yield through specific combining ability. Combining ability analysis is of special importance in a highly cross

pollinated crop like maize as it helps in identifying potential inbred lines which can be used for developing hybrids and synthetic varieties and thus assists in isolating basic material on which the success of any breeding programme depends. The inbred lines showing high gca effects are good for producing synthetics. The present study was therefore planned and carried out to evaluate thirty nine newly developed inbreds of maize with the objectives to estimate the gca of inbred lines and to identify superior inbreds for hybrid breeding programme. The results of this study are presented and discussed below.

**4.1 Analysis of variance for various characters**

The analysis of variance for various characters is presented in table 1. The mean squares due to genotypes, parents and parent vs. top crosses were highly significant for all the nine characters studied i.e. days to 50% tasseling, days to 50% silking, days to maturity, plant height, cob length, cob girth, number of grains $cob^{-1}$, 100 grain weight and grain yield $plant^{-1}$. The mean square due to top crosses was significant for all the seven characters except days to 50% silking and days to maturity. Significant mean squares for the different components like genotypes, parents, top crosses and parent vs. top crosses indicated that sufficient variability was present in the material under study. Wide variability among the inbreds, their top crosses and standard check for the characters like plant height, ear length, ear diameter, 100 kernel weight, grain yield etc. were also observed by Hussain and Aziz (1998) and Bajaj *et al.* (2007). A significant variation among the experimental material for different characters observed from analysis of variance can be exploited in a better way in hybrid maize breeding programme.

Table 1. Analysis of variance for experimental design

| Source of Variation | d.f. | Mean Squares | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Days to 50% tasseling | Days to 50% silking | Days to maturity | Plant height (cm) | Cob length (cm) | Cob girth (cm) | No. of seeds $cob^{-1}$ | 100 seed weight (g) | Seed yield $plant^{-1}$ (g) |
| Replication | 1 | 1.07 | 0.31 | 15.82 | 307.44 | 0.01 | 0.0024 | 24.09 | 0.78 | 24.23 |
| Genotypes | 78 | 12.35** | 15.35** | 21.86** | 454.53** | 6.20** | 2.92** | 4891.47** | 14.85** | 238.99** |
| Parents | 39 | 11.92** | 16.37** | 22.09** | 373.73** | 3.72** | 2.71** | 2085.25** | 14.71** | 77.12** |
| Top crosses | 38 | 7.55* | 7.25 | 10.65 | 228.04** | 3.63** | 1.00** | 3463.18** | 10.36** | 145.17** |
| Parents vs. top crosses | 1 | 211.32** | 283.48** | 438.31** | 12212.04** | 200.43** | 83.97** | 168609.13** | 190.86** | 10117.91** |
| Error | 78 | 4.23 | 6.21 | 8.08 | 120.25 | 0.49 | 0.28 | 197.46 | 0.85 | 17.44 |

* $P \leq 0.05$ ** $P \leq 0.01$

**4.2 Mean performance of various characters**

The *per se* performance of parents and their top crosses for various characters under this study are presented in table 2 and table 3 respectively.

**A. Days to 50% tasseling**

Among the thirty nine parents studied, the mean values for day to 50% tasseling ranged from 48.00 days to 57.50 days. NM-0934 was the earliest (48.00 days) to attain 50% tasseling followed by NM-0981 and NM-0983 (49.00 days) and NM-0943, NM-0969 and NM-0980 (49.50 days).

Among the thirty nine top crosses studied, the mean values for days to 50% tasseling ranged from 45.50 days to 55.00 days. NM-0981 x PKVM Shatak was the earliest (45.50 days) to attain 50% tasseling followed by NM-0934 x PKVM Shatak and NM-0984 x PKVM Shatak (47.00 days) and NM-091 x PKVM Shatak, NM-0916 x PKVM Shatak and NM-0974 x PKVM Shatak (47.50 days).

**B. Days to 50% silking**

Among the thirty nine parents under study, NM-0970 was the earliest (58.00 days) followed by NM-0934 and NM-0980 (59.00 days) and NM-0969, NM-0979 and NM-0981 (60.00 days).

The mean values for days to 50% silking observed among thirty nine top crosses ranged from 56.00 days to 65.50 days. The early crosses were NM-0981 x PKVM Shatak (56.00 days), NM-0934 x PKVM Shatak (57.50) and NM-0969 x PKVM Shatak, NM-0974 x PKVM Shatak, NM-0982 x PKVM Shatak and NM-0984 x PKVM Shatak (58.00 days).

Table 2. Mean performance of parents for various characters

| Sr. No. | Parents | Days to 50% tasseling | Days to 50% silking | Days to maturity | Plant height (cm) | Cob length (cm) | Cob girth (cm) | No. of seeds cob$^{-1}$ | 100 seed weight (g) | Seed yield plant$^{-1}$ (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NM-091 | 50.00 | 62.00 | 92.00 | 140.30 | 12.66 | 11.43 | 142.60 | 22.78 | 33.28 |
| 2 | NM-094 | 53.50 | 63.50 | 94.00 | 146.60 | 12.60 | 12.01 | 138.90 | 23.90 | 35.88 |
| 3 | NM-099 | 53.50 | 64.00 | 93.50 | 145.55 | 13.26 | 11.38 | 157.50 | 20.10 | 37.87 |
| 4 | NM-0914 | 53.00 | 63.50 | 93.50 | 134.15 | 13.64 | 10.61 | 126.90 | 22.37 | 29.30 |
| 5 | NM-0916 | 55.00 | 66.50 | 96.00 | 138.90 | 10.80 | 9.35 | 117.00 | 18.95 | 26.38 |
| 6 | NM-0919 | 53.00 | 62.50 | 93.50 | 139.50 | 12.40 | 11.08 | 156.50 | 20.61 | 29.17 |
| 7 | NM-0926 | 54.00 | 65.50 | 96.50 | 115.80 | 10.68 | 7.59 | 123.00 | 16.33 | 25.80 |
| 8 | NM-0927 | 55.00 | 66.00 | 97.50 | 118.00 | 12.23 | 9.52 | 128.00 | 16.31 | 21.23 |
| 9 | NM-0929 | 51.50 | 62.00 | 92.50 | 146.90 | 14.07 | 10.67 | 170.00 | 17.05 | 27.86 |
| 10 | NM-0934 | 48.00 | 59.00 | 90.00 | 142.35 | 12.00 | 10.25 | 157.10 | 19.91 | 29.08 |
| 11 | NM-0935 | 53..00 | 64.00 | 99.00 | 145.45 | 12.86 | 10.40 | 138.40 | 22.49 | 32.90 |
| 12 | NM-0938 | 53.50 | 63.50 | 91.50 | 157.60 | 12.06 | 10.70 | 142.80 | 21.02 | 24.77 |
| 13 | NM-0943 | 49.50 | 60.50 | 90.50 | 131.70 | 9.29 | 9.56 | 149.15 | 16.52 | 29.33 |
| 14 | NM-0944 | 51.50 | 61.00 | 92.00 | 160.20 | 13.19 | 11.17 | 193.70 | 22.94 | 35.21 |
| 15 | NM-0949 | 51.50 | 63.50 | 92.00 | 125.40 | 11.79 | 8.18 | 144.50 | 13.85 | 18.59 |
| 16 | NM-0952 | 51.50 | 61.00 | 89.00 | 140.40 | 11.78 | 10.47 | 211.80 | 20.40 | 29.11 |
| 17 | NM-0954 | 53.00 | 62.50 | 93.00 | 161.85 | 12.13 | 10.66 | 123.10 | 22.11 | 29.18 |
| 18 | NM-0961 | 51.00 | 61.50 | 91.00 | 143.35 | 11.36 | 11.34 | 157.35 | 23.60 | 40.63 |
| 19 | NM-0962 | 56.00 | 67.00 | 99.00 | 121.00 | 10.74 | 9.84 | 138.00 | 17.27 | 25.30 |
| 20 | NM-0966 | 57.50 | 68.00 | 100.00 | 131.20 | 9.73 | 9.45 | 117.65 | 19.61 | 29.85 |
| 21 | NM-0967 | 53.00 | 63.00 | 92.00 | 140.75 | 10.76 | 9.78 | 164.90 | 14.14 | 21.28 |
| 22 | NM-0968 | 50.50 | 61.50 | 92.00 | 135.35 | 10.74 | 9.36 | 111.20 | 18.57 | 22.43 |

Continued....

| Sr. No. | Parents | Days to 50% tasseling | Days to 50% silking | Days to maturity | Plant height (cm) | Cob length (cm) | Cob girth (cm) | No. of seeds $cob^{-1}$ | 100 seed weight (g) | Seed yield $plant^{-1}$ (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| 23 | NM-0969 | 49.50 | 60.00 | 91.00 | 128.50 | 13.06 | 11.09 | 228.80 | 20.54 | 27.45 |
| 24 | NM-0970 | 50.50 | 58.00 | 92.50 | 120.90 | 13.85 | 9.97 | 125.00 | 20.81 | 30.65 |
| 25 | NM-0971 | 51.50 | 61.50 | 91.50 | 145.75 | 13.85 | 10.71 | 186.80 | 19.50 | 36.06 |
| 26 | NM-0973 | 52.50 | 62.00 | 95.00 | 157.75 | 14.55 | 11.57 | 210.20 | 21.27 | 43.96 |
| 27 | NM-0974 | 50.00 | 60.50 | 91.00 | 156.15 | 12.54 | 10.91 | 159.15 | 22.40 | 36.12 |
| 28 | NM-0978 | 50.00 | 61.50 | 91.50 | 149.80 | 11.55 | 10.12 | 130.30 | 17.98 | 25.92 |
| 29 | NM-0979 | 50.50 | 60.00 | 93.00 | 157.55 | 13.32 | 11.52 | 216.30 | 17.49 | 42.44 |
| 30 | NM-0980 | 49.50 | 59.00 | 93.50 | 153.35 | 11.25 | 10.26 | 135.10 | 17.82 | 28.57 |
| 31 | NM-0981 | 49.00 | 60.00 | 94.00 | 126.55 | 13.30 | 10.09 | 148.30 | 18.99 | 29.73 |
| 32 | NM-0982 | 50.50 | 61.00 | 91.50 | 127.75 | 11.86 | 9.51 | 116.50 | 21.97 | 29.00 |
| 33 | NM-0983 | 49.00 | 62.00 | 92.50 | 119.65 | 9.39 | 7.25 | 111.50 | 20.86 | 28.80 |
| 34 | NM-0984 | 55.00 | 67.00 | 100.50 | 124.45 | 13.55 | 11.28 | 199.00 | 18.70 | 24.98 |
| 35 | NM-0985 | 55.00 | 66.00 | 96.50 | 132.45 | 13.33 | 10.45 | 121.60 | 24.40 | 43.43 |
| 36 | NM-0987 | 52.00 | 61.50 | 92.50 | 152.30 | 14.18 | 11.12 | 178.80 | 20.16 | 31.46 |
| 37 | NM-0988 | 57.00 | 70.00 | 100.50 | 127.10 | 12.48 | 10.53 | 111.80 | 22.82 | 22.96 |
| 38 | NM-0990 | 57.50 | 69.00 | 102.50 | 112.97 | 14.70 | 9.65 | 190.00 | 21.50 | 33.45 |
| 39 | NM-09-13 | 54.00 | 64.50 | 95.00 | 137.75 | 11.45 | 9.04 | 136.65 | 22.53 | 24.55 |
| 40 | PKVM-Shatak(check) | 50.50 | 60.50 | 91.00 | 157.80 | 13.95 | 12.34 | 179.80 | 26.03 | 57.60 |
| | **SE(m)±** | **1.45** | **1.76** | **2.00** | **7.75** | **0.49** | **0.37** | **9.93** | **0.65** | **2.95** |
| | **CD at 5%** | **4.09** | **4.93** | **5.61** | **21.74** | **1.37** | **1.04** | **27.86** | **1.82** | **8.27** |

**Table 3. Mean performances of top crosses for various characters.**

| Sr. No. | Top crosses | Days to 50% tasseling | Days to 50% silking | Days to maturity | Plant Height (cm) | Cob length (cm) | Cob girth (cm) | No. of seeds $cob^{-1}$ | 100 seed weight (g) | Seed yield $plant^{-1}$ (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NM-091×PKVM Shatak | 47.50 | 59.50 | 88.50 | 148.60 | 15.49 | 12.05 | 234.30 | 21.07 | 45.19 |
| 2 | NM-094×PKVM Shatak | 51.00 | 61.00 | 93.00 | 155.30 | 14.94 | 12.44 | 212.90 | 24.39 | 53.14 |
| 3 | NM-099×PKVM Shatak | 52.00 | 61.50 | 92.00 | 154.30 | 14.34 | 11.45 | 179.30 | 20.23 | 42.63 |
| 4 | NM-0914×PKVM Shatak | 51.00 | 62.00 | 91.00 | 177.30 | 16.57 | 12.12 | 293.90 | 20.13 | 57.06 |
| 5 | NM-0916×PKVM Shatak | 47.50 | 59.00 | 89.00 | 156.60 | 14.01 | 12.44 | 245.40 | 20.71 | 51.14 |
| 6 | NM-0919×PKVM Shatak | 51.00 | 61.50 | 91.50 | 149.25 | 17.22 | 12.29 | 254.00 | 21.27 | 52.62 |
| 7 | NM-0926×PKVM Shatak | 51.50 | 62.00 | 92.50 | 144.70 | 16.99 | 12.34 | 244.40 | 23.40 | 52.81 |
| 8 | NM-0927×PKVM Shatak | 48.50 | 60.00 | 89.50 | 153.85 | 13.42 | 11.99 | 181.40 | 23.19 | 43.30 |
| 9 | NM-0929×PKVM Shatak | 49.50 | 60.50 | 93.00 | 159.80 | 15.16 | 12.79 | 233.00 | 25.31 | 56.17 |
| 10 | NM-0934×PKVM Shatak | 47.00 | 57.50 | 87.50 | 154.20 | 14.05 | 11.23 | 194.90 | 22.99 | 38.10 |
| 11 | NM-0935×PKVM Shatak | 53.50 | 62.50 | 92.50 | 146.95 | 13.80 | 10.54 | 162.70 | 20.31 | 36.96 |
| 12 | NM-0938×PKVM Shatak | 51.00 | 61.00 | 91.00 | 160.50 | 14.40 | 12.64 | 176.70 | 24.14 | 38.37 |
| 13 | NM-0943×PKVM Shatak | 49.00 | 59.50 | 88.50 | 158.20 | 13.43 | 11.52 | 177.65 | 26.66 | 49.55 |
| 14 | NM-0944×PKVM Shatak | 49.00 | 58.50 | 88.50 | 164.00 | 14.50 | 11.91 | 215.20 | 22.33 | 39.22 |
| 15 | NM-0949×PKVM Shatak | 51.00 | 61.00 | 91.00 | 155.10 | 11.47 | 11.16 | 173.40 | 19.84 | 30.27 |
| 16 | NM-0952×PKVM Shatak | 50.00 | 59.00 | 88.00 | 159.75 | 15.20 | 12.38 | 228.10 | 22.46 | 50.93 |
| 17 | NM-0954×PKVM Shatak | 49.00 | 59.50 | 89.00 | 167.60 | 13.87 | 12.23 | 206.80 | 25.27 | 49.61 |
| 18 | NM-0961×PKVM Shatak | 50.50 | 61.00 | 90.00 | 145.00 | 14.00 | 12.00 | 224.10 | 24.31 | 47.85 |
| 19 | NM-0962×PKVM Shatak | 55.00 | 65.50 | 97.00 | 131.35 | 12.83 | 9.22 | 152.75 | 18.28 | 32.07 |
| 20 | NM-0966×PKVM Shatak | 50.00 | 60.00 | 91.50 | 143.00 | 13.57 | 10.03 | 200.15 | 20.60 | 46.08 |
| 21 | NM-0967×PKVM Shatak | 51.00 | 61.50 | 91.50 | 149.37 | 14.67 | 11.28 | 188.60 | 21.17 | 33.28 |
| 22 | NM-0968×PKVM Shatak | 50.00 | 59.00 | 89.00 | 148.30 | 12.99 | 11.26 | 153.70 | 23.85 | 40.28 |

Continued....

| Sr. No. | Top crosses | Days to 50% tasseling | Days to 50% silking | Days to maturity | Plant Height (cm) | Cob length (cm) | Cob girth (cm) | No. of seeds $cob^{-1}$ | 100 seed weight (g) | Seed yield $plant^{-1}$ (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| 23 | NM-0969×PKVM Shatak | 48.50 | 58.00 | 88.00 | 154.45 | 15.70 | 12.87 | 241.85 | 26.68 | 46.24 |
| 24 | NM-0970×PKVM Shatak | 50.50 | 61.50 | 91.00 | 140.80 | 12.90 | 10.52 | 141.30 | 25.55 | 33.89 |
| 25 | NM-0971×PKVM Shatak | 49.00 | 59.50 | 91.50 | 158.20 | 17.73 | 12.54 | 246.00 | 22.84 | 53.14 |
| 26 | NM-0973×PKVM Shatak | 50.00 | 60.00 | 91.00 | 181.60 | 15.36 | 12.13 | 291.60 | 19.06 | 49.19 |
| 27 | NM-0974×PKVM Shatak | 47.50 | 58.00 | 87.50 | 160.00 | 13.78 | 11.57 | 205.05 | 18.42 | 39.40 |
| 28 | NM-0978×PKVM Shatak | 49.00 | 58.50 | 89.00 | 171.50 | 15.74 | 11.93 | 265.50 | 23.12 | 56.86 |
| 29 | NM-0979×PKVM Shatak | 49.00 | 60.00 | 90.50 | 170.95 | 14.65 | 11.84 | 279.60 | 18.76 | 53.45 |
| 30 | NM-0980×PKVM Shatak | 51.50 | 61.00 | 93.00 | 164.65 | 13.18 | 11.22 | 194.35 | 19.29 | 37.08 |
| 31 | NM-0981×PKVM Shatak | 45.50 | 56.00 | 87.00 | 157.75 | 14.74 | 11.60 | 253.80 | 22.03 | 55.76 |
| 32 | NM-0982×PKVM Shatak | 48.00 | 58.00 | 89.00 | 163.70 | 13.60 | 11.88 | 205.30 | 23.79 | 49.68 |
| 33 | NM-0983×PKVM Shatak | 50.00 | 60.50 | 91.50 | 140.90 | 13.38 | 11.14 | 190.25 | 20.86 | 38.67 |
| 34 | NM-0984×PKVM Shatak | 47.00 | 58.00 | 89.00 | 140.60 | 15.12 | 12.06 | 283.00 | 20.10 | 40.02 |
| 35 | NM-0985×PKVM Shatak | 50.50 | 62.00 | 93.00 | 151.97 | 14.61 | 12.51 | 233.95 | 19.92 | 43.38 |
| 36 | NM-0987×PKVM Shatak | 50.50 | 60.00 | 90.50 | 164.00 | 14.38 | 12.48 | 191.10 | 24.52 | 45.41 |
| 37 | NM-0988×PKVM Shatak | 53.00 | 63.50 | 96.00 | 168.40 | 16.93 | 12.74 | 299.50 | 24.07 | 66.59 |
| 38 | NM-0990×PKVM Shatak | 53.00 | 64.00 | 95.00 | 164.75 | 14.95 | 12.52 | 247.20 | 24.05 | 59.38 |
| 39 | NM-09-13×PKVM Shatak | 51.00 | 62.00 | 91.50 | 161.30 | 12.97 | 10.97 | 189.00 | 21.95 | 47.35 |
| 40 | PKVM-Shatak (check) | 50.50 | 60.50 | 91.00 | 157.80 | 13.95 | 12.34 | 179.80 | 26.03 | 57.60 |
| | **SE(m)±** | **1.45** | **1.76** | **2.00** | **7.75** | **0.49** | **0.37** | **9.93** | **0.65** | **2.95** |
| | **CD at 5%** | **4.09** | **4.93** | **5.61** | **21.74** | **1.37** | **1.04** | **27.86** | **1.82** | **8.27** |

**C. Days to maturity**

The mean values of thirty nine parents for days to maturity ranged from 89.00 days to 102.50 days. The early maturing parents were NM-0952 (89.00 days) followed by NM-0934 (90.00 days) and NM-0943 (90.50 days).

The mean values for days to maturity observed among thirty nine top crosses ranged from 87.00 days to 97.00 days. The early maturing top crosses were NM-0981 x PKVM Shatak (87.00 days) followed by NM-0934 x PKVM Shatak and NM-0974 x PKVM Shatak (87.50 days) and NM-0952 x PKVM Shatak and NM-0969 x PKVM Shatak (88.00 days).

**D. Plant height (cm)**

Plant height of thirty nine parents ranged from 112.97 cm to 161.85 cm. NM-0954 was the tallest (161.85 cm) followed by NM-0944 (160.20 cm) and NM-0973 (157.75 cm).

Plant height at maturity ranged from 131.35 cm to 181.60 cm among the top crosses studied. NM-0973 x PKVM Shatak (181.60 cm) was the tallest followed by NM-0914 x PKVM Shatak (177.30 cm) and NM-0978 x PKVM Shatak (171.50 cm).

**E. Cob length (cm)**

Cob length among the thirty nine parents ranged from 9.29 cm to 14.70 cm. The parent NM-0990 (14.70 cm) produced the longest cob followed by NM-0973 (14.55 cm) and NM-0987 (14.18 cm).

The range for cob length among crosses studied was from 11.47 cm to 17.73 cm. The top cross NM-0971 x PKVM Shatak

(17.73 cm) produced the longest cob followed by NM-0919 x PKVM Shatak (17.22 cm) and NM-0926 x PKVM Shatak (16.99 cm).

**F. Cob girth (cm)**

The range of parents for cob girth was found to be from 7.25 cm to 12.01 cm. Parent NM-094 (12.01 cm) recorded the highest cob girth followed by NM-0973 (11.57 cm) and NM-0979 (11.52 cm).

The range of crosses for cob girth was from 9.22 cm to 12.87 cm. Top cross NM-0969 x PKVM Shatak (12.87 cm) recorded the highest cob girth followed by crosses NM-0929 x PKVM Shatak (12.79 cm) and NM-0988 x PKVM Shatak (12.74 cm).

**G. Number of grains cob$^{-1}$**

The range of thirty nine parents for number of grains cob$^{-1}$ was found to be from 111.20 to 228.80. Parent NM-0969 (228.80) recorded the highest number of grains cob$^{-1}$ followed by NM-0979 (216.30) and NM-0952 (211.80).

The number of grains cob$^{-1}$ ranged from 141.30 to 299.50 among the thirty nine top crosses studied. The top cross NM-0988 x PKVM Shatak (299.50) had maximum grains cob$^{-1}$ followed by NM-0914 x PKVM Shatak (293.90) and NM-0973 x PKVM Shatak (291.60).

**H. 100 grain weight (g)**

Among the thirty nine parents 100 grain weight ranged from 13.85 g to 24.40 g. Parent NM-0985 (24.40 g) recorded the highest

100 grain weight followed by NM-094 (23.90 g) and NM-0961 (23.60 g).

The range for 100 grain weight was found to be from 18.28 g to 26.68 g. Top cross NM-0969 x PKVM Shatak (26.68 g) recorded the highest 100 grain weight followed by crosses NM-0943 x PKVM Shatak (26.66 g) and NM-0970 x PKVM Shatak (25.55 g).

**I. Grain yield plant$^{-1}$ (g)**

Among the thirty nine parents, grain yield plant$^{-1}$ ranged from 18.59 g to 43.96 g. The parent NM-0973 (43.96 g) recorded the highest grain yield plant$^{-1}$ followed by NM-0985 (43.43 g) and NM-0979 (42.44 g).

Grain yield plant$^{-1}$ ranged from 30.27 g to 66.59 g among all thirty nine top crosses, NM-0988 x PKVM Shatak (66.59 g) was the high yielder followed by crosses NM-0990 x PKVM Shatak (59.38 g) and NM-0914 x PKVM Shatak (57.06 g).

Based on yield performance none of the inbreds were excellent for all the characters suggesting the value of synthetics for substantial yield improvement. Except for number of grains cob$^{-1}$ for all the other yield and yield contributing characters i.e. grain yield plant$^{-1}$, cob length, cob girth and 100 grain weight, none of the inbreds could surpass the yield of check (PKVM Shatak) The inbreds NM-0969, NM-0979, NM-0952 and NM-0973 were significantly superior over the check for number of grains cob$^{-1}$. Similar type of results was also reported by Bajaj *et al.* (2007).

The cross NM-0988 x PKVM Shatak superseded the check significantly in grain yield plant$^{-1}$. The top crosses NM-0988 x PKVM Shatak, NM-0914 x PKVM Shatak, NM-0978 x PKVM Shatak and NM-0990 x PKVM Shatak were found to be significantly superior

over check for number of grains cob$^{-1}$ and also produced high yield but were at par with check for grain yield plant$^{-1}$. Besides these four crosses sixteen other top crosses were significantly superior over check for number of grains cob$^{-1}$ which is an important yield contributing character. On the basis of *per se* performance of top crosses, inbreds NM-0988, NM-0914, NM-0978 and NM-0990 were identified as good inbreds for number of grains cob$^{-1}$.However *per se* performance did not give sufficient information in this study for the selection of inbreds for their exploitation in heterosis breeding. Mathur *et al.* (1998) and Bajaj *et al.* (2007) also obtained similar results in their studies where *per se* performance of parents and crosses were not useful for identification of superior inbreds.

**4.3 General combining ability effects of inbreds**

The general combining ability effects of inbreds are presented in table 4. The gca effects of days to 50% silking and days to maturity were not calculated as their respective mean squares were non-significant.

**A. Days to 50% tasseling**

The gca effects of inbreds for days to 50% tasseling ranged from -4.47 to 5.02. The inbred line NM-0981 recorded the maximum negative and significant gca effect of -4.47 followed by NM-0984 and NM-0934 which recorded gca effect of -2.97. Among the thirty nine inbreds four showed positive significant and three negative significant gca effects.

**B. Plant height (cm)**

The inbred lines exhibited gca effects for plant height in the range of -25.03 to 25.21. The highest significant positive gca effect of 25.21 was recorded by NM-0973 and followed by NM-0914

**Table 4. General combining ability of parents**

| Sr. No. | Inbred lines | Days to 50% tasseling | Plant height (cm) | Cob length (cm) | Cob girth (cm) | No. of seeds cob$^{-1}$ | 100 seed weight (g) | Seed yield plant$^{-1}$ (g) |
|---|---|---|---|---|---|---|---|---|
| 1 | NM-091 | -2.47 | -7.78 | 0.95 | 0.25 | 16.56 | -1.21 | -1.53 |
| 2 | NM-094 | 1.02 | -1.08 | 0.41 | 0.64 | -4.83 | 2.10** | 6.41* |
| 3 | NM-099 | 2.02 | -1.98 | -0.19 | -0.34 | -38.43** | -2.53** | -2.20 |
| 4 | NM-0914 | 1.02 | 20.91** | 2.03** | 0.32 | 76.16** | 0.08 | 10.33** |
| 5 | NM-0916 | -2.47 | 0.21 | -0.52 | 0.64 | 27.66** | -1.57* | 4.50 |
| 6 | NM-0919 | 1.02 | -7.13 | 2.68** | 0.49 | 36.26** | -1.01 | 5.89* |
| 7 | NM-0926 | 1.52 | -11.68 | 2.45** | 0.54 | 26.66** | 1.11 | 6.08* |
| 8 | NM-0927 | -1.47 | -2.53 | -1.11* | 0.19 | -36.33** | 0.90 | -3.57 |
| 9 | NM-0929 | -0.47 | 3.41 | 0.62 | 0.99** | 15.26 | 3.02** | 9.44** |
| 10 | NM-0934 | -2.97* | -2.18 | -0.48 | -0.56 | -22.83* | 0.70 | -8.62** |
| 11 | NM-0935 | 3.52** | -9.43 | -0.73 | -0.25 | -55.03** | -1.96** | -9.75** |
| 12 | NM-0938 | 1.02 | 4.11 | -0.13 | -1.09** | -41.03** | 1.85** | -8.34** |
| 13 | NM-0943 | -0.97 | 1.81 | -0.09 | -0.27 | -40.08** | 4.38** | 2.82 |
| 14 | NM-0944 | -0.97 | 7.61 | -0.03 | 0.11 | -2.53 | 0.04 | -7.50* |
| 15 | NM-0949 | 1.02 | -1.28 | -0.05 | -0.63 | -44.33** | -2.44** | -16.44** |
| 16 | NM-0952 | 0.02 | 3.36 | 0.66 | 0.58 | 10.36 | 0.17 | 8.70** |
| 17 | NM-0954 | -0.97 | 11.21 | -0.66 | 0.43 | -10.93 | 2.98** | 2.88 |
| 18 | NM-0961 | 0.52 | -11.38 | -0.53 | 0.20 | 6.36 | 2.02** | 1.12 |
| 19 | NM-0962 | 5.02** | -25.03** | -1.69** | -1.96** | -64.98** | -4.00** | -14.64** |
| 20 | NM-0966 | 0.02 | -13.38 | -0.95 | -1.29** | -17.58 | -1.68* | -0.63 |
| 21 | NM-0967 | 1.02 | -6.68 | 0.13 | -0.51 | -29.13** | -1.11 | -13.43** |
| 22 | NM-0968 | 0.02 | -8.08 | -1.54** | -0.53 | -64.03** | 1.43* | -6.43* |
| 23 | NM-0969 | -1.47 | -1.93 | 1.16* | 1.11** | 24.11* | 4.39** | 9.51** |

Continued....

| Sr. No. | Inbred lines | Days to 50% tasseling | Plant height (cm) | Cob length (cm) | Cob girth (cm) | No. of seeds cob$^{-1}$ | 100 seed weight (g) | Seed yield plant$^{-1}$ (g) |
|---|---|---|---|---|---|---|---|---|
| 24 | NM-0970 | 0.52 | -15.58** | -1.63** | -1.27** | -76.43** | 3.26** | -12.83** |
| 25 | NM-0971 | -0.97 | 1.71 | 3.19** | 0.74 * | 28.26** | 0.55 | 6.42* |
| 26 | NM-0973 | 0.02 | 25.21** | 0.82 | 0.33 | 73.86** | -3.22** | 2.46 |
| 27 | NM-0974 | -2.47 | 3.61 | -0.75 | -0.22 | -12.68 | -3.85** | -7.31* |
| 28 | NM-0978 | -0.97 | 15.11 | 1.21* | 0.13 | 47.76** | 0.84 | 9.83** |
| 29 | NM-0979 | -0.97 | 14.56 | 0.11 | 0.04 | 61.86** | -3.52** | 6.72* |
| 30 | NM-0980 | 1.52 | 8.26 | -1.35** | -0.57 | -23.38* | -2.98** | -9.63** |
| 31 | NM-0981 | -4.47** | 1.36 | 0.20 | -0.19 | 36.06** | -0.25 | 9.03** |
| 32 | NM-0982 | -1.97 | 7.31 | -0.93 | 0.08 | -12.43 | 1.51* | 2.95 |
| 33 | NM-0983 | 0.02 | -15.48* | -1.14* | -0.65 | -27.48** | -1.42* | -8.04** |
| 34 | NM-0984 | -2.97* | -15.78* | 0.68 | 0.26 | 65.26** | -2.18** | -6.70* |
| 35 | NM-0985 | 0.52 | -4.43 | 0.07 | 0.71 | 16.21 | -2.36** | 1.66 |
| 36 | NM-0987 | 0.52. | 7.61 | -0.15 | 0.68 | -26.63** | 2.23** | -1.31 |
| 37 | NM-0988 | 3.02* | 12.01 | 2.40** | 0.94* | 81.76** | 1.79** | 18.86** |
| 38 | NM-0990 | 3.02* | 8.36 | 0.41 | 0.72 | 29.46** | 1.76** | 12.66** |
| 39 | NM-09-13 | 1.02 | 4.91 | -1.55** | -0.82* | -28.73** | -0.33 | 0.62 |
| | **SE(m)±** | **1.45** | **7.75** | **0.49** | **0.37** | **9.93** | **0.65** | **2.95** |

*P ≤ 0.05 **P ≤ 0.01

**Note:** GCA effect of inbred lines for days to 50% tasseling and days to maturity were not calculated as their respective mean squares were non-significant.

(20.91). Two inbreds out of thirty nine inbreds studied showed positive significant gca effect and four showed negative gca effects.

**C. Cob length (cm)**

Cob length among the inbreds recorded the gca effects ranging from -1.69 to 3.19. Inbred line NM-0971 exhibited the maximum and significant gca effect of 3.19 followed by NM-0919 (2.68), NM-0926 (2.45) and NM-0988 (2.40). Significant positive and negative gca effects were exhibited by seven out of thirty nine inbreds studied.

**D. Cob girth (cm)**

The gca effect of the inbreds for cob girth ranged from -1.96 to 1.11. Four inbreds exhibited positive significant gca effect and five inbreds exhibited negative significant gca effect. Highest significant positive gca effect was recorded by NM-0969 (1.11) followed by NM- 0929 (0.99) and NM-0988 (0.94).

**E. No. of grains cob$^{-1}$**

The inbred lines exhibited gca effects for number of grains cob$^{-1}$ in the range of -76.43 to 81.76. Out of thirty nine inbreds, thirteen inbreds exhibited positive significant gca effect and fifteen inbreds exhibited negative significant gca effect. Highest significant positive gca effect was recorded by NM-0988 (81.76) followed by NM-0914 (76.16), NM-0973 (73.86) and NM-0984 (65.26).

**F. 100 grain weight (g)**

The gca effect of the inbreds for 100 grain weight ranged from -4.00 to 4.39. The highest significant positive gca effect of 4.39 was recorded by NM-0969, followed by NM-0943 (4.38), NM-0970 (3.26) and NM-0929 (3.02). Significant positive and

negative gca effects were exhibited by thirteen out of thirty nine inbreds studied.

**G. Grain yield plant$^{-1}$ (g)**

Grain yield plant$^{-1}$ among the inbreds recorded the gca effects ranging from -16.44 to 18.86. Inbred line NM-0988 exhibited the maximum and significant positive gca effect of 18.86 followed by NM-0990 (12.66), NM-0914 (10.33) and NM-0978 (9.83). Significant positive and negative gca effects were exhibited by thirteen out of thirty nine inbreds studied.

The estimates of gca effects among the inbreds showed wide variation in the level of significance for various characters. None of the inbreds had high and significant gca in the desirable direction for all the characters studied. Significant gca effects of the inbreds in top crosses were also reported by Soliman and Sadek (1999), Karunaratne (2002) and Mosa (2010) in maize.

The estimates of gca effects revealed that among the inbreds NM- 0988 and NM-0969 were found to be the best combiner as they recorded significant positive gca effect for five economically important characters such as grain yield plant$^{-1}$, cob length, cob girth, 100 grain weight and no. of grains cob$^{-1}$. The inbreds NM-0971 was observed to be good general combiner as it recorded significant positive gca effect for four economically important characters mentioned above except 100 grain weight. NM-0914 was found to be general combiner as it recorded significant positive gca effect for four characters grain yield plant$^{-1}$, plant height, cob length and no. of grains cob$^{-1}$. NM- 0919, NM-0926 and NM-0978 were also found to be good general combiner as they recorded significant positive gca effect for three important characters i.e. grain yield

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plant$^{-1}$, cob length and no. of grains cob$^{-1}$ and hence were also identified as good general combiner. NM-0990 as it recorded significant positive gca effect for grain yield plant$^{-1}$ number of grains of cob$^{-1}$ and 100 grain weight is also a good combiner. These eight inbred lines were identified as good combiner for yield and yield contributing characters and can be used as parents in the exploitation of heterosis. The inbred NM-0984 as it recorded negative significant gca for days to 50% tasseling can be used for developing early maturing hybrids. Mathur *et al.* (1998) and Bajaj *et al.* (2007) also obtained similar results in their studies where they found significant differences in top crosses and selected lines on the basis of good *per se* performance as well as good general combining ability in cross combinations, so that the selected inbreds can be then tested for their specific combining ability and their utilization in heterosis breeding.

Therefore, the criterion of selecting superior inbreds which is the objective of this study is high *per se* performance and high general combining ability. It is observed from the result of the study that the pattern of *per se* performance of inbreds, *per se* performance of inbreds in top crosses and the gca effects of inbreds were noncorresponding to one another. The non corresponding pattern between gca effects and *per se* performance may be due to the fact that a particular parent may have better performance for a character but may not be competent with other genotypes in the desirable direction in a series of cross combination primarily because it may have recessive gene for higher expression of the character which may be dominated by the undesirable dominant gene of the other parent in cross combinations. These findings were similar to those as Bajaj *et al.* (2007), were they found significant

differences among the top crosses for gca and selected lines on the basis of higher gca values.

**Selection of inbreds**

Maize breeding is a science of maize cultivar development. Heterosis has been successfully applied by maize breeders world wide to adopt and improve germplasm sources for desirable traits. Single cross hybrid technology has been widely adopted in maize because of its high yield, uniformity, easy production methods, ability to withstand biotic and abiotic stresses food and nutritional content. (Anonymous, 2009b). Considering these points the main focus of research efforts for developing high yielding single cross hybrids is the development of vigorous genetically diverse inbred lines. Therefore the major point of interest in the present study was to identify specific set of inbred lines based on gca effects giving little importance to *per se* performance. On this basis the inbreds NM-0988, NM-0994, NM-0978 and NM-0990 were identified as superior inbreds for yield and yield contributing character based on gca effect and top cross *per se* performance. These inbreds NM-0988, NM-0914, NM-0978 and NM-0990 can be directly utilized for the exploitation of heterosis for yield and yield contributing characters. Besides this, NM-0969, NM-0971, NM-0919 and NM-0926 were also found to be superior for yield and few yield contributing characters on the basis of gca effects. It is therefore suggested that a diallel mating between these eight selected inbreds should be done to get superior single crosses. The inbred NM-0984 was identified as superior inbred for days to 50% tasseling based on its negative significant gca effect and top cross *per se* performance.

**Table 5. Promising inbreds and their performance for economically important characters**

| Sr. No. | Inbred | Components | Characters | | | | |
|---|---|---|---|---|---|---|---|
| | | | Seed yield Plant$^{-1}$ (g) | Cob length (cm) | Cob girth (cm) | No. of Seeds cob$^{-1}$ | 100 seed weight (g) |
| 1 | NM-0988 | Inbred *per se* performance | 22.96 | 12.48 | 10.53 | 111.80. | 22.82 |
| | | *Per se* performance of inbred in top cross | 65.59 | 16.93 | 12.74 | 299.50 | 24.07 |
| | | GCA effect | 18.86** | 2.40** | 0.94* | 81.76** | 1.79** |
| 2 | NM-0969 | Inbred *per se* performance | 27.45 | 13.06 | 11.09 | 228.80 | 20.54 |
| | | *Per se* performance of inbred in top cross | 46.24 | 15.70 | 12.87 | 241.85 | 26.68 |
| | | GCA effect | 9.51* | 1.16* | 1.11** | 24.11* | 4.39** |
| 3 | NM-0971 | Inbred *per se* performance | 36.06 | 13.85 | 10.71 | 186.80 | 19.50 |
| | | *Per se* performance of inbred in top cross | 53.14 | 17.73 | 12.54 | 246.00 | 22.84 |
| | | GCA effect | 6.42* | 3.19** | 0.74* | 28.26** | 0.55 |
| 4 | NM-0914 | Inbred *per se* performance | 29.30 | 13.6 | 10.61 | 126.90 | 22.37 |
| | | *Per se* performance of inbred in top cross | 57.06 | 16.57 | 12.12 | 293.90 | 20.13 |
| | | GCA effect | 10.33* | 2.03** | 0.32 | 76.16** | 0.08 |
| 5 | NM-0978 | Inbred *per se* performance | 25.92 | 11.55 | 10.12 | 130.30 | 17.98 |
| | | *Per se* performance of inbred in top cross | 56.86 | 15.74 | 11.93 | 265.50 | 23.12 |
| | | GCA effect | 9.83** | 1.21* | 0.13 | 47.76** | 0.84 |
| 6 | NM-0926 | Inbred *per se* performance | 25.80 | 10.68 | 7.59 | 123.00 | 16.33 |
| | | *Per se* performance of inbred in top cross | 52.81 | 16.99 | 12.34 | 244.40 | 23.40 |
| | | GCA effect | 6.08* | 2.45** | 0.54 | 26.66** | 1.11 |
| 7 | NM-0919 | Inbred *per se* performance | 29.17 | 12.40 | 11.08 | 156.50 | 20.61 |
| | | *Per se* performance of inbred in top cross | 52.62 | 17.22 | 12.29 | 254.00 | 21.27 |
| | | GCA effect | 5.89* | 2.68** | 0.49 | 36.26** | -1.01 |
| 8 | NM-0990 | Inbred *per se* performance | 33.45 | 14.70 | 9.65 | 190.00 | 21.50 |
| | | *Per se* performance of inbred in top cross | 59.38 | 14.95 | 12.52 | 247.20 | 24.05 |
| | | GCA effect | 12.66** | 0.41 | 0.72 | 26.46** | 1.76** |

*P ≤ 0.05 **P ≤ 0.01

## Chapter - V
# SUMMARY AND CONCLUSIONS

The study entitled "Evaluation of newly developed inbred lines for general combining ability in maize (*Zea mays* L.)" was undertaken to evaluate thirty nine newly developed inbreds of maize for their gca effects and to identify superior inbreds for hybrid breeding programme. To achieve these objectives, thirty nine inbreds were crossed with PKVM-Shatak (tester as well as check) in top cross method to secure thirty nine top crosses. These thirty nine top crosses along with forty parents (thirty nine lines and one tester) were sown in a Randomized complete block design replicated twice at the farm of Agricultural Botany Section, College of Agriculture, Nagpur during *kharif* 2010. The data were recorded on days to 50% tasseling, days to 50% silking, days to maturity, plant height (cm), cob length (cm), cob girth (cm), number of grains cob$^{-1}$, 100 grain weight and grain yield plant$^{-1}$.

Considerable variability existed among the genotypes, parents, parents vs. top crosses for all the characters studied. Top crosses had considerable variability among them for all the characters studied except days to 50% silking and days to maturity.

Among the inbreds studied, none of them could surpass the yield of check (PKVM-Shatak), however, inbreds NM-0969, NM-0979, NM-0952 and NM-0973 were significantly superior over the check for number of grains cob$^{-1}$. The top cross NM-0988 × PKVM Shatak significantly superseded the check for grain yield plant$^{-1}$, whereas the top crosses NM-0988 × PKVM Shatak, NM-0984 × PKVM Shatak, NM-0978 × PKVM Shatak and

NM-0990 x PKVM Shatak superseded the check for number of grains $cob^{-1}$.

The estimate of gca effects showed wide variation in the level of significance for various characters. The gca estimates of inbreds emphasized the importance of inbreds viz., NM-0988, NM-0969, NM-0971, NM-0914, NM-0919, NM-0926, NM-0978 and NM-0990 for their use in producing single cross hybrids.

The pattern of *per se* performance of inbreds, *per se* performance of inbreds in top cross and gca effects of inbreds was observed to be non corresponding to one another. Therefore, the selection criterion for better performing inbred was considered to be gca effects with little importance to *per se* performance. On this basis, NM-0988, NM-0914, NM-0978, NM-0990, NM-0969, NM-0971, NM-0919 and NM-0926 were identified as superior inbreds for yield and yield contributing characters. Therefore diallel mating between these eight inbreds was suggested to get superior single cross. The inbred NM-0984 was identified as superior inbred for early days to 50% tasseling.

## Chapter - VI

# LITERATURE CITED


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*__Note:__ - Original not seen.

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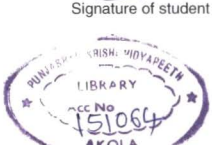


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