

**GENETIC ANALYSIS OF YIELD AND ITS COMPONENTS
IN SELECTED TROPICAL AND SUB-TROPICAL
MAIZE (*Zea mays* L.) INBREDS**

By
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M.Sc. (Ag.)

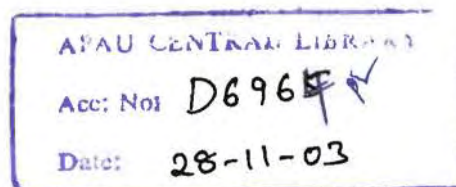
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THESIS SUBMITTED TO THE
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN THE FACULTY OF AGRICULTURE

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JULY, 2003

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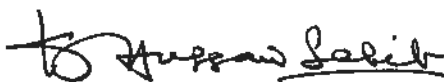
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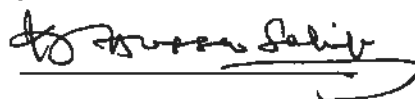
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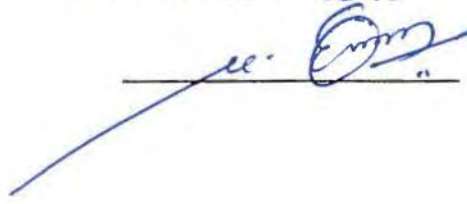
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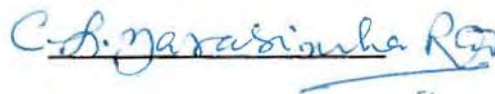
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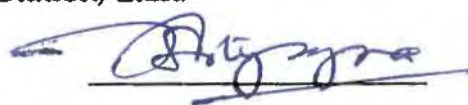
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ACKNOWLEDGEMENTS

I wish to take this opportunity to express my deep sense of gratitude and sincere thanks to Dr K. Hussain Sahib, Professor and Head, Department of Genetics and Plant Breeding, College of Agriculture, Rajendranagar, Hyderabad and chairman of the advisory committee for his valuable guidance and encouragement during the course of investigation.

I humbly express my sincere thanks to the member of advisory committee Dr. R. Sai Kumar, Principal Scientist and Head, ARS – Amberpet, Hyderabad for his timely suggestions.

I take this opportunity to express my gratefulness to Dr. M. Ganesh, Principal Scientist, National Seed Project, Rajendranagar, Hyderabad and member of the advisory committee for his pragmatic suggestions in preparation of thesis.

I express my profound thanks to Dr.C.L. Narasimha Rao, Principal Scientist, R.A.R.S. Lath and member of the advisory committee for his kind cooperation.

My sincere thanks are due to Sri A. Satyanarayana, Professor and Head, Computer Centre, ANGRAU, and member of the advisory committee for the cooperation extended in statistical analysis of research data.

It is a privilege to express my deep sense of reverence and gratitude to Dr.Narendra Kulakarni, Principal Scientist and Head, Rice section, Agricultural Research Institute, Rajendranagar, Hyderabad for his constant help, persistent encouragement, valuable suggestions and incisive criticism in editing and presentation of thesis.

I extend my sincere thanks to Sri. K. Narasimha Reddy, Scientist, ICRISAT for his heartfelt guidance and cooperation extended in preparation of thesis.

I convey my thanks to Dr.S. Sokka Reddy, Associate Professor and staff of Department of Genetics and Plant Breeding, College of Agriculture, Rajendranagar for their help rendered during my Ph. D programme.

My heartfull thanks are due to all the staff members of Rice Section, ARI, Rajendranagar for their cooperation and encouragement given during the course of investigation.

I take this opportunity to thank Dr.E. Satyanarayana, Principal Scientist, Dr.S. Venkatesh, Scientist and all the staff members at ARS, Amberpet, Hyderabad; ARS, Karimnagar and Tandoor for the help extended in supply of seed material and conducting experiments.

I am thankful to Mrs. Falhima Sulthana, Scientist, National Seed Project, Rajendranagar, Hyderabad for analysing oil content in maize seed samples.

I wish to express my unboundfull gratitude to my beloved parents and brother for the love and affection they showed on me and the pain they had taken to sculpt me to the present position .

I am deeply indebted to my wife Padmaja, children Pradyumna, Pramod, brother-in-law Sreedhar and all other family members without whose wholehearted cooperation, cheerfulness and invaluable moral support I would have found it difficult to complete the Ph.D. programme.

I acknowledge Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad for giving deputation and financial assistance during the course of my Ph.D. studies.

I am thankful to K. Pradeep Kumar and S. NARSING RAO for timely and neat typing of my thesis.

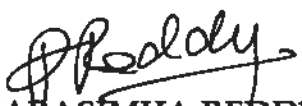

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DECLARATION

I, Mr. P. NARASIMHA REDDY, hereby declare that the thesis entitled "GENETIC ANALYSIS OF YIELD AND ITS COMPONENTS IN SELECTED TROPICAL AND SUB-TROPICAL MAIZE (*Zea mays* L.) INBREDS" submitted to the Acharya N.G. Ranga Agricultural University for the degree of "DOCTOR OF PHILOSOPHY IN AGRICULTURE" is a result of original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

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Title of the thesis : GENETIC ANALYSIS OF YIELD AND ITS COMPONENTS IN SELECTED TROPICAL AND SUB-TROPICAL MAIZE (*Zea mays L.*) INBREDS

Degree to which it is submitted : DOCTOR OF PHILOSOPHY

Faculty : AGRICULTURE

Department : GENETICS AND PLANT BREEDING

Major advisor : Dr. K. HUSSAIN SAHIB

University : ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY

Year of submission : 2003

ABSTRACT

Ten maize parental lines comprising five each from tropical and sub-tropical types were selected after evaluating by top cross method a total of 180 lines at two locations during 1999-2000 *rabi* season. Forty five crosses along with parents were studied for heterosis, nature of gene action, genetic parameters, character association, G x E interaction and stability for grain yield, oil, protein content and yield components during *kharif* 2001 in completely randomized complete block design at three locations viz., Rajendranagar, Karimnagar and Tandoor.

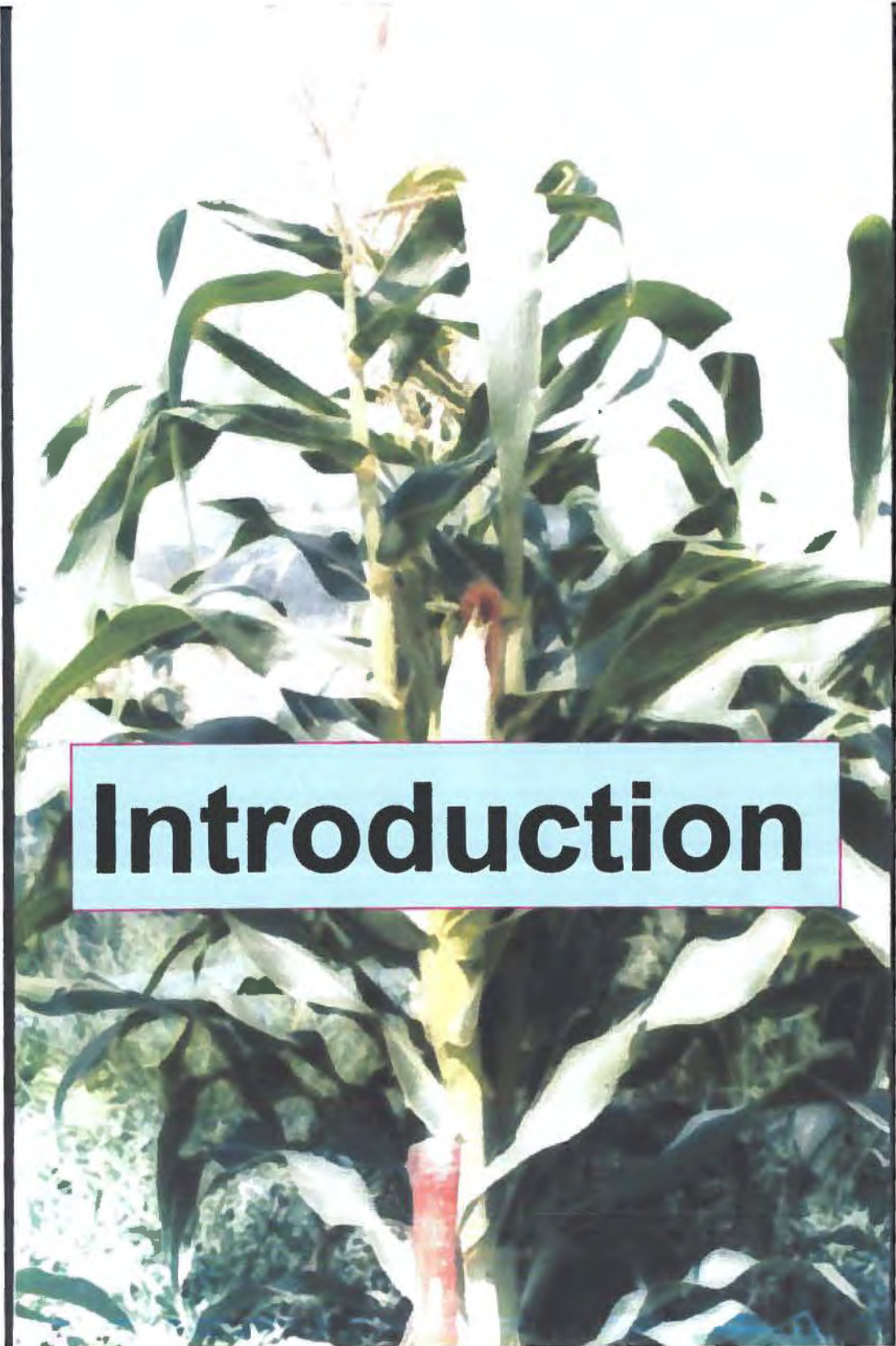
Non-additive gene action primarily governed days to 50% tasseling, silking, brown husk, ear height, plant height, ear length, ear girth, shelling %, 100 seed weight, grain yield, oil and protein content. Among the parental lines the tropical parents had higher number of seed rows, seed number, shelling out turn, 100 seed weight and grain yield. Whereas, parents from sub-tropics possessed higher protein content. Among the parents, P5 and P6 were good combiners for earliness. For plant height, P5, P8 and P9, for ear length P8 and P7 and for ear girth P5 contributed maximum favorable genes. The tropical parent P4 was good combiner for number of seed rows and seed number per ear. The tropical parents P5 and P4 for shelling % and P7, P8 and P5 for 100 seed weight contributed favorable genes. P6 and P8 were good

general combiners for oil % while, P3, P5 and P2 for protein %. All the tropical parents viz., P7, P8, P4 and P5 were good general combiners for yield. Considering all characters over three locations, the parents P5, P7 and P4 (all tropicals) can be given the status of best combiners.

Estimates of heterosis, heterobeltiosis and standard heterosis were variable among crosses in desirable direction. P4xP10 for earliness, P5xP7 for ear length, P4xP8 and P4xP9 for number of seeds per ear, P1xP2, P5xP7, P2xP6 for protein and P2xP9, P3xP7, P4xP10 for oil % were best specific crosses with high heterosis. Heterosis for yield was accomplished due to heterosis for ear girth, seed number, shelling % and 100 seed weight. P5xP8 and P1xP2 for grain yield exhibited 26.0 and 21.6% standard heterosis. These two crosses were also stable across the locations. The most heterotic cross P4 xP8 has both the parents as good combiners and are of tropical type. The true breeding progenies can be spotted from segregating generations of this cross.

The estimates of genetic parameters exhibited high heritability and genetic advance for ear height, number of seeds per ear, 100 seed weight, grain yield and protein content, since these characters are governed by additive gene action. Considerable improvement can be sought by selection for these characters. Grain yield was positively correlated at both phenotypic and genotypic level with ear girth, ear length, number of seed rows and seeds per ear, ear height, plant height, shelling % and oil % at all the three locations. The path coefficient study revealed direct effect of plant height, number of seed rows, number of seeds per ear, 100 seed weight on grain weight. The indirect effect of 100 seed weight and number of seeds for grain yield is very prominent at all the locations.

Genotype x Environment interaction was significant for 50% tasseling, 50% brown husk, plant height, ear length, number of seed rows per ear, 100 seed weight and oil %. The non-linear component of G x E interaction alone accounted for variation in respect of ear height, number of seeds per ear, shelling % and grain yield. P5, P6 and P7 were stable for earliness, P3 and P8 for ear length, P1 and P5 for ear girth, P4 for number of seed rows per ear, P10 for number of seeds per ear, P4 and P5 for shelling %, P7 and P5 for 100 seed weight, P7 and P10 for oil and P8 for protein. P7 and P8 had introgression, least regression from deviation. Among the crosses P4xP10, P5xP6 and P3xP10 were stable for earliness. The crosses P5xP8, P1xP2, P4xP9 and P1xP7 with higher *per se* for grain yield were found to be stable. The grain yield was stable mainly due to stability for shelling %, ear length, number of seed rows and number of seeds per ear.



Introduction

CHAPTER I

INTRODUCTION

Maize is an important cereal crop because of its great significance as food, feed and industrial utilization. The corn strains of United States contain 18-20 per cent oil which contains predominantly essential polyunsaturated fatty acids which makes the oil of good quality (Kumar *et al.*, 1997). Total area in the country during 2000-2001 under maize was 6.5 million hectares and registered record production of 12.06 million tonnes. The increase in area was mainly from Jammu and Kashmir, Andhra Pradesh and Rajasthan whereas the increase in production was largely from the states of Karnataka, Bihar, Madhya Pradesh and Tamil Nadu (Singh, 2002). The country witnessed wide spread drought during 2002 which adversely affected the production of most of the cereals. However, the effect was very less on maize compared to other cereals (Kallo, 2003).

Due to continuous drought, maize area in Andhra Pradesh has increased and there was a shift from other crops to maize as it has comparative and competitive advantage over other crops. The area under maize found to increase further even in rice areas prone to irrigation water shortage. The maize productivity in India has increased from 1441kg/ha (1978-79) to 1840 kg/ha (2000-2001). In Andhra Pradesh, the productivity during 2000-2001 was 2994 kg/ha (Anonymous, 2002). This increase was possible mainly due to induction of high yielding hybrids.

Maize breeding research in India during the last three decades has been mainly oriented towards the development of either hybrids or composites. Hybrid breeding till date has been confined to exploitation of hybrid vigour in double cross and double top cross hybrids whereas in USA and other developed countries, single cross hybrids, which alone are capable

of attaining the maximum heterotic potential, have been the main commercial entity. In the Indian maize development programme, the reasons for failure to capitalize on this fact may be attributed to poor *per se* performance of the inbred lines, which necessitated the development of hybrid types other than single cross. For single cross hybrids to be economically viable, it is imperative that the inbred lines must be highly productive and agronomically superior. In India, improvement of inbred lines has been neglected and emphasis was laid in deriving new inbred lines from narrow genetic sources. Introgression of tropical maize germplasm into temperate maize has broadened the germplasm base and few successful commercial hybrids in temperate areas were reported (Wellhausen 1965, and Goodman 1985).

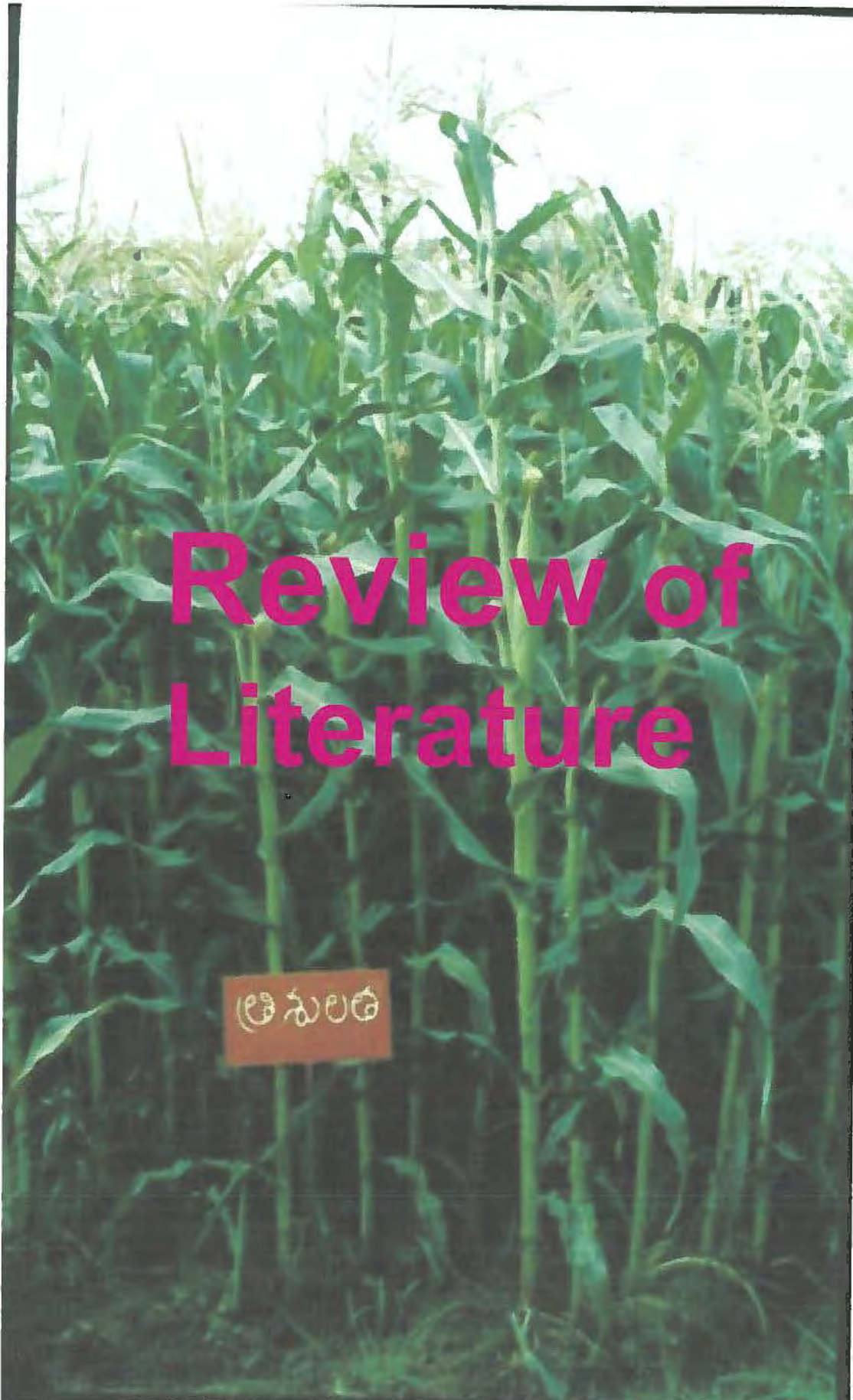
To sustain the productivity and increase the yield further, successful use of tropical maize to improve temperate populations has been reported by Pandey and Gardner (1993). Chen Yan Hui *et al.* (2000) advocated the use of temperate x tropical crosses with an advantage of having long ear, increased kernel per row and kernel weight.

One hundred and eighty selections were made from tropical and sub tropical populations at Agricultural Research Station (Maize), Amberpet, Hyderabad. They were evaluated by top cross method by involving with two testers (CM119 and CM211) and the F1's were studied at two locations based on top cross performance, 5 tropical and 5 sub tropical type inbreds were selected to study for combining ability and stability. In order to use them in future breeding programmes, it is very essential to know the genetic background of parental lines which helps in formulating breeding strategies and also to broaden genetic base by blending the tropical and sub tropical gene pool.

Diallel technique is widely used in genetic analysis and in present study also it was thought to be appropriate as experimentally it is systematic approach and analytically provides overall genetic information. It also helps

in evaluating genetic relationship among the parents and measures additive and dominant variances in the material to be tested. These selected parents were crossed in diallel fashion with the following objectives.

1. To study the combining ability for selected inbreds for grain yield, yield components, oil and protein content
2. To estimate magnitude of heterosis for yield, yield components, oil and protein content over locations
3. To evaluate the single crosses for specific combining ability (SCA) for yield components, oil and protein content
4. To study Genotype $\times$ Environment (G $\times$ E) interaction and stability parameters for yield and yield attributes
5. To estimate genetic parameters, character association, direct and indirect effects among the yield, yield attributes, oil and protein content



Review of Literature

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CHAPTER II

REVIEW OF LITERATURE

Maize is one of the most intensively studied crops and hence, a wealth of information is available on genetics of several hereditary parameters. The literature available on genetic analysis of yield and its components in maize (*Zea mays* L.) is reviewed under the following sub heads.

- 2.1 Combining ability analysis
- 2.2 Heterosis
- 2.3 Stability
- 2.4 Heritability and genetic advance
- 2.5 Correlation studies
- 2.6 Path coefficient analysis

2.1 COMBINING ABILITY ANALYSIS

Combining ability of the inbred lines is the ultimate factor for determining future usefulness of the lines. Combining ability is a general concept of classifying inbred lines relative to their cross performance.

Sprague and Tatum (1942) elaborated the concept of combining ability through preliminary studies with maize. He defined general combining ability (GCA) as the "average performance of a line in hybrid combinations" while the specific combining ability (SCA) as the "deviation from performance predicted on the basis of GCA". They revealed in their experiments using single crosses in maize that general combining ability (GCA) is primarily due to additive effect of genes and specific combining ability (SCA) is due to non additive effect of genes.

Griffing (1956 a, 1956 b) proposed a generalized concept and methodology for combining ability analysis of diallel crosses with two models and four methods in each model.

In model - I (Fixed Effects Model), parent materials are selected with some purpose and the results obtained are applicable to the materials investigated. The main interest lies in estimation of combining ability effects. In model - II (Random Effects Model), the parents are random samples from the populations about which the inferences are to be drawn. Here the interest lies in estimation of different genetic components of the population variance.

In maize, several workers have studied combining ability and gene action controlling traits as given below.

Matzinger and Kempthorne (1956) showed that estimates of general combining ability variance included additive genetic variance and portions of the additive and higher order additive based epistatic variances. Similarly, estimates of specific combining ability variance included dominance and portions of all the epistatic variance. Estimation of additive and dominance genetic variances can be obtained from a diallel cross only in the absence of epistasis. This limitation is common to all the factor mating designs.

It is usually necessary to assume that there is no epistasis when giving a genetic interpretation to diallel statistics. Gilbert (1958) concluded that such an assumption could be justified on an empirical basis.

Singh and Joshi (1966) from their studies on line x tester analysis reported that non additive effects were of greater importance and suggested to use single or double crosses as testers involving inbreds with high SCA and also indicated that parental performance itself was not necessarily a guarantee of its usefulness in breeding programmes.

Ottaviano *et al.* (1970) reported preponderance of additive gene action for ear weight, whereas for other yield components a complex of gene interactions along with additive effect was noticed.

Inone and Kaneko (1974) found that the genetic differences were closely associated with SCA effects in crosses involving the inbreds.

Arunachalam (1976) emphasized that combining ability analysis operated with feasible and practical assumptions and hence more realistic to plant breeding problems. This model operates under the sole assumption that parents of the diallel cross are inbreds and have an advantage of maintenance of genetic uniformity when the hybrids and the parents are raised in plots (usually one row or few rows) in the field. The qualitative characters can be measured on a random sample of plants from a plot. The estimates of the variance due to GCA and SCA provide an apt diagnosis of the predominant role of the additive / non additive gene action. The GCA and SCA effects will help to locate the parents and crosses that are responsible in establishing a particular type of gene action.

Simmonds (1979) concluded that the attraction of combining abilities provide empirical survey of complex observations and a reasonable basis for forecasting the performance of untested crosses. They are statistically robust due to their dependence on first degree statistics (means) and they are equally applicable to in breeders and out breeders, whether seed propagated or clonal.

Pal and Prodhan (1994) reported that the mean square estimates for both GCA and SCA were significant for maturity, oil content and grain yield. SCA components were higher than GCA components for above characters indicating the importance of non additive gene effects in controlling these traits.

Combining ability studies for oil improvement in maize (Kumar *et al.*, 1999) at Rajendranagar revealed a preponderance of non additive gene action for grain yield, yield attributing characters and oil content.

Studies were conducted (Nass *et al.*, 2000) in tropical areas to examine the containing abilities and their interaction with environments in ten selected maize inbred lines in diallel crosses for identifying promising hybrid combinations. The combining ability analysis of diallel data across environments showed highly significant ($P < 0.01$) effects for environment, GCA, SCA and GCA x environment interaction. The SCA x environment interaction was not significant.

Direction of combining ability effects provides useful inference to plant breeders, for example, probability of obtaining heterosis in a single cross, when the divergence in the direction of GCA effects of parents is ensured and found to be high when the SCA effect is not significant. The literature on combining ability and gene action since 1970's in maize have been summarized for yield and yield attributing characters.

2.2 HETEROSIS

Heterosis is expressed as percentage increase or decrease of F1 hybrid over the mid parental value. The superiority of F1 hybrid over the better of two parents is known as heterobeltiosis while F1 superiority over the standard check is termed as standard heterosis.

Shull (1952) explained the heterosis concept in maize. Heterosis results in increased yield, early maturity, taller plants and seed weight.

Non allelic interaction might be the cause of heterosis rather than the special relation between the genes at same locus (Jinks, 1955). Falconer (1960) explained heterosis as complementary to inbreeding depression. Heterosis is directly proportional to $\sum d^2$ where 'd' is the degree of

Summary of different types of combining ability variances in maize

Sl.No.	Character	General combining ability (GCA)	Specific combining ability (SCA)	Both GCA and SCA
1	Days to 50% tasseling	Russel and Stuber (1985), Benavidez and Jasa (1993), Singh <i>et al.</i> (1998), Choudhary <i>et al.</i> (2000)	Murthy <i>et al.</i> (1981), Lee (1983), Guo <i>et al.</i> (1986), Widstrom <i>et al.</i> (1993)	Hassaballa <i>et al.</i> (1980), Lee (1983), Pal and Prodhon (1994), Paul and Debnath (1999)
2	Days to 50% silking	Ottaviano and Camussi (1981), Beck <i>et al.</i> (1990), Ndewton and Eagles (1991), Vasal <i>et al.</i> (1992), Benavidez and Jasa (1993), Pandey <i>et al.</i> (1994), Altinbas (1995), Singh <i>et al.</i> (1998), Leta Tulu and Ramachandrappa (1998), Mathur <i>et al.</i> (1998)	Murthy <i>et al.</i> (1981), Ramesha (1988)	Dhillon and Singh (1977b), Hassaballa <i>et al.</i> (1980), Vasla <i>et al.</i> (1993), Pal and Prodhon (1994), Singh and Mishra (1996), Paul and Debnath (1999)
3	Ear height	Zamperi <i>et al.</i> (1986), Salem <i>et al.</i> (1986), Pandey <i>et al.</i> (1994), Altinbas (1995), Singh <i>et al.</i> (1998a), Leta Tulu and Ramachandrappa (1998), Zelleke (2000), Venkat Nagesh kumar (2001)	Dhillon and Singh (1977b), Widstrom <i>et al.</i> (1993)	Dhillon and Singh (1977c), Hassaballa <i>et al.</i> (1980), Qadri <i>et al.</i> (1983), El-Hosary and Sedhom (1990), Beck <i>et al.</i> (1990), Zhang and Wang (1991), Muralikrishna and Patil (1992), Lima <i>et al.</i> (1995), Paul and Debnath (1999)
4	Plant height	Salem <i>et al.</i> (1986), Beck <i>et al.</i> (1990), Vasal <i>et al.</i> (1992), Ajala (1993), Singh <i>et al.</i> (1998a), Leta Tulu and Ramachandrappa (1998), Zelleke (2000)	Pajic (1986), Herbert and Gallais (1986), Altinbas (1995)	Hassaballa <i>et al.</i> (1980), Lin and Chen (1986), Zhang and Wang (1991), Vasal <i>et al.</i> (1993), Lima <i>et al.</i> (1995), Paul and Debnath (1999)
5	Ear length	Salem <i>et al.</i> (1986), Liao <i>et al.</i> (1987), Ivanov and Tomov (1995), Mathur <i>et al.</i> (1998), Singh and Singh (1998)	Pajic (1986), Muralikrishna and Patil (1992), Pal and Prodhon (1994), Choudhary <i>et al.</i> (2000)	Dhillon and Singh (1977b), Shen and Lai (1987), Zhang and Wang (1991), Alika (1994), Singh and Mishra (1996), Ivanov (1998)
6	Ear girth	Shahi and Singh (1986), Salem <i>et al.</i> (1986), Prasad <i>et al.</i> (1988), Pal and Prodhon (1994), Alika (1994), Mathur <i>et al.</i> (1998)	Debnath <i>et al.</i> (1983), Nagda <i>et al.</i> (1995), Singh and Singh (1998)	Qadri <i>et al.</i> (1983), Zhang and Wang (1991), Singh and Mishra (1996)

Contd...

Sl.No.	Character	General combining ability (GCA)	Specific combining ability (SCA)	Both GCA and SCA
7	Number of Seed rows per ear	Ottaviano and Camussi (1981), Pajic (1986), Mathur <i>et al.</i> (1998), Singh and Singh(1998), Choukan (1999)	Khristova <i>et al.</i> (1983), Ali and Topera (1986), Muthaiah <i>et al.</i> (1989), Pal and Prodhana (1994)	Ivanov and Tomov (1995), El Hosary and Sedhom (1990), Venkat Nagesh Kumar (2001)
8	Number of Seeds per row	Salem <i>et al.</i> (1986), Prasad <i>et al.</i> (1988), Mathur <i>et al.</i> (1998), Choukan (1999)	Pal and Prodhana (1994), Nagda <i>et al.</i> (1995), Singh and Singh (1998)	Ottaviano and Camussi (1981), El-Hefnawy and El-Zeir (1991) Ivanov (1998)
9	100-seed weight	Salem <i>et al.</i> (1986), Pal and Prodhana (1994), Alika (1994), Joshi <i>et al.</i> (1998)	Pajic (1986), Liao <i>et al.</i> (1987), Debnath <i>et al.</i> (1988), Nagda <i>et al.</i> (1995), Zelleke (2000)	Lin and Chen (1986), Singh and Mishra(1996), El-Hosary and Sedhom (1990), Venkat Nagesh Kumar (2001)
10	Grain yield per plot	Gerrish (1983), Lee (1983), Kimani (1984), Zambari <i>et al.</i> (1986), Mungoma and Pollak (1988), Genova (1988), Beck <i>et al.</i> (1990), Vasal <i>et al.</i> (1992), Vasal <i>et al.</i> (1993), Ajala (1993), Ferrao <i>et al.</i> (1994), Pandey <i>et al.</i> (1994), Leta Tulu and Ramachandrappa (1988), Mathur <i>et al.</i> (1998)	Pajic (1986), Liao <i>et al.</i> (1987), Debnath and Sarkar (1987), Han <i>et al.</i> (1991), Jha and Khehra (1992), Widstrom <i>et al.</i> (1993), Ivanov and Tomov (1995), Altinbas (1995), Joshi <i>et al.</i> (1998), Singh and Singh (1998), Choudhary <i>et al.</i> (2000), Zelleke (2000)	Odongo (1983), Baktash <i>et al.</i> (1985), Salem <i>et al.</i> (1986), Lin and Chen (1986), Lee (1987), Ramesha (1988), El-Hosary and Sedhom (1990), Perez <i>et al.</i> (1991), Pixley and Bjarnasou (1993), Pal and Prodhana (1994), Lima <i>et al.</i> (1995), Gama <i>et al.</i> (1995), Singh and Mishra (1996), Veragara <i>et al.</i> (1998), Paul and Debnath (1999), Nass <i>et al.</i> (2000) Venkat Nagesh, Kumar (2000)
11	Oil	Venugopal (2000)		
12	Protein	Venugopal (2000)		

Summary of work done on gene action in maize

S. No.	Character	Additive	Non-additive	Both additive and non-additive
1	Days to 50% tasseling	Rood and Major (1980), Hassaballa <i>et al.</i> (1980), Murthy <i>et al.</i> (1981), Sanghi <i>et al.</i> (1983), Mungoma and Pollak (1988), Gouesnard <i>et al.</i> (1989), Pal and Prodhan (1994), Mathur and Bhatnagar (1995), Malvar <i>et al.</i> (1996), Singh <i>et al.</i> (1998), Choudary <i>et al.</i> (2000)	Nawar and El-Hosary (1984), Guo <i>et al.</i> (1986)	Mukherjee <i>et al.</i> (1971), Hansen <i>et al.</i> (1977), Hassaballa <i>et al.</i> (1980), Ramesha (1988)
2	Days to 50% silking	Dhillon and singh (1977c), Hassaballa <i>et al.</i> (1980), Murthy <i>et al.</i> (1981), Sanghi <i>et al.</i> (1983), pal <i>et al.</i> (1986), Mungoma and pollak (1998), Pal and Prodhan (1994), Altinbas (1995), Mathur and Bhatnagar (1995), Nagda <i>et al.</i> (1995), Malvar <i>et al.</i> (1996), Singh <i>et al.</i> (1998), Leta Tulu and Ramchandrapa (1998), Mathur <i>et al.</i> (1998), Krishnam Raju (2001)	Crossa <i>et al.</i> (1990), Paul and Duara (1991), Appunu (2002)	Hansen <i>et al.</i> (1977), Bhalla and Khehra (1980), Hassaballa <i>et al.</i> (1980), Ramesha (1988), Leon <i>et al.</i> (1989).
3	Ear height	Dhillon and singh (1977b), Harville and Josephson (1979), Qadri <i>et al.</i> (1983) Nawar (1986), Gouesnard <i>et al.</i> (1989), El-Hefnawy and El Zeir (1991), Lima <i>et al.</i> (1995), Altinbas (1995), Singh <i>et al.</i> (1998) Leta Tulu and Ramachandrappa (1998), Zelleke (2000), Krishnam Raju (2001)	Mukherjee <i>et al.</i> (1974), Dhillon and Singh (1977c), Mathur and Bhjatnagar (1995), Malvar <i>et al.</i> (1996), Appunu (2002)	Mukherjee <i>et al.</i> (1974), Pal <i>et al.</i> (1986), Debnath and Sarkar (1987), Mungoma and Pollak (1988), Rao <i>et al.</i> (1991)
4	Plant height	Salem <i>et al.</i> (1986), Nawar (1986), Hallauer and Miranda (1988), Crossa <i>et al.</i> (1990), El-Hefnawy and El-Zeir (1991), Lima <i>et al.</i> (1995), Singh <i>et al.</i> (1998), Leta Tulu and Ramachandrappa (1998), Zelleke (2000)	Ivanovic (1979), Mahmoud <i>et al.</i> (1990), Mathur and Bhatnagar (1995), Malvar <i>et al.</i> (1996)	Mukherjee <i>et al.</i> (1974), Pal <i>et al.</i> (1986), Debnath and Sarkar (1987), Venkat Nagesh Kumar (2001)

Contd.

Sl.No.	Character	Additive	Non-additive	Both additive and non-additive
5	Ear length	Qadri <i>et al.</i> (1983), Pal <i>et al.</i> (1986), Nawar (1986), Hallauer and Miranda (1988), Mahmoud <i>et al.</i> (1990), El-Hefnawy and El Zeir (1991), Alika (1994), Mathur <i>et al.</i> (1998), Krishnam Raju (2000)	Mukherjee <i>et al.</i> (1974), Martin and Hallauer (1976), Ivanovic (1979), Genova (1988), Pajic (1986), Stuber <i>et al.</i> (1987), Satyanarayana <i>et al.</i> (1990), Pal and Prodhan (1994), Mathur and Bhatnagar (1995), Nagda <i>et al.</i> (1995), Malvar <i>et al.</i> (1996), Choudary <i>et al.</i> (2000), Appunu (2002)	Kalsy and Sharma (1970), Mukherjee <i>et al.</i> (1974), Setty (1975), Mukherjee and Dhawan (1976), Saha (1981), Debnath and Sarkar (1990), Venkat Nagesh Kumar (2001)
6	Ear girth	Wright <i>et al.</i> (1971), Mukherjee <i>et al.</i> (1974), Dhillon and Singh (1977c), Qadri <i>et al.</i> (1983), Nawar (1986), Pal <i>et al.</i> (1986), Hallauer and Miranda (1988), El-Hefnawy and El Zeir (1991), Pal and Prodhan (1994), Alika (1994), Mathur <i>et al.</i> (1998)	Debnath <i>et al.</i> (1998), Satyanarayana <i>et al.</i> (1990), Debnath and Sarkar (1990), Nagda <i>et al.</i> (1995), Mathur and Bhatnagar (1995), Appunu (2002)	Saha and Mukherjee (1979), Saha (1981), Ahuja <i>et al.</i> (1983)
7	Number of seed rows per ear	Wright <i>et al.</i> (1971), Mukherjee <i>et al.</i> (1974), Dhillon and Singh (1977), Qadri <i>et al.</i> (1983), Nawar (1986), Pal <i>et al.</i> (1986), Satmari (1988), Leon <i>et al.</i> (1989), El-Hefnawy and El Zeir (1991), Pal and Prodhan (1994), Nagda <i>et al.</i> (1995), Malvar <i>et al.</i> (1996), Mathur <i>et al.</i> (1996), Krishnam Raju (2001)	Khristova <i>et al.</i> (1983), Satyanarayana <i>et al.</i> (1990), El-Hosary and Sedhom (1990), Mathur and Bhatnagar (1995)	Singh <i>et al.</i> (1977b), Debnath <i>et al.</i> (1988), Debnath and Sarkar (1990), Choukan (1999), Venkat Nagesh Kumar (2001)
8	Number of seeds per row	Johnson (1973), Ottaviano and Camussi (1981), Salem <i>et al.</i> (1986), Mathur <i>et al.</i> (1998), Krishnam Raju (2001)	Nawar <i>et al.</i> (1980), El Hosary and Sedhom (1990), Pal and Prodhan (1994), Mathur and Bhatnagar (1995), Nagda <i>et al.</i> (1995), Appunu (2002)	Debnath <i>et al.</i> (1988), Debnath and Sarkar (1990), Choukan (1999)

Contd...

Sl.No.	Character	Additive	Non-additive	Both additive and non-additive
9	100 seed weight	Kumar (1974), Ramamurthy (1978), Leon <i>et al.</i> (1989), Salem <i>et al.</i> (1986), El-Hefnawy and El-Zeir (1991), Pal and Prodhan (1994), Alika (1994), Malvar <i>et al.</i> (1996), Joshi <i>et al.</i> (1998), Krishnam Raju (2001)	Khristova <i>et al.</i> (1983), Kimani (1984), Pajic (1986), Liao <i>et al.</i> (1987), Debnath <i>et al.</i> (1988), Mahmoud <i>et al.</i> (1990), Debnath and Sarkar (1990), Nagda <i>et al.</i> (1995), Mathur and Bhatnagar (1995), Zelleke (2000), Appunu (2002)	Ramamurthy (1978), Singh <i>et al.</i> (1979), Pal <i>et al.</i> (1986), Ramesha (1988), Venkat Nagesh Kumar (2001)
10	Grain yield per plot	Robinson <i>et al.</i> (1955), Sprague and Russel (1957), Choudhary (1964), Stuber <i>et al.</i> (1966), Hallauer and Wright (1967), Hallauer (1968), Singh <i>et al.</i> (1971), Wright <i>et al.</i> (1971), Singh <i>et al.</i> (1977a), Singh <i>et al.</i> (1977b), Sanghi <i>et al.</i> (1983), Khamis (1983), Nawar (1986), Pal <i>et al.</i> (1986), Hallauer and Miranda (1988), Lee (1987), Cosmin <i>et al.</i> (1991), El-Hosary and Sedhom (1990), Paul and Duara (1991), Ferrao <i>et al.</i> (1994), Gama <i>et al.</i> (1995), Leta Tulu and Ramachandrappa (1998), Mathur <i>et al.</i> (1998), Krishnam Raju (2001)	Hull (1952), Matzinger <i>et al.</i> (1959), Stuber <i>et al.</i> (1966), Mukherjee and Dhawan (1970), Wright <i>et al.</i> (1971), Darrah and Hallauer (1972), Cornelius and Dudley (1976), Dhillon and Singh (1977a), Ivanovic (1979), Murthy <i>et al.</i> (1981), Khristova <i>et al.</i> (1983), Pajic (1986), Guo <i>et al.</i> (1986), Debnath <i>et al.</i> (1988), Crossa <i>et al.</i> (1990), Debnath and Sarkar (1990), Mahmoud <i>et al.</i> (1990), Pal and Prodhan (1994), Mathur and Bhatnagar (1995), Nagda <i>et al.</i> (1995), Malvar <i>et al.</i> (1996), Joshi <i>et al.</i> (1998), Choudhary <i>et al.</i> (2000), Zelleke (2000), Appunu (2002)	Moll <i>et al.</i> (1960), Eberhart (1971), Mukherjee <i>et al.</i> (1971, 1974), Johnson (1973), Kumar (1974), Setty (1975), Singh <i>et al.</i> (1979), Saha and Mukherjee (1979), Pinto <i>et al.</i> (1988), Muthaiah, <i>et al.</i> (1989), Benavidez and Jasa (1993), Sharma and Bhalia (1993), Choukan (1999), Nass <i>et al.</i> (2000), Venkat Nagesh Kumar (2001)
11	Oil	Krishnam Raju (2001)	Arnel and Miranda (1989)	Lima and de Lima (2000)
12	Protein	Krishnam Raju (2001)	Legesse <i>et al.</i> (1998)	Zarkadas <i>et al.</i> (2000)

dominance component of gene action and 'y' is the difference in the gene frequencies of the parents involved in the cross. The success of heterosis breeding depends on the amount of genetic diversity present in the material.

Ganguli *et al.* (1989) reported positive heterosis over the better parent for grain yield, ear height, plant height and days to silking. Beck *et al.* (1990) observed low and moderate heterosis over the better parent. Sharma and Bhalla (1991) found high heterosis for grain yield. Dubey *et al.* (2001) from their studies reported significant heterotic response for oil content.

The literature available on heterosis was summarized and presented below:

Summary of review of heterosis in maize

Characters with significant relative heterosis	References
Days to 50 per cent tasseling	Daniel and Bajbay (1976), Rama Murthy (1978), Hassaballa <i>et al.</i> (1980), Widstom <i>et al.</i> (1993), Mandal (1996) and Venkatesh (1997)
Days to 50 per cent silking	Daniel and Bajbay (1976), Dhillon and Singh (1977a) Rama Murthy (1978), Crossa <i>et al.</i> (1990), Vasal <i>et al.</i> (1992 a, b), Altinbas (1995), Mandal (1996), Venkatesh (1997) and Vasal <i>et al.</i> (1999).
Plant Height	Dhillon and Singh (1977 a), Mabo (1977), Rama Murthy (1978), Hassaballa <i>et al.</i> (1980), Todorov (1981), Crossa <i>et al.</i> (1987), Misevic (1989 c), Beck <i>et al.</i> (1990), El Hefnawy and El Zeir (1991), Bhatnagar <i>et al.</i> (1993), Mandal (1996) and Venkatesh (1997).
Ear Height	Dhillon and Singh (1977 a), Lin and Chen (1986), Beck <i>et al.</i> (1990), Bhatnagar <i>et al.</i> (1993), Pandey <i>et al.</i> (1994), Mandal (1996) and Venkatesh (1997).

Contd...

Characters with significant relative heterosis	References
Ear Length	Verma and Singh (1980), Nawar and Khamis (1983), Debnath (1984), Mukherjee and Saha (1984), Tomov and Min (1990), Mandal (1996), Venkatesh (1997).
Ear girth	Yurankova <i>et al.</i> (1989), Mandal (1996) and Venkatesh (1997).
Number of seed rows per ear	Appadurai and Nagarajan (1975), Mabo (1977), Genova (1984), Tomov and Min (1990), Mandal (1996) and Venkatesh (1997).
Hundred seed weight	Shakoor and Atullah (1979), Verma and Singh (1980), Mukherjee and Saha (1984), Mandal (1996) and Venkatesh (1997)
Grain Yield	Krolikowski (1971), Mabo (1977), Verma and Singh (1980), Akthar and Singh (1981), Debnath (1984), Younus <i>et al.</i> (1987), Mahmoud <i>et al.</i> (1990), Tomov and Min (1990), Muralikrishna and Patil (1992), Vasal <i>et al.</i> (1992 a, b), Widstrom <i>et al.</i> (1993), Bhatnagar <i>et al.</i> (1993), Pandey <i>et al.</i> (1994), Santos <i>et al.</i> (1994), Altinbas (1995), Mandal (1996), Venkatesh (1997), Wang <i>et al.</i> (1998), Appunu (2000), Venu Gopal (2000), Venkat Nagesh Kumar (2001).
Oil	Venu Gopal (2000).
Protein	Wang <i>et al.</i> (1998), Konak <i>et al.</i> (1999) and Venu Gopal (2000)

2.3 STABILITY

Eberhart and Russell (1966) emphasized the need of considering both linear (bi) and non linear (S^2di) components. In order to be of practical use, the variety should have desirable mean.

Genotype x Environment (GxE) interactions which commonly occur in plant material are of considerable importance in developing improved varieties and rationalization of policy and procedure in breeding programmes aimed at further genetic improvement in crop plants. Hence, in recent years much emphasis has been laid on the nature of GxE interactions. Earlier Finlay and Wilkinson (1963) considered linear regression as a measure of stability.

Gentinetta *et al.* (1988) evaluated 7 opaque 2 maize hybrids for agronomic viz., grain yield, plant height, ear height, 100 seed weight and protein content at 11 locations. Two hybrids maintained high yields and stability for the yield traits in different locations.

Vega and Vega (1992) evaluated 24 maize hybrids at 7 locations to obtain estimates of parameters describing yield stability over environments. The estimates were used for empirical comparisons and association study. The methods based on the effects or sum of squares of G x E interaction were useful and their stability parameters showed the highest coefficient of correlation.

Information on stability was also derived (Mahajan and Khehra, 1992) from data on 6 yield components in 28 F1 hybrids from a diallel cross of 8 maize inbred lines grown at 2 locations in Punjab during winter. Deviation from regression appeared to be more important parameter than regression for measuring stability.

For evaluating maize top crosses for their potential use in breeding programme, Gomes-e-Gama *et al.* (1993) conducted experiments at three locations in Brazil. Both single cross hybrids and populations had longer environmental interactions than the top crosses.

Information on stability was derived based on grain yield of 11 genotypes when grown in temperate wet areas of Himachal Pradesh.

Gautam *et al.* (1998) reported that the local check performed well by recording highest average yield.

In order to estimate the phenotypic stability of parameters of tropical maize hybrids, Castanon and Tosquy (1998) used two statistical techniques viz., regression method adjusted by multiplicative model and principal component analysis. Results revealed that the genotype environment interaction sum of squares (GEISS) was better estimated by PC technique where only two components explained 54.4% of GEISS variation.

The effect of additive, dominant and epistatic gene action for oil content was investigated by Rosulj and Saratic (1998) in two maize inbred lines differing in oil content. The additive gene effects were highly significant at two locations. Epistasis did not contribute significantly to the inheritance of oil content. A comparison of gene effects in the different environments did not show significant genotype x environment interaction.

The methods to be used to estimate stability of corn hybrids for grain yield depends on the characteristics of the experiment. Luquez and Jura (2000) used three methods to estimate stability, among which the test of relative yield (RY) that uses standard deviation as the measure of stability found to be the best in corn improvement programmes, as there is possibility to classify some materials as high yielding and stable, avoiding the bias that high yielding environments given to the general average.

Scapion *et al.* (2000) evaluated twenty maize cultivators at eight locations for two years using three procedures to analyse cultivar stability and adaptability. The level of association among the three parameters was assessed using Spearman's rank correlation. The results revealed that the most responsive cultivars tended to have smaller π_i and did not correlate with Huehn's non parametric measurements S_i (2) and S_i (3) but correlated

positively with S_i (1) indicating that superior genotypes with lower p_i could also be stable.

2.4 HERITABILITY AND GENETIC ADVANCE

Heritability is the proportion of total genotypic variance to total phenotypic variance. Genetic advance is the gain obtained through selection of superior individuals, which can be evaluated from heritability values. Basic information on heritability and genetic advance controlling the yield and yield components is a prerequisite for planning any breeding programme. Though the heritable estimates give useful indication of relative values of selection based on phenotypic expression, heritability values along with the genetic gain has to be considered jointly to arrive at a more reliable conclusion (Johnson, 1955).

Ramamurthy *et al.* (1970) reported high and low heritability estimates for days to silking and 100 grain weight respectively, while Singh and Sharma (1970) reported low heritability for silking days and 100 grain weight and high genetic advance for plant height, number of grains per ear and grain yield.

Khehra *et al.* (1985) presented information on the genetic variance and heritability on grain yield per plant and four selected traits following analysis of data from 64 half sib and 256 full sib families. The expected genetic advance per selection cycle was highest for full sib selection followed by half-sib and mass selection.

Kumar and Singh (1986) analyzed the data on grain yield per plant from forty diverse genotypes and recorded high heritability (90.62%) and genetic advance (73.14%). Heritability for plant height, panicle weight, internode length and 1000 grain weight varied from 85.3% to 93.9% indicating desirable selection of these traits for crop improvement.

Lamkey and Hallaner (1987) calculated heritability and other genetic parameters for yield using variances among progenies for 121 selection experiments. The estimates for heritability from pooled analysis were 68% (full-sib), 58.5% (half-sib), 54.9% (full - sib reciprocal recurrent selection), 79.8% (S1 *per se* progeny), 77.3% (S2 *per se* progeny), 53.3% (test cross with an inbred tester) and 62.7% (test cross with a broad based tested). The estimate of heritability was smaller for S2 than S1 selection due to the importance of dominance effects in the individual populations under going selection.

Gouesnard *et al.* (1989) showed high heritability for plant height and ear height, while moderate to high heritability values for rows per ear (23.5%) and grains per row (67%) were reported by Hosary (1989) in composite variety, cabo 1.

Reddy and Agarwal (1992) reported a genetic advance of 8.90% for plant height and high heritability for ear height. According to Saha and Mukherjee (1993) high genetic advance and heritability were recorded for number of grains per row and grain yield per plant.

Ayala Osuna and Churata (1995) reported heritability estimates for grain yield (33.7%), plant height (54.6%) and ear height (63.4%) which indicated good potential for grain yield improvement as well as reduction in plant height and ear height through recurrent selection.

High heritability along with high genetic advance was exhibited by days to silking, grain yield and ear height whereas for plant height, the values were moderate and low for rest of the characters viz., days to maturity and 100 grain weight (Mani and Bisht, 1996).

Fountain and Hallaner (1996) based on their studies on nine different populations reported that the integration of two primary maize

breeding methods viz., pedigree selections within F2 populations and genetic improvement of broad-base, synthetic populations is appropriate for continued genetic advance.

Tusuz and Balabanli (1997) reported highest heritability in the broad sense for 50 per cent silking (0.93) and it was low for plant height (0.12), ear height (0.31) and yield (0.06).

Samanch *et al.* (1998) reported high heritability for characters viz., plant height (0.58), ear height (0.47) and days to 50 per cent tasseling (0.53).

Singha and Prodhan (2000) reported high heritability estimates along with high expected genetic advance for gross ear yield, ear height ear length and total soluble solids.

The yield attributing characters viz., days to 50 per cent silking, ear length, ear height, number of seed rows per cob, 100 seed weight, protein content, oil content and grain yield had high heritability whereas days to 50 per cent tasseling recorded moderately high heritability coupled with low GCA indicating the predominance of non-additive gene action and hence improvement of such traits is possible through heterosis breeding programme (Krishnam Raju, 2001).

2.5 CORRELATION STUDIES

A knowledge about the correlation of yield and yield components of maize and also the chemical components of kernel will help in formulating selection criterion. Correlation forms the basis of selection index thereby helping the plant breeder in crop improvement.

Yield is a complex character, which depends upon a number of yield components. Correlation studies indicate the magnitude of association between any two characters.

Stuber *et al.* (1966) reported that there is strong genetic association between plant height and ear height since tall plants normally have high ear heights. Shakhov (1975) reported a close association between ear height, ear diameter and number of grains per row.

Geortz *et al.* (1978) noticed highly significant and positive correlation between grain yield and the number of ears per plant. Positive and significant correlation was also reported (Laptev, 1981) for grain yield, plant height and ear height.

A close correlation between grain yield, 100 grain weight and number of grains per ear was reported by Karavaer (1982). Days to maturity and grain yield of maize also showed positive correlation (Parth *et al.*, 1986).

Ivankhenko and Orlyanki (1987) reported that high yielding inbred lines can be obtained through selection for ear diameter and number of grains per ear. Sharma and Kumar (1987) also reported that grain yield per plant was positively correlated with plant height, ear girth, grain number per row and kernel rows per ear.

According to Annapurna (1989), there was positive and significant correlation between grain yield, plant height, ear length, ear girth, number of seeds per ear and 100 seed weight where as days to 75 per cent tasseling and 75 per cent silking had a negative correlation.

Mahajan *et al.* (1990) found significant positive correlation among kernel yield, ear length, number of kernels per row and plant height. However, Malwar *et al.* (1996) did not find any significant correlation among yield attributing components viz., number of grains per row, ear length and kernel weight.

Mittal *et al.* (1997) reported that days to silking and days to pollen shed were important parameters for estimating maturity under Indian conditions.

Netaji (1998) found significant and positive correlation between grain yield and 50 per cent tasseling, silking and maturity. According to Reddy (1998) there was significant positive correlation between plant height and ear height and negative correlation between 50 per cent silking, 50 per cent maturity and grain yield.

Gautam *et al.* (1999) studied 50 indigenous genotypes of maize collected from different agro-climatic situations and reported that the grain yield was positively correlated with plant height and ear height.

Umakanth *et al.* (2000) found negative correlation for grain yield and days to 50 per cent silking. However, plant height and ear height were positively correlated with grain yield.

Correlation studies were also worked out for yield attributing characters and chemical components of grain.

Zozulya (1971) found significant positive correlation between oil content and grain yield of maize. Raman *et al.* (1983) also reported significant positive correlation between grain oil content and grain weight and yield. Similar results were also reported by Pamin (1985).

Dudley *et al.* (1977) and Umakanth (1993) reported negative correlation of grain yield with per cent oil and protein.

Chmielewa *et al.* (1988) found significant positive correlation between protein and oil contents. Results of Proksza and Harmati (1988) revealed that oil yields were usually high in hybrids with moderate oil content coupled with high yielding capacity. Lambert *et al.* (1997) reported

that high oil hybrids with increased oil content were found to be inferior in grain yield than normal hybrids.

Cao *et al.* (1999) reported highly significant positive correlations between oil content and protein contents. However, these two chemical components were negatively correlated with ear weight, 100 grain weight and ear diameter.

According to Venu Gopal (2000), there was negative and non significant correlation between grain yield and oil content of maize kernels. Existence of positive correlation between oil and protein contents and negative correlation with grain yield indicates the possibility of simultaneous improvement of protein and oil but leading to reduction in grain yield (Krishnam Raju, 2001).

Ravindra Babu (2002) reported in his studies that oil and protein contents had significant positive correlation with each other and negative correlation with yield.

2.6 PATH COEFFICIENT ANALYSIS

Direct effect of a character on yield may be found through the study of genetic correlation. But, path coefficient analysis helps to separate the direct effect and their indirect effects through other attributes by partitioning the correlation coefficients (Wright, 1921).

Panchanathan *et al.* (1978) reported that the 1000 grain weight had the maximum direct effect towards increase in grain yield.

Path coefficient studies of Rupak *et al.* (1979) revealed that there was maximum direct effect of plant height on yield followed by 100 seed weight, ear girth and ear length. Kang *et al.* (1983) reported positive effect of

ear weight on grain yield at both phenotypic and genotypic levels. The direct effect of plant height on grain yield was also positive and highly desirable.

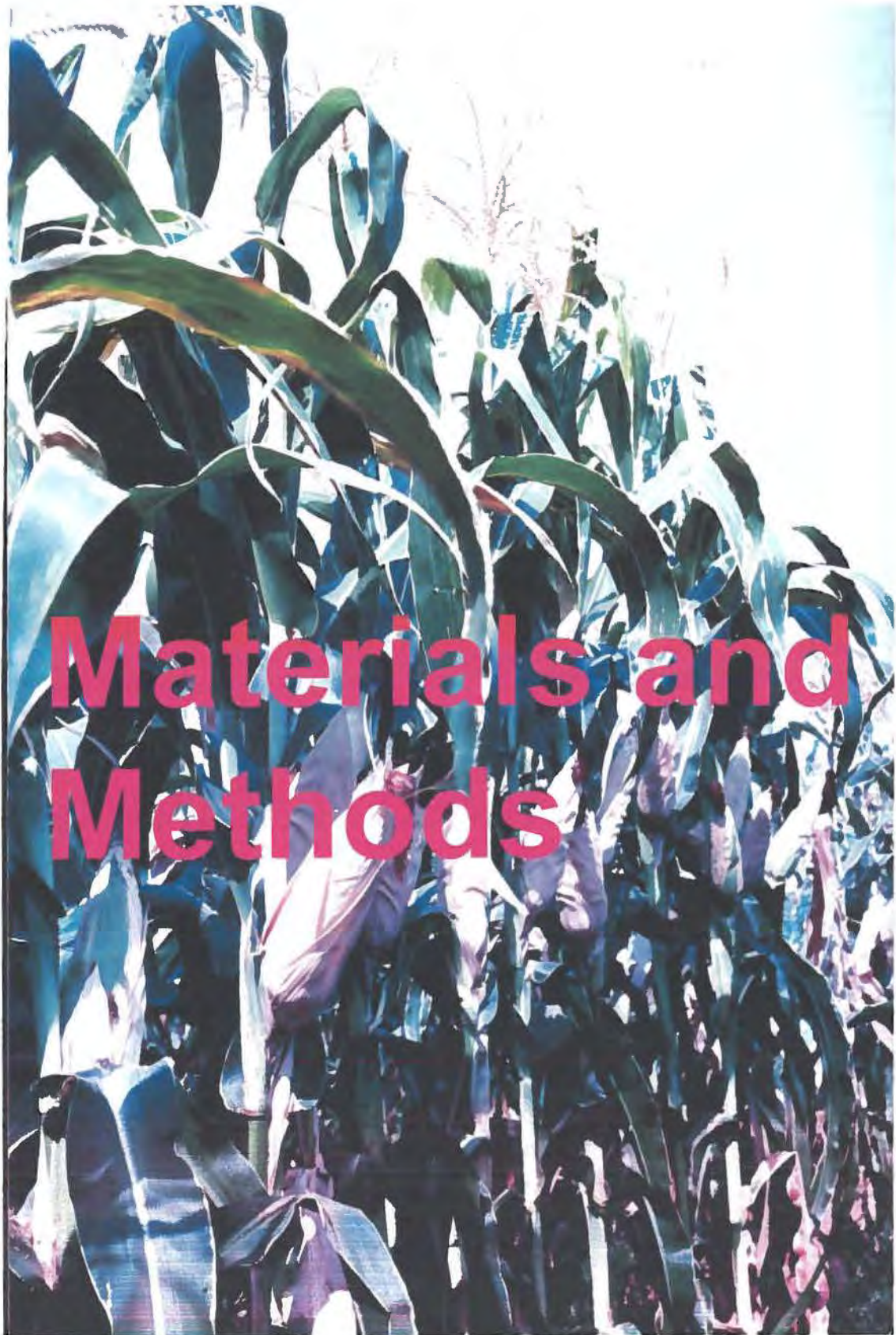
Swarnalatha Devi (1990) also reported that the 100 seed weight and total seeds per ear had maximum direct effect on yield. Dwivedi and Godawat (1994) observed that the total number of grains per ear, ear girth, shelling percentage and 100 kernel weight showed maximum positive direct effect on grain yield of maize. According to Netaji (1998) and Gautham *et al.* (1999) the maximum direct effects towards grain yield were contributed by ear length followed by shelling percentage.

Chandramohan (1999) reported that the number of seeds per row, 100 seed weight and ear girth had direct effect on grain yield while oil content and protein content had direct negative effects on yield.

Venu Gopal (2000) emphasized the need for selection based on plant type with greater number of seeds per row, 100 seed weight, plant height and number of seed rows per ear in addition to early duration since these characters found to be important and had direct effect on grain yield.

Krishnam Raju (2001) studied the path coefficient analysis and revealed that 100 seed weight, number of seeds per row, ear length, ear girth, number of seed rows per ear and protein yield were the major characters which had direct influence on grain yield.

Ravindra Babu (2002) also emphasized that number of seeds per row, 100 seed weight and number of seeds per cob were the best direct contributors to grain yield.



CHAPTER III

MATERIAL AND METHODS

The present investigation was carried during the years 1999 to 2001 at College of Agriculture, Rajendranagar (ANGRAU) which is situated at an altitude of 542m above mean sea level, 79°23' E longitude and 17°19' N latitude in southern Telangana region of Andhra Pradesh..

The material used in the present investigation, field plot techniques used to generate the data and the statistical procedures followed for analyzing the data are described in the following heads.

- 3.1. Selection of experimental material
- 3.2. Generation of breeding material
- 3.3. Observations recorded
- 3.4. Statistical procedures

3.1 SELECTION OF EXPERIMENTAL MATERIAL

The experimental material consists of 180 tropical and sub-tropical yellow maize inbred lines after recycling at Agricultural Research Station (Maize), Amberpet, Hyderabad. These inbreds were Top crossed with two extremely selected testers viz., CM 119 and CM 211 and obtained 360 top cross hybrids. The set of 360 top cross hybrids including one popular check (CM 119 X CM 211) were raised in 19x19 Simple Lattice Design replicated twice and were evaluated in two locations viz., Rajendranagar and Tandoor during *kharif* 1999.

Analysis of variance of REML obtained by using GENSTAT 6.0 revealed highly significant differences among locations and the entries tested. Based on General Combining Ability (GCA) of parents involved in the

development of top crosses, 10 best performing parents were selected i.e., 5 from each group of tropical and sub-tropical lines. These parents were crossed in diallel fashion and details of the parental lines are given below:

Details of selected Parental lines used in Diallel crosses

Entry Code	Parent	Tropical / Subtropical	Pedigree	Index number	Days to 50% tasseling	Days to 50% silking	Grain colour, texture
P1	B - 57	Subtropical	B-57-1-2- x # -1-1- x	6031	57	61	Yellow, semi dent , white shank
P2	WRGL - 22	Tropical	WRGL-22-97-1-2-1- x	6468	59	62	Orange yellow, flint, white shank
P3	MMH - 9607	Subtropical	MMH-9607-B-85-1-2-1- x	6343	59	61	Orange yellow, flint White shank
P4	MED - 9	Tropical	MEDAK OP9-B-93-1-2-1- x	6291	57	59	Yellow, flint, white shank
P5	WRGL - 34	Tropical	WRGL-34-B-97-1-2-1- x -b-1-x	6504	56	60	Yellow, semi dent , White shank
P6	PARB - 96	Subtropical	PARBHANI-896OP-1-2-1-2- x	6390	56	59	Orange yellow, flint, white shank
P7	MED - 5	Tropical	MEDAK OP5-B97-1-2-1- x -1- x	6282	55	59	Orange yellow, flint, white shank
P8	DMR - 110	Tropical	DMR110-OT-896-1-2-1-1- x -1- x	6704	59	63	Yellow, flint, white shank
P9	P 8326	Subtropical	P8326-B-2-1-1-#-3- x -1- x	6120	60	63	Yellow, semi dent , white shank
P10	CM 595	Subtropical	(CM595-30050xCL-00331-)-B97-1-2-1- x -1- x -1- x	7460	58	62	Orange, dent white shank

3.2 GENERATION OF BREEDING MATERIAL

The selected 10 parents were crossed in diallel fashion as per Griffing's model I Method-II, during *rabi* 2000, to generate 45 F1 crosses. During *kharif* 2001, diallel set of 45 crosses along with 10 parents and 3 checks viz., CM 119XCM 211 (single cross), Trishulatha (three way cross) and DHM-105 (double cross), were sown in Randomized Block Design with three replications at three locations viz., Rajendranagar, Karimnagar and Tandoor. Each entry was sown in two rows of five metres length with a spacing of 75 cm between rows and 20 cm between the plants. The recommended fertilizers of NPK were applied in the ratio 100: 80: 60 kg/ha. The entire p and k and half dose of nitrogen was applied as basal, the remaining nitrogen was applied in two equal split doses at knee height and tasseling stages. Other cultural practices were taken as per the requirement.

3.3 OBSERVATIONS RECORDED

Observations on 12 different quantitative characters were recorded in each plot on five competitive random plants except for days to 50 per cent tasseling, days to 50 per cent silking, days to 50 per cent brown husk and grain yield which were recorded on plot basis. The average of five plants was taken as the mean of the treatment.

3.3.1 Days to 50 per cent tasseling

Number of days taken from the date of sowing to 50 per cent pollen shed was recorded.

3.3.2 Days to 50 per cent silking

Number of days taken from the date of sowing to 50 per cent silk emergence was recorded.

3.2 GENERATION OF BREEDING MATERIAL

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3.3.1 Days to 50 per cent tasseling

Number of days taken from the date of sowing to 50 per cent pollen shed was recorded.

3.3.2 Days to 50 per cent silking

Number of days taken from the date of sowing to 50 per cent silk emergence was recorded.

3.3.3 Days to 50 per cent brown husk

Number of days from the date of sowing to date of 50 per cent of the plants turned to brown husk.

3.3.4 Plant height (cm)

This character was recorded in centimetres from the base of the plant to tip of the tassel.

3.3.5 Ear height (cm)

Measurement was taken from the base of the plant to the node of attachment of the uppermost ear in centimetres.

3.3.6 Ear length (cm)

Length of ear was measured from the base to the tip of the ear in centimeters.

3.3.7 Ear girth (cm)

Ear girth was recorded in centimetres by measuring the diameter of the five randomly selected ears at the broadest portion of the ear.

3.3.8 Number of seed rows per ear

Number of seed rows per ear was recorded by counting the number of rows per ear at the middle of the ear for five randomly selected ears.

3.3.9 Number of seeds per ear

Number of seeds per ear was recorded by counting the number of seeds per ear for five randomly selected ears.

3.3.10 Shelling percentage

The shelling percentage was calculated as under

$$\frac{\text{Total ear weight}}{\text{Seed weight}} \times 100$$

3.3.11 100 seed weight (g)

100 seeds were counted and the weight was recorded precisely with the help of an electronic top pan balance.

3.3.12 Grain yield per plot (kg)

All the ears in a plot (entry) were harvested in each replication and after thorough drying, the weight was recorded precisely, moisture percentage of the seeds was determined, later on the yield was adjusted to 15 per cent moisture level.

3.3.13 Oil per cent

Oil content in grain was assessed using Nuclear Magnetic Resonance (NMR) Spectroscopy. Grains from each entry in each replication were dried in hot air to get moisture content of 4.5 per cent. 15 grams of seed sample was then used for assessing oil content, using NMR Spectroscopy against a standard reference sample.

3.3.14 Protein per cent

The protein content in maize seeds was estimated by standard procedure given by Lowry *et al* (1951).

3.4 STATISTICAL PROCEDURES

3.4.1 Analysis of variance

The analysis of variance for each character was carried out by using the method described by Panse and Sukhatme (1985).

3.4.2 Genotypic and phenotypic coefficient of variation (GCV and PCV)

The coefficients of variation were worked out using the formulae given by Burton (1952):

$$GCV = \frac{\sqrt{\sigma^2 g}}{\bar{X}} \times 100$$

Where $\sigma^2 g$ = genotypic variance

$\bar{X}$ = general mean

$$PCV = \frac{\sqrt{\sigma^2 p}}{\bar{X}} \times 100$$

Where $\sigma^2 p$ = phenotypic variance

$\bar{X}$ = general mean

3.4.3 Heritability (broad sense) h^2

The heritability (h^2) in broad sense for the different characters were estimated by using the following formula suggested by Hanson *et al.* (1956):

$$\text{Heritability (Broad sense)} = \frac{\text{Genotypic variance}(\sigma^2 g)}{\text{Phenotypic variance}(\sigma^2 p)} \times 100$$

3.4.4 Genetic advance

Genetic advance was estimated as per Johnson *et al* (1955)

$$\text{Genetic advance} = \frac{\sigma^2_g}{\sigma^2_p} \times k \cdot \sigma_p$$

Where, σ^2_g = genotypic variance

σ^2_p = phenotypic variance

k = Selection differential at 5 per cent selection intensity which accounts to a constant value 2.06.

σ_p = phenotypic standard deviation

$$\text{Genetic advance as per cent of mean} = \frac{\text{GA}}{\text{Grand Mean}(\bar{X})} \times 100$$

Where, GA = genetic advance

$\bar{X}$ = is the grand mean of the character

3.4.5 Combining ability analysis

The data obtained from F1s and parents were analyzed as per Method II (F1s + parents) and Model -I (fixed effect) of Griffing (1956a) for combining ability.

The mathematical model for combining ability is

$$X_{ij} = \mu + g_i + g_j + S_{ij} + \frac{1}{bc} \sum_k \sum_l e_{ijkl}$$

$i, j = 1, \text{-----} p$
 $K = 1, \text{-----} b$
 $L = 1, \text{-----} c$

Where

- b = Number of blocks
 c = Number of observations on $(i,j)^{th}$ genotype in K^{th} block
 μ = Population mean
 g_i = gca effect of the i^{th} parent
 g_j = gca effect of the j^{th} parent
 S_{ij} = sca effect of the cross between i^{th} and j^{th} parents such that
 $s_{ij} = S_{ji}$ and
 e_{ijkl} = Environment effect pertaining to the $ijkl^{th}$ observation
 ij^{th} individual in K^{th} block

With i^{th} female parent and j^{th} male parent

The restrictions imposed on this model are

$$\begin{aligned} \sum_i g_i &= 0 \\ \sum_j s_{ij} + s_{ii} &= 0 \quad (\text{for each } i) \end{aligned}$$

Analysis of variance

Source	Df	S. S.	M. S.	Expected mean square
General Combining Ability	$(P - 1)$	S_g	M_g	$\sigma^2_e + (P+2) (1/P-1) \sum_i g_i^2$
Specific Combining Ability	$P(P - 1) / 2$	S_s	M_s	$\sigma^2_e + \frac{2}{P(P-1)} \sum_i \sum_j s_{ij}^2$
Error	M	S_e	M_e	σ^2_e

$$S_g = \frac{1}{(P+2)} \left[\sum_i (x_i + x_{ii})^2 - \frac{4}{P} x^2_{..} \right]$$

$$S_s = \sum_i \sum_j x_{ij}^2 - \frac{1}{(P+2)} \sum_i (x_i + x_{ii})^2 + \frac{2}{(P+1)(P+2)} x^2_{..}$$

Where

S_g	=	Sum of square due to GCA
S_s	=	Sum of square due to SCA
P	=	Number of parents
x_i	=	Total of the array involving i^{th} parent
x_{ii}	=	Mean value of i^{th} parent
X	=	Grand total of $\frac{1}{2}(p)(p-1)$ progenies
X_{ij}	=	Progeny mean value in the diallel table
m	=	Degree of freedom for error

Mean square GCA to SCA variance ratio was calculated to know the type of gene action in the inheritance of that particular trait.

$$\sigma^2_{gca} = \frac{Mg - M'e}{n+2}$$

$$\hat{g}_i = \frac{1}{(P+2)} \left[\sum (x_i + x_{ii}) - \frac{2}{P} x_{...} \right]$$

$$\sigma^2_{sca} = Ms - Me'$$

Estimation of *gca* and *sca* effects

i) General combining ability effects of i^{th} parent with restriction $\sum g_i = 0$

$$\hat{S}_{ij} = X_{ij} - \frac{1}{(P+2)} (x_i + x_{ii} + x_j + x_{jj}) + \frac{2}{(P+1)(P+2)} x_{...}$$

ii) Specific combining ability effects of ij^{th} cross:

with restriction $\sum s_{ij} + s_{ii} = 0$

Where,

P , x_{ij} , x_i , x_{ii} and $x_{..}$ denotes the same term as mentioned earlier.

Standard Errors

$$S.E.\hat{g}_i = \sqrt{\frac{(P-1)}{(P+2)}\sigma^2_e}$$

$$S.E.\hat{S}_{ii} = \sqrt{\frac{P(P-1)}{(P+1)(P+2)}\sigma^2_e}$$

$$S.E.\hat{S}_{ij} = \sqrt{\frac{P^2 + P + 2}{(P+1)(P+2)}\sigma^2_{e(i\#j)}}$$

Each g_{ci} and s_{ci} value was tested against zero for its significance by 't' test.

$$t = (g-e)/SE(\hat{g}_i) \text{ or } t=(S_{ij}=0)/SE(s_{ij})$$

3.4.6 Estimation of heterosis

Estimates of heterosis was calculated according to Fonseca and Patterson (1968) and Standard heterosis according to Virmani *et al.* (1982).

$$\text{Relative Heterosis}(H_1) = \frac{\overline{F_1} - \overline{M.P.}}{\overline{M.P.}} \times 100$$

$$\text{Heterobeltiosis}(H_2) = \frac{\overline{F_1} - \overline{B.P.}}{\overline{B.P.}} \times 100$$

$$\text{Standard Heterosis}(H_3) = \frac{\overline{F_1} - \overline{S.C.}}{\overline{S.C.}} \times 100$$

Where

$\overline{F_1}$ = Mean of F_1

$\overline{M.P.}$ = Mid parental value

$\overline{B.P.}$ = Better parental value

$\overline{S.C.}$ = Standard Check Value

The significance of heterosis, was tested by using 't' test as suggested by Snedecor and Cochran (1989) and Paschal and Wilcox (1975).

$$\text{Heterosis } t = \frac{\overline{F1} - \overline{M.P.}}{\sqrt{1.5 \text{EMS} / r}}$$

$$\text{Heterobeltiosis } t = \frac{\overline{F1} - \overline{B.P.}}{\sqrt{2 \text{EMS} / r}}$$

$$\text{Standard Heterosis } t = \frac{\overline{F1} - \overline{S.C.}}{\sqrt{2 \text{EMS} / r}}$$

Where

EMS = Error Mean Square

r = Number of replications

The calculated 't' value was compared with table 't' value at error degrees of freedom.

3.4.7 Stability Analysis

Data obtained from the three environments were subjected to pooled analysis of variance (Panse and Sukhatme, 1985). The genotype x environment interactions were significant for most of the characters and hence the data were further analysed to determine the phenotypic stability of different hybrids.

(i) Phenotypic stability analysis

Following the methodology of Eberhart and Russell's model (1966), three parameters namely (i) overall mean of each genotype over a range of environments, (ii) the regression of each genotype on the environmental index and (iii) a function of the squared deviation from the regression were estimated. Eberhart and Russell (1966) used to study the stability of genotypes under different environments.

$$Y_{ij} = \mu_i + b_i I_j + \delta_{ij}$$

Where, Y_{ij} = Mean of i^{th} genotype in j^{th} environment.

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

b_i = Regression coefficient of the i^{th} genotype on the environmental index which measures the response of this genotype to varying environments

I_j = Environmental index which is defined as the deviation of the mean of all the genotypes at a given location from overall mean with $E_j - I_j = 0$

δ_{ij} = The deviation from regression of the i^{th} genotype at j^{th} environment

(II) Analysis of variance for stability

The analysis of variance proposed by Eberhart and Russell (1966) is given below.

ANOVA to estimate stability parameters (Eberhart and Russell, 1966)

Source	d. f	S. S	M. S. S
1. Total	$(ge - 1)$	$\sum_i \sum_j Y_{ij}^2 - C. F.$	
2. Genotype	$(g - 1)$	$\frac{1}{e} \sum_i Y_i^2 - C. F.$	MS 1
3. Environment	$g(e - 1)$	$\sum_i \sum_j (Y_{ij}^2 - \sum_i Y_i^2 / e)$	
4. Environment (Linear)	1	$\frac{1}{e} \sum_j (Y_j I_j)^2 / \sum_j I_j^2$	
5. Genotype x Environment (Linear)	$(g - 1)$	$\sum_i (\sum_j Y_{ij} I_j)^2 / \sum_i I_j^2 - \text{Environment (linear) S. S.}$	MS 2
6. Pooled deviation	$g(e - 2)$	$\sum_i \sum_j \sigma_{ij}^2$	MS 3
7. Deviation due to genotype 1	$(e - 2)$	$\sum_i Y_{i1}^2 - \frac{(\sum_i Y_i)^2}{e} - \frac{(\sum_j Y_{ij} I_j)^2}{\sum_j I_j^2} = \sum_j \sigma_{ij}^2$	
Genotype g	$(e - 2)$	$\sum_j Y_{gj}^2 - \frac{(\sum_j Y_g)^2}{e} - \frac{(\sum_j Y_{gj} I_j)^2}{\sum_j I_j^2} = \sum_j \sigma_{gj}^2$	
8. Pooled error	$e(r - 1)(g - 1)$		

g = genotype; e = environment; r = replications

(III) Computation of regression coefficient (b_i) for each genotype

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

Where,

b_i = regression coefficient of i^{th} genotype

$\sum_j I_j^2$ = the sum of squares of environmental indices which are common to each value of b_i .

$\sum_j Y_{ij}^2$ = (for each genotype) = the sum of products of environmental index and the corresponding means (X) of that variety at each location. These values may be obtained in the following manner.

$$(X)(\bar{I}_j) = \sum_j Y_{ij} I_j = (S)$$

(I_j) = Vector for environmental index, and

(S) = Vector for sum of products i.e., $\sum Y_{ij} I_j$

(IV) Computation of S^2_{di} :

In a regression analysis, it is possible to partition the variance of dependent variable (Y) into two parts, the one which explains the linearity between dependent and independent variables (variance due to regression) and the other which explains the variance due to deviations from linearity symbolically.

$$\sigma^2 Y^2 = \sigma^2 \text{ regression } \sigma^2 \text{ deviation from regression}$$

The variance of means over different locations with regard to individual genotypes may be obtained in the following way.

$$\sigma^2 g_i = Y_{ij} - (Y^2 i / g)$$

The variance due to deviations from regression ($\sum_i \delta_{ij}^2$) for a genotype being:

$$\sum_j \delta_{ij}^2 = \left[\sum_j Y^2_{ij} - Y^2 i / g \right] - \frac{(\sum_j Y_{ij} I_j)^2}{\sum_j I_j^2}$$

Where,

$\sum_j Y_{ij}^2 - Y_i^2 / g =$ The variance due to dependent variable

$(\sum_j Y_{ij} - ij)^2 / (\sum_j ij)^2 =$ The variance due to regression

Because

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

From

$\sum_j \delta^2_{ij} =$ Values, the stability parameter,

S^2_{di} for each genotype is computed as follows:

$$S^2_{di} = \sum_j \delta^2_{ij} / (e - 2) - (S^2_e / r)$$

$$\text{Mean square} = \frac{\text{Deviation from regression}}{\text{d.f. for environment}} - \frac{\text{Pooled error deviation}}{\text{Number of replications}}$$

The variance due to genotypes, environments and the pooled error were the same as those calculated in the pooled analysis of the data, except that the total sum of squares was mainly partitioned into three main components.

- i. Sum of squares due to genotypes
- ii. Sum of squares due to environments + (G x E) and
- iii. Pooled error

Again sum of squares due to G x E was further partitioned into two parts namely

- i. S.S due to G X E (linear) which is in fact S.S due to regression and
- ii. S.S due to deviation from linearity of response (i.e., due to pooled deviation).

The different computational steps involved were as follows.

$$a) \text{S.S. due to environment} + (G \times E) = \sum_i \sum_j Y_{ij}^2 - (\sum_i Y_i^2 / e)$$

$$b) \text{S.S. due to environment} + (\text{linear}) = \frac{1}{g} \sum_j Y_j l_j^2 / \sum_j l_j^2$$

$$c) \text{S.S. due to GxE (linear)} = \sum_j (\sum_i Y_{ij} l_j^2 / \sum_j l_j^2) - \text{environment (linear) S.S.}$$

Where,

$$(\sum_j Y_j l_j^2) / \sum_j l_j^2 = b_i \sum_j Y_{ij} l_j \text{ for each variety}$$

Test of Significance

The following tests of significance were carried out:

1. To test the significance of the difference among genotype means namely:

$$H_0 = \mu_1 = \mu_2 = \mu_3 = \dots \mu_n$$

$$F = \frac{\text{Mean square due to genotype}}{\text{Mean square due to pooled deviation}} = \frac{MS_1}{MS_3}$$

2. To test that the genotypes did not differ for their regression on environmental index

i.e.,

$$H_0 = b_1 = b_2 = b_3 \dots b_n$$

$$F = \frac{\text{M.S. due to } G \times E \text{ (linear)}}{\text{M.S. due to pooled deviation}} = \frac{MS_2}{MS_3}$$

$$F = \frac{\text{M.S due to } G \times E \text{ (linear)}}{MS^2}$$

3. Individual deviation from linear regression was tested as follows:

$$F = [(\sum_j \delta^2_{ij}) / (S - 2)] / \text{pooled error}$$

Against F table value at $(e-2)(g-2)$, at 5% or 1% probability level.

4. The hypothesis that any regression coefficient did not differ from unity or zero was tested by appropriate 't' test i.e.,

$$\text{For } (b - 0), t = \frac{|b - 0|}{SE(b_i)} \text{ for } (g - 2) \text{ df at 5\% level of probability}$$

$$\text{For } (1 - b), t = \frac{|b - 1|}{SE(b_i)} \text{ for } (g - 2) \text{ df at 5\% level of probability}$$

Where,

$$SE\ b_i = \sqrt{\sum_j \delta^2_{ij} / (e - 2) / \sum_j I_j^2}$$

Stable genotypes

A genotype with unit regression coefficient ($b_i=1$) and deviation not significantly different from zero ($Sd^2=0$) was taken to be a stable genotype with unit response.

Mean and standard error of 'b'

$$\text{Mean of } b = \bar{b} = \sum_i b_i / g$$

$$\text{S.E.}(b) = \sqrt{\frac{\text{M.S. due to pooled deviation}}{\sum_i l_j^2}}$$

Population mean (μ) and standard error was calculated as

Population mean (μ) = Grand total / No. of observations

$$\text{S.E.}(\text{mean}) = \sqrt{\frac{\text{M.S. due to pooled deviation}}{\text{Number of environments} - 1}}$$

3.4.8 Correlation coefficients

Simple correlation coefficients (r) for grain yield and its components of the hybrids and parents were calculated by using the method given by Johnson *et al.* (1955):

$$r_s(xy) = \frac{\text{Cov}(xy)}{\sqrt{\text{var}(x) \cdot \text{var}(y)}}$$

$$\text{Cov}(xy) = \frac{1}{n} \left[xy - \frac{(xy)}{n} \right]$$

$$\text{Var}(x) = \frac{1}{n} \left[x^2 - \frac{(x^2)}{n} \right]$$

where,

- $r(xy)$ = correlation between x and y
- $\text{Cov}(xy)$ = covariance for characters x and y
- $\text{Var}(x)$ = variance for x
- $\text{Var}(y)$ = variance for y
- r = correlation coefficient
- xy = two independent variables

3.4.9 Path coefficient analysis

The estimates of direct and indirect contribution of various characters were calculated through path analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

Where,

r_{1y} is correlation coefficient between X_1 and Y

P_{1y} = Direct effect of X_1 on Y

P_{2yr12} = Indirect effect of X_1 on y through X_2

P_{3yr13} = Indirect effect of X_1 on y through X_3

r_{12} = Correlation coefficient between X_1 and X_2

r_{13} = Correlation coefficient between X_1 and X_3

P_{kyr1k} = Indirect effect of X_1 and Y through K variables



CHAPTER IV

RESULTS

The results of the present investigation for grain yield and its components including protein and oil contents are presented under following heads.

- 4.1 **VARLABILITY**
 - 4.1.1 Selection of inbred lines
 - 4.1.2 Analysis of variance
 - 4.1.3 Study of means
- 4.2 **NATURE OF GENE ACTION**
 - 4.2.1 Combining ability analysis
 - 4.2.1.1 General combining ability effects
 - 4.2.1.2 Specific combining ability effects
- 4.3 **HETEROSIS**
- 4.4 **STABILITY PARAMETERS FOR GRAIN YIELD AND YIELD COMPONENTS**
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 - 4.4.3 Stability of crosses
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 - 4.6.2 Path coefficient analysis

4.1 VARIABILITY

4.1.1 Selection of inbred lines

One hundred and eighty tropical and subtropical inbred lines of maize were recycled at Maize Research Station Amberpet Hyderabad. These inbreds were top crossed with two broad based testers viz., CM119 and CM211 and obtained 360 top cross hybrids. The set of 361 top cross hybrids including one dummy entry (CM119 x CM211) to suit the design were evaluated in 19x19 Simple Lattice Design replicated twice at Rajendranagar and Tandoor locations during *Kharif* 1999. Based on general combining ability (GCA) of parents involved in the development of top crosses, 10 parents were selected, five from each group of tropical and sub tropical lines. These parents were used for effecting diallel crosses.

The selected 10 parents were crossed in a diallel fashion and resulting 45 crosses along with 10 parents and 3 checks, viz., CM119 x CM211, Trishulatha and DHM105, were evaluated in RBD with 3 replications at three locations viz., Rajendranagar, Karimnagar, and Tandoor. The data was collected on 14 characters including grain yield, oil content and protein content.

4.1.2 Analysis of variance

The genotypic differences were significant for all the characters. The differences between the parental lines were also significant. The partition of parental lines into tropicals and subtropicals has revealed significant differences among themselves for most of the characters (Table 1).

The genotypic differences among the tropicals were significant for all characters except ear length at Tandoor, ear girth and number of seeds per ear at Karimnagar. The differences among the subtropicals were also significant, except for days to 50 per cent tasseling, ear length and number of

Table 1: Analysis of Variance (Mean Squares) for 14 characters in maize.

Source	DF.	Days to 50% tasseling			Days to 50% silking			Days to 50% br husk			Plant height		
		Rajendra-nagar	Karimnagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
Replications	2	2.66	0.17	1.50	16.94**	21.50**	2.69	2.75	1.63	1.69	0.75	12.25	55.38
Genotypes	54	6.12**	11.33**	8.17**	7.86**	6.60**	7.94**	12.01**	16.64**	13.35**	1081.90**	2361.58**	1465.81**
Parents	9	3.96**	8.58**	8.00**	7.64**	7.07**	6.80**	4.15**	8.83**	5.84**	1366.48**	1123.39**	797.77**
Tropicals (T)	4	3.17	12.60**	9.60**	7.90**	8.07**	7.17**	2.1	11.77**	6.27**	2370.67**	1093.67**	1040.10**
Sub-Tropicals (ST)	4	2.73	6.17**	6.77*	9.17**	7.77**	8.10**	4.24**	7.44**	6.34**	682.23**	1363.43**	750.07**
T Vs. ST	1	12.04**	2.13	6.53	0.54	0.31	0.14	12.03**	2.67	2.11	86.73	282.13*	19.23
Hybrids	44	5.41**	5.50**	5.67**	6.74**	2.78**	6.09**	13.31**	18.55**	15.00**	354.91**	618.90**	449.28**
T x T Hybrids	9	3.24*	4.33**	3.42	2.83	1.91	2.74*	10.31**	23.59**	10.00**	869.64**	376.07**	394.72**
T x ST Hybrids	13	6.02**	7.00**	9.01**	9.21**	4.19**	6.84**	15.27**	22.29**	18.96**	259.91**	720.60**	417.43**
ST x T Hybrids	10	7.34**	5.45**	4.96*	5.42**	1.79	6.43**	12.96**	4.99**	6.87**	246.36**	359.45**	177.59**
ST x ST Hybrids	9	5.72**	5.57**	4.23	9.14**	3.10*	9.19**	11.17**	19.26**	18.97**	350.30**	956.09**	943.93**
Residue	3	1.88	2.46	4.66	5.01*	1.69	2.50	21.44**	30.27**	28.06**	198.06*	759.95**	172.67**
Parents Vs. Hybrids	1	56.91**	292.52**	119.64**	58.74**	170.12**	99.67**	25.30**	2.91	8.54**	30508.34**	90183.34**	52205.57**
Error	108	1.38	1.35	2.27	1.57	1.32	1.36	1.09	0.90	1.21	69.72	59.85	39.32

* : Significant (P<0.05)

** : Significant (P<0.01)

Tabel 1 contd...

Source	DF.	Ear height			Ear length			Ear girth			No. of seed rows/ear		
		Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
Replications	2	4.13	2.44	24.72*	2.64	5.55**	1.75	0.95	2.59**	0.56	0.32	1.04	0.02
Genotypes	54	369.86**	463.92**	401.23**	12.80**	13.11**	9.32**	5.68**	5.56**	4.02**	5.27**	4.65**	4.66**
Parents	9	193.34**	116.58**	113.74**	2.50**	5.87**	2.09**	2.13**	0.46**	2.44**	1.91**	2.68**	2.39**
Tropicals (T)	4	292.50**	81.77**	143.67**	3.60*	8.10**	1.77	2.40**	0.27	3.60**	4.00**	3.07**	3.60*
Sub-Tropicals (ST)	4	142.10**	177.83**	111.23**	1.50	5.10**	2.93	2.10*	0.77	1.77	0.27	1.33	0.93
T Vs. ST	1	1.63	10.80	4.03	2.13	0.00	0.03	1.2	0.03	0.53	0.13	6.53**	3.33
Hybrids	44	197.87**	231.10**	169.77**	7.48**	4.98**	3.77**	1.97**	1.11**	1.22	4.69**	3.75**	3.71**
T x T Hybrids	9	250.13**	206.68**	190.33**	8.21**	5.86**	5.05**	2.58**	1.41**	0.97	6.65**	3.69**	4.74**
T x ST Hybrids	13	84.24**	207.37**	62.96**	3.50**	4.30**	2.92	2.59**	1.47**	1.66	5.92**	3.87**	3.99**
ST x T Hybrids	10	323.60**	340.10**	282.82**	7.12**	4.63**	2.72	0.65	0.47	0.55	4.90**	4.00**	4.65**
ST x ST Hybrids	9	201.62**	182.74**	186.58**	6.24**	3.04**	1.84	2.17**	1.19*	1.79	2.09**	4.46**	2.39*
Residue	3	103.21**	188.94**	143.58**	27.55**	12.34**	12.89**	1.32	0.58	0.58	0.60	0.41	0.32
Parents Vs. Hybrids	1	9525.70**	13834.25**	13173.40**	339.40**	436.04**	318.76**	200.67**	247.29**	141.38**	61.10**	62.26**	66.98**
Error	108	10.03	14.52	6.18	1.05	1.00	1.74	0.62	0.47	0.96	0.59	0.87	1.09

* : Significant ($P < 0.05$)** : Significant ($P < 0.01$)

Table 1 contd...

Source	DF.	No. of seeds/ear			Shelling percentage			100 Seed weight			Grain yield		
		Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
Replications	2	1546.00**	192.00	178.00	0.00	0.88	0.69	0.68	2.13	0.34	0.02	0.00	0.00
Genotypes	54	27124.52**	25606.59**	24996.30**	32.79**	25.75**	24.84**	57.63**	58.36**	60.54**	1.64**	1.58**	1.60**
Parents	9	2301.51**	598.30**	2849.69**	54.80**	37.85**	44.31**	28.03**	31.47**	25.99**	0.08**	0.09**	0.10**
Tropicals (T)	4	3002.73**	375.99	2035.63**	65.10**	56.10**	56.10**	39.57**	42.00**	35.17**	0.13**	0.06**	0.07**
Sub-Tropicals (ST)	4	2140.40**	962.68	2673.73**	43.50**	26.67**	31.57**	16.50**	22.27**	16.77**	0.02*	0.07**	0.06**
T Vs. ST	1	141.08	30.00	6809.76**	58.80**	9.63**	48.15**	28.03**	26.13**	26.13**	0.08**	0.30**	0.40**
Hybrids	44	9912.95**	8206.23**	8790.30**	9.45**	9.47**	6.26**	25.04**	22.99**	24.32**	0.36**	0.22**	0.33**
T x T Hybrids	9	17775.76**	11813.80**	13105.52**	9.20**	4.80**	5.26**	22.16**	20.76**	20.31**	0.41**	0.21**	0.48**
T x ST Hybrids	13	7825.16**	8877.67**	8955.03**	9.89**	14.16**	10.02**	34.83**	26.95**	32.83**	0.34**	0.25**	0.33**
ST x T Hybrids	10	8035.11**	8016.61**	8167.65**	10.03**	6.92**	4.36**	28.85**	26.70**	28.89**	0.32**	0.13**	0.21**
ST x ST Hybrids	9	9686.44**	1264.85*	5666.82**	6.30**	7.04**	2.21	17.57**	21.06**	17.79**	0.26**	0.24**	0.42**
Residue	3	2310.54**	15930.15**	6576.84**	15.76**	18.97**	11.41**	0.94	6.04**	3.78*	0.77**	0.39**	0.07**
Parents Vs. Hybrids	1	1007840.81**	1016297.31**	937379.44**	861.89**	632.87**	667.44**	1757.99**	1856.28**	1965.35**	71.78**	74.74**	70.98**
Error	108	305.67	584.11	385.96	0.63	1.06	1.14	0.97	1.03	1.02	0.01	0.01	0.01

* : Significant (P<0.05)

** : Significant (P<0.01)

Table 1 contd...

Source	DF.	Oil percentage			Protein percentage		
		Rajendra-nagar	Karim- nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
Replications	2	0.00	0.03**	0.01	0.22**	0.01	0.05*
Genotypes	54	1.37**	1.23**	1.14**	13.61**	14.57**	14.72**
Parents	9	1.53**	1.00**	0.97**	12.05**	13.35**	13.30**
Tropicals (T)	4	2.71**	1.87**	1.85**	8.84**	8.57**	9.34**
Sub-Tropicals (ST)	4	0.72**	0.37**	0.34**	9.86**	12.45**	11.90**
T Vs. ST	1	0.05**	0.01	0.03	33.58**	36.12**	34.73**
Hybrids	44	1.22**	1.11**	0.99**	14.15**	15.01**	15.19**
T x T Hybrids	9	1.69**	1.33**	0.81**	12.25**	13.13**	13.01**
T x ST Hybrids	13	1.12**	1.02**	0.86**	10.65**	11.07**	11.16**
ST x T Hybrids	10	0.70**	0.68**	0.48**	18.73**	20.63**	20.14**
ST x ST Hybrids	9	1.24**	1.40**	1.69**	14.77**	14.95**	17.27**
Residue	3	1.89**	1.35**	1.74**	17.85**	19.17**	16.43**
Parents Vs. Hybrids	1	6.38**	8.78**	8.84**	4.20**	6.17**	7.01**
Error	108	0.00	0.00	0.01	0.03	0.02	0.02

* : Significant ($P < 0.05$)** : Significant ($P < 0.01$)

seed rows per ear at Rajendranagar, ear girth, number of seeds per ear at Karimnagar and ear girth at Tandoor. There was no significant variation for number of tropicals vs. subtropicals for days to 50 per cent silking, ear height, ear length and ear girth at all the locations. However, significant differences were noticed for days to 50 per cent tasseling, days to 50 per cent brown husk, ear girth and oil per cent at Rajendranagar, plant height, ear length at Karimnagar and number of seeds per ear at Tandoor. The tropical vs. subtropicals were significant at all locations for shelling percentage, 100 seed weight, grain yield and protein percentage (Table 1).

All the crosses evaluated for 14 characters differed significantly and their comparison with parents was also highly significant. The cross combinations of tropical x tropical, tropical x subtropical or subtropical x tropical and subtropical x subtropical were also significant for all the characters studied at Rajendranagar, Karimnagar and Tandoor, except for days to 50 per cent tasseling, ear girth and ear length (except tropical x tropical) at Tandoor. The proportional contribution of tropical x tropical hybrids was of higher magnitude for grain yield, number of seeds per ear, ear height, ear length, number of seed rows per ear, protein and oil per cent.

4.1.3 Study of means

The mean values of parents and hybrids for 12 morphological characters, oil and protein content at 3 locations viz., Rajendranagar, Karimnagar, and Tandoor are presented in table 2. The variation in means of tropicals compared to subtropical parents was more for the characters viz., number of seed rows per ear, number of seeds per ear, shelling percentage, 100 seed weight and grain yield. The subtropical parents possessed higher protein per cent than tropical parents.

Table 2: Mean performance of parents and crosses for 14 characters at three locations

	Days to 50% tasseling			Days to 50% silking			Days to 50% br-husk		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
Tropical Parents									
WRGL - 22 (P2)	58	59	59	62	62	61	88	89	89
Med-9 (P4)	58	56	57	63	61	61	88	86	87
WRGL-34 (P5)	57	55	56	61	60	60	87	85	86
Med-5 (P7)	56	55	55	59	59	61	87	85	86
DMR-110 (P8)	59	59	59	63	63	64	89	89	89
Mean	58	57	57	62	61	61	88	87	87
Sub-Tropical Parents									
B-57 (P1)	59	56	58	63	60	60	89	86	88
MMH-9607 (P3)	59	58	59	63	60	61	89	88	89
PARB-96 (P6)	58	56	56	59	60	60	87	86	86
P 8326 (P9)	60	59	60	63	63	64	90	89	89
CM 595 (P10)	59	58	58	62	62	61	90	88	88
Mean	59	57	58	62	61	61	89	87	88
T x T hybrids									
P2 x P4	58	54	56	61	60	60	91	90	90
P2 x P5	55	55	54	59	58	58	89	88	88
P2 x P7	57	55	56	60	59	59	91	90	89
P2 x P8	57	54	57	61	60	59	92	91	89
P4 x P5	57	54	56	60	58	60	90	89	90
P4 x P7	56	51	54	59	58	59	90	89	89
P4 x P8	57	53	56	60	59	60	91	89	90
P5 x P7	55	53	54	59	58	57	86	84	85
P5 x P8	57	52	57	62	58	60	87	83	87
P7 x P8	58	53	56	61	58	60	88	85	87
Mean	57	53	56	60	58	59	90	88	88
T x ST Hybrids									
P2 x P3	57	51	55	59	57	58	89	87	88
P2 x P6	56	52	55	59	58	58	90	89	89
P2 x P9	55	54	54	59	59	58	89	90	89
P2 x P10	57	53	56	63	57	60	93	90	91
P4 x P6	56	55	57	60	59	59	90	89	89
P4 x P9	59	55	57	62	59	61	92	89	91
P4 x P10	54	50	52	57	56	57	85	81	82
P5 x P6	55	53	53	58	58	57	86	84	84
P5 x P9	58	55	56	61	60	60	89	86	86
P5 x P10	58	53	57	62	59	60	88	83	88
P7 x P9	56	55	55	59	59	58	86	86	86
P7 x P10	57	55	56	61	59	61	87	85	87
P8 x P9	57	55	56	61	60	61	87	86	87
P8 x P10	59	55	58	62	59	61	89	85	88
Mean	57	54	55	60	58	59	89	87	88
ST x T hybrids									
P1 x P2	55	53	53	60	58	59	90	89	90
P1 x P4	56	56	56	60	59	61	90	90	91
P1 x P5	59	56	58	63	60	62	93	90	92
P1 x P7	57	53	54	61	58	58	91	88	88
P1 x P8	57	52	55	61	58	58	91	88	89
P3 x P4	59	53	57	62	58	60	91	89	90
P3 x P5	58	54	56	61	59	58	92	90	88
P3 x P7	57	54	56	61	60	61	91	90	92
P3 x P8	57	55	56	61	59	60	91	89	90
P6 x P7	54	55	56	58	58	58	85	86	88
P6 x P8	59	53	56	62	58	61	90	88	88
Mean	57	54	56	61	59	60	90	89	90
ST x ST hybrids									
P1 x P3	56	53	54	60	58	59	90	88	89
P1 x P6	55	55	55	59	59	59	89	89	89
P1 x P9	58	55	56	63	59	60	93	91	90
P1 x P10	58	54	57	62	59	62	92	89	92
P3 x P6	57	55	56	60	59	59	90	89	90
P3 x P9	54	53	53	57	57	56	88	88	86
P3 x P10	55	51	55	58	56	56	89	87	87
P6 x P9	57	53	54	60	58	60	88	84	86
P6 x P10	57	52	54	60	58	60	87	84	84
P9 x P10	57	53	55	60	58	59	88	84	86
Mean	57	53	55	60	58	59	89	87	88
Grand Mean	57	54	56	61	59	60	89	87	88
S.E.m. $\pm$	0.07	0.06	0.08	0.07	0.06	0.06	0.06	0.05	0.06
CM119xCM211	56	52	54	60	56	59	87	83	86
Trishulata	55	51	53	59	57	57	85	82	84
DHM 105	58	54	56	61	57	60	90	89	88
Mean	56	52	54	60.00	56.67	58.67	87.33	84.67	86.00

Table 2 contd...

	Plant height (cm)			Ear height (cm)			Ear length (cm)		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
Tropical Parents									
WRGL-22 (P2)	152.00	92.67	120.00	53.00	41.67	42.00	13.00	11.00	12.00
Med-9 (P4)	108.67	96.67	104.33	47.00	43.00	45.33	11.00	11.00	11.00
WRGL-34 (P5)	155.33	113.00	140.00	54.00	45.33	48.00	11.00	10.00	11.00
Med-5 (P7)	91.00	73.33	92.33	30.00	31.67	30.00	10.00	13.00	11.00
DMR-110 (P8)	138.00	122.67	126.00	41.00	40.67	39.67	11.00	14.00	12.67
Mean	129.00	99.67	116.53	45.00	40.47	41.00	11.20	11.80	11.53
Sub-Tropical Parents									
B-57 (P1)	145.00	90.67	92.33	53.33	35.00	35.00	10.00	11.00	11.00
MMH-9607 (P3)	136.67	99.67	130.67	47.67	41.33	46.33	11.67	13.00	13.00
PARB-96 (P6)	107.33	82.33	105.00	35.33	33.67	36.00	11.00	12.00	11.33
P 8326 (P9)	118.33	128.00	124.33	48.67	52.00	48.67	10.67	10.00	10.33
CM 595 (P10)	120.67	128.33	122.33	42.33	46.33	42.67	10.00	13.00	11.67
Mean	125.60	105.80	114.93	45.47	41.67	41.73	10.67	11.80	11.47
T x T hybrids									
P2 x P4	172.33	162.00	162.00	70.67	67.00	67.00	17.33	17.00	16.00
P2 x P5	155.00	164.00	162.67	62.00	65.67	65.00	13.00	14.67	14.00
P2 x P7	132.00	145.00	140.00	55.00	61.00	59.00	14.33	14.00	14.00
P2 x P8	159.00	164.67	161.00	60.33	56.00	61.33	15.00	17.00	16.00
P4 x P5	163.67	158.33	160.00	58.67	56.33	57.00	14.00	16.00	14.33
P4 x P7	148.33	162.00	151.00	59.33	62.33	60.33	16.00	18.00	17.00
P4 x P8	169.33	179.67	172.67	79.33	80.00	79.33	18.00	17.00	17.00
P5 x P7	179.67	183.00	180.33	71.67	73.00	72.00	17.67	18.00	17.67
P5 x P8	168.00	167.67	164.33	71.00	69.67	69.67	16.00	16.00	16.00
P7 x P8	140.67	153.67	150.00	49.33	53.67	52.33	16.00	18.00	16.00
Mean	158.80	164.00	160.40	63.73	64.47	64.30	15.73	16.57	15.80
T x ST Hybrids									
P2 x P3	149.67	128.00	135.00	60.00	52.33	54.00	14.00	15.00	14.67
P2 x P6	167.00	170.33	161.67	72.67	74.00	70.33	16.00	13.00	14.33
P2 x P9	162.33	157.67	155.00	67.33	65.00	64.00	13.00	16.00	13.67
P2 x P10	165.00	182.33	175.00	65.67	87.33	65.00	16.00	17.00	16.67
P4 x P6	153.00	169.00	161.67	61.33	67.33	64.67	14.00	15.33	14.00
P4 x P9	168.00	181.00	171.67	67.00	72.67	68.67	15.00	16.67	15.67
P4 x P10	156.33	157.67	152.67	65.67	66.67	64.00	14.67	16.00	16.00
P5 x P6	162.33	164.00	160.67	67.67	64.33	67.33	14.00	16.00	15.67
P5 x P9	182.00	186.00	180.00	72.67	71.67	72.00	15.00	16.00	15.67
P5 x P10	151.00	172.33	165.00	54.33	60.33	60.67	14.00	16.00	14.00
P7 x P9	163.67	159.00	164.33	63.67	61.33	64.00	15.00	16.00	16.00
P7 x P10	165.67	170.00	158.33	58.00	59.67	59.00	15.33	18.00	16.00
P8 x P9	174.67	178.33	160.00	69.67	72.00	64.00	16.00	17.67	16.33
P8 x P10	174.00	187.67	180.33	62.67	66.00	65.33	17.00	16.00	16.00
Mean	163.90	168.81	162.95	64.88	67.19	64.50	14.93	16.05	15.33
ST x T hybrids									
P1 x P2	148.33	163.67	155.00	45.33	49.00	46.67	14.00	15.33	14.33
P1 x P4	162.67	146.67	155.67	65.00	58.67	62.67	14.00	18.00	16.00
P1 x P5	167.00	146.33	158.33	60.67	51.00	55.33	13.33	14.00	14.00
P1 x P7	155.00	145.67	152.33	46.67	44.00	45.67	17.00	17.00	16.00
P1 x P8	166.33	165.00	160.00	75.33	74.67	72.67	17.00	15.00	15.33
P3 x P4	163.00	165.00	168.33	66.67	67.67	68.67	13.00	16.00	14.00
P3 x P5	158.00	162.33	160.00	66.67	68.67	67.67	12.00	16.00	13.33
P3 x P7	162.67	158.00	159.00	64.00	62.00	62.67	14.00	16.00	15.67
P3 x P8	174.33	172.33	164.33	79.00	78.00	74.33	14.00	18.00	14.33
P6 x P7	152.67	146.00	146.00	60.67	59.67	59.00	15.00	17.00	15.67
P6 x P8	179.00	175.00	174.33	70.33	65.33	68.67	15.00	17.00	15.67
Mean	162.64	158.73	159.39	63.67	61.70	62.18	14.39	16.30	14.94
ST x ST hybrids									
P1 x P3	173.00	140.33	160.00	75.33	61.33	69.67	14.00	14.00	14.00
P1 x P6	161.67	152.33	159.00	71.33	65.33	68.33	11.00	16.00	14.00
P1 x P9	160.33	147.00	151.67	64.33	58.67	61.00	13.00	16.00	13.67
P1 x P10	169.00	148.67	160.00	64.33	57.33	64.33	15.00	15.00	15.00
P3 x P6	144.33	154.00	145.00	57.67	61.67	58.00	12.00	13.67	13.67
P3 x P9	160.33	154.67	151.00	77.33	75.00	73.00	14.00	15.00	14.33
P3 x P10	171.33	170.67	173.00	68.33	67.00	69.33	12.33	15.00	14.67
P6 x P9	170.33	168.00	180.00	76.67	78.00	77.67	13.00	15.00	14.00
P6 x P10	152.00	162.33	159.33	52.33	55.33	54.67	15.33	17.00	16.00
P9 x P10	181.00	203.33	205.67	68.33	72.67	78.00	15.00	14.33	13.33
Mean	164.33	160.13	164.47	67.60	65.23	67.40	13.47	15.10	14.27
Grand Mean	156.15	152.33	153.47	61.35	60.49	60.32	13.98	15.25	14.45
S.E.m. $\pm$	0.4639	0.4298	0.3484	0.1759	0.2117	0.1382	0.0569	0.0554	0.0733
CM119xCM211	161.00	166.00	162.00	64.00	66.00	65.00	13.00	15.00	15.00
Trishulata	157.00	157.00	160.00	61.00	61.00	64.00	13.00	14.00	14.00
DHM 105	162.00	180.00	169.00	57.00	60.00	60.00	14.00	15.00	14.00
Mean	160.00	167.67	163.67	60.67	62.33	63.00	13.33	14.67	14.33

Table 2 contd...

	Ear girth (cm)			No. of seed rows/ear			No. of seeds / ear		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
Tropical Parents									
WRGL - 22 (P2)	10.00	10.67	11.33	11.33	12.00	12.00	304.00	304.00	308.67
Med-9 (P4)	10.00	10.67	12.33	14.00	14.00	14.00	354.67	326.67	364.00
WRGL-34 (P5)	12.00	10.33	12.00	12.00	12.00	12.00	317.33	302.00	322.00
Med-5 (P7)	10.00	10.00	10.00	11.33	11.33	11.33	271.67	298.67	294.67
DMR-110 (P8)	10.00	10.67	10.00	11.33	12.00	11.33	336.00	312.00	316.67
Mean	10.40	10.47	11.13	12.00	12.27	12.13	316.73	308.67	321.20
Sub-Tropical Parents									
B-57 (P1)	12.00	11.00	12.00	12.00	12.00	12.00	329.33	291.33	286.00
MMH-9607 (P3)	11.00	11.00	11.00	11.33	10.67	11.33	294.00	306.00	273.33
PARB-96 (P6)	11.00	10.00	10.33	12.00	12.00	12.00	291.33	299.33	290.00
P 8326 (P9)	10.00	10.00	10.00	12.00	10.67	10.67	296.00	299.33	264.67
CM 595 (P10)	10.00	10.67	11.00	12.00	11.33	11.33	351.33	337.33	341.33
Mean	10.80	10.53	10.87	11.87	11.33	11.47	312.40	306.67	291.07
T x T hybrids									
P2 x P4	14.00	15.00	13.67	14.00	14.00	14.00	620.00	578.67	513.33
P2 x P5	14.00	14.00	13.00	14.00	12.67	13.33	523.33	462.67	468.67
P2 x P7	13.00	13.00	12.67	16.00	15.33	15.33	421.33	538.00	472.67
P2 x P8	12.00	13.00	13.00	12.00	13.33	13.33	504.67	494.67	482.67
P4 x P5	14.00	14.00	13.67	14.00	12.67	13.33	520.00	524.00	523.33
P4 x P7	12.00	13.00	13.00	12.00	12.67	12.00	464.00	529.33	506.00
P4 x P8	13.67	13.67	13.00	14.00	14.00	14.00	664.00	668.00	670.67
P5 x P7	14.00	14.33	14.00	13.33	14.00	14.00	528.00	588.00	525.33
P5 x P8	14.00	13.67	14.00	14.00	12.67	13.33	577.33	470.00	562.67
P7 x P8	12.00	13.00	12.33	10.67	11.33	10.67	439.33	492.67	428.00
Mean	13.27	13.67	13.23	13.40	13.27	13.33	526.20	534.60	515.33
T x ST Hybrids									
P2 x P3	13.00	12.00	12.67	14.00	12.00	12.67	482.00	448.00	482.67
P2 x P6	14.00	14.00	13.00	14.00	12.67	13.33	539.33	420.00	420.00
P2 x P9	12.00	14.33	13.00	14.00	14.67	13.33	532.67	565.33	473.33
P2 x P10	13.00	13.33	12.67	14.00	13.33	14.00	560.00	507.33	476.00
P4 x P6	13.00	13.67	13.00	12.00	13.33	13.33	472.00	555.33	531.33
P4 x P9	15.00	14.67	14.67	16.00	15.33	16.00	642.67	595.33	616.00
P4 x P10	14.00	14.00	14.00	14.67	15.33	15.33	591.33	596.67	596.00
P5 x P6	15.00	14.33	14.00	15.33	13.33	14.00	520.00	535.33	504.00
P5 x P9	14.00	14.00	14.00	12.00	12.67	12.67	495.67	524.67	516.67
P5 x P10	13.00	14.33	14.00	14.00	14.00	14.00	528.00	561.00	574.00
P7 x P9	13.00	13.33	13.00	12.00	12.00	12.00	464.00	446.00	460.67
P7 x P10	13.00	13.67	13.00	12.00	12.00	12.00	501.33	520.00	490.00
P8 x P9	13.00	14.67	14.00	12.00	13.33	12.67	460.00	494.67	480.67
P8 x P10	12.00	13.33	12.00	12.00	14.00	14.00	507.00	505.33	486.00
Mean	13.36	13.83	13.36	13.43	13.43	13.52	521.14	519.64	507.67
ST x T hybrids									
P1 x P2	14.00	13.67	13.67	14.00	14.00	14.00	504.33	541.33	518.00
P1 x P4	14.00	13.67	14.00	16.67	14.00	16.00	579.33	580.67	547.33
P1 x P5	14.00	14.00	14.00	13.33	13.33	13.33	496.00	524.00	464.67
P1 x P7	13.00	13.67	13.33	12.67	12.67	12.00	576.67	504.67	490.00
P1 x P8	14.00	13.33	13.67	14.00	12.67	13.33	606.00	491.33	562.67
P3 x P4	14.00	14.00	14.00	14.00	14.67	13.33	514.00	579.00	562.67
P3 x P5	14.00	14.00	14.00	14.00	13.33	13.33	469.00	463.67	429.33
P3 x P7	13.00	13.67	13.33	12.67	12.00	13.33	462.00	480.33	491.33
P3 x P8	13.00	12.67	13.00	12.00	11.33	11.33	453.33	423.33	435.33
P6 x P7	14.00	13.33	13.00	12.67	13.33	12.67	478.00	445.33	442.00
P6 x P8	14.00	13.33	13.00	14.67	15.33	14.67	512.67	538.67	553.33
Mean	13.73	13.58	13.55	13.70	13.33	13.39	513.76	506.58	499.70
ST x ST hybrids									
P1 x P3	14.00	13.00	13.00	13.33	13.33	13.33	585.67	482.67	553.33
P1 x P6	14.00	14.67	14.33	14.67	16.00	15.33	438.67	502.00	472.67
P1 x P9	13.00	13.67	13.33	12.67	14.00	13.33	428.33	502.67	416.00
P1 x P10	12.00	12.33	12.00	14.00	13.33	14.00	572.67	462.67	491.33
P3 x P6	14.00	13.67	14.33	14.00	14.67	14.00	453.33	465.33	448.00
P3 x P9	15.00	14.00	14.00	14.00	13.33	14.00	540.33	476.00	476.00
P3 x P10	13.00	13.33	13.00	12.67	12.67	12.00	465.33	440.00	434.00
P6 x P9	14.00	14.00	14.33	14.00	14.00	13.33	504.00	480.67	473.33
P6 x P10	13.00	13.33	13.33	14.00	12.00	13.33	534.67	499.67	536.00
P9 x P10	13.00	13.67	13.00	12.00	12.00	12.67	541.67	496.67	512.00
Mean	13.50	13.57	13.47	13.53	13.53	13.53	506.47	480.83	481.27
Grand Mean	12.94	13.1	12.96	13.22	13.1	13.15	480.36	474.15	466.02
S.E.m. ±	0.0437	0.0381	0.0544	0.0426	0.0518	0.0579	0.9713	1.3427	1.0914
CM119xCM211	15.00	15.00	15.00	14.00	14.00	12.00	458.00	462.00	444.00
Trishulata	13.00	13.00	12.00	12.00	12.00	12.00	421.00	429.00	419.00
DHM 105	13.00	12.00	12.00	14.00	12.00	14.00	474.00	466.00	452.00
Mean	13.67	13.33	13.00	13.33	12.67	12.67	451.00	452.33	438.33

Table 2 contd...

	Shelling percentage			100 Seed weight (g)			Grain yield / plot (g)		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
Tropical Parents									
WRGL - 22 (P2)	71.00	71.00	71.00	21.00	21.00	21.00	1.06	1.45	1.30
Med-9 (P4)	81.00	81.00	81.00	16.00	16.00	16.00	1.53	1.21	1.16
WRGL-34 (P5)	82.00	81.00	81.00	24.00	25.00	24.33	1.34	1.58	1.57
Med-5 (P7)	75.00	76.00	76.00	25.00	25.00	24.00	1.59	1.49	1.41
DMR-110 (P8)	80.00	80.00	80.00	23.67	23.00	23.00	1.30	1.44	1.46
Mean	77.80	77.80	77.80	21.93	22.00	21.67	1.36	1.57	1.38
Sub-Tropical Parents									
B-57 (P1)	70.00	75.00	72.00	19.00	18.67	18.00	1.28	1.09	1.03
MMH-9607 (P3)	73.00	73.00	73.00	18.00	18.00	18.33	1.13	1.10	1.00
PARB-96 (P6)	80.00	81.00	80.33	23.00	24.00	23.00	1.36	1.44	1.33
P 8326 (P9)	77.00	77.33	75.00	22.00	22.00	21.67	1.27	1.31	1.14
CM 595 (P10)	75.00	77.00	76.00	18.00	18.00	18.00	1.27	1.21	1.23
Mean	75.00	76.67	75.27	20.00	20.13	19.80	1.26	1.23	1.15
T x T hybrids									
P2 x P4	83.00	83.67	83.00	26.67	26.33	27.00	3.14	3.11	2.77
P2 x P5	80.67	81.67	81.33	30.00	30.00	30.00	3.23	2.97	2.81
P2 x P7	84.00	81.00	81.00	28.67	29.00	29.00	3.03	3.22	2.74
P2 x P8	84.00	83.00	81.00	30.00	31.33	30.00	2.55	3.10	2.89
P4 x P5	80.00	81.00	79.67	25.00	24.67	25.00	3.02	2.86	2.61
P4 x P7	80.00	81.67	81.00	28.00	29.00	29.00	3.67	3.18	2.93
P4 x P8	83.00	84.00	82.00	27.67	27.00	27.67	3.43	3.78	3.71
P5 x P7	85.00	84.00	83.00	29.00	29.67	30.33	3.89	3.49	3.18
P5 x P8	83.00	84.00	84.00	33.67	33.67	33.33	3.37	3.24	3.75
P7 x P8	82.00	82.00	83.00	33.33	31.00	33.33	3.15	3.01	2.85
Mean	82.47	82.60	81.90	29.20	29.17	29.47	3.25	3.19	3.02
T x ST Hybrids									
P2 x P3	80.00	79.00	79.00	31.00	31.00	30.33	3.30	2.78	2.92
P2 x P6	85.00	83.67	85.00	30.00	30.00	30.00	2.42	2.54	2.52
P2 x P9	85.00	85.00	85.00	24.00	25.33	25.00	3.17	2.96	2.36
P2 x P10	85.00	85.00	85.00	28.33	28.33	27.00	2.67	2.87	2.57
P4 x P6	85.00	83.00	82.00	32.00	32.00	32.00	2.60	3.55	3.40
P4 x P9	81.00	83.00	82.00	26.67	25.67	26.00	3.07	3.16	3.20
P4 x P10	81.00	81.33	81.00	26.00	26.00	26.00	3.46	3.17	3.10
P5 x P6	82.00	79.00	81.00	33.33	33.00	33.33	3.06	3.53	3.36
P5 x P9	81.00	82.00	81.33	34.00	33.00	33.00	2.53	3.46	3.40
P5 x P10	84.00	84.00	81.33	24.00	26.00	24.00	3.25	2.91	2.75
P7 x P9	81.00	83.00	81.33	34.00	34.33	34.00	3.01	3.06	3.13
P7 x P10	82.00	80.33	81.33	30.00	30.00	30.00	2.91	3.12	2.94
P8 x P9	83.00	84.00	83.00	31.67	31.00	32.00	2.97	3.07	3.08
P8 x P10	83.00	86.00	84.00	29.33	30.00	29.00	3.46	3.16	2.82
Mean	82.71	82.74	82.31	29.60	29.69	29.40	2.99	3.09	2.97
ST x T hybrids									
P1 x P2	80.00	83.00	82.00	31.00	30.00	31.00	3.40	3.31	3.21
P1 x P4	83.00	83.00	81.00	28.00	27.33	28.00	2.58	3.17	3.06
P1 x P5	83.00	81.00	81.00	26.00	28.00	27.00	2.63	2.93	2.51
P1 x P7	82.00	84.00	81.00	31.00	31.00	31.00	3.11	3.13	3.04
P1 x P8	86.00	86.00	85.00	25.67	27.00	25.67	2.26	2.65	2.88
P3 x P4	80.67	81.67	82.00	26.00	27.00	26.67	2.72	3.28	3.00
P3 x P5	84.00	81.00	82.00	29.00	29.33	29.00	3.02	2.91	2.49
P3 x P7	85.00	83.00	81.00	33.67	35.00	34.00	2.90	3.36	3.34
P3 x P8	83.00	82.00	81.00	32.00	33.67	33.00	3.24	2.95	2.87
P6 x P7	81.00	81.00	81.00	34.00	34.00	34.67	2.76	3.13	3.06
P6 x P8	82.00	83.00	81.00	27.00	28.00	28.00	3.02	3.15	3.10
Mean	82.70	82.61	81.64	29.39	30.03	29.82	2.88	3.09	2.96
ST x ST hybrids									
P1 x P3	80.33	80.67	80.33	29.00	29.00	29.00	3.24	2.93	3.21
P1 x P6	80.00	84.00	82.00	30.00	30.67	30.00	3.57	3.12	2.83
P1 x P9	80.00	79.00	79.67	26.33	25.00	27.00	2.86	2.57	2.25
P1 x P10	83.00	82.00	81.00	25.00	27.00	26.00	2.99	2.50	2.55
P3 x P6	80.00	79.00	80.00	33.33	33.00	33.00	3.10	3.07	2.96
P3 x P9	84.00	82.00	82.00	30.00	32.00	33.00	2.70	3.05	3.14
P3 x P10	82.00	80.00	81.00	29.00	29.00	28.67	2.60	2.55	2.49
P6 x P9	80.00	81.00	80.33	30.00	31.00	31.00	3.21	2.97	2.93
P6 x P10	81.00	81.33	82.00	30.00	32.00	31.67	2.92	3.17	3.40
P9 x P10	82.00	82.00	81.00	32.00	33.00	32.00	2.75	3.28	3.27
Mean	81.23	81.10	80.93	29.47	30.17	30.13	2.99	2.92	2.90
Grand Mean	81.25	81.39	80.8	27.89	28.18	28.05	2.71	2.76	2.65
S.E.m. ±	0.0441	0.0573	0.0594	0.0547	0.0563	0.0562	0.0047	0.0425	0.0042
CM119xCM211	81.00	79.00	79.00	30.00	30.00	31.00	2.65	2.83	2.75
Trishulata	82.00	81.00	80.00	31.00	31.00	31.00	2.63	2.66	2.59
DHM 105	80.00	79.00	79.00	28.00	28.00	27.00	1.24	2.61	2.44
Mean	81.00	79.67	79.33	29.67	29.67	29.67	2.17	2.70	2.59

Table 2 contd...

	Oil percentage			Protein percentage		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
Tropical Parents						
WRGL - 22 (P2)	5.28	5.14	5.07	10.34	10.41	10.32
Med-9 (P4)	3.73	3.90	4.02	6.85	7.07	6.86
WRGL-34 (P5)	5.04	5.15	5.23	8.14	8.44	8.60
Med-5 (P7)	5.80	5.68	5.72	9.18	9.40	9.46
DMR-110 (P8)	6.23	5.96	6.09	11.17	11.42	11.52
Mean	5.22	5.17	5.22	9.14	9.35	9.35
Sub-Tropical Parents						
B-57 (P1)	4.41	4.54	4.63	9.39	9.51	9.35
MMH-9607 (P3)	5.05	5.24	5.15	13.29	13.46	12.86
PARB-96 (P6)	5.04	5.14	5.18	9.27	9.19	9.33
P 8326 (P9)	5.53	5.28	5.30	12.13	12.44	12.64
CM 595 (P10)	5.64	5.48	5.55	12.17	13.11	13.34
Mean	5.13	5.13	5.16	11.25	11.54	11.50
T x T hybrids						
P2 x P4	6.24	6.25	6.37	7.21	7.27	7.33
P2 x P5	5.20	5.45	5.35	10.34	10.39	10.53
P2 x P7	4.53	4.65	4.55	11.91	12.41	12.47
P2 x P8	5.90	5.84	5.62	11.18	11.51	11.31
P4 x P5	5.35	5.55	5.57	7.40	7.33	7.44
P4 x P7	6.30	6.41	5.82	12.23	12.46	12.61
P4 x P8	4.86	5.03	5.26	10.24	10.31	10.46
P5 x P7	5.51	5.67	5.76	13.42	13.25	13.43
P5 x P8	3.96	4.28	4.85	10.53	10.83	10.65
P7 x P8	5.76	5.61	5.81	8.92	8.87	9.07
Mean	5.36	5.47	5.50	10.34	10.46	10.53
T x ST Hybrids						
P2 x P3	5.23	5.43	5.34	7.22	7.33	7.49
P2 x P6	6.25	6.43	6.19	13.03	13.49	12.48
P2 x P9	6.60	6.75	6.85	7.11	7.43	7.40
P2 x P10	5.15	5.64	5.72	10.48	10.61	10.35
P4 x P6	6.24	6.17	6.34	11.14	11.23	11.52
P4 x P9	4.72	4.91	5.12	11.20	11.53	12.51
P4 x P10	6.47	6.41	6.58	10.20	10.40	10.46
P5 x P6	6.39	6.29	6.46	10.44	10.48	10.47
P5 x P9	5.28	5.13	5.44	9.16	9.25	9.45
P5 x P10	5.98	5.45	5.78	10.26	10.47	10.46
P7 x P9	4.97	5.11	5.32	8.20	8.52	8.20
P7 x P10	6.08	6.26	6.16	7.84	7.74	7.44
P8 x P9	5.99	6.14	6.22	7.16	7.24	7.39
P8 x P10	5.92	6.16	6.33	7.35	7.83	7.50
Mean	5.80	5.88	5.99	9.34	9.54	9.51
ST x T hybrids						
P1 x P2	5.49	5.35	5.44	13.51	13.64	13.63
P1 x P4	6.11	6.09	6.25	7.58	7.72	7.42
P1 x P5	6.08	6.17	6.28	10.70	10.49	10.44
P1 x P7	6.48	6.54	6.30	12.20	12.44	12.33
P1 x P8	5.93	6.13	5.95	7.39	7.40	7.38
P3 x P4	5.10	5.82	5.65	12.73	13.54	12.84
P3 x P5	5.32	5.11	5.58	11.95	12.22	11.87
P3 x P7	6.54	6.54	6.43	13.19	13.48	13.40
P3 x P8	6.27	6.05	6.21	11.40	11.85	11.38
P6 x P7	5.50	5.33	5.25	7.33	7.59	7.36
P6 x P8	6.19	5.88	5.85	7.83	7.83	7.60
Mean	5.91	5.91	5.92	10.53	10.75	10.51
ST x ST hybrids						
P1 x P3	5.59	5.55	5.34	9.31	9.16	9.42
P1 x P6	6.55	6.56	6.62	7.81	7.59	7.76
P1 x P9	4.64	4.56	4.55	12.13	12.39	12.76
P1 x P10	6.18	6.25	6.35	7.66	7.54	7.44
P3 x P6	5.19	5.41	5.12	11.36	11.47	11.74
P3 x P9	6.27	6.51	6.68	8.19	8.35	8.43
P3 x P10	4.97	5.08	5.18	12.56	12.68	12.60
P6 x P9	5.20	5.45	5.35	6.37	6.86	6.21
P6 x P10	6.14	6.21	6.36	7.55	7.53	7.50
P9 x P10	5.28	5.06	5.24	7.19	7.45	7.31
Mean	5.60	5.66	5.68	9.01	9.10	9.12
Grand Mean	5.59	5.64	5.69	9.86	10.03	9.99
S.E.m. $\pm$	0.0036	0.0029	0.0063	0.0091	0.0072	0.0068
CM119xCM211	4.17	4.24	4.3	7.43	7.74	7.55
Trishulata	5.36	5.23	5.14	7.84	7.43	7.42
DHM 105	5.61	5.36	5.54	9.15	9.2	9.34
Mean	5.05	4.94	4.99	8.14	8.12	8.10

4.1.3.1 Days to 50 per cent tasseling

The mean number of days to 50 per cent tasseling was 57 days with a range of 54 to 60 days at Rajendranagar. The mean for parents ranged from 56 (P7) to 60 days (P9) and for crosses it varied from 54 days (P3xP9, P4xP10, P6xP7) to 59 days (P3xP4, P4xP9, P6xP8, P8xP10). The check CM 119 x CM 211 recorded 56 days to 50 per cent tasseling.

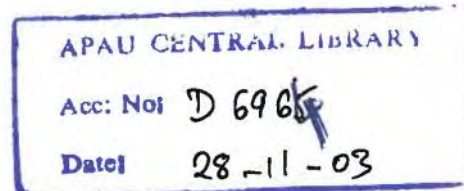
At Karimnagar, mean number of days to 50 per cent tasseling was 54 with a range of 51 to 59 days. Parents showed a mean range of 55 days (P5 and P7) to 59 days (P2, P8 and P9). Hybrids ranged from 51 days (P2xP3, P3xP10 and P4xP7) to 56 days (P1xP4 and P1xP5) while check CM119xCM211 recorded 52 days.

At Tandoor the average number of days to 50 per cent tasseling was 56 with a range of from 52 to 60 days. The mean days to 50 per cent tasseling for parents ranged from 56 (P5 and P6) to 60 days (P9) while for hybrids the range varied from 52 days (P4xP10) to 58 days (P1xP5 and P8xP10). The check CM 119 x CM 211 recorded 54 days for 50 per cent tasseling.

4.1.3.2 Days to 50 per cent silking

At Rajendranagar, the number of days to 50 per cent silking ranged from 57 days to 63 days with a mean of 61 days. For parents the days to 50 per cent silking varied from 59 days (P6 and P7) to 63 days (P1, P3, P4, P8 and P9) and for crosses it was from 57 days (P3xP9 and P4xP10) to 63 days (P1xP5, P1xP9 and P2xP10). The check CM 119 x CM 211 recorded 60 days to 50 per cent silking (Table 2).

At Karimnagar, the mean number of days to 50 per cent silking was 59 with a range of 56 to 63 days while the parents showed a mean range of 59 days (P7) to 63 days (P8 and P9). The hybrids ranged from 56 days (P3xP10,



P4xP10) to 60 days (P1xP5, P5xP9 and P8xP9) and the check CM 119 x CM 211 recorded 56 days.

At Tandoor, the average number of days to 50 per cent silking was 60 days with a range of 56 to 64 days. The mean days to 50 per cent silking for parents ranged from 60 days (P1, P5 and P6) to 64 days (P8 and P9), while for hybrids the range was from 56 days (P3xP9 and P3xP10) to 62 days (P1xP5 and P1xP10). The check CM 119 x CM 211 recorded 59 days.

4.1.3.3 Days to 50 per cent Brown husk

The average number of days to 50 per cent brown husk was 89 days with a range of 85 to 93 days at Rajendranagar. The mean for parents ranged from 87 days (P5, P6 and P7) to 90 days (P9 and P10) while that of crosses varied from 85 days (P4xP10 and P6xP7) to 93 days (P1xP5, P1xP9 and P2xP10). CM 119 x CM 211 check recorded 85 days for 50 per cent brown husk.

At Karimnagar, mean number of days to 50 per cent brown husk was 87 days with a range of 81 to 91 days. Parents showed a mean range of 85 days (P5 and P7) to 89 days (P2, P8 and P9), the hybrids ranged from 81 days (P4xP10) to 91 days (P1xP9, and P2xP8), while the check ,CM119 x CM211 recorded 83 days to 50 per cent brown husk (Table 2).

At Tandoor, the number of days to 50 per cent brown husk varied from 82 to 92 days with a mean of 88 days. The mean days to 50 per cent brown husk for parents ranged from 86 days (P5, P6 and P7) to 89 days (P2, P3, P8 and P9), while for hybrids the range varied from 82 days (P4xP10), to 92 days (P1xP5, and P1xP10), the check CM 119 x CM 211 recorded 86 days.

4.1.3.4 Plant height (cm)

The plant height of genotypes at Rajendranagar ranged from 91 to 182 cm with a mean of 156.15cm. The mean plant height for parents ranged from 91 cm (P7) to 155.33cm (P5). In case of hybrids, the mean plant height ranged from 132cm (P2xP7) to 182 cm (P5xP9). The plant height of check CM119 x CM 211 found to be 161cm.

At Karimnagar, the mean plant height ranged from 82.33 to 203.33cm with an average height of 152.33cm. For parental lines, the plant height ranged from 73.3cm (P7) to 128.3cm (P9 and P10). Whereas for hybrids the height ranged from 128 cm (P2xP3) to 203.3 cm (P9xP10). The check CM119 x CM 211 showed a plant height of 166 cm (Table2).

At Tandoor, mean plant height of 153.47 cm was recorded, showing range from 92.33 to 205.67cm. The parents were in the range of 92.2cm (P1 and P7) to 140cm (P5). In hybrids, mean plant height ranged from 135 cm (P2xP3) to 205.67cm (P9xP10). The check CM 119 x CM 211 recorded a plant height of 162cm.

4.1.3.5 Ear height (cm)

The ear height at Rajendranagar ranged from 41cm to 79.33cm with a mean of 61.35cm. The mean ear height for parents ranged from 41 (P8) to 54 cm (P5). Among hybrids, cross P1xP2 recorded the lowest value of 45.33cm and highest value of 79.3cm was recorded by cross P4xP8. The check (CM 119 x CM 211) recorded 64cm for ear height (Table 2).

At Karimnagar, a general mean of 60.49cm was recorded with a range of 31.67 to 87.33cm. The ear height of parents ranged from 31.67 (P7) to 52 cm (P9) while that of hybrids ranged from 44cm (P1xP7) to 87.3cm (P2xP10). The check CM 119 x CM 211 recorded 66cm of ear height.

At Tandoor, the mean ear height ranged from 30 to 79.33 cm with a mean of 60.32 cm. The ear height of parents ranged from 30cm (P7) to 48.67cm (P9), whereas mean ear height in hybrids ranged from 45.67 (P1xP7) to 79.3cm (P4xP8). The check, CM 119 x CM 211 recorded an ear height of 65 cm (Table 2).

4.1.3.6 Ear length (cm)

The ear length at Rajendranagar ranged from 10 to 18cm with a mean of 13.98cm. The parents recorded an ear length ranging from 10cm (P1, P7 and P10) to 13cm (P2). For hybrids, the mean ear length varied from 13cm (P2xP5 and P2xP9) to 18cm, (P4xP8). The check CM119 x CM 211 recorded 13cm of ear length.

Ear length at Karimnagar varied from 10 to 18cm with a general mean of 15.25cm. The ear length for parents ranged from 10 (P5 and P9) to 14cm (P8). In case of hybrids, the lowest (13cm) and the highest values (18cm) were recorded by the crosses (P2xP6 and P3xP8) respectively. The check CM 119 x CM 211 recorded 15cm of ear length.

An ear length of 10.33cm to 17.67 was recorded at Tandoor centre with a mean of 14.45cm. The parents recorded an ear length ranging from 10.33cm (P9) to 13cm (P3), while for hybrids, the range was 13.33cm (P3xP5) to 17.6cm (P5xP7). The check CM 119 x CM 211 recorded 15cm of ear length. (Table 2)

4.1.3.7 Ear girth (cm)

The ear girth of genotypes at Rajendranagar ranged from 10 to 15cm with a general mean of 12.94cm. The mean ear girth for parents ranged from 10 cm (P2, P4, P7, P8, P9, and P10) to 12cm (P1 and P5). In case of hybrids the mean ear girth ranged from 12cm (P1x P10, P2xP8, P2xP9, P4xP7,

P7xP8 and P8xP10) to 15cm (P5xP6, P3xP9 and P4xP9). The check CM119 x CM211 also recorded 15 cm of ear girth.

At Karimnagar, mean ear girth ranged from 10 to 15cm with a general mean of 13.09cm. The parents had a range of 10cm (P7 and P9) to 11cm (P1 and P3). The mean ear girth in crosses ranged from 12cm (P2xP3) to 15 cm (P2xP4). The check CM 119 x CM 211 recorded 15cm of ear girth.

Tandoor centre recorded a mean of 12.96cm with a range of 10 to 14.67cm. Parents showed a range of 10cm (P7, P8 and P9) to 12.33cm (P4). The ear girth in crosses ranged from 12cm (P1xP10 and P8xP10) to 14.6cm (P4xP9), while that of check CM 119 x CM 211 found to be 15cm (Table 2).

4.1.3.8 Number of seed rows per ear

Number of seed rows per ear at Rajendranagar location was 13.22 with a range of 10.67 to 16.67. The seed rows of tropical parents ranged from 11.3 (P2) to 14 (P4) while that of subtropicals varied from 11.3 (P3) to 12 (P1, P6, P9 and P10). The tropical x tropical crosses varied from 10.67 (P7xP8) to 16.0 (P2xP7) while tropical x subtropical or subtropical x tropical varied from 12.0(P4xP6, P7xP9, P8xP9, P8xP10 and P5xP9) to 16.67 (P1xP4). The crosses of subtropical x subtropical type varied from 12.0 (P9xP10) to 14.67 (P1xP6). The check of CM 119 x CM 211 found to have 14 seed rows per ear (Table 2).

The average number of seed rows per ear at Karimnagar was found to be 13.1 with a range of 11.33 to 16. The number of seed rows per ear for tropical parents ranged from 11.33 (P7) to 14 (P4). The subtropical parents ranged from 10.67 (P3) to 12.0 (P1 and P6). The mean range for tropical x tropical hybrids ranged from 11.3 (P7xP8) to 15.33 (P2xP7). The tropical x subtropical and subtropical x tropical crosses varied from 11.33 (P3xP8) to 15.33 (P4xP9 and P4xP10). The crosses among subtropicals varied from 12.0 (P6xP10)

and P9xP10) to 16.0 (P1xP6). The check CM 119 x CM 211 recorded 14 seed rows per ear.

At Tandoor, the number of seed rows per ear varied from 10.67 to 16 with a mean of 13.15. The tropical parents had a range from 11.33 (P7 and P8) to 14 (P4). The subtropical parents had a range of 10.67 (P9) to 12 (P1 and P6). For tropical x tropical hybrids, a mean range of 10.6 (P7xP8) to 15.33 (P2xP7) was recorded. The values of tropical x subtropical and subtropical x tropical crosses varied from 11.33 (P3xP8) to 16.0 (P4xP9 and P1xP4). The subtropical crosses showed a range from 12.0 (P3xP10) to 15.33 (P1xP6). The check (CM119xCM 211) found to have 12 seed rows per ear (Table 2).

4.1.3.9 Number of seeds per ear

Number of seeds per ear is also an important yield attributing character. The mean number of seeds per ear at Rajendranagar was 480.36 with a range of 271.67 to 664. The seeds per ear of tropical parents varied from 271.67 (P7) to 354.67 (P4) and subtropicals from 291.33 (P6) to 351.33 (P10). The tropical x tropical crosses had a range of 421.33 (P2xP7) to 664 (P4xP8). The range for tropical x subtropical or subtropical x tropical was from 453.33 (P3xP8) to 642.47 (P4xP9) while the crosses among the subtropicals varied from 428.33 (P1xP9) to 585.67 (P1xP3). The check CM 119 x CM 211 found to have 458 seeds per ear.

The average number of seeds per ear at Karimnagar found to be 474.15, with a range of 291.33 to 668. The number of seeds per ear in tropical parents ranged from 298.67 (P7) to 326.67 (P4). The subtropical parents ranged from 291.33 (P1) to 337.33 (P10). The range for tropical x tropical hybrids was from 462.67 (P2xP5) to 668 (P4xP8). The mean of tropical x subtropical and subtropical x tropical ranged from 420 (P2xP6) to 596.67 (P4xP10). The crosses involving subtropicals had a range of 440 (P3xP10) to 502.7 (P1xP9). The check CM 119 x CM211 recorded 462 seeds per ear (Table 2).

At Tandoor, the number of seeds per ear varied from 264.67 to 670.67, with a mean of 466.02. The tropical parents had the values ranging from 294.67 (P7) to 364 (P4). The subtropical parents ranged from 264.67 (P9) to 341.33 (P10). For tropical x tropical hybrids, the number of seeds per ear varied from 428 (P7xP8) to 670.67 (P4xP8). The crosses of subtropicals ranged from 416 (P1xP9) to 553.3 (P1xP3). The check CM119xCM211 recorded 444 seeds per ear (Table 2).

The cross (P4xP8) recorded the highest number of seeds per ear at three locations.

4.1.3.10 Shelling per cent

The average shelling per cent at Rajendranagar was 81.25 with a range of 70 to 86 per cent, where as for tropical parents, the shelling per cent ranged from 71 (P2) to 82 (P5). Subtropical parents had a range of 70.0 (P1) to 80.0 (P6). Among tropical x tropical crosses, the shelling per cent varied from 80 (P4xP5 and P4xP7) to 85 (P5xP7). The mean range for tropical x subtropical and subtropical x tropical was from 80 (P1xP2 and P2xP3) to 86 (P1xP8). The crosses involving subtropical parents ranged from 80 (P1xP6) to 84 (P3xP9). The check CM 119 x CM 211 recorded shelling percentage of 81 (Table 2).

At Karimnagar, the mean shelling per cent found to be 81.39 and ranged from 71 to 86 per cent. The tropical parents had a shelling per cent ranging from 71 (P2) to 81 (P4 and P5). The subtropicals ranged from 73 (P3) to 81 (P6). In case of tropical x tropical hybrids, the range was 81 (P2xP7 and P4xP5) to 84 per cent (P4xP8, P5xP7 and P5xP8). The crosses of tropical x subtropical and subtropical x tropical ranged from 79 (P2xP3 and P5xP6) to 86 (P1xP8 and P8xP10). Subtropical x subtropical crosses ranged from 79 (P1xP9 and P3xP6) to 84 (P1xP6). The check CM119 x CM211 recorded 79 shelling per cent.

Shelling per cent at Tandoor varied from 71 to 85 per cent with a mean of 80.8, where as in tropical parents, P2 recorded lowest value (71 per cent) and P5 recorded the highest value (81 per cent). Shelling per cent of subtropical parents ranged from 72 (P1) to 80.33 (P6). Among the tropical x tropical crosses, the range was between 79.77 per cent (P4xP5) and 84 per cent (P5xP8). Shelling per cent of tropical x subtropical and subtropical x tropical crosses ranged from 79 (P2xP3) to 85 (P2xP6; P2xP9, P2xP10 and P1xP8). There was a range of 79.77 (P1xP9) to 82 (P1xP6, P3xP9 and P6xP10) among subtropical x subtropical crosses and the check CM 119 x CM 211 recorded 79 shelling per cent.

4.1.3.11 100 seed weight

At Rajendranagar, the mean grain weight found to be 27.89 g with a range of 16 to 34g. Among the tropical parents, the highest and the lowest values ranged from 16g (P4) to 25g (P7), while the values of subtropicals varied from 18.0 (P3 and P10) to 23.0g (P6). The tropical x tropical crosses varied from 25.00 (P4xP5) to 33.67g (P5xP8), tropical x subtropical or subtropical x tropical crosses ranged from 24 (P2xP9) to 34g (P5xP9 and P7xP9). The 100 seed weight of subtropical x subtropical varied from 25 (P1xP10) to 33.33g (P3xP6). The check CM 119 x CM 211 recorded 30g for 100 seed weight.

The mean values at Karimnagar ranged from 16 to 35.0g with a mean of 28.18g. The tropical parents had a range from 16g (P4) to 25g (P5 and P7) and the subtropicals from 18g and (P3 and P10) to 23g (P6). The tropical x tropical crosses exhibited a mean range of 24.67g (P4xP5) to 33.67g (P5xP8). The tropical x subtropical and subtropical x tropical crosses varied from 25.33 (P2xP9) to 35g (P3xP7). The crosses among subtropicals varied from 25 (P1xP9) to 33g (P3xP6 and P9xP10). The check CM 119 x CM 211 recorded 30g for 100 seed weight.

At Tandoor, the general mean was 28.05g with a range of 16 to 34.67g. Tropical parents had a range from 16g (P4) to 24.33g (P5). The subtropical parents ranged from 18 (P1 and P10) to 23g (P6). In case of tropical x tropical hybrids, the values varied from 25g (P4xP5) to 33.33g (P5xP8 and P7xP8). The tropical x subtropical or subtropical x tropical crosses varied from 24g (P5xP10) to 34.67g (P6xP7). The crosses of subtropicals ranged from 26 (P1xP10) to 33g (P3xP9). The check CM119 x CM211 recorded 31g for 100 seed weight (Table 2).

4.1.3.12 Grain yield per plot

Grain yield per plot is the most important character, which determines the worthiness of a hybrid. Grain yield at Rajendranagar showed a range of 1.06 to 3.89kg per plot with a general mean of 2.71kg per plot. The grain yield of tropical parents ranged from 1.06kg (P2) to 1.59kg (P7), subtropicals from 1.13kg (P3) to 1.36kg (P6), while that of tropical x tropical hybrids ranged from 2.55kg (P2xP8) to 3.89kg (P5xP7). The tropical x subtropical and subtropical x tropical crosses varied from 2.26 (P1xP8) to 3.46kg (P4xP10 and P8xP10). The crosses among the subtropicals varied from 2.60 (P3xP10) to 3.57kg (P1xP6). The check CM 119 x CM 211 recorded 2.65kg per plot.

The average grain yield per plot at Karimnagar was 2.76kg, showing a range of 1.09 to 3.78kg. The tropical parents found to have the values ranging from 1.21kg (P4) to 1.58kg (P5) and sub-tropicals from 1.09kg (P1) to 1.44kg (P6). Compared to parents, the grain yield recorded by hybrids was high, the tropical x tropical crosses ranged from 2.86kg (P4xP5) to 3.78kg (P4xP8). The tropical x subtropical or subtropical x tropical had a range from 2.54 (P2xP6) to 3.55kg (P4xP6) while crosses among the subtropicals varied from 2.5 (P1xP10) to 3.28kg (P9xP10). The check CM 119 x CM 211 recorded 2.83kg of grain yield per plot.

At Tandoor, mean grain yield was 2.65kg with a range of 1.0 to 3.75kg per plot. The grain yield of tropical parents in this centre varied from 1.16kg (P4) to 1.57kg (P5) and sub-tropicals from 1.00kg (P3) to 1.33kg (P6). Among tropical x tropical hybrids, P4xP5 cross recorded the lowest grain yield of 2.61kg where as highest grain yield of 3.75kg was recorded by P5xP8 cross. The tropical x subtropical and subtropical x tropical crosses varied from 2.36 (P2xP9) to 3.40kg (P4xP6 and P5xP9) while crosses among the subtropicals varied from 2.25 (P1xP9) to 3.40kg (P6xP10). The check CM119 x CM211 recorded 2.75kg for grain yield per plot.

4.1.3.13 Oil

The mean oil content in maize seeds was 5.59 per cent and the lowest and highest values ranged from 3.73 to 6.60 per cent at Rajendranagar. The oil per cent in parents ranged from 3.73 (P4) to 6.23 (P8) and for crosses it varied from 3.96 (P5xP8) to 6.6 per cent (P2xP9). The check CM119 x CM211 recorded 4.17 per cent oil.

At Karimnagar, mean oil per cent was 5.64 with a range of 3.90 to 6.75 per cent. The oil content of parents varied from 3.90 (P4) to 5.96 per cent (P2, P8 and P9). The check CM 119 x CM 211 found to have an oil content of 4.24 per cent.

At Tandoor, the mean oil per cent recorded was 5.69 with a range of 4.02 to 6.85 per cent. The mean of parents ranged from 4.02 (P4) to 6.09 per cent (P8), for crosses, it varied from 4.55 (P2xP7) to 6.85 per cent (P2xP9) while that of check CM 119 x CM 211 had an oil per cent of 4.3 (Table 2).

In all the three locations, the oil content of P8 was highest and P4 was the lowest.

4.1.3.14 Protein

At Rajendranagar, mean protein per cent found to be 9.86 with a range of 6.37 to 13.51 per cent, where as the protein per cent of tropical parents ranged from 6.85 (P4) to 11.17 (P8) and subtropicals from 9.27 (P6) to 13.29 (P3). Among tropical x tropical crosses, the range was between 7.21 (P2xP4) and 13.42 (P5xP7). The tropical x subtropical and subtropical x tropical crosses varied from 7.11 (P2xP9) to 13.51 (P1xP2). The subtropical x subtropical crosses had a range of 7.19 (P9xP10) to 12.56 (P3xP10). The check CM119 x CM211 recorded 7.43 per cent of protein (Table 2).

At Karimnagar, the mean protein per cent found to be 10.03 and ranged from 6.86 to 13.64 per cent, the tropical parents showed a range of 7.07 (P4) to 11.42 per cent (P8) and subtropicals 9.19 (P6) to 13.46 (P3). Among the tropical x tropical hybrids, the lowest and the highest values ranged from 7.27 per cent (P2xP4) to 13.25 per cent (P5xP7). The tropical x subtropical and subtropical x tropical crosses varied from 7.24 (P8xP9) to 13.64 (P1xP2) while crosses among the subtropicals had a range from 7.45 (P9xP10) to 12.68 (P3xP10). The check CM119 x CM211 recorded 7.74 per cent of protein.

Protein per cent at Tandoor ranged from 6.21 to 13.63 with a mean of 9.99 per cent, where as in tropical parents the protein per cent ranged from 6.86 (P4) to 11.52 (P8) and subtropicals from 9.33 (P6) to 13.34 (P10). In case of tropical x tropical hybrids, the values varied from 7.33 (P2xP4) to 13.43 per cent (P5xP7). The tropical x subtropical or subtropical x tropical crosses varied from 7.36 (P6xP7) to 13.63 (P1xP2). The crosses of subtropicals ranged from 7.31 (P9xP10) to 12.76 (P1xP9) and the check CM119 x CM211 recorded 7.55 per cent of protein (Table 2).

4.2 NATURE OF GENE ACTION

4.2.1 Combining ability analysis

The analysis of variance for combining ability in F1 diallel studied at three locations for grain yield and its yield components is presented in Table 3. General combining ability (GCA) and specific combining ability (SCA) mean squares were found to be significant for all the characters studied at three locations. Estimates of variances revealed that the SCA variance was of higher magnitude compared to GCA and it ranged from -0.01 to 0.36.

4.2.1.1 GCA effects

4.2.1.1.1 Days to 50 per cent tasseling

The parents P6 and P7 recorded significant negative GCA effects indicating earliness for 50 per cent tasseling at Rajendranagar and Tandoor on the other hand P8 and P9 were the best combiners with significantly positive GCA effects indicating late 50 per cent tasseling. At Karimnagar, P6 was the best combiner with highly significant negative GCA effects indicating earliness 50 per cent tasseling (Table 4).

4.2.1.1.2 Days to 50 per cent silking

Parent P6 and P7 at Rajendranagar, P3 and P7 at Karimnagar and P2, P3 and P6 at Tandoor was the best combiners with significant negative GCA effects for days to 50 per cent silking. Parent P8 at Rajendranagar, P8 and P9 at Karimnagar and Tandoor exhibited highly significant positive GCA effects indicating lateness for 50 per cent silking (Table 4).

4.2.1.1.3 Days to 50 per cent brown husk

Majority of the parents were the best combiners for either earliness or lateness. Parents P5, P6 and P7 at Rajendranagar, P5, P6, P7 and P10 at

Table 3 . Combining ability analysis for grain yield,yield components,oil and protein at three locations.

Source	d.f	50% Tasseling (days)			50% Silking (days)			50% Brown husk (days)		
		Rajendra-nagar	Karim Nagar	Tandoor	Rajendra-nagar	Karim Nagar	Tandoor	Rajendra-nagar	Karim Nagar	Tandoor
GCA	9	1.979**	1.441**	1.970**	3.988**	1.454**	2.718**	7.091**	12.552**	8.169**
SCA	45	2.052**	4.241**	2.873**	2.344**	2.347**	2.633**	3.385**	4.143**	3.705**
Error	108	0.458	0.451	0.757	0.523	0.432	0.452	0.363	0.298	0.402
σ^2 gca		0.126	0.083	0.101	0.288	0.085	0.188	0.561	1.021	0.647
σ^2 sca		1.594	3.790	2.166	1.821	1.915	2.181	3.022	3.845	3.303
σ^2 gca / σ^2 sca		0.080	0.022	0.048	0.158	0.044	0.086	0.186	0.266	0.196

Table 3: (contd.)

Source	d.f	Plant height (cm)			Ear height (cm)			Ear length (cm)		
		Rajendra-nagar	Karim Nagar	Tandoor	Rajendra-nagar	Karim Nagar	Tandoor	Rajendra-nagar	Karim Nagar	Tandoor
GCA	9	347.645**	820.379**	149.799**	124.941**	150.245**	120.022**	4.158**	3.906**	0.166**
SCA	45	363.238**	700.569**	502.377**	122.954**	155.520**	136.487**	4.288**	4.464**	3.296**
Error	108	23.241	19.951	13.106	3.343	4.841	2.061	0.349	0.332	0.579
σ^2 gca		27.033	66.702	11.391	10.133	12.117	9.830	0.317	0.298	-0.035
σ^2 sca		339.997	680.612	489.271	119.611	150.679	134.426	3.939	4.132	2.717
σ^2 gca / σ^2 sca		0.079	0.098	0.023	0.084	0.080	0.073	0.081	0.072	-0.012

* Significant (P<0.05)

** Significant (P<0.01)

Table 3: (contd.)

Source	d.f	Ear girth (cm)			No of seed rows/ear			No of seeds/ear		
		Rajendra-nagar	Karim Nagar	Tandoor	Rajendra-nagar	Karim Nagar	Tandoor	Rajendra-nagar	Karim Nagar	Tandoor
GCA	9	1.892**	0.400*	1.263**	2.723**	1.998**	2.477**	5902.991**	5376.357**	6755.488**
SCA	45	1.893**	2.145**	1.355**	1.564**	1.461**	1.370**	9669.193**	9167.343**	8647.372**
Error	108	0.206	0.156	0.319	0.195	0.289	0.362	101.888	194.703	128.654
σ^2 gca		0.140	0.020	0.078	0.210	0.142	0.176	483.425	431.804	552.236
σ^2 sca		1.686	1.989	1.036	1.369	1.172	1.008	9567.31	8972.64	8518.718
σ^2 gca / σ^2 sca		0.083	0.010	0.076	0.154	0.121	0.175	0.050	0.048	0.065

Table 3: (contd.)

Source	d.f	Shelling%			100 Seed weight (g)			Grain yield (kg)		
		Rajendra-nagar	Karim Nagar	Tandoor	Rajendra-nagar	Karim Nagar	Tandoor	Rajendra-nagar	Karim Nagar	Tandoor
GCA	9	7.522**	9.068**	7.112**	23.983**	25.714**	26.076**	0.071**	0.162**	0.121**
SCA	45	11.613**	8.485**	8.516**	18.255**	18.199**	19.000**	0.640**	0.600**	0.617**
Error	108	0.209	0.354	0.380	0.322	0.342	0.341	0.002	0.010	0.002
σ^2 gca		0.609	0.726	0.561	1.97	2.114	2.145	0.069	0.013	0.010
σ^2 sca		11.404	8.131	8.136	17.933	17.857	18.659	0.638	0.590	0.615
σ^2 gca / σ^2 sca		0.053	0.089	0.069	0.109	0.118	0.114	0.108	0.022	0.016

* Significant ($P < 0.05$)** Significant ($P < 0.01$)

Table 3: (contd.)

Source	d.f	Oil percentage			Protein percentage		
		Rajendra-nagar	Karim Nagar	Tandoor	Rajendra-nagar	Karim Nagar	Tandoor
GCA	9	0.312**	0.204**	0.150**	4.724**	4.418**	3.803**
SCA	45	0.535**	0.451**	0.424**	5.577**	4.943**	5.127**
Error	108	0.001	0.009	0.004	0.008	0.005	0.005
σ^2 gca		0.026	0.016	0.012	0.393	0.367	0.316
σ^2 sca		0.534	0.442	0.420	5.569	4.938	5.122
σ^2 gca / σ^2 sca		0.048	0.036	0.028	0.071	0.074	0.062

* Significant ($P < 0.05$)** Significant ($P < 0.01$)

Karimnagar and P5,P6,P7,P9 and P10 at Tandoor recorded significant negative GCA effects indicating their contribution for earliness. Parents P1, P2, P3 at Rajendranagar and in addition to these P4 at Karimnagar and P4 and P5 at Tandoor were the best combiners with significant GCA effects for brown husk revealing their contribution for late maturity. Interestingly, P5, P6 and P7 were found as best combiners for 50 per cent brown husk with highly significant negative GCA effects at all locations (Table 4).

4.2.1.1.4 Plant height

Parents P1, P5, P8 and P9 at Rajendranagar, P5,P8,P9 and P10 at Karimnagar, P5,P8,P9, and P10 at Tandoor were found as best combiners with significantly high positive GCA effects for plant height. Significant negative GCA effects were recorded in case of P4, P6, P7 at Rajendranagar, P1, P2, P3, P6,P7 and P8 at Karimnagar and P1, P2, P4, P6 and P7 at Tandoor indicating their contribution for dwarfness. Among all parents, P5, P8 and P9 recorded highly significant positive GCA effects at all locations. Parents P6, and P7 were the best combiners for short height at all locations (Table 4).

4.2.1.1.5 Ear height

Only two parents P8 and P9 were found as best combiners with highly significant positive GCA effects at all locations for this trait. Rajendranagar was found as best location for P3, P4, P5, P8 and P9 for their ear height with significant positive GCA effects. P4, P8, P9 and P10 at Karimnagar and P3, P4, P5, P8 and P9 at Tandoor exhibited highly significant GCA effects for ear height. On the other hand P6, P7 and P10 at Rajendranagar, P1, P4 and P7 at Karimnagar and P1, P2 and P7 at Tandoor are the poor combiners with significantly high GCA effects (Table 4).

Table 4: Estimates of General Combining Ability effects of the ten parents for Grain Yield, Yield components and Oil and Protein at three locations

Parent	Days to 50% tasseling			Days to 50% silking			Days to 50% brush husk		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
B-57 (P1)	0.09	0.22	-0.15	0.62**	0.03	0.21	1.26**	1.08**	1.28**
WRGL - 22 (P2)	-0.36	0.17	-0.01	-0.13	0.11	-0.37*	0.71**	1.61**	0.98**
MMH-9607 (P3)	0.03	-0.14	0.07	-0.16	-0.36*	-0.57**	0.62**	0.94**	0.67**
Med-9 (P4)	0.09	-0.36	0.07	-0.02	-0.03	0.21	0.29	0.47**	0.48**
WRGL-34 (P5)	-0.16	-0.11	-0.04	0.06	-0.06	-0.34	-0.68**	-1.28**	-0.83**
PARB-96 (P6)	-0.47*	-0.14	-0.57*	-1.02**	-0.28	-0.43**	-1.02**	-0.73**	-0.99**
Med-5 (P7)	-0.61**	-0.31	-0.54*	-0.74**	-0.36*	-0.29	-1.04**	-0.78**	-0.58**
DMR-110 (P8)	0.70**	0.25	0.88	0.92**	0.53**	0.93**	0.29	-0.01	0.17**
P 8326 (P9)	0.39*	0.75**	0.24	0.23	0.64**	0.43**	-0.16	0.05	-0.36*
CM 595 (P10)	0.28	-0.33	0.04	0.26	-0.22	0.21	-0.27	-1.34**	-0.83**
SE(gi)	0.34	0.33	0.43	0.36	0.33	0.33	0.30	0.27	0.31
SE(gi-gi)	0.50	0.50	0.64	0.53	0.49	0.50	0.45	0.40	0.47

Table 4 contd...

Parent	Plant height (cm)			Ear height (cm)			Ear length (cm)		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
B-57 (P1)	2.98*	-11.55**	-7.62**	0.01	-6.28**	-3.93**	-0.45**	-0.45**	-0.38
WRGL - 22 (P2)	-0.24	-4.38**	-3.40**	-0.82	-0.39	-2.27**	0.41*	-0.56**	-0.11
MMH-9607 (P3)	1.03	-5.91**	-0.93	2.96**	0.91	2.21**	-0.92**	-0.26	-0.36
Med-9 (P4)	-3.63**	-0.08	-1.98**	1.07*	1.61**	1.62**	0.36*	0.36	0.26
WRGL-34 (P5)	6.64**	4.53**	6.93**	1.54**	0.49	1.59**	-0.23	-0.42**	-0.19
PARB-96 (P6)	-5.05**	-4.16**	-2.54**	-1.13**	-0.59	-0.24	-0.53**	-0.31*	-0.27
Med-5 (P7)	-11.27**	-8.88**	-8.51**	-7.21**	-5.45**	-5.79**	0.55**	0.86**	0.59**
DMR-110 (P8)	5.31**	9.48**	4.24**	2.01**	2.61**	1.96**	1.02**	0.99**	0.76**
P 8326 (P9)	3.48**	9.62**	6.66**	4.12**	5.47**	4.68**	-0.28	-0.42**	-0.47**
CM 595 (P10)	0.76	11.34**	7.16**	-2.54**	1.63**	0.18	0.08	0.22	0.17
SE(gi)	2.39	2.21	1.79	0.91	1.09	0.71	0.29	0.29	0.38
SE(gi-gi)	3.56	3.30	2.67	1.35	1.63	1.06	0.44	0.43	0.56

Table 4 contd...

Parent	Ear girth			No. of seeds rows/ear			No. of seeds/ear		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
B-57 (P1)	0.31*	-0.01	0.23	0.32**	0.27	0.33*	13.53**	-3.42	-3.19
WRGL - 22 (P2)	-0.28*	-0.03	-0.22	0.27*	0.16	0.22	0.98	-4.31	-16.80**
MMH-9607 (P3)	0.22	-0.14	0.06	-0.18	-0.46**	-0.39*	-22.58**	-28.78**	-22.24**
Med-9 (P4)	0.11	0.24*	0.42**	0.82**	0.82**	0.89**	41.06**	53.72**	55.70**
WRGL-34 (P5)	0.64**	0.27*	0.51**	0.21	-0.12	0.06	0.67	3.47	7.20
PARB-96 (P6)	0.39**	0.02	0.03	0.32**	0.38*	0.28	-20.72**	-14.56**	-13.80**
Med-5 (P7)	-0.44**	-0.26*	-0.41**	-0.73**	-0.51**	-0.67**	-33.83**	-6.17	-19.24**
DMR-110 (P8)	-0.39**	-0.17	-0.38*	-0.62**	-0.18	-0.39*	9.37**	-1.08	14.09**
P 8326 (P9)	-0.03	0.19	0.06	-0.23*	-0.12	-0.28	-6.88*	-2.92	-14.36**
CM 595 (P10)	-0.53**	-0.12	-0.3	-0.18	-0.23	-0.06	18.39**	4.03	12.64**
SE(gi)	0.23	0.20	0.28	0.22	0.27	0.30	5.00	6.92	5.62
SE(gi-gi)	0.34	0.29	0.42	0.33	0.40	0.44	7.46	10.31	8.38

Table 4 contd...

Parent	Shelling percentage			100 Seed weight (g)			Grain yield / plot (g)		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
B-57 (P1)	-1.37**	-0.22	-0.98**	-1.40**	-1.47**	-1.49**	-0.05*	-0.16**	-0.13**
WRGL - 22 (P2)	-0.42**	-0.69**	-0.37*	-0.43**	-0.56**	-0.61**	-0.07**	-0.05*	-0.15**
MMH-9607 (P3)	-0.73**	-1.74**	-1.21**	0.18	0.42*	0.39*	-0.06**	-0.11**	-0.07**
Med-9 (P4)	0.41**	0.76**	0.57**	-2.4**	-2.75**	-2.44**	0.08**	0.11**	0.08**
WRGL-34 (P5)	1.08**	0.37*	0.66**	0.43*	0.61**	0.42**	0.07**	0.09**	0.07**
PARB-96 (P6)	0.19	0.14	0.52**	1.57**	1.81**	1.76**	-0.04*	0.06**	0.09**
Med-5 (P7)	-0.14	-0.27	-0.26	2.07**	1.92**	2.06**	0.15**	0.11**	0.07**
DMR-110 (P8)	1.27**	1.56**	1.27**	0.91**	0.72**	0.78**	0.02	0.05*	0.14**
P 8326 (P9)	-0.23	0.03	-0.26	0.49**	0.36*	0.64**	-0.08**	-0.01	-0.01
CM 595 (P10)	-0.06	0.06	0.07	-1.43**	-1.06**	-1.52**	-0.02	-0.10**	-0.07**
SE(g)	0.23	0.30	0.31	0.28	0.29	0.29	0.02	0.02	0.02
SE(gi-g)	0.34	0.44	0.46	0.42	0.43	0.43	0.04	0.03	0.03

Table 4 contd...

Parent	Oil percentage			Protein percentage		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
B-57 (P1)	0.03**	0.02*	-0.02	-0.11**	-0.25**	-0.22**
WRGL - 22 (P2)	-0.03**	0.00	-0.08**	0.36**	0.38**	0.31**
MMH-9607 (P3)	-0.08**	0.00	-0.06**	1.34**	1.39**	1.25**
Med-9 (P4)	-0.22**	-0.13**	-0.13**	-0.40**	-0.37**	-0.30**
WRGL-34 (P5)	-0.20**	-0.22**	-0.08**	0.17**	0.10**	0.17**
PARB-96 (P6)	0.18**	0.16**	0.11**	-0.58**	-0.66**	-0.72**
Med-5 (P7)	0.14**	0.12**	0.02	0.43**	0.43**	0.44**
DMR-110 (P8)	0.14**	0.08**	0.14**	-0.34**	-0.32**	-0.34**
P 8326 (P9)	-0.13**	-0.15**	-0.10**	-0.62**	-0.54**	-0.41**
CM 595 (P10)	0.16**	0.12**	0.19**	-0.25**	-0.16**	-0.18**
SE(g)	0.02	0.02	0.03	0.05	0.04	0.04
SE(gi-g)	0.03	0.02	0.05	0.07	0.06	0.05

4.2.1.1.6 Ear length

The parental lines exhibited differential GCA effects at different locations. Parents P2, P4 at Rajendranagar, and P7 and P8 at all the three locations were found to be best contributing parents for ear length with significant positive GCA effects. Parent P9 was the poor combiner at all locations for this trait (Table 4).

4.2.1.1.7 Ear Girth

Parent P1, P5 and P6 at Rajendranagar, P4 and P5 at Karimnagar and Tandoor were the good combiners with significant positive GCA effects for ear girth. Only parent P7 was the poor combiner with significant negative GCA effects at all locations.

4.2.1.1.8 Number of seed rows per ear

Only parent P4 was found as best combiner with highly significant positive GCA effects at all locations. On the other hand P1, P2 and P6 at Rajendranagar, P6 at Karimnagar and P1 at Tandoor were the best combiners for this trait. Parent P7 was the poor combiner with highly significant negative GCA effects at all locations.

4.2.1.1.9 Number of seeds per ear

For number of seeds per ear also, P4 was found superior with highly significant positive GCA effects at all locations. The other good combiners for this trait are P1, P8 and P10 at Rajendranagar and P8, P10 at Tandoor with highly significant positive GCA effect. Three parents namely P3, P6 and P7 were the poor combiners for this trait at all locations (Table 4).

4.2.1.1.10 Shelling per cent

Only three parents, P4, P5 and P8 found as best combiners for shelling per cent with significant positive GCA effects at all locations. P2 and P3 are the poor combiners at all locations for this trait.

4.2.1.1.11 100 seed weight

As many as five parents viz., P5, P6, P7, P8 and P9 were the best combiners with significant positive GCA effects at all locations for this important yield contributing character. However, P3 was also a good combiner at Rajendranagar and Tandoor. P4 and P9 were the poor combiners for this trait at all locations (Table 4).

4.2.1.1.12 Grain yield

Only three parents namely P4, P5 and P7 were the best combiners with highly significant positive GCA effects at all locations. P6 and P8 were also best combiners at Karimnagar and Tandoor. P1, P2 and P3 were the poor combiners for yield at all locations.

4.2.1.1.13 Oil content

Among the parents, P6, P8 and P10 were the best combiners with highly significant positive GCA effects for oil content at all locations. P1 and P7 at Rajendranagar and P1, P7 and P10 at Karimnagar were the other best combiners, while P4, P5 and P9 were the poor combiners for oil content.

4.2.1.1.14 Protein content

As many as four parents, P2, P3, P5 and P7 were found as the best combiners for protein content with highly significant positive GCA effects at all locations. On the other hand, P1, P4, P6, P8, P9 and P10 at all the locations recorded significant negative GCA effects (Table 4).

4.2.1.2 Specific combining ability

Specific combining ability effects of 45 F1 hybrids for yield and its components, oil and protein content at three locations are presented in table 5.

4.2.1.2.1 Days to 50 per cent tasseling

Out of 45 hybrids, 9 hybrids at Rajendranagar, 14 hybrids at Karimnagar and 6 hybrids at Tandoor recorded significant negative SCA effects. Three hybrids viz., P1xP2, P3xP9 and P4xP10 exhibited significant negative SCA effects at all locations. Four hybrids at Rajendranagar, three at Karimnagar and one at Tandoor exhibited significant positive SCA effects. Only one hybrid P1xP5 recorded significant positive SCA effects at all locations (Table 5).

4.2.1.2.2 Days to 50 per cent silking

Significant negative SCA effects for 50 per cent silking were recorded in 7 hybrids each at Rajendranagar, 9 hybrids at Karimnagar and 8 hybrids at Tandoor. Three hybrids P3xP9, P3xP10 and P4xP10 exhibited significant negative SCA effects at all locations.

Three hybrids at Rajendranagar and One at Karimnagar and four hybrids at Tandoor recorded significant positive SCA effects.

4.2.1.2.3 Days to 50 per cent brown husk

As many as 9 hybrids at Rajendranagar, 13 at Karimnagar and 8 at Tandoor recorded significant negative SCA effects. Four hybrids P2xP3, P4xP10, P5xP6 and P5xP7 recorded significant negative SCA effects at all locations. Six hybrids P1xP5, P1xP10, P3xP6, P3xP7, P4xP6 and P4xP9 exhibited significant positive SCA effects at all locations (Table 5).

Table 6: Estimates of Specific Combining Ability effects of the 46 hybrids for yield, yield components, oil and protein at three locations

Crosses	Days to 50% tasseling			Days to 50% silking			Days to 50% brown husk		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
P1 x P2	-1.79**	-1.63*	-2.70**	-1.08	-1.02	-0.46	-0.89	-1.11*	-0.8
P3	-0.84	-1.33*	-1.78*	-1.39	-0.55	-0.26	-1.14	-1.11*	-0.83
P4	-1.23	1.90**	0.22	-1.53*	0.12	0.96	-1.14	0.69	0.7
P5	2.02**	1.65*	1.99*	2.06**	1.15	2.52**	3.49**	2.78**	3.34**
P6	-1.68*	1.01	-0.14	-1.19	0.37	-0.4	-0.51	1.22*	0.51
P7	0.46	-1.16	-1.17	0.53	-0.55	-1.21	1.52*	0.28	-0.58
P8	-0.84	-2.71**	-1.92*	-1.14	-1.43*	-2.76**	0.52	-0.17	-0.66
P9	0.46	-0.21	0.38	1.56*	-0.55	-0.26	2.63**	2.44**	1.2
P10	0.57	-0.13	0.91	0.53	0.32	1.96**	1.74**	2.16**	3.34**
P2 x P3	0.27	-2.94**	-1.26	-1.31	-1.63*	-0.68	-1.59**	-2.64**	-1.86**
P4	1.21	-0.05	0.41	0.56	0.7	0.54	0.74	0.16	0.34
P5	-1.54*	0.37	-1.48	-1.53*	-0.93	-0.9	-0.28	-0.09	-0.36
P6	-0.23	-1.94**	-0.28	-0.44	-1.05	-0.82	1.05	0.36	1.14
P7	0.91	0.56	0.69	0.28	0.37	0.04	1.74**	1.41**	0.73
P8	-0.4	-0.99	0.27	-0.39	0.15	-1.18	1.74**	1.64**	-0.02
P9	-1.76**	-1.16	-2.09*	-1.69*	-0.63	-1.35*	-0.48	1.25*	0.17
P10	0.02	-1.08	0.11	2.28**	-1.77**	0.54	3.30**	2.30**	2.98**
P3 x P4	1.82**	-1.08	0.66	1.25	-0.49	0.74	0.83	-0.17	0.98
P5	0.74	0.01	0.11	0.83	0.54	-0.71	2.47**	2.58**	0.28
P6	0.38	1.04	0.63	0.58	0.76	0.38	1.47*	1.36*	1.78**
P7	0.52	0.2	0.61	1.31	1.51*	2.24**	2.16**	2.41**	3.37**
P8	-0.79	0.65	-0.81	-0.36	-0.05	-0.32	1.16	0.97	0.95
P9	-3.48**	-1.85**	-3.17**	-3.67**	-2.16**	-3.48**	-1.73**	-0.75	-2.19**
P10	-2.37**	-2.77**	-0.98	-2.69**	-2.30**	-2.93**	-0.62	-0.03	-1.38*
P4 x P5	0.02	0.23	0.44	-0.64	-0.8	0.18	1.13	2.72**	2.48**
P6	-0.68	1.26	1.3	0.44	0.76	-0.4	1.80**	2.16**	1.64**
P7	-0.2	-2.91**	-1.06	-0.83	-0.82	-0.54	1.16	1.89**	0.89
P8	-0.84	-1.13	-0.81	-1.17	-0.71	-1.1	1.16	1.11*	1.14
P9	1.46*	0.04	1.16	0.86	-0.49	0.74	2.27**	1.39*	2.34**
P10	-3.09**	-3.21**	-4.31**	-3.83**	-2.63**	-3.04**	-4.28**	-5.22**	-6.19**
P5 x P6	-1.43*	-0.99	-2.26**	-1.64*	-0.55	-1.85**	-1.89**	-1.42**	-2.05**
P7	-1.29	-0.83	-0.95	-0.92	-0.46	-1.98**	-1.53*	-1.36*	-2.13**
P8	-0.59	-2.05**	0.3	0.08	-1.68*	-0.21	-1.53*	-3.47**	-0.55
P9	0.71	0.12	0.27	0.11	0.54	0.29	0.24	-0.53	-1.02
P10	0.82	-0.46	1.13	1.08	0.4	0.52	-0.31	-1.47**	1.12
P6 x P7	-1.65*	0.87	1.24	-0.83	-0.57	-0.9	-2.20**	-0.25	1.03
P8	1.71*	-1.35*	-0.17	1.17	-0.8	0.88	1.13	0.97	0.28
P9	0.02	-1.85**	-1.2	0.53	-0.91	0.04	-0.42	-2.42**	-0.86
P10	0.46	-1.44*	-1.67	0.5	-0.71	0.6	-0.64	-1.36*	-2.38**
P7 x P8	0.85	-1.19	0.13	0.22	-1.38*	-0.6	-0.17	-1.97**	-1.13
P9	-0.84	0.31	-0.56	-1.08	-0.49	-1.76**	-1.73**	-1.03	-0.94
P10	0.27	1.40*	0.63	0.89	0.7	1.46*	-0.62	-0.31	0.2
P8 x P9	-1.15	-0.24	-0.98	-0.42	-0.05	0.02	-2.39**	-1.47**	-1.02
P10	0.96	0.51	1.22	0.22	-0.18	0.24	0.05	-0.75	0.12
P9 x P10	-0.40	-1.66*	-1.14	-0.75	-1.63*	-1.26	-1.17	-2.47**	-1.36*
SE(sj)	0.62	0.62	0.8	0.61	0.61	0.62	0.56	0.5	0.58

* Significant at (P<0.05)

** Significant at (P<0.01)

Table 6 contd..

Crosses	Plant height			Ear height			Ear length		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
P1 x P2	-10.55*	27.27**	12.56**	-15.21**	-4.81*	-7.45**	0.06	1.1	0.37
P3	12.84**	5.47	15.08**	11.02**	6.21**	11.07**	1.40*	-0.54	0.29
P4	7.18	5.97	11.81**	2.57	2.85	4.66**	0.12	2.85**	1.68*
P5	1.23	1.02	5.56	-2.23	-3.7	-2.65	0.04	-0.38	0.12
P6	7.59	15.72**	15.69**	11.10**	11.71**	12.18**	-1.99**	1.51**	0.21
P7	7.15	13.77**	15.00**	-7.48**	-4.76*	-4.93**	2.92**	1.35*	1.35
P8	1.9	14.74**	9.92**	11.96**	17.85**	14.32**	2.45**	-0.79	0.51
P9	-2.27	-3.39	-0.83	-1.15	-1.01	-0.07	-0.24	1.62**	0.07
P10	9.12	-3.45	7	5.52**	1.49	7.77**	1.40*	-0.02	0.76
P2 x P3	-7.27	-14.03**	-14.14**	-3.48	-8.67**	-6.26**	0.54	0.57	0.68
P4	20.07**	14.13**	13.92**	9.07**	5.30*	7.32**	2.59**	1.96**	1.4
P5	-7.55	11.52**	5.67	-0.07	5.08*	5.35**	-1.16	0.4	-0.15
P6	16.15**	26.55**	14.14**	13.27**	14.49**	12.52**	2.15**	-1.38*	0.26
P7	-12.63**	5.94	-1.56	1.68	6.35**	6.74**	-0.6	-1.54**	-0.93
P8	-2.21	7.24	6.69	-2.21	-6.70**	1.32	-0.41	1.32*	0.9
P9	2.95	0.11	-1.72	2.68	-0.56	1.27	-1.1	1.73**	-0.21
P10	8.34	23.05**	17.78**	7.68**	25.60**	6.77**	1.54**	2.10**	2.15**
P3 x P4	9.45*	18.66**	17.78**	1.29	4.66*	4.52**	-0.41	0.65	-0.35
P5	-5.82	11.38*	0.53	0.82	6.77**	3.55*	-0.83	1.43*	-0.57
P6	-7.8	11.74**	-5	-5.51**	0.85	-4.29**	-0.52	-1.02	-0.15
P7	16.76**	20.47**	14.97**	6.90**	6.05**	5.93**	0.4	0.15	0.98
P8	11.84*	16.44**	7.56*	12.68**	13.99**	9.85**	-0.08	2.01**	-0.52
P9	-0.32	-1.37	-8.19*	8.90**	8.13**	5.80**	1.23*	0.43	0.71
P10	13.40**	12.91**	13.31**	6.57**	3.96	6.63**	-0.8	-0.21	0.4
P4 x P5	4.51	1.55	1.58	-5.29**	-6.26**	-6.54**	-0.1	0.82	-0.18
P6	5.54	20.91**	12.72**	0.04	5.83**	2.96*	0.2	0.04	-0.43
P7	7.09	18.63**	8.03*	4.13*	5.69**	4.18**	1.12	1.54**	1.71*
P8	11.51*	17.94**	16.94**	14.90**	15.30**	15.43**	2.65**	0.4	1.54*
P9	12.01*	19.13**	13.53**	0.46	5.10*	2.05	0.95	1.48**	1.43
P10	3.07	-5.92	-5.97	5.79**	2.94	1.88	0.26	0.18	1.12
P5 x P6	4.59	11.30*	2.81	5.90**	3.94	5.66**	0.79	1.48**	1.68*
P7	28.15**	35.02**	28.44**	15.99**	17.46**	15.88**	3.37**	2.32**	2.82**
P8	-0.1	1.33	-0.31	6.10**	6.08**	5.80**	1.23*	0.18	0.98
P9	15.73**	19.52**	12.94**	5.65**	5.21*	5.41**	1.54**	1.60**	1.87*
P10	-12.55**	4.13	-2.56	-6.01**	-2.29	-1.43	0.17	0.96	-0.43
P6 x P7	12.84**	6.72	3.58	7.65**	5.21*	4.71**	1.01	1.21*	0.9
P8	22.59**	17.36**	19.17**	8.10**	2.83	6.63**	0.54	1.07	0.73
P9	15.76**	10.22*	22.42**	12.32**	12.63**	12.91**	-0.16	0.48	0.29
P10	0.15	2.83	1.25	-5.35**	-6.20**	-5.59**	1.81**	1.85**	1.65*
P7 x P8	-9.52*	0.74	0.81	-6.82**	-3.98	-4.15**	0.45	0.9	0.21
P9	15.32**	5.94	12.72**	5.40**	0.83	4.80**	0.76	0.32	1.43
P10	20.04**	15.22**	6.22	6.40**	2.99	4.30**	0.73	1.68**	0.79
P8 x P9	9.73*	6.91	-4.36	2.18	3.44	-2.95*	1.29*	1.85**	1.60*
P10	11.79*	14.52**	15.47**	1.85	1.27	2.88*	1.92**	-0.46	0.62
P9 x P10	20.62**	30.05**	38.39**	5.40**	5.08*	12.82**	1.23*	-0.71	-0.82
SE _{ij}	0.42	0.36	0.52	0.41	0.59	0.55	9.30	12.85	10.45

* Significant at (P<0.05)

** Significant at (P<0.01)

Table 5 contd..

Crosses	Ear glrth			No. of seed rows/ear			No. of seeds/ear		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
P1 x P2	1.03*	0.61	0.69	0.19	0.47	0.29	9.46	74.90**	71.96**
P3	0.53	0.05	-0.25	-0.04	0.42	0.24	114.35**	40.71**	112.74**
P4	0.64	0.33	0.39	2.30**	-0.19	1.63**	44.38**	56.21**	28.80*
P5	0.12	0.64	0.3	-0.42	0.09	-0.21	1.44	49.79**	-5.37
P6	0.37	1.55**	1.11*	0.8	2.25**	1.57**	-34.51**	45.82**	23.63*
P7	0.2	0.83*	0.55	-0.15	-0.19	-0.82	116.60**	40.10**	46.41**
P8	1.14*	0.41	0.86	1.08*	-0.53	0.24	102.74**	21.68	85.74**
P9	-0.22	0.39	0.08	-0.65	0.75	0.13	-58.67**	34.85*	-32.48**
P10	-0.72	-0.64	-0.89	0.63	0.2	0.57	60.38**	-12.1	15.85
P2 x P3	0.12	-0.92*	-0.14	0.69	-0.8	-0.32	23.24*	6.93	55.69**
P4	1.23**	1.69**	0.5	-0.31	-0.08	-0.26	97.60**	55.10**	8.41
P5	0.7	0.66	-0.25	0.3	-0.47	-0.1	41.33**	-10.65	12.24
P6	0.95*	0.91*	0.22	0.19	-0.97	-0.32	78.71**	-35.29*	-15.42
P7	0.78	0.19	0.33	3.24**	2.59**	2.63**	-26.17**	74.32**	42.69**
P8	-0.27	0.11	0.64	-0.87*	0.25	0.35	13.96	25.9	19.35
P9	-0.63	1.08**	0.19	0.74	1.53**	0.24	58.21**	98.40**	38.46**
P10	0.87	0.39	0.22	0.69	0.31	0.68	60.27**	33.46*	14.13
P3 x P4	0.73	0.80*	0.55	0.13	1.20*	-0.32	15.16	79.90**	63.19**
P5	0.2	0.78	0.47	0.74	0.81	0.52	10.55	14.82	-21.65
P6	0.45	0.69	1.28*	0.63	1.64**	0.96	16.27	34.52*	18.02
P7	0.28	0.97*	0.72	0.35	-0.14	1.24*	38.05**	41.13**	66.80**
P8	0.23	-0.11	0.36	-0.42	-1.14*	-1.04	-13.81	-20.96	-22.54*
P9	1.87**	0.86*	0.91	1.19**	0.81	1.52*	89.44**	33.54*	46.58**
P10	0.37	0.5	0.28	-0.2	0.25	-0.71	-10.84	-9.4	-22.42*
P4 x P5	0.31	0.39	-0.22	-0.26	-1.14*	-0.76	-2.09	-7.35	-5.59
P6	-0.44	0.3	-0.42	-2.37**	-0.97	-0.98	-28.70**	42.02**	23.41*
P7	-0.61	-0.09	0.03	-1.31**	-0.75	-1.37*	-23.59*	7.63	3.52
P8	1.01*	0.5	0	0.58	0.25	0.35	133.21**	141.21**	134.85**
P9	1.98**	1.14**	1.22*	2.19**	1.53**	2.24**	128.13**	70.38**	108.63**
P10	1.48**	0.78	0.91	0.8	1.64**	1.35*	51.52**	64.77**	61.63**
P5 x P6	1.03*	0.94*	0.5	1.58**	-0.03	0.52	59.69**	72.27**	44.58**
P7	0.87	1.22**	0.94	0.63	1.53**	1.46*	80.80**	116.54**	71.35**
P8	0.81	0.47	0.91	1.19**	-0.14	0.52	86.94**	-6.54	75.35**
P9	0.45	0.44	0.47	-1.20**	-0.19	-0.26	21.52*	49.96**	57.80**
P10	-0.05	1.08**	0.83	0.74	1.25*	0.85	28.58**	79.35**	88.13**
P6 x P7	1.12*	0.47	0.41	-0.15	0.36	-0.1	52.19**	-8.1	9.02
P8	1.06*	0.39	0.39	1.74**	2.03**	1.63**	43.66**	80.15**	87.02**
P9	0.7	0.69	1.28*	0.69	0.64	0.18	51.24**	23.99	35.46**
P10	0.2	0.33	0.64	0.63	-1.25*	-0.04	56.63**	36.04**	71.13**
P7 x P8	-0.11	0.33	0.16	-1.20**	-1.08*	-1.43*	-16.56	25.77	-32.87**
P9	0.53	0.3	0.39	-0.26	-0.47	-0.21	24.35*	-19.07	28.24*
P10	1.03*	0.94*	0.75	-0.31	-0.36	-0.43	36.41**	47.99**	30.58**
P8 x P9	0.48	1.55**	1.36*	-0.37	0.53	0.18	-22.84*	24.52	14.91
P10	-0.02	0.53	-0.28	-0.42	1.31*	1.29*	-1.12	28.24*	-6.76
P9 x P10	0.62	0.5	0.28	-0.81	-0.75	-0.15	49.80**	21.4	47.69**
SE(sj)	4.44	4.11	3.33	1.68	2.03	1.32	0.54	0.53	0.70

* Significant at (P<0.05)

** Significant at (P<0.01)

Table 5 contd..

Crosses	Shelling percentage			100 seed weight			Grain yield		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
P1 x P2	0.54	2.52**	2.56**	4.94**	3.85**	5.05**	0.80**	0.76**	0.84**
P3	1.18*	1.24*	1.72**	2.33**	1.87**	2.05**	0.64**	0.43**	0.75**
P4	2.71**	1.07	0.61	3.91**	3.37**	3.88**	-0.16**	0.46**	0.46**
P5	2.04**	-0.54	0.53	-0.92	0.68	0.02	-0.10*	0.24**	-0.08
P6	-0.07	2.68**	1.67**	1.94**	2.15**	1.68**	0.95**	0.45**	0.23**
P7	2.26**	3.10**	1.44*	2.44**	2.37**	2.38**	0.30**	0.41**	0.45**
P8	4.85**	3.27**	3.92**	-1.73**	-0.43	-1.68**	-0.42**	-0.01	0.22**
P9	0.35	-2.20**	0.11	-0.65	-2.07**	-0.2	0.29**	-0.02	-0.26**
P10	3.18**	0.77	1.11	-0.06	1.35*	0.96	0.35**	-0.01	0.10*
P2 x P3	-0.1	0.05	-0.22	3.35**	2.96**	2.49**	0.72**	0.18**	0.49**
P4	1.76**	2.21**	2.00**	1.60**	1.46*	1.99**	0.42**	0.29**	0.19**
P5	-1.24**	0.6	0.25	2.10**	1.76**	2.13**	0.52**	0.17**	0.24**
P6	3.98**	2.82**	4.06**	0.96	0.57	0.8	-0.19**	-0.23**	-0.07
P7	3.32**	0.57	0.83	-0.87	-0.54	-0.51	0.23**	0.40**	0.17**
P8	1.90**	0.74	-0.69	1.63**	2.98**	1.77**	-0.11*	0.34**	0.25**
P9	4.40**	4.27**	4.83**	-3.95**	-2.65**	-3.09**	0.61**	0.26**	-0.13**
P10	4.23**	4.24**	4.50**	2.30**	1.76**	1.07	0.05	0.26**	0.14**
P3 x P4	-0.27	1.27*	1.83**	0.33	1.15*	0.66	-0.01	0.52**	0.33**
P5	2.40**	0.99	1.75**	0.49	0.12	0.13	0.30**	0.17**	-0.17**
P6	-0.71	-0.79	-0.11	3.69**	2.60**	2.80**	0.49**	0.35**	0.28**
P7	4.62**	3.63**	1.67**	3.52**	4.48**	3.49**	0.10*	0.60**	0.68**
P8	1.21**	0.8	0.14	3.02**	4.35**	3.77**	0.57**	0.24**	0.15**
P9	3.71**	2.32**	2.67**	1.44*	3.04**	3.91**	0.13**	0.41**	0.56**
P10	1.54**	0.3	1.33*	2.35**	1.46*	1.74**	-0.03	-0.01	-0.03
P4 x P5	-2.74**	-1.51*	-2.36**	-0.92	-1.38*	-1.04	0.16**	-0.10*	-0.18**
P6	3.15**	0.71	0.11	4.94**	4.76**	4.63**	-0.16**	0.62**	0.58**
P7	-1.52**	-0.2	-0.11	0.44	1.65**	1.32*	0.74**	0.20**	0.13**
P8	0.07	0.3	-0.64	1.27*	0.85	1.27*	0.62**	0.86**	0.84**
P9	-0.43	0.82	0.89	0.69	-0.13	-0.26	0.37**	0.30**	0.48**
P10	-0.6	-0.87	-0.44	1.94**	1.62**	1.91**	0.70**	0.40**	0.44**
P5 x P6	-0.52	-2.90**	-0.97	3.44**	2.40**	3.10**	0.31**	0.62**	0.55**
P7	2.82**	2.52**	1.81**	-1.40*	-1.04	-0.2	0.95**	0.53**	0.39**
P8	-0.6	0.68	1.28*	4.44**	4.15**	4.07**	0.57**	0.34**	0.89**
P9	-1.10*	0.21	0.14	5.19**	3.85**	3.88**	-0.17**	0.62**	0.69**
P10	1.73**	2.18**	-0.19	-2.90**	-1.74**	-2.95**	0.49**	0.16**	0.10*
P6 x P7	-0.29	-0.26	-0.06	2.46**	2.10**	2.80**	-0.06	0.20**	0.25**
P8	-0.71	-0.09	-1.58*	-3.37**	-2.71**	-2.59**	0.33**	0.27**	0.22**
P9	-1.21**	-0.57	-0.72	0.05	0.65	0.55	0.62**	0.17**	0.21**
P10	-0.38	-0.26	0.61	1.96**	3.07**	3.38**	0.27**	0.45**	0.73**
P7 x P8	-0.38	-0.68	1.19	2.46**	0.18	2.43**	0.27**	0.09*	-0.01
P9	0.12	1.85**	1.06	3.55**	3.87**	3.24**	0.23**	0.21**	0.42**
P10	0.96*	-0.84	0.72	1.46**	0.96	1.41*	0.07	0.35**	0.29**
P8 x P9	0.71	1.02	1.19	2.38**	1.73**	2.52**	0.33**	0.27**	0.30**
P10	0.54	2.99**	1.86**	1.96**	2.15**	1.68**	0.75**	0.45**	0.10*
P9 x P10	1.04*	0.52	0.39	5.05**	5.51**	4.82**	0.15**	0.63**	0.70**
SE _{ij}	0.42	0.55	0.48	0.52	0.54	0.54	0.04	0.05	0.04

* Significant at (P<0.05)

** Significant at (P<0.01)

Table 5 contd..

Crosses	Oil percentage			Protein percentage		
	Rajendra-nagar	Karim-nagar	Tandoor	Rajendra-nagar	Karim-nagar	Tandoor
P1 x P2	-0.10**	-0.31**	-0.15*	3.41**	3.47**	3.54**
P1 x P3	0.05	-0.11**	-0.27**	-1.78**	-2.01**	-1.60**
P1 x P4	0.71**	0.56**	0.71**	-1.76**	-1.69**	-2.05**
P1 x P5	0.66**	0.73**	0.69**	0.78**	0.61**	0.50**
P1 x P6	0.75**	0.74**	0.84**	-1.35**	-1.54**	-1.30**
P1 x P7	0.71**	0.76**	0.61**	2.02**	2.22**	2.11**
P1 x P8	0.17**	0.39**	0.13*	-2.02**	-2.07**	-2.05**
P1 x P9	-0.86**	-0.95**	-1.02**	3.00**	3.15**	3.40**
P1 x P10	0.40**	0.47**	0.50**	-1.84**	-2.09**	-2.15**
P2 x P3	-0.25**	-0.21**	-0.20**	-4.33**	-4.47**	-4.06**
P2 x P4	0.90**	0.74**	0.89**	-2.61**	-2.77**	-2.67**
P2 x P5	-0.17**	0.02	-0.17*	-0.04	-0.12	0.06
P2 x P6	0.50**	0.62**	0.47**	3.41**	3.74**	2.90**
P2 x P7	-1.18**	-1.11**	-1.08**	1.26**	1.57**	1.72**
P2 x P8	0.20**	0.12**	-0.13*	1.31**	1.42**	1.35**
P2 x P9	1.16**	1.26**	1.34**	-2.48**	-2.44**	-2.48**
P2 x P10	-0.57**	-0.12**	-0.07	0.52**	0.36**	0.22**
P3 x P4	-0.19**	0.32**	0.15*	1.94**	2.49**	1.90**
P3 x P5	0	-0.30**	0.04	0.58**	0.70**	0.46**
P3 x P6	-0.50**	-0.39**	-0.62**	0.75**	0.72**	1.22**
P3 x P7	0.88**	0.79**	0.78**	1.56**	1.63**	1.72**
P3 x P8	0.61**	0.33**	0.44**	0.54**	0.75**	0.49**
P3 x P9	0.88**	1.03**	1.15**	-2.39**	-2.53**	-2.40**
P3 x P10	-0.71**	-0.67**	-0.64**	1.61**	1.42**	1.54**
P4 x P5	0.17**	0.26**	0.1	-2.23**	-2.44**	-2.42**
P4 x P6	0.69**	0.50**	0.67**	2.26**	2.22**	2.54**
P4 x P7	0.78**	0.79**	0.24**	2.34**	2.36**	2.47**
P4 x P8	-0.66**	-0.56**	-0.44**	1.12**	0.97**	1.11**
P4 x P9	-0.52**	-0.44**	-0.34**	2.36**	2.40**	3.23**
P4 x P10	0.94**	0.78**	0.83**	0.99**	0.89**	0.95**
P5 x P6	0.81**	0.71**	0.75**	0.99**	1.01**	1.02**
P5 x P7	-0.03	0.13**	0.13*	2.96**	2.68**	2.83**
P5 x P8	-1.58**	-1.23**	-0.89**	0.85**	1.02**	0.83**
P5 x P9	0.01	-0.13**	-0.06	-0.24**	-0.35**	-0.30**
P5 x P10	0.43**	-0.09**	-0.01	0.48**	0.49**	0.48**
P6 x P7	-0.42**	-0.59**	-0.58**	-2.37**	-2.21**	-2.35**
P6 x P8	0.27**	0	-0.1	-1.10**	-1.22**	-1.33**
P6 x P9	-0.45**	-0.20**	-0.35**	-2.28**	-1.97**	-2.65**
P6 x P10	0.20**	0.29**	0.37**	-1.48**	-1.69**	-1.60**
P7 x P8	-0.12**	-0.23**	-0.05	-1.03**	-1.28**	-1.02**
P7 x P9	-0.64**	-0.49**	-0.29**	-1.47**	-1.41**	-1.82**
P7 x P10	0.18**	0.38**	0.26**	-2.20**	-2.57**	-2.82**
P8 x P9	0.38**	0.57**	0.49**	-1.74**	-1.94**	-1.84**
P8 x P10	0.02	0.31**	0.31**	-1.92**	-1.72**	-1.97**
P9 x P10	-0.35**	-0.54**	-0.53**	-1.79**	-1.89**	-2.08**
SEsij	0.03	0.03	0.06	0.46	0.45	0.06

* Significant at (P<0.05)

** Significant at (P<0.01)

4.2.1.2.4 Plant height

Significant and desirable positive significant positive SCA effects were recorded in 19 hybrids at Rajendranagar, 26 hybrids at Karimnagar and 24 hybrids at Tandoor respectively. The hybrids P2xP4, P2xP6, P3xP7, P3xP8, P3xP10, P4xP8, P4xP9, P5xP7, P5xP9, P6xP8, P6xP9, P8xP10 and P9xP10 have recorded positive SCA effects at all locations. Four hybrids at Rajendranagar, one at Karimnagar and two at Tandoor recorded significant negative SCA effects. The hybrid P2xP3, recorded significant negative SCA effects at Karimnagar and Tandoor (Table 5).

4.2.1.2.5 Ear height

As many as 24 hybrids at Rajendranagar, 23 at Karimnagar and 30 at Tandoor exhibited significant positive SCA effects 17 hybrids recorded significant Positive SCA effects at all locations and some of them are three hybrids P1xP2, P4xP5 and P6xP10 recorded significant negative SCA effects at all locations.

4.2.1.2.6 Ear length

Significant and desirable positive SCA effects were recorded in 16 hybrids at Rajendranagar, 19 at Karimnagar and 9 at Tandoor. The hybrids P2xP10, P4xP7, P5xP7, P5xP9, P6xP10 and P8xP9 exhibited significant positive SCA effects at all locations. Only one hybrid at Rajendranagar and two at Karimnagar recorded significant negative SCA effects. None of the hybrids recorded significant negative SCA effects at Tandoor.

4.2.1.2.7 Ear girth

As many as 12 hybrids at Rajendranagar, 14 at Karimnagar and 4 at Tandoor exhibited significant positive SCA effects. The hybrid which exhibited

significant positive SCA effect was P4xP9 at all locations. None of the hybrids exhibited significant negative SCA effects at any locations (Table 5).

4.2.1.2.8 Number of seed rows per ear

Eight hybrids at Rajendranagar 11 at Karimnagar and 10 at Tandoor recorded significant positive SCA effects. Three hybrids viz., P2xP7, P4xP9 and P6xP8 recorded significant positive SCA effects at all locations. Five hybrids at Rajendranagar, four at Karimnagar and two at Tandoor registered significant negative SCA effects (Table 5).

4.2.1.2.9 Number of seeds per ear

Out of 45 hybrids, 28 hybrids at Rajendranagar, 27 hybrids at Karimnagar and 27 at Tandoor recorded significant SCA effects in desired direction. As many as 16 hybrids recorded significant positive SCA effects at all locations. The best specific crosses were P4xP9, P1xP7, P3xP9, P5xP7 and P6xP8.

4.2.1.2.10 Shelling per cent

Twenty two hybrids at Rajendranagar, 16 at Karimnagar and 17 at Tandoor exhibited positive SCA effects. The hybrids P1xP3, P1xP7, P1xP8, P2xP6, P2xP9, P2xP10, P3xP7, P3xP9 and P5xP7 recorded significant positive SCA effects at all locations. Only 5 hybrids at Rajendranagar, 3 at Karimnagar and 2 at Tandoor recorded significant negative SCA effects (Table 5).

4.2.1.2.11 100 Seed weight

Twenty nine hybrids at Rajendranagar, Karimnagar and Tandoor exhibited significant positive SCA effects in the desirable direction. A total of 24 crosses recorded significant positive SCA effects while only few hybrids recorded significant negative SCA effects at all locations. The best specific crosses were P5xP9, P7xP9, P3xP7, P5xP8, P3xP8 and P3xP6.

4.2.1.2.12 Grain yield

Out of 45 hybrids, 33 hybrids at Rajendranagar, 39 hybrids at Karimnagar and 37 hybrids at Tandoor recorded significant positive SCA effects. 28 hybrids exhibited significant positive SCA effects at all locations. The hybrid combinations P5xP7, P4xP8, P5xP8, P5xP6, P1xP2, P4xP7 and P4xP10 recorded the significantly higher SCA effects at all the locations. Seven hybrids at Rajendranagar, two at Karimnagar and four at Tandoor recorded significant negative SCA effects. None of the hybrids exhibited significant negative effects at all the three locations (Table 5).

4.2.1.2.13 Oil per cent

As many as 23 hybrids at Rajendranagar, 24 at Karimnagar and 22 at Tandoor recorded significant positive SCA effects. Eighteen hybrids recorded significant positive SCA effects at all locations, some of the best specific crosses were P3xP9, P5xP6, P4xP10, P4xP7, P4xP1, P8xP9, P4xP6 and P3xP8.

4.2.1.2.14 Protein per cent

Twenty three hybrids at Rajendranagar, 22 each at Karimnagar and Tandoor recorded significant positive SCA effects. As many as 22 hybrids recorded significant positive SCA effect at all locations. Twenty one hybrids recorded significant negative SCA effects at all locations (Table 5). The cross combinations P1xP2, P1xP9, P2xP6, P3xP4, P4xP9, P3xP7, P5xP7, P5xP8 and P5xP10 registered significant positive SCA effects at all locations.

4.3 HETEROSIS

Heterosis was estimated in 45 hybrids for 14 characters viz., days to 50 per cent tasseling, days to 50 per cent silking, days to 50 per cent brown husk, plant height, ear height, ear length, ear girth, number of seed rows per ear, number of seeds per ear, shelling percentage, 100 seed weight, grain yield

per plot, oil per cent and protein per cent at three locations viz., Rajendranagar, Karimnagar and Tandoor which is expressed as Heterosis over the mid parent, heterobeltiosis over the better parent and standard heterosis over the high yielding check "CM119xCM211". The negative heterotic values for days to 50 per cent tasseling, days to 50 per cent silking, days to 50 per brown husk indicates earliness which is desirable. For other characters positive estimates were considered as desirable. The character-wise performance of hybrids is presented in Tables 6a to 6n and Figures 2 to 4. The values are expressed in per cent.

4.3.1 Days to 50 per cent tasseling

At Rajendranagar many of the hybrids recorded negative heterosis and heterobeltiosis which ranged from -9.5 (P3xP9) to 2.02 (P1xP5) and -8.47 (P3xP9) to 2.96 (P7xP8) respectively and standard heterosis ranged from -3.57 (P3xP9) to 5.36 (P1xP5). Significant negative heterosis and heterobeltiosis was recorded by 16 and 19 hybrids respectively. Where as one hybrid (P3xP9) found to have highest significant negative standard heterosis of -3.57. This cross also recorded highest significant negative heterosis and heterobeltiosis. Whereas significant positive standard heterosis was observed in 11 hybrids which ranged from 3.57 to 5.36 (Table 6a).

Significant heterosis in negative direction was observed in all hybrids except P1xP5 tested at Karimnagar, which ranged from -12.25 (P2xP3) to 0.90 (P1xP5) and heterosis varied from -12.99 (P2xP3) to 0.00 (P1xP5) heterobeltiosis in P1xP6. Significant negative heterosis in 37 hybrids and heterobeltiosis in 34 hybrids were observed. None of the hybrid exhibited significant positive heterosis. Twenty two hybrids showed significant positive standard heterosis which ranged from 3.85 to 7.69, while none of the hybrids recorded significant negative standard heterosis.

Table 6(a): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids	Days to 50% tasselling								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis
P1 x P2	-5.71**	-6.25**	-1.79	-7.83**	-5.36**	1.92	-9.14**	-8.09**	-1.85
P1 x P3	-4.25**	-3.98*	0.60	-7.02**	-5.36**	1.92	-7.43**	-6.36**	0.00
P1 x P4	-4.00*	-4.55**	0.00	0.00	0.00	7.69**	-2.33	-2.89	3.70
P1 x P5	2.02	0.57	5.36**	0.90	0.00	7.69**	1.47	0.00	6.79**
P1 x P6	-5.44**	-6.25**	-1.79	-0.90	-1.19	6.41**	-3.23	-4.62*	1.85
P1 x P7	-0.87	-2.84	1.79	-4.50**	-5.36**	1.92	-4.14	-6.36**	0.00
P1 x P8	-3.12	-2.84	1.79	-9.57**	-7.14**	0.00	-6.29**	-5.20*	1.23
P1 x P9	-2.52	-1.14	3.57*	-4.35**	-1.79	5.77**	-4.25*	-2.31	4.32
P1 x P10	-1.42	-1.14	3.57*	-5.26**	-3.57*	3.85*	-2.02	-1.73	4.94*
P2 x P3	-2.56	-1.72	1.79	-12.25**	-12.99**	-1.28	-7.34**	-7.34**	1.23
P2 x P4	0.00	0.00	3.57*	-6.09**	-8.47**	3.85*	-2.87	-4.52*	4.32
P2 x P5	-4.35**	-5.17**	-1.79	-4.09*	-7.34**	5.13**	-5.51*	-7.91**	0.62
P2 x P6	-3.17	-3.45*	0.00	-8.72**	-11.30**	0.64	-4.35*	-6.78**	1.85
P2 x P7	-0.29	-1.72	1.79	-4.09*	-7.34**	5.13**	-1.75	-5.08*	3.70
P2 x P8	-2.56	-1.72	1.79	-9.04**	-9.04**	3.21	-3.39	-3.39	5.56*
P2 x P9	-6.48**	-4.60**	-1.19	-8.47**	-8.47**	3.85*	-9.24**	-8.47**	0.00
P2 x P10	-2.56	-1.72	1.79	-9.40**	-10.17**	1.92	-4.27*	-5.08*	3.70
P3 x P4	0.85	0.00	5.36**	-7.60**	-9.20**	1.28	-2.30	-3.95	4.94*
P3 x P5	-0.57	-2.26	2.98	-4.42**	-6.90**	3.85*	-2.61	-5.08*	3.70
P3 x P6	-2.29	-3.39*	1.79	-3.23	-5.17**	5.77**	-2.61	-5.08*	3.70
P3 x P7	-1.16	-3.39*	1.79	-4.42**	-6.90**	3.85*	-1.75	-5.08*	3.70
P3 x P8	-3.39*	-3.39*	1.79	-5.98**	-5.17**	5.77**	-5.08*	-5.08*	3.70
P3 x P9	-9.50**	-8.47**	-3.57*	-9.40**	-8.62**	1.92	-10.92**	-10.17**	-1.85
P3 x P10	-6.78**	-6.78**	-1.79	-12.07**	-12.07**	-1.92	-5.98**	-6.78**	1.85
P4 x P5	-0.87	-1.72	1.79	-2.70	-3.57*	3.85*	-0.29	-1.17	4.32
P4 x P6	-3.17	-3.45*	0.00	-1.49	-1.79	5.77**	0.29	-0.58	4.94*
P4 x P7	-1.46	-2.87	0.60	-8.71**	-9.52**	-2.56	-2.98	-4.68*	0.62
P4 x P8	-2.56	-1.72	1.79	-7.83**	-5.36**	1.92	-3.45	-1.75	3.70
P4 x P9	-0.28	1.72	5.36**	-4.93**	-2.38	5.13**	-1.99	0.58	6.17**
P4 x P10	-7.12**	-6.32**	-2.98	-11.70**	-10.12**	-3.21	-10.14**	-9.36**	-4.32
P5 x P6	-4.07*	-3.51*	-1.79	-4.22*	-3.64*	1.92	-5.36*	-5.36*	-1.85
P5 x P7	-2.94	-3.51*	-1.79	-3.64*	-3.64*	1.92	-2.10	-2.98	0.62
P5 x P8	-1.72	0.00	1.79	-8.19**	-4.85**	0.64	-0.87	1.79	5.56*
P5 x P9	-1.14	1.75	3.57*	-3.51*	0.00	5.77**	-2.87	0.60	4.32
P5 x P10	0.00	1.75	3.57*	-5.60**	-3.03	2.56	0.00	1.79	5.56*
P6 x P7	-4.68**	-5.78**	-2.98	-1.20	-1.80	5.13**	0.90	0.00	3.70
P6 x P8	1.14	2.31	5.36**	-7.56**	-4.79**	1.92	-2.61	0.00	3.70
P6 x P9	-3.39*	-1.16	1.79	-7.56**	-4.79**	1.92	-6.32**	-2.98	0.62
P6 x P10	-1.71	-0.58	2.38	-7.92**	-5.99**	0.64	-5.85**	-4.17	-0.62
P7 x P8	0.58	2.96	3.57*	-7.02**	-3.64*	1.92	-1.17	2.42	4.32
P7 x P9	-4.00*	-0.59	0.00	-3.51*	0.00	5.77**	-4.35*	0.00	1.85
P7 x P10	-1.16	1.18	1.79	-2.65	0.00	5.77**	-0.88	1.82	3.70
P8 x P9	-4.47**	-3.39*	1.79	-6.78**	-6.78**	5.77**	-5.88**	-5.08*	3.70
P8 x P10	0.00	0.00	5.36**	-6.55**	-7.34**	5.13**	-0.85	-1.69	7.41**
P9 x P10	-3.91*	-4.97**	2.38	-9.40**	-10.17**	1.92	-6.78**	-8.33**	1.85

Nineteen hybrids at Tandoor showed significant negative heterosis which ranged from -10.92 (P3xP9) to -4.25 (P1xP9), heterobeltiosis ranged from -10.17 (P3xP9) to -4.52 (P2xP4). None of the hybrid showed negative significant standard heterosis. The significant positive standard heterosis ranged from 7.41 (P8xP10) to 4.94 (P3xP4) considering all the locations. Ten hybrids exhibited significant negative heterosis and heterobeltiosis and promising ones are P1xP2, P1xP3, P2xP5, P2xP9, P3xP9, P4xP10 and P5xP6.

4.3.2 Days to 50 per cent silking

Heterosis for days to 50 per cent silking ranged from -9.76 (P3xP9) to 2.43 (P1xP5) at Rajendranagar, -9.19 (P4xP10) to 0.28 (P1xP5) at Karimnagar and -10.40 (P3xP9) to 3.33 (P1xP5) at Tandoor. The heterobeltiosis ranged from -9.52 (P3xP9) to 4.52 (P6xP8) at Rajendranagar, -8.95 (P9xP10) to 0.00 (P1xP5) at Karimnagar and -8.20 (P3xP9) to 3.33 (P1xP5) at Tandoor. The standard heterosis ranged from -5.00 (P3xP9) to 5.56 (P1xP5) at Rajendranagar, 0.00 (P3xP10) to 7.14 (P5xP9) at Karimnagar and -5.08 (P3xP9) to 5.08 (P1xP10) at Tandoor. Significant negative standard heterosis was observed in P3xP9, P4xP10 at Rajendranagar and in addition to these P3xP10 at Tandoor (Table 6b).

Through varying levels of heterosis and heterobeltiosis was observed at each location only 6 hybrids viz., P2xP3, P2xP5, P2xP9, P3xP9 and P4xP10 exhibited significant negative heterosis and heterobeltiosis.

4.3.3 Days to 50 per cent brown husk

Heterosis ranged from -4.49 (P4xP10) to 6.26 (P1xP5), heterobeltiosis from -3.41 (P4xP10) to 5.26 (P1xP5) and standard heterosis -2.30 (P6xP7) to 7.28 (P1xP5) at Rajendranagar. Five hybrids recorded negative heterosis, 4 heterobeltiosis and 2 standard heterosis at Rajendranagar (Table 6c).

At Karimnagar, heterosis ranged from -6.69 (P4xP10) to 5.26 (P1xP5), heterobeltiosis from -6.34 (P9xP10) to 5.81 (P1xP9) and standard heterosis from

Table 6(b): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids		Days to 50% silking								
		Rajendranagar			Karimnagar			Tandoor		
		Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis
P1 x	P2	-3.74*	-4.26**	0.00	-4.92**	-3.33*	3.57*	-2.48	-1.67	0.00
	P3	-5.04**	-4.79**	-0.56	-3.60*	-3.33*	3.57*	-2.48	-1.67	0.00
	P4	-5.04**	-4.79**	-0.56	-2.48	-1.67	5.36**	0.83	1.67	3.39*
	P5	2.43	1.06	5.56**	0.28	0.00	7.14**	3.33*	3.33*	5.08**
	P6	-3.01	-5.85**	-1.67	-1.39	-1.67	5.36**	-1.67	-1.67	0.00
	P7	0.00	-2.66	1.67	-2.52	-3.33*	3.57*	-3.31*	-2.78	-1.13
	P8	-3.17	-2.66	1.67	-5.69**	-3.33*	3.57*	-6.45**	-3.33*	-1.69
	P9	0.00	0.53	5.00**	-4.32**	-1.67	5.36**	-3.23*	0.00	1.69
	P10	-0.53	-1.06	3.33	-3.54*	-1.67	5.36**	2.48	3.33*	5.08**
P2 x	P3	-5.60**	-4.84**	-1.67	-6.81**	-8.06**	1.79	-4.92**	-4.92**	-1.69
	P4	-2.40	-1.61	1.67	-2.98	-3.76*	6.55**	-1.64	-1.64	1.69
	P5	-4.07*	-4.84**	-1.67	-4.66**	-6.45**	3.57*	-4.13**	-4.92**	-1.69
	P6	-2.48	-4.84**	-1.67	-5.21**	-6.99**	2.98	-4.13**	-4.92**	-1.69
	P7	-1.10	-3.23	0.00	-2.48	-4.84**	5.36**	-3.01	-3.28*	0.00
	P8	-2.66	-1.61	1.67	-4.53**	-3.76*	6.55**	-5.60**	-3.28*	0.00
	P9	-5.85**	-4.84**	-1.67	-5.85**	-4.84**	5.36**	-6.67**	-4.37**	-1.13
	P10	1.61	1.61	5.00**	-8.31**	-8.06**	1.79	-1.64	-1.64	1.69
	P3 x	P4	-2.12	-2.12	2.78	-4.40**	-3.87*	3.57*	-1.64	-1.64
P5		-1.08	-2.65	2.22	-1.67	-2.21	5.36**	-4.13**	-4.92**	-1.69
P6		-1.64	-4.76**	0.00	-1.67	-2.21	5.36**	-2.48	-3.28*	0.00
P7		-0.27	-3.17	1.67	0.00	-1.10	6.55**	0.27	0.00	3.39*
P8		-3.43*	-3.17	1.67	-4.32**	-2.21	5.36**	-4.53**	-2.19	1.13
P9		-9.76**	-9.52**	-5.00**	-7.82**	-5.52**	1.79	-10.40**	-8.20**	-5.08**
P10		-7.20**	-7.94**	-3.33	-8.70**	-7.18**	0.00	-7.65**	-7.65**	-4.52**
P4 x	P5	-3.23	-4.76**	0.00	-3.87*	-4.92**	3.57*	-1.38	-2.19	1.13
	P6	-1.64	-4.76**	0.00	-1.66	-2.73	5.95**	-2.48	-3.28*	0.00
	P7	-3.54*	-6.35**	-1.67	-3.89*	-5.46**	2.98	-3.01	-3.28*	0.00
	P8	-4.49**	-4.23**	0.56	-5.38**	-3.83*	4.76**	-4.53**	-2.19	1.13
	P9	-2.37	-2.12	2.78	-5.09**	-3.28*	5.36**	-2.40	0.00	3.39*
	P10	-8.80**	-9.52**	-5.00**	-9.19**	-8.20**	0.00	-6.56**	-6.56**	-3.39*
P5 x	P6	-3.33	-4.92**	-3.33	-2.79	-2.79	3.57*	-5.00**	-5.00**	-3.39*
	P7	-1.94	-3.28	-1.67	-2.25	-2.79	3.57*	-5.52**	-5.00**	-3.39*
	P8	-0.80	1.09	2.78	-5.98**	-3.35*	2.98	-3.23*	0.00	1.69
	P9	-1.88	0.00	1.67	-2.44	0.56	7.14**	-3.23*	0.00	1.69
	P10	0.81	1.64	3.33	-3.28*	-1.12	5.36**	-0.83	0.00	1.69
P6 x	P7	-1.97	-1.69	-3.33	-2.81	-3.35*	2.98	-3.87*	-3.33*	-1.69
	P8	0.82	4.52**	2.78	-4.89**	-2.23	4.17*	-1.61	1.67	3.39*
	P9	-1.36	2.26	0.56	-5.15**	-2.23	4.17*	-3.76*	-0.56	1.13
	P10	-0.28	2.26	0.56	-5.46**	-3.35*	2.98	-0.83	0.00	1.69
P7 x	P8	-0.54	2.81	1.67	-5.46**	-2.26	2.98	-4.28**	-1.65	1.13
	P9	-3.80*	-0.56	-1.67	-4.09**	-0.56	4.76**	-6.95**	-4.40**	-1.69
	P10	0.55	2.81	1.67	-2.75	0.00	5.36**	0.27	0.55	3.39*
P8 x	P9	-3.16	-3.16	2.22	-5.01**	-4.76**	7.14**	-4.69**	-4.69**	3.39*
	P10	-1.06	-2.11	3.33	-5.85**	-6.35**	5.36**	-2.40	-4.69**	3.39*
P9 x	P10	-3.72*	-4.74**	0.56	-8.22**	-8.95**	2.98	-5.60**	-7.81**	0.00

Table 6(c): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids	Days to 50% brown husk								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis
P1 x P2	2.26*	1.88	3.83**	1.71	3.49**	7.23**	1.51	2.28*	4.26**
P3	1.31	1.50	3.45**	1.53	2.71**	6.43**	1.13	1.90	3.88**
P4	1.51	1.13	3.07**	4.26**	4.26**	8.03**	3.82**	3.42**	5.43**
P5	6.26**	5.26**	7.28**	5.26**	4.65**	8.43**	5.95**	4.94**	6.98**
P6	1.14	0.38	2.30*	3.69**	3.49**	7.23**	2.69**	1.52	3.49**
P7	3.61**	2.63**	4.60**	2.72**	2.33**	6.02**	1.53	0.76	2.71**
P8	2.81**	3.01**	4.98**	0.95	2.71**	6.43**	0.75	1.52	3.49**
P9	3.91**	4.89**	6.90**	3.80**	5.81**	9.64**	2.07*	3.04**	5.04**
P10	2.99**	3.76**	5.75**	2.49**	3.88**	7.63**	4.55**	4.94**	6.98**
P2 x P3	0.56	1.14	2.30*	-1.32	-1.87*	5.22**	-1.12	-1.12	2.33*
P4	3.41**	3.41**	4.60**	2.48**	0.75	8.03**	2.27*	1.12	4.65**
P5	1.71	1.14	2.30*	0.77	-1.50	5.62**	0.57	-1.12	2.33*
P6	2.66**	2.27*	3.45**	1.53	-0.37	6.83**	2.29*	0.37	3.88**
P7	3.62**	3.03**	4.21**	2.87**	0.75	8.03**	1.90	0.37	3.88**
P8	3.95**	4.55**	5.75**	1.87*	1.87*	9.24**	0.37	0.37	3.88**
P9	0.19	1.52	2.68**	1.31	1.50	8.84**	-0.19	0.00	3.49**
P10	4.49**	5.68**	6.90**	1.50	1.12	8.43**	3.01**	2.62**	6.20**
P3 x P4	2.82**	2.25*	4.60**	1.92*	0.76	6.83**	2.65**	1.50	5.04**
P5	4.17**	3.00**	5.36**	3.66**	1.89*	8.03**	0.95	-0.75	2.71**
P6	2.46*	1.50	3.83**	2.50**	1.14	7.23**	2.67**	0.75	4.26**
P7	3.41**	2.25*	4.60**	3.85**	2.27**	8.43**	4.56**	3.00**	6.59**
P8	2.62**	2.62**	4.98**	0.94	1.52	7.63**	1.12	1.12	4.65**
P9	-1.86	-1.12	1.15	-1.13	-0.38	5.62**	-3.18**	-3.00**	0.39
P10	-0.56	0.00	2.30*	-1.32	-1.14	4.82**	-2.26*	-2.62**	0.78
P4 x P5	2.86**	2.27*	3.45**	4.48**	3.88**	7.63**	4.43**	3.83**	5.04**
P6	3.04**	2.65**	3.83**	4.08**	3.88**	7.63**	3.47**	2.68**	3.88**
P7	2.48*	1.89	3.07**	3.89**	3.49**	7.23**	2.69**	2.30*	3.49**
P8	2.82**	3.41**	4.60**	1.71	3.49**	7.23**	2.27*	3.45**	4.65**
P9	2.80**	4.17**	5.36**	1.90*	3.88**	7.63**	2.84**	4.21**	5.43**
P10	-4.49**	-3.41**	-2.30*	-6.69**	-5.43**	-2.01*	-6.84**	-5.13**	-5.04**
P5 x P6	-1.72	-1.53	-1.53	-1.56	-1.18	1.20	-1.75	-1.94	-1.94
P7	-1.15	-1.15	-1.15	-1.37	-1.18	1.20	-1.74	-1.55	-1.55
P8	-0.76	0.38	0.38	-4.98**	-2.75**	-0.40	-0.57	1.16	1.16
P9	0.00	1.92	1.92	-1.72	0.78	3.21**	-1.90	0.00	0.00
P10	-0.56	1.15	1.15	-3.85**	-1.96*	0.40	0.57	1.94	1.94
P6 x P7	-2.49*	-2.67**	-2.30*	0.19	0.00	3.21**	1.94	2.33*	1.94
P8	1.70	2.67**	3.07**	0.38	2.33**	5.62**	0.38	2.33*	1.94
P9	-1.31	0.38	0.77	-3.62**	-1.56	1.61	-1.71	0.39	0.00
P10	-1.50	0.00	0.38	-3.45**	-1.95*	1.20	-3.45**	-1.95	-2.33*
P7 x P8	0.38	1.53	1.53	-2.87**	-0.78	2.01*	-1.14	0.39	0.78
P9	-2.63**	-0.77	-0.77	-1.91*	0.39	3.21**	-1.71	0.00	0.39
P10	-1.32	0.38	0.38	-2.11*	-0.39	2.41**	-0.38	0.77	1.16
P8 x P9	-2.97**	-2.25*	0.00	-3.55**	-3.37**	3.61**	-2.43*	-2.25*	1.16
P10	-0.19	0.37	2.68**	-3.76**	-4.12**	2.81**	-1.13	-1.50	1.94
P9 x P10	-2.77**	-2.95**	0.77	-5.82**	-6.34**	0.80	-3.56**	-4.10**	-0.39

-2.01 (P4xP10) to 9.64 (P1xP9). 11 hybrids exhibited significant negative heterosis, 8 heterobeltiosis and only one (P4xP10) standard heterosis.

At Tandoor, heterosis ranged from -6.84 (P4xP9) to 5.95 (P1xP5), heterobeltiosis -6.13 (P4xP10) to 4.94 (P1xP5) and standard heterosis from -5.04 (P4xP10) to 6.98 (P1xP10). All the types of heterosis in negative direction and recorded in the cross P4xP10 at all locations while maximum positive heterosis was registered in P1xP5.

4.3.4 Plant height

At Rajendranagar, heterosis for plant height ranged from -0.11 (P1xP2) to 56.54 (P1xP10), heterobeltiosis from -13.16 (P2xP7) to 50.00 (P9xP10) and standard heterosis from -18.01 (P2xP7) to 13.04 (P5xP9). Significant positive heterosis was recorded in 39 hybrids, heterobeltiosis in 29 and standard heterosis in 4 hybrids. None of the hybrids recorded significant negative values for heterosis but one hybrid (P2xP7) exhibited significant negative heterobeltiosis and showed significant negative standard heterosis. Maximum standard heterosis in positive direction was recorded in P5xP7, P5xP9, P6xP8, P8xP9 and P9xP10 (Table 6d).

At Karimnagar, heterosis ranged from 33.10 (P2xP3) to 96.42 (P5xP7) heterobeltiosis from 14.84 (P1xP2) to 83.81 (P2xP6) and standard heterosis -22.89 (P2xP3) to 22.49 (P9xP10). Interestingly all the hybrids recorded significant positive heterosis and heterobeltiosis, whereas seven hybrids found to have significant positive standard heterosis.

At Tandoor, heterosis varied from 7.71 (P2xP3) to 66.76 (P9xP10), heterobeltiosis from 3.3 (P2xP3) to 65.42 (P9xP10) and standard heterosis from -16.67(P2xP3) to 26.95(P9xP10). All hybrids (except) recorded significant positive heterosis as well as heterobeltiosis. With regard to standard heterosis nine hybrids were significant positive and eight hybrids were significantly

Table 6(d): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids	Plant height								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis
P1 x P2	-0.11	-2.41	-7.87	78.55**	76.62**	-1.41	46.00**	29.17**	-4.32
P3	22.84**	19.31**	7.45	47.46**	40.80**	-15.46**	43.50**	22.45**	-1.23
P4	28.25**	12.18**	1.04	56.58**	51.72**	-11.65**	58.31**	49.20**	-3.91
P5	11.21*	7.51	3.73	43.70**	29.50**	-11.85**	36.30**	13.10**	-2.26
P6	28.14**	11.49*	0.41	76.11**	68.01**	-8.23*	61.15**	51.43**	-1.85
P7	31.36**	6.90	-3.73	77.64**	60.66**	-12.25**	64.98**	64.98**	-5.97
P8	17.55**	14.71**	3.31	54.69**	34.51**	-0.60	46.56**	26.98**	-1.23
P9	21.77**	10.57*	-0.41	34.45**	14.84**	-11.45**	40.00**	21.98**	-6.38*
P10	27.23**	16.55**	4.97	35.77**	15.84**	-10.44**	49.07**	30.79**	-1.23
P2 x P3	3.70	-1.54	-7.04	33.10**	28.43**	-22.89**	7.71	3.32	-16.67**
P4	32.23**	13.38**	7.04	71.13**	67.59**	-2.41	44.43**	35.00**	0.00
P5	0.87	-0.21	-3.73	59.48**	45.13**	-1.20	25.13**	16.19**	0.41
P6	28.79**	9.87*	3.73	94.67**	83.81**	2.61	43.70**	34.72**	-0.21
P7	8.64	-13.16**	-18.01**	74.70**	56.47**	-12.65**	31.87**	16.67**	-13.58**
P8	9.66*	4.61	-1.24	52.94**	34.24**	-0.80	30.89**	27.78**	-0.62
P9	20.10**	6.80	0.83	42.90**	23.18**	-5.02	26.88**	24.66**	-4.32
P10	21.03**	8.55	2.48	65.01**	42.08**	9.84**	44.43**	43.05**	8.02*
P3 x P4	32.88**	19.27**	1.24	68.08**	65.55**	-0.60	43.26**	28.83**	3.91
P5	8.22	1.72	-1.86	52.66**	43.66**	-2.21	18.23**	14.29**	-1.23
P6	18.31**	5.61	-10.35*	69.23**	54.52**	-7.23	23.06**	10.97**	-10.49**
P7	42.90**	19.02**	1.04	82.66**	58.53**	-4.82	42.60**	21.68**	-1.85
P8	26.94**	26.33**	8.28	55.02**	40.49**	3.82	28.05**	25.77**	1.44
P9	25.75**	17.32**	-0.41	35.87**	20.83**	-6.83	18.43**	15.56**	-6.79*
P10	33.16**	25.37**	6.42	49.71**	32.99**	2.81	36.76**	32.40**	6.79*
P4 x P5	23.99**	5.36	1.66	51.03**	40.12**	-4.62	30.97**	14.29**	-1.23
P6	41.67**	40.80**	-4.97	88.83**	74.83**	1.81	54.46**	53.97**	-0.21
P7	48.58**	36.50**	-7.87	90.59**	67.59**	-2.41	53.56**	44.73**	-6.79*
P8	37.30**	22.71**	5.18	63.83**	46.47**	8.23*	49.93**	37.04**	6.58*
P9	48.02**	41.97**	4.35	61.13**	41.41**	9.04*	50.15**	38.07**	5.97
P10	36.34**	29.56**	-2.90	40.15**	22.86**	-5.02	34.71**	24.80**	-5.76
P5 x P6	23.60**	4.51	0.83	67.92**	45.13**	-1.20	31.16**	14.76**	-0.82
P7	45.87**	15.67**	11.59**	96.42**	61.95**	10.24**	55.24**	28.81**	11.32**
P8	14.55**	8.15	4.35	42.29**	36.68**	1.00	23.56**	17.38**	1.44
P9	33.01**	17.17**	13.04**	54.36**	45.31**	12.05**	36.19**	28.57**	11.11**
P10	9.42	-2.79	-6.21	42.82**	34.29**	3.82	25.79**	17.86**	1.85
P6 x P7	53.95**	42.24**	-5.18	87.58**	77.33**	-12.05**	47.97**	39.05**	-9.88**
P8	45.92**	29.71**	11.18**	70.73**	42.66**	5.42	50.94**	38.36**	7.61*
P9	50.96**	43.94**	5.80	59.75**	31.25**	1.20	56.98**	44.77**	11.11**
P10	33.33**	25.97**	-5.59	54.11**	26.49**	-2.21	40.18**	30.25**	-1.65
P7 x P8	22.85**	1.93	-12.63**	56.80**	25.27**	-7.43	37.40**	19.05**	-7.41*
P9	56.37**	38.31**	1.66	57.95**	24.22**	-4.22	51.69**	32.17**	1.44
P10	56.54**	37.29**	2.90	68.60**	32.47**	2.41	47.52**	29.43**	-2.26
P8 x P9	36.28**	26.57**	8.49*	42.29**	39.32**	7.43	27.83**	26.98**	-1.23
P10	34.54**	26.09**	8.07	49.54**	46.23**	13.05**	45.23**	43.12**	11.32**
P9 x P10	51.46**	50.00**	12.42**	58.65**	58.44**	22.49**	66.76**	65.42**	26.95**

negative direction. All types of heterosis in positive direction was found in cross P9xP10 at Tandoor. Significant positive standard heterosis was observed in Nine hybrids at Tandoor.

4.3.5 Ear height

Heterosis ranged from -14.73 (P1xP2) to 85.71 (P6xP7), heterobeltiosis from -15.0 (P1xP2) to 71.70 (P6xP7) and standard heterosis from -29.17 (P1xP2) to 23.96 (P4xP9) at Rajendranagar. Forty three hybrids exhibited heterosis, 41 heterobeltiosis and 14 standard heterosis in positive direction. The maximum standard heterosis was observed in the crosses P4xP8, P3xP8 and P3xP9 (Table 6e).

At Karimnagar, heterosis varied from 26.1 (P2xP3) to 97.36 (P1xP8), heterobeltiosis from 12.5 (P1xP5) to 88.7 (P3xP8) and standard heterosis from -33.33 (P1xP7) to 32.32 (P2xP10). All hybrids exhibited significant positive heterosis and 44 hybrids recorded heterobeltiosis. Ten hybrids exhibited all three types of heterosis and maximum was recorded in P2xP10, P4xP8 and P1xP8.

At Tandoor, heterosis ranged from 21.21 (P1xP2) to 94.64 (P1xP8), heterobeltiosis from 11.11 (P1xP2) to 89.81 (P1xP6) and standard heterosis from -29.74 (P1xP7) to 22.05 (P4xP8). Interestingly, all hybrids recorded significant positive heterosis and heterobeltiosis. Twelve hybrids recorded significant positive standard heterosis and 14 hybrids recorded significant negative standard heterosis. As many as 7 hybrids possessed all types of heterosis and high values were observed in crosses P4xP8, P6xP9, P3xP8 and P1xP8.

4.3.6 Ear length

Many hybrids exhibited significant positive heterosis at Karimnagar (43) followed by Tandoor (40) and Rajendranagar (39). The range of variation for heterosis was highest at Rajendranagar (Table 6f).

Table 6(e): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids	Ear height								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis
P1 x P2	-14.73**	-15.00**	-29.17**	27.83**	17.60*	-25.76**	21.21**	11.11*	-28.21**
P3	49.17**	41.25**	17.71**	60.70**	48.39**	-7.07	71.31**	50.36**	7.18*
P4	29.57**	21.88**	1.56	50.43**	36.43**	-11.11*	56.02**	38.24**	-3.59
P5	13.04**	12.35**	-5.21	26.97**	12.50	-22.73**	33.33**	15.28**	-14.87**
P6	60.90**	33.75**	11.46**	90.29**	86.67**	-1.01	92.49**	89.81**	5.13
P7	12.00	-12.50**	-27.08**	32.00**	25.71**	-33.33**	40.51**	30.48**	-29.74**
P8	59.72**	41.25**	17.71**	97.36**	83.61**	13.13**	94.64**	83.19**	11.79**
P9	26.14**	20.63**	0.52	34.87**	12.82*	-11.11*	45.82**	25.34**	-6.15*
P10	34.49**	20.63**	0.52	40.98**	23.74**	-13.13**	65.67**	50.78**	-1.03
P2 x P3	19.21**	13.21**	-6.25	26.10**	25.60**	-20.71**	22.26**	16.55**	-16.92**
P4	41.33**	33.33**	10.42**	58.27**	55.81**	1.52	53.44**	47.79**	3.08
P5	15.89**	14.81**	-3.13	50.96**	44.85**	-0.51	44.44**	35.42**	0.00
P6	64.53**	37.11**	13.54**	96.46**	77.60**	12.12*	80.34**	67.46**	8.21**
P7	32.53**	3.77	-14.06**	66.36**	46.40**	-7.58	63.89**	40.48**	-9.23**
P8	28.37**	13.84**	-5.73	36.03**	34.40**	-15.15**	50.20**	46.03**	-5.64
P9	32.46**	27.04**	5.21	38.79**	25.00**	-1.52	41.18**	31.51**	-1.54
P10	37.76**	23.90**	2.60	98.48**	88.49**	32.32**	53.54**	52.34**	0.00
P3 x P4	40.85**	39.86**	4.17	60.47**	57.36**	2.53	49.82**	48.20**	5.64
P5	31.15**	23.46**	4.17	58.46**	51.47**	4.04	43.46**	40.97**	4.10
P6	38.96**	20.98**	-9.90*	64.44**	49.19**	-6.57	40.89**	25.18**	-10.77**
P7	64.81**	34.27**	0.00	69.86**	50.00**	-6.06	64.19**	35.25**	-3.59
P8	78.20**	65.73**	23.44**	90.24**	88.71**	18.18**	72.87**	60.43**	14.36**
P9	60.55**	58.90**	20.83**	60.71**	44.23**	13.64**	53.68**	50.00**	12.31**
P10	51.85**	43.36**	6.77	52.85**	44.60**	1.52	55.81**	49.64**	6.67*
P4 x P5	16.17**	8.64	-8.33*	27.55**	24.26**	-14.65**	22.14**	18.75**	-12.31**
P6	48.99**	30.50**	-4.17	75.65**	56.59**	2.02	59.02**	42.65**	-0.51
P7	54.11**	26.24**	-7.29	66.96**	44.96**	-5.56	60.18**	33.09**	-7.18*
P8	80.30**	68.79**	23.96**	91.24**	86.05**	21.21**	86.67**	75.00**	22.05**
P9	40.07**	37.67**	4.69	52.98**	39.74**	10.10*	46.10**	41.10**	5.64
P10	47.01**	39.72**	2.60	49.25**	43.88**	1.01	45.45**	41.18**	-1.54
P5 x P6	51.49**	25.31**	5.73	62.87**	41.91**	-2.53	60.32**	40.28**	3.59
P7	70.63**	32.72**	11.98**	89.61**	61.03**	10.61*	84.62**	50.00**	10.77**
P8	49.47**	31.48**	10.94**	62.02**	53.68**	5.56	58.94**	45.14**	7.18*
P9	41.56**	34.57**	13.54**	47.26**	37.82**	8.59	48.97**	47.95**	10.77**
P10	12.80*	0.62	-15.10**	31.64**	30.22**	-8.59	33.82**	26.39**	-6.67*
P6 x P7	85.71**	71.70**	-5.21	82.65**	77.23**	-9.60*	78.79**	63.89**	-9.23**
P8	84.28**	71.54**	9.90*	75.78**	60.66**	-1.01	81.50**	73.11**	5.64
P9	82.54**	57.53**	19.79**	82.10**	50.00**	18.18**	83.46**	59.59**	19.49**
P10	34.76**	23.62**	-18.23**	38.33**	19.42**	-16.16**	38.98**	28.12**	-15.90**
P7 x P8	38.97**	20.33**	-22.92**	48.39**	31.97**	-18.69**	50.24**	31.93**	-19.49**
P9	61.86**	30.82**	-0.52	46.61**	17.95**	-7.07	62.71**	31.51**	-1.54
P10	60.37**	37.01**	-9.38*	52.99**	28.78**	-9.60*	62.39**	38.28**	-9.23**
P8 x P9	55.39**	43.15**	8.85*	55.40**	38.46**	9.09	44.91**	31.51**	-1.54
P10	50.40**	48.03**	-2.08	51.72**	42.45**	0.00	58.70**	53.12**	0.51
P9 x P10	50.18**	40.41**	6.77	47.80**	39.74**	10.10*	70.80**	60.27**	20.00**

Table 6(f): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids		Ear length								
		Rajendranagar			Karimnagar			Tandoor		
		Heterosis	Hetero-beltiosis	Standard Heterosis	Heterosis	Hetero-beltiosis	Standard Heterosis	Heterosis	Hetero-beltiosis	Standard Heterosis
P1 x	P2	21.74**	7.69	7.69	39.39**	39.39**	2.22	24.64**	19.44*	-4.44
	P3	29.23**	20.00**	7.69	16.67*	7.69	-6.67	16.67	7.69	-6.67
	P4	33.33**	27.27**	7.69	63.64**	63.64**	20.00**	45.45**	45.45**	6.67
	P5	26.98**	21.21**	2.56	33.33**	27.27**	-6.67	27.27**	27.27**	-6.67
	P6	4.76	0.00	-15.38*	39.13**	33.33**	6.67	25.37**	23.53*	-6.67
	P7	70.00**	70.00**	30.77**	41.67**	30.77**	13.33*	45.45**	45.45**	6.67
	P8	61.90**	54.55**	30.77**	20.00**	7.14	0.00	29.58**	21.05*	2.22
	P9	25.81**	21.87**	0.00	52.38**	45.45**	6.67	28.13**	24.24*	-8.89
	P10	50.00**	50.00**	15.38*	25.00**	15.38*	0.00	32.35**	28.57**	0.00
P2 x	P3	13.51*	7.69	7.69	25.00**	15.38*	0.00	17.33*	12.82	-2.22
	P4	44.44**	33.33**	33.33**	54.55**	54.55**	13.33*	39.13**	33.33**	6.67
	P5	8.33	0.00	0.00	39.68**	33.33**	-2.22	21.74*	16.67	-6.67
	P6	33.33**	23.08**	23.08**	13.04	8.33	-13.33*	22.86*	19.44*	-4.44
	P7	24.64**	10.26	10.26	16.67*	7.69	-6.67	21.74*	16.67	-6.67
	P8	25.00**	15.38*	15.38*	36.00**	21.43**	13.33*	29.73**	26.32**	6.67
	P9	9.86	0.00	0.00	52.38**	45.45**	6.67	22.39*	13.89	-8.89
	P10	39.13**	23.08**	23.08**	41.67**	30.77**	13.33*	40.85**	38.89**	11.11
P3 x	P4	14.71*	11.43	0.00	33.33**	23.08**	6.67	16.67	7.69	-6.67
	P5	5.88	2.86	-7.69	39.13**	23.08**	6.67	11.11	2.56	-11.11
	P6	5.88	2.86	-7.69	9.33	5.13	-8.89	12.33	5.13	-8.89
	P7	29.23**	20.00**	7.69	23.08**	23.08**	6.67	30.56**	20.51*	4.44
	P8	23.53**	20.00**	7.69	33.33**	28.57**	20.00**	11.69	10.26	-4.44
	P9	25.37**	20.00**	7.69	30.43**	15.38*	0.00	22.86*	10.26	-4.44
	P10	13.85	5.71	-5.13	15.38*	15.38*	0.00	18.92*	12.82	-2.22
P4 x	P5	27.27**	27.27**	7.69	52.38**	45.45**	6.67	30.30**	30.30**	-4.44
	P6	27.27**	27.27**	7.69	33.33**	27.78**	2.22	25.37**	23.53*	-6.67
	P7	52.38**	45.45**	23.08**	50.00**	38.46**	20.00**	54.55**	54.55**	13.33
	P8	63.64**	63.64**	38.46**	36.00**	21.43**	13.33*	43.66**	34.21**	13.33
	P9	38.46**	36.36**	15.38*	58.73**	51.52**	11.11*	46.88**	42.42**	4.44
	P10	39.68**	33.33**	12.82*	33.33**	23.08**	6.67	41.18**	37.14**	6.67
P5 x	P6	27.27**	27.27**	7.69	45.45**	33.33**	6.67	40.30**	38.24**	4.44
	P7	68.25**	60.61**	35.90**	56.52**	38.46**	20.00**	60.61**	60.61**	17.78*
	P8	45.45**	45.45**	23.08**	33.33**	14.29*	6.67	35.21**	26.32**	6.67
	P9	38.46**	36.36**	15.38*	60.00**	60.00**	6.67	46.88**	42.42**	4.44
	P10	33.33**	27.27**	7.69	39.13**	23.08**	6.67	23.53*	20.00*	-6.67
P6 x	P7	42.86**	36.36**	15.38*	36.00**	30.77**	13.33*	40.30**	38.24**	4.44
	P8	36.36**	36.36**	15.38*	30.77**	21.43**	13.33*	30.56**	23.68**	4.44
	P9	20.00**	18.18*	0.00	36.36**	25.00**	0.00	29.23**	23.53*	-6.67
	P10	46.03**	39.39**	17.95**	36.00**	30.77**	13.33*	39.13**	37.14**	6.67
P7 x	P8	52.38**	45.45**	23.08**	33.33**	28.57**	20.00**	35.21**	26.32**	6.67
	P9	45.16**	40.62**	15.38*	39.13**	23.08**	6.67	50.00**	45.45**	6.67
	P10	53.33**	53.33**	17.95**	38.46**	38.46**	20.00**	41.18**	37.14**	6.67
P8 x	P9	47.69**	45.45**	23.08**	47.22**	26.19**	17.78**	42.03**	28.95**	8.89
	P10	61.90**	54.55**	30.77**	18.52**	14.29*	6.67	31.51**	26.32**	6.67
P9 x	P10	45.16**	40.62**	15.38*	24.64**	10.26	-4.44	21.21*	14.29	-11.11

At Rajendranagar, heterosis for ear length ranged from 4.76 (P1xP6) to 70.00 (P1xP7). Significant positive heterosis was recorded in case of 39 hybrids indicating their superior contribution for ear length. None of the hybrids exhibited negative heterosis. Heterobeltiosis ranged from 0.00 (P1xP6) to 70.0 (P1xP7) and as many as 35 hybrids recorded significant positive heterobeltiosis. The standard heterosis ranged from -15.38 (P1xP6) to 38.46 (P4xP8). Twenty three hybrids exhibited significant positive heterosis, on the other hand only one hybrid exhibited significant negative standard heterosis.

At Karimnagar, heterosis ranged from 9.33 (P3xP6) to 63.64 (P1xP4). All hybrids except, P2xP6 and P3xP6 exhibited significant positive heterosis. The heterobeltiosis at this location ranged from 5.13 (P3xP6) to 63.64 (P1xP4) with significant positive values in case of 39 hybrids. Standard heterosis ranged from -13.33 (P2xP6) to 20.00 (P5xP7) and the significant positive values were recoded for 16 hybrids and only one hybrid P2xP6 recorded significant negative standard heterosis.

At Tandoor, as many as 40 hybrids exhibited significant positive heterosis with a range of 11.11 (P3xP5) to 60.61 (P5xP7). Heterobeltiosis ranged from 2.56 (P3xP5) to 60.61 (P5xP7) and 33 hybrids showed significant positive values. Standard heterosis ranged from -11.11 (P3xP5) to 17.78 (P5xP7) and one hybrid exhibited significant standard heterosis in positive direction.

4.3.7 Ear girth

At Rajendranagar, heterosis and heterobeltiosis ranged widely when compared to Tandoor. At Rajendranagar, heterosis ranged from 9.09 (P1xP10) to 50.0 (P4xP9) and all hybrids except P1xP10 exhibited significant positive heterosis. Heterobeltiosis ranged from 0.0 (P1xP10) to 50.0 (P4xP9) and 41 hybrids showed significant positive heterobeltiosis. All hybrids exhibited either negative or no standard heterosis (Table 6g).

Table 6(g): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids	Ear girth								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis
P1 x P2	27.27**	16.67**	-6.67	26.15**	24.24**	-8.89*	17.14*	13.89*	-8.89
P1 x P3	21.74**	16.67**	-6.67	18.18**	18.18**	-13.33**	13.04	8.33	-13.33*
P1 x P4	27.27**	16.67**	-6.67	26.15**	24.24**	-8.89*	15.07*	13.51*	-6.67
P1 x P5	16.67**	16.67**	-6.67	31.25**	27.27**	-6.67	16.67*	16.67*	-6.67
P1 x P6	21.74**	16.67**	-6.67	39.68**	33.33**	-2.22	28.36**	19.44**	-4.44
P1 x P7	18.18**	8.33	-13.33**	30.16**	24.24**	-8.89*	21.21**	11.11	-11.11*
P1 x P8	27.27**	16.67**	-6.67	23.08**	21.21**	-11.11**	24.24**	13.89*	-8.89
P1 x P9	18.18**	8.33	-13.33**	30.16**	24.24**	-8.89*	21.21**	11.11	-11.11*
P1 x P10	9.09	0.00	-20.00**	13.85**	12.12*	-17.78**	4.35	0.00	-20.00**
P2 x P3	23.81**	18.18**	-13.33**	10.77*	9.09	-20.00**	13.43	11.76	-15.56**
P2 x P4	40.00**	40.00**	-6.67	40.62**	40.62**	0.00	15.49*	10.81	-8.89
P2 x P5	27.27**	16.67**	-6.67	33.33**	31.25**	-6.67	11.43	8.33	-13.33*
P2 x P6	33.33**	27.27**	-6.67	35.48**	31.25**	-6.67	20.00**	14.71*	-13.33*
P2 x P7	30.00**	30.00**	-13.33**	25.81**	21.87**	-13.33**	18.75*	11.76	-15.56**
P2 x P8	20.00**	20.00**	-20.00**	21.87**	21.87**	-13.33**	21.88**	14.71*	-13.33*
P2 x P9	20.00**	20.00**	-20.00**	38.71**	34.37**	-4.44	21.88**	14.71*	-13.33*
P2 x P10	30.00**	30.00**	-13.33**	25.00**	25.00**	-11.11**	13.43	11.76	-15.56**
P3 x P4	33.33**	27.27**	-6.67	29.23**	27.27**	-6.67	20.00**	13.51*	-6.67
P3 x P5	21.74**	16.67**	-6.67	31.25**	27.27**	-6.67	21.74**	16.67*	-6.67
P3 x P6	27.27**	27.27**	-6.67	30.16**	24.24**	-8.89*	34.38**	30.30**	-4.44
P3 x P7	23.81**	18.18**	-13.33**	30.16**	24.24**	-8.89*	26.98**	21.21**	-11.11*
P3 x P8	23.81**	18.18**	-13.33**	16.92**	15.15**	-15.56**	23.81**	18.18*	-13.33*
P3 x P9	42.86**	36.36**	0.00	33.33**	27.27**	-6.67	33.33**	27.27**	-6.67
P3 x P10	23.81**	18.18**	-13.33**	23.08**	21.21**	-11.11**	18.18*	18.18*	-13.33*
P4 x P5	27.27**	16.67**	-6.67	33.33**	31.25**	-6.67	12.33	10.81	-8.89
P4 x P6	23.81**	18.18**	-13.33**	32.26**	28.12**	-8.89*	14.71*	5.41	-13.33*
P4 x P7	20.00**	20.00**	-20.00**	25.81**	21.87**	-13.33**	16.42*	5.41	-13.33*
P4 x P8	36.67**	36.67**	-8.89*	28.12**	28.12**	-8.89*	16.42*	5.41	-13.33*
P4 x P9	50.00**	50.00**	0.00	41.94**	37.50**	-2.22	31.34**	18.92**	-2.22
P4 x P10	40.00**	40.00**	-6.67	31.25**	31.25**	-6.67	20.00**	13.51*	-6.67
P5 x P6	30.43**	25.00**	0.00	40.98**	38.71**	-4.44	25.37**	16.67*	-6.67
P5 x P7	27.27**	16.67**	-6.67	40.98**	38.71**	-4.44	27.27**	16.67*	-6.67
P5 x P8	27.27**	16.67**	-6.67	30.16**	28.12**	-8.89*	27.27**	16.67*	-6.67
P5 x P9	27.27**	16.67**	-6.67	37.70**	35.48**	-6.67	27.27**	16.67*	-6.67
P5 x P10	18.18**	8.33	-13.33**	36.51**	34.37**	-4.44	21.74**	16.67*	-6.67
P6 x P7	33.33**	27.27**	-6.67	33.33**	33.33**	-11.11**	27.87**	25.81**	-13.33*
P6 x P8	33.33**	27.27**	-6.67	29.03**	25.00**	-11.11**	27.87**	25.81**	-13.33*
P6 x P9	33.33**	27.27**	-6.67	40.00**	40.00**	-6.67	40.98**	38.71**	-4.44
P6 x P10	23.81**	18.18**	-13.33**	29.03**	25.00**	-11.11**	25.00**	21.21**	-11.11*
P7 x P8	20.00**	20.00**	-20.00**	25.81**	21.87**	-13.33**	23.33**	23.33**	-17.78**
P7 x P9	30.00**	30.00**	-13.33**	33.33**	33.33**	-11.11**	30.00**	30.00**	-13.33*
P7 x P10	30.00**	30.00**	-13.33**	32.26**	28.12**	-8.89*	23.81**	18.18*	-13.33*
P8 x P9	30.00**	30.00**	-13.33**	41.94**	37.50**	-2.22	40.00**	40.00**	-6.67
P8 x P10	20.00**	20.00**	-20.00**	25.00**	25.00**	-11.11**	14.29	9.09	-20.00**
P9 x P10	30.00**	30.00**	-13.33**	32.26**	28.12**	-8.89*	23.81**	18.18*	-13.33*

At Karimnagar, heterosis varied from 10.77 (P2xP3) to 41.94 (P4xP9), heterobeltiosis from 9.09 (P2xP3) to 40.62 (P2xP4) and standard heterosis from -20.00 (P2xP3) to 0.00 (P2xP4). All hybrids for heterosis and 44 hybrids for heterobeltiosis were found superior with significant positive values. On the other hand, standard heterosis in 27 hybrids was significant but in negative direction.

At Tandoor, heterosis varied from 4.35 (P1xP10) to 40.98 (P6xP9), heterobeltiosis from 0.00 (P1xP10) to 40.00 (P8xP9) and standard heterosis from -20.0 (P1xP10) to -2.22 (P4xP9). As many as 38 hybrids for heterosis and 31 hybrids for heterobeltiosis recorded significant positive values. Twenty five hybrids exhibited significant negative standard heterosis.

4.3.8 Number of seed rows per ear

At Rajendranagar, 29 hybrids exhibited significant positive heterosis, while the heterobeltiosis was significantly positive in case of 24 hybrids. Only two hybrids recorded significant negative heterobeltiosis. Standard heterosis was significant and positive in 4 hybrids and it was significantly negative in 15 hybrids. Heterosis ranged from -7.69 (P4xP6) to 28.2 (P1xP4), heterobeltiosis from -14.29 (P4xP7) to 41.18 (P2xP7) and standard heterosis from -23.81 (P7xP8) to 19.05 (P1xP4) (Table 6h).

At Karimnagar, heterosis varied from -2.86 (P7xP8) to 33.33 (P1xP6), heterobeltiosis from -4.76 (P4xP6) to 33.33 (P1xP6) and standard heterosis from -19.05 (P7xP8) to 14.29 (P1xP6). Only 22 hybrids for heterosis, 12 hybrids for heterobeltiosis and one hybrid for standard heterosis showed significant positive values. Eight hybrids exhibited significant negative standard heterosis.

At Tandoor, heterosis varied from -5.26 (P4xP7) to 31.43 (P2xP7), heterobeltiosis from -14.29 (P4xP7) to 27.78 (P2xP7) and standard heterosis

Table 6(h): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids	No. of seed rows/ear								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Hetero-beltiosis	Standard Heterosis	Heterosis	Hetero-beltiosis	Standard Heterosis	Heterosis	Hetero-beltiosis	Standard Heterosis
P1 x P2	20.00**	16.67**	0.00	16.67**	16.67**	0.00	16.67*	16.67*	16.67*
P3	14.29**	11.11*	-4.76	17.65**	11.11	-4.76	14.29	11.11	11.11
P4	28.21**	19.05**	19.05**	7.69	0.00	0.00	23.08**	14.29*	33.33**
P5	11.11*	11.11*	-4.76	11.11	11.11	-4.76	11.11	11.11	11.11
P6	22.22**	22.22**	4.76	33.33**	33.33**	14.29**	27.78**	27.78**	27.78**
P7	8.57	5.56	-9.52*	8.57	5.56	-9.52	2.86	0.00	0.00
P8	20.00**	16.67**	0.00	5.56	5.56	-9.52	14.29	11.11	11.11
P9	5.56	5.56	-9.52*	23.53**	16.67**	0.00	17.65*	11.11	11.11
P10	16.67**	16.67**	0.00	14.29*	11.11	-4.76	20.00**	16.67*	16.67*
P2 x P3	23.53**	23.53**	0.00	5.88	0.00	-14.29**	8.57	5.56	5.56
P4	10.53*	0.00	0.00	7.69	0.00	0.00	7.69	0.00	16.67*
P5	20.00**	16.67**	0.00	5.56	5.56	-9.52	11.11	11.11	11.11
P6	20.00**	16.67**	0.00	5.56	5.56	-9.52	11.11	11.11	11.11
P7	41.18**	41.18**	14.29**	31.43**	27.78**	9.52	31.43**	27.78**	27.78**
P8	5.88	5.88	-14.29**	11.11	11.11	-4.76	14.29	11.11	11.11
P9	20.00**	16.67**	0.00	29.41**	22.22**	4.76	17.65*	11.11	11.11
P10	20.00**	16.67**	0.00	14.29*	11.11	-4.76	20.00**	16.67*	16.67*
P3 x P4	10.53*	0.00	0.00	18.92**	4.76	4.76	5.26	-4.76	11.11
P5	20.00**	16.67**	0.00	17.65**	11.11	-4.76	14.29	11.11	11.11
P6	20.00**	16.67**	0.00	29.41**	22.22**	4.76	20.00**	16.67*	16.67*
P7	11.76*	11.76*	-9.52*	9.09	5.88	-14.29**	17.65*	17.65*	11.11
P8	5.88	5.88	-14.29**	0.00	-5.56	-19.05**	0.00	0.00	-5.56
P9	20.00**	16.67**	0.00	25.00**	25.00**	-4.76	27.27**	23.53**	16.67*
P10	8.57	5.56	-9.52*	15.15*	11.76	-9.52	5.88	5.88	0.00
P4 x P5	7.69	0.00	0.00	-2.56	-9.52	-9.52	2.56	-4.76	11.11
P6	-7.69	-14.29**	-14.29**	2.56	-4.76	-4.76	2.56	-4.76	11.11
P7	-5.26	-14.29**	-14.29**	0.00	-9.52	-9.52	-5.26	-14.29*	0.00
P8	10.53*	0.00	0.00	7.69	0.00	0.00	10.53	0.00	16.67*
P9	23.08**	14.29**	14.29**	24.32**	9.52	9.52	29.73**	14.29*	33.33**
P10	12.82**	4.76	4.76	21.05**	9.52	9.52	21.05**	9.52	27.78**
P5 x P6	27.78**	27.78**	9.52*	11.11	11.11	-4.76	16.67*	16.67*	16.67*
P7	14.29**	11.11*	-4.76	20.00**	16.67**	0.00	20.00**	16.67*	16.67*
P8	20.00**	16.67**	0.00	5.56	5.56	-9.52	14.29	11.11	11.11
P9	0.00	0.00	-14.29**	11.76	5.56	-9.52	11.76	5.56	5.56
P10	16.67**	16.67**	0.00	20.00**	16.67**	0.00	20.00**	16.67*	16.67*
P6 x P7	8.57	5.56	-9.52*	14.29*	11.11	-4.76	8.57	5.56	5.56
P8	25.71**	22.22**	4.76	27.78**	27.78**	9.52	25.71**	22.22**	22.22**
P9	16.67**	16.67**	0.00	23.53**	16.67**	0.00	17.65*	11.11	11.11
P10	16.67**	16.67**	0.00	2.86	0.00	-14.29**	14.29	11.11	11.11
P7 x P8	-5.88	-5.88	-23.81**	-2.86	-5.56	-19.05**	-5.88	-5.88	-11.11
P9	2.86	0.00	-14.29**	9.09	5.88	-14.29**	9.09	5.88	0.00
P10	2.86	0.00	-14.29**	5.88	5.88	-14.29**	5.88	5.88	0.00
P8 x P9	2.86	0.00	-14.29**	17.65**	11.11	-4.76	15.15	11.76	5.56
P10	2.86	0.00	-14.29**	20.00**	16.67**	0.00	23.53**	23.53**	16.67*
P9 x P10	0.00	0.00	-14.29**	9.09	5.88	-14.29**	15.15	11.76	5.56

from -11.11 (P7xP8) to 33.33 (P1xP4). Significant positive values were recorded in case of 18 hybrids for heterosis, 15 for heterobeltiosis and 17 for standard heterosis.

4.3.9 Number of seeds per ear

At three locations, all the hybrids exhibited significant positive heterosis and heterobeltiosis. At Rajendranagar, thirty hybrids showed significantly positive standard heterosis, while only two hybrids recorded significant negative standard heterosis. Heterosis ranged from 36.99 (P1xP9) to 97.54 (P4xP9), heterobeltiosis from 30.06 (P1xP9) to 87.22 (P4xP8) and standard heterosis from -8.01 (P2xP7) to 44.98 (P4xP8) (Table 6i).

At Karimnagar 24 hybrids showed significantly positive performance for standard heterosis and one hybrid in the negative direction. Range of variation was 36.79 (P3xP10) to 109.19 (P4xP8) for heterosis, 30.43 (P3xP10) to 104.49 (P4xP8) for heterobeltiosis and -9.09 (P2xP6) to 44.59 (P4xP8) for standard heterosis.

At Tandoor, heterosis varied from 40.02 (P7xP8) to 97.85 (P1xP3), heterobeltiosis from 27.15 (P3xP10) to 93.47 (P1xP3) and standard heterosis from -6.31 (P1xP9) to 51.05 (P4xP8). Thirty hybrids recorded significant positive standard heterosis.

4.3.10 Shelling percentage

At Rajendranagar, heterosis varied from -1.84 (P4xP5) to 16.44 (P2xP10), heterobeltiosis from -2.44 (P4xP5) to 13.33 (P2xP10) and standard heterosis from -1.23 (P4xP5) to 6.17 (P1xP8). As many as 43 hybrids exhibited heterosis, 30 heterobeltiosis and 21 standard heterosis with significant positive values. Only one hybrid for heterosis and two hybrids for heterobeltiosis showed significantly negative values (Table 6j).

Table 6(i): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids	No. of seeds/ear								
	Rajendranagar			Kerimnagar			Tandoor		
	Heterosis	Hetero-beltiosis	Standard Heterosis	Heterosis	Hetero-beltiosis	Standard Heterosis	Heterosis	Hetero-beltiosis	Standard Heterosis
P1 x P2	59.26**	53.14**	10.12**	81.86**	78.07**	17.17**	74.22**	67.82**	16.67**
P3	87.91**	77.83**	27.87**	61.61**	57.73**	4.47	97.85**	93.47**	24.62**
P4	69.40**	63.35**	26.49**	87.92**	77.76**	25.69**	68.41**	50.37**	23.27**
P5	53.40**	50.61**	8.30**	76.63**	73.51**	13.42**	52.85**	44.31**	4.65
P6	41.35**	33.20**	-4.22	69.98**	67.71**	8.66*	64.12**	62.99**	6.46
P7	91.90**	75.10**	25.91**	71.07**	68.97**	9.24*	68.77**	66.29**	10.36**
P8	82.16**	80.36**	32.31**	62.87**	57.48**	6.35	86.73**	77.68**	26.73**
P9	36.99**	30.06**	-6.48*	70.20**	67.93**	8.80*	51.09**	45.45**	-6.31
P10	68.27**	63.00**	25.04**	47.19**	37.15**	0.14	56.64**	43.95**	10.66**
P2 x P3	61.20**	58.55**	5.24	46.89**	46.41**	-3.03	65.86**	56.37**	8.71*
P4	88.26**	74.81**	35.37**	83.51**	77.14**	25.25**	52.63**	41.03**	15.62**
P5	68.45**	64.92**	14.26**	52.70**	52.19**	0.14	48.63**	45.55**	5.56
P6	81.19**	77.41**	17.76**	39.23**	38.16**	-9.09*	40.31**	36.07**	-5.41
P7	46.38**	38.60**	-8.01*	78.54**	76.97**	16.45**	56.69**	53.13**	6.46
P8	57.71**	50.20**	10.19**	60.61**	58.55**	7.07	54.37**	52.42**	8.71*
P9	77.56**	75.22**	16.30**	87.40**	85.96**	22.37**	65.12**	53.35**	6.61
P10	70.91**	59.39**	22.27**	58.21**	50.40**	9.81*	46.46**	39.45**	7.21*
P3 x P4	58.48**	44.92**	12.23**	83.03**	77.24**	25.32**	76.57**	54.58**	26.73**
P5	53.44**	47.79**	2.40	52.52**	51.53**	0.36	44.23**	33.33**	-3.30
P6	54.90**	54.20**	-1.02	53.74**	52.07**	0.72	59.05**	54.48**	0.90
P7	63.35**	57.14**	0.87	58.88**	56.97**	3.97	73.00**	66.74**	10.66**
P8	43.92**	34.92**	-1.02	37.00**	35.68**	-8.37	47.57**	37.47**	-1.95
P9	83.16**	82.55**	17.98**	57.27**	55.56**	3.03	76.95**	74.15**	7.21*
P10	44.21**	32.45**	1.60	36.79**	30.43**	-4.76	41.21**	27.15**	-2.25
P4 x P5	54.76**	46.62**	13.54**	66.70**	60.41**	13.42**	52.58**	43.77**	17.87**
P6	46.13**	33.08**	3.06	77.42**	70.00**	20.20**	62.49**	45.97**	19.67**
P7	48.16**	30.83**	1.31	69.30**	62.04**	14.57**	53.64**	39.01**	13.96**
P8	92.28**	87.22**	44.98**	109.19**	104.49**	44.59**	97.06**	84.25**	51.05**
P9	97.54**	81.20**	40.32**	90.20**	82.24**	28.86**	95.97**	69.23**	38.74**
P10	67.52**	66.73**	29.11**	79.72**	76.88**	29.15**	69.00**	63.74**	34.23**
P5 x P6	70.87**	63.87**	13.54**	78.05**	77.26**	15.87**	64.71**	56.52**	13.51**
P7	79.29**	66.39**	15.28**	95.78**	94.70**	27.27**	70.38**	63.15**	18.32**
P8	76.73**	71.83**	26.06**	53.09**	50.64**	1.73	76.20**	74.74**	26.73**
P9	61.63**	56.20**	8.22**	74.50**	73.73**	13.56**	76.14**	60.46**	16.37**
P10	57.93**	50.28**	15.28**	75.50**	66.30**	21.43**	73.07**	68.16**	29.28**
P6 x P7	69.80**	64.07**	4.37	48.94**	48.78**	-3.61	51.20**	50.00**	-0.45
P8	63.44**	52.58**	11.94**	76.23**	72.65**	16.59**	82.42**	74.74**	24.62**
P9	71.62**	70.27**	10.04**	60.58**	60.58**	4.04	70.67**	63.22**	6.61
P10	66.39**	52.18**	16.74**	56.96**	48.12**	8.15	69.80**	57.03**	20.72**
P7 x P8	44.60**	30.75**	-4.08	61.35**	57.91**	6.64	40.02**	35.16**	-3.60
P9	63.48**	56.76**	1.31	49.16**	49.00**	-3.46	64.72**	56.33**	3.75
P10	60.94**	42.69**	9.46**	63.52**	54.15**	12.55**	54.09**	43.55**	10.36**
P8 x P9	45.57**	36.90**	0.44	61.83**	58.55**	7.07	65.37**	51.79**	8.26*
P10	47.53**	44.31**	10.70**	55.65**	49.80**	9.38*	47.72**	42.38**	9.46**
P9 x P10	67.35**	54.17**	18.27**	56.02**	47.23**	7.50	68.98**	50.00**	15.32**

Table 6(j): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids	Shelling percentage								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis
P1 x P2	13.48**	12.68**	-1.23	13.70**	10.67**	5.06**	14.69**	13.89**	3.80**
P1 x P3	12.35**	10.05**	-0.82	9.01**	7.56**	2.11*	10.80**	10.05**	1.69
P1 x P4	9.93**	2.47**	2.47**	6.41**	2.47*	5.06**	5.88**	0.00	2.53*
P1 x P5	9.21**	1.22	2.47**	3.85**	0.00	2.53*	5.88**	0.00	2.53*
P1 x P6	6.67**	0.00	-1.23	7.69**	3.70**	6.33**	7.66**	2.07	3.80**
P1 x P7	13.10**	9.33**	1.23	11.26**	10.53**	6.33**	9.46**	6.58**	2.53*
P1 x P8	14.67**	7.50**	6.17**	10.97**	7.50**	8.86**	11.84**	6.25**	7.59**
P1 x P9	8.84**	3.90**	-1.23	3.72**	2.16*	0.00	8.39**	6.22**	0.84
P1 x P10	14.48**	10.67**	2.47**	7.89**	6.49**	3.80**	9.46**	6.58**	2.53*
P2 x P3	11.11**	9.59**	-1.23	9.72**	8.22**	0.00	9.72**	8.22**	0.00
P2 x P4	9.21**	2.47**	2.47**	10.09**	3.29**	5.91**	9.21**	2.47*	5.06**
P2 x P5	5.45**	-1.63*	-0.41	7.46**	0.82	3.38**	7.02**	0.41	2.95**
P2 x P6	12.58**	6.25**	4.94**	10.09**	3.29**	5.91**	12.33**	5.81**	7.59**
P2 x P7	15.07**	12.00**	3.70**	10.20**	6.58**	2.53*	10.20**	6.58**	2.53*
P2 x P8	11.26**	5.00**	3.70**	9.93**	3.75**	5.06**	7.28**	1.25	2.53*
P2 x P9	14.86**	10.39**	4.94**	14.61**	9.91**	7.59**	16.44**	13.33**	7.59**
P2 x P10	16.44**	13.33**	4.94**	14.86**	10.39**	7.59**	15.65**	11.84**	7.59**
P3 x P4	4.76**	-0.41	-0.41	6.06**	0.82	3.38**	6.49**	1.23	3.80**
P3 x P5	8.39**	2.44**	3.70**	5.19**	0.00	2.53*	6.49**	1.23	3.80**
P3 x P6	4.58**	0.00	-1.23	2.60*	-2.47*	0.00	4.35**	-0.41	1.27
P3 x P7	14.86**	13.33**	4.94**	11.41**	9.21**	5.06**	8.72**	6.58**	2.53*
P3 x P8	8.50**	3.75**	2.47**	7.19**	2.50*	3.80**	5.88**	1.25	2.53*
P3 x P9	12.00**	9.09**	3.70**	9.09**	6.03**	3.80**	10.81**	9.33**	3.80**
P3 x P10	10.81**	9.33**	1.23	6.67**	3.90**	1.27	8.72**	6.58**	2.53*
P4 x P5	-1.84*	-2.44**	-1.23	0.00	0.00	2.53*	-1.65	-1.65	0.84
P4 x P6	5.59**	4.94**	4.94**	2.47*	2.47*	5.06**	1.65	1.23	3.80**
P4 x P7	2.56**	-1.23	-1.23	4.03**	0.82	3.38**	3.18**	0.00	2.53*
P4 x P8	3.11**	2.47**	2.47**	4.35**	3.70**	6.33**	1.86	1.23	3.80**
P4 x P9	2.53**	0.00	0.00	4.84**	2.47*	5.06**	5.13**	1.23	3.80**
P4 x P10	3.85**	0.00	0.00	2.95**	0.41	2.95**	3.18**	0.00	2.53*
P5 x P6	1.23	0.00	1.23	-2.47*	-2.47*	0.00	0.41	0.00	2.53*
P5 x P7	8.28**	3.66**	4.94**	7.01**	3.70**	6.33**	5.73**	2.47*	5.06**
P5 x P8	2.47**	1.22	2.47**	4.35**	3.70**	6.33**	4.35**	3.70**	6.33**
P5 x P9	1.89*	-1.22	0.00	3.58**	1.23	3.80**	4.27**	0.41	2.95**
P5 x P10	7.01**	2.44**	3.70**	6.33**	3.70**	6.33**	3.61**	0.41	2.95**
P6 x P7	4.52**	1.25	0.00	3.18**	0.00	2.53*	3.62**	0.83	2.53*
P6 x P8	2.50**	2.50**	1.23	3.11**	2.47*	5.06**	1.04	0.83	2.53*
P6 x P9	1.91*	0.00	-1.23	2.32*	0.00	2.53*	3.43**	0.00	1.69
P6 x P10	4.52**	1.25	0.00	2.95**	0.41	2.95**	4.90**	2.07	3.80**
P7 x P8	5.81**	2.50**	1.23	5.13**	2.50*	3.80**	6.41**	3.75**	5.06**
P7 x P9	6.58**	5.19**	0.00	8.26**	7.33**	5.06**	7.73**	7.02**	2.95**
P7 x P10	9.33**	9.33**	1.23	5.01**	4.33**	1.69	7.02**	7.02**	2.95**
P8 x P9	5.73**	3.75**	2.47**	6.78**	5.00**	6.33**	7.10**	3.75**	5.06**
P8 x P10	7.10**	3.75**	2.47**	9.55**	7.50**	8.86**	7.69**	5.00**	6.33**
P9 x P10	7.89**	6.49**	1.23	6.26**	6.03**	3.80**	7.28**	6.58**	2.53*

At Karimnagar, heterosis varied from -2.47 (P5xP6) to 14.86 (P2xP10), heterobeltiosis from -2.47 (P5xP6) to 10.67 (P1xP2) and standard heterosis from 0.00 (P3xP6) to 8.86 (P1xP8). Forty three hybrids recorded significant positive heterosis, 32 heterobeltiosis and 39 standard heterosis. While, significant values in the negative direction were observed in one hybrid for heterosis and two hybrids for heterobeltiosis.

At Tandoor, heterosis varied from -1.65 (P4xP5) to 16.44 (P2xP9), heterobeltiosis from -1.65 (P4xP5) to 13.89 (P1xP2) and standard heterosis from 0.0 (P2xP3) to 7.59 (P1xP8). Forty hybrids for heterosis, 23 for heterobeltiosis and 39 for standard heterosis recorded significant positive estimates.

4.3.11 100 seed weight

All hybrids exhibited significant positive heterosis at all locations. At Rajendranagar, 43 hybrids exhibited significant positive heterobeltiosis. Standard heterosis was significantly positive in 12 hybrids and it was significantly negative in 16 hybrids. Heterosis ranged from 11.63 (P2xP9) to 64.10 (P4xP6), heterobeltiosis from 0.00 (P5xP10) to 61.11 (P3xP10) and standard heterosis from -20 (P2xP9) to 13.33 (P5xP9) (Table 6k).

At Karimnagar, heterosis varied from 17.83 (P2xP9) to 65.00 (P9xP10), heterobeltiosis from -1.33 (P4xP5) to 61.11 (P3xP10) and standard heterosis from -17.78 (P4xP5) to 16.67 (P3xP7). Forty three hybrids for heterobeltiosis and 12 for standard heterosis showed significant positive values. On the other hand, 15 hybrids exhibited significant negative standard heterosis.

At Tandoor, heterosis varied from 13.39 (P5xP10) to 65.00 (P3xP9), heterobeltiosis from -1.37 (P5xP10) to 58.18 (P1xP3) and standard heterosis from -22.58 (P5xP10) to 11.83 (P6xP7). Significant positive values were

Table 6(k): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids		100 seeds weight (g)								
		Rajendranagar			Karimnagar			Tandoor		
		Heterosis	Hetero-beltiosis	Standard Heterosis	Heterosis	Hetero-beltiosis	Standard Heterosis	Heterosis	Hetero-beltiosis	Standard Heterosis
P1 x	P2	55.00**	47.62**	3.33	51.26**	42.86**	0.00	58.97**	47.62**	0.00
	P3	56.76**	52.63**	-3.33	58.18**	55.36**	-3.33	59.63**	58.18**	-6.45*
	P4	60.00**	47.37**	-6.67*	57.69**	46.43**	-8.89**	64.71**	55.58**	-9.68**
	P5	20.93**	8.33*	-13.33**	28.24**	12.00**	-6.67*	27.56**	10.96**	-12.90**
	P6	42.86**	30.43**	0.00	43.75**	27.78**	2.22	46.34**	30.43**	-3.23
	P7	40.91**	24.00**	3.33	41.98**	24.00**	3.33	47.62**	29.17**	0.00
	P8	20.31**	8.45*	-14.44**	29.60**	17.39**	-10.00**	25.20**	11.59**	-17.20**
	P9	28.46**	19.70**	-12.22**	22.95**	13.64**	-16.67**	36.13**	24.62**	-12.90**
	P10	35.14**	31.58**	-16.67**	47.27**	44.64**	-10.00**	44.44**	44.44**	-16.13**
P2 x	P3	58.97**	47.62**	3.33	58.97**	47.62**	3.33	54.24**	44.44**	-2.15
	P4	44.14**	26.98**	-11.11**	42.34**	25.40**	-12.22**	45.95**	28.57**	-12.90**
	P5	33.33**	25.00**	0.00	30.43**	20.00**	0.00	32.35**	23.29**	-3.23
	P6	36.36**	30.43**	0.00	33.33**	25.00**	0.00	36.36**	30.43**	-3.23
	P7	24.64**	14.67**	-4.44	26.09**	16.00**	-3.33	28.89**	20.83**	-6.45*
	P8	34.33**	26.76**	0.00	42.42**	36.23**	4.44	36.38**	30.43**	-3.23
	P9	11.63**	9.09*	-20.00**	17.83**	15.15**	-15.56**	17.19**	15.38**	-19.35**
	P10	45.30**	34.92**	-5.56*	45.30**	34.92**	-5.56*	38.46**	28.57**	-12.90**
P3 x	P4	52.94**	44.44**	-13.33**	58.82**	50.00**	-10.00**	55.34**	45.45**	-13.98**
	P5	38.10**	20.83**	-3.33	36.43**	17.33**	-2.22	35.94**	19.18**	-6.45*
	P6	62.60**	44.93**	11.11**	57.14**	37.50**	10.00**	59.68**	43.48**	6.45*
	P7	56.59**	34.67**	12.22**	62.79**	40.00**	16.67**	60.63**	41.67**	9.68**
	P8	53.60**	35.21**	6.67*	64.23**	46.38**	12.22**	59.68**	43.48**	6.45*
	P9	50.00**	36.36**	0.00	60.00**	45.45**	6.67*	65.00**	52.31**	6.45*
	P10	61.11**	61.11**	-3.33	61.11**	61.11**	-3.33	57.80**	56.36**	-7.53**
P4 x	P5	25.00**	4.17	-16.67**	20.33**	-1.33	-17.78**	23.97**	2.74	-19.35**
	P6	64.10**	39.13**	6.67*	60.00**	33.33**	6.67*	64.10**	39.13**	3.23
	P7	36.59**	12.00**	-6.67*	41.46**	16.00**	-3.33	45.00**	20.83**	-6.45*
	P8	39.50**	16.90**	-7.78**	38.46**	17.39**	-10.00**	41.88**	20.29**	-10.75**
	P9	40.35**	21.21**	-11.11**	35.09**	16.67**	-14.44**	38.05**	20.00**	-16.13**
	P10	52.94**	44.44**	-13.33**	52.94**	44.44**	-13.33**	52.94**	44.44**	-16.13**
P5 x	P6	41.84**	38.89**	11.11**	34.69**	32.00**	10.00**	40.85**	36.99**	7.53**
	P7	18.37**	16.00**	-3.33	18.67**	18.67**	-1.11	25.52**	24.66**	-2.15
	P8	41.26**	40.28**	12.22**	40.28**	34.67**	12.22**	40.85**	36.99**	7.53**
	P9	47.83**	41.67**	13.33**	40.43**	32.00**	10.00**	43.48**	35.62**	6.45*
	P10	14.29**	0.00	-20.00**	20.93**	4.00	-13.33**	13.39**	-1.37	-22.58**
P6 x	P7	41.67**	36.00**	13.33**	38.78**	36.00**	13.33**	47.52**	44.44**	11.83**
	P8	15.71**	14.08**	-10.00**	19.15**	16.67**	-6.67*	21.74**	21.74**	-9.68**
	P9	33.33**	30.43**	0.00	34.78**	29.17**	3.33	38.81**	34.78**	0.00
	P10	46.34**	30.43**	0.00	52.38**	33.33**	6.67*	54.47**	37.68**	2.15
P7 x	P8	36.99**	33.33**	11.11**	29.17**	24.00**	3.33	41.84**	38.89**	7.53**
	P9	44.68**	36.00**	13.33**	46.10**	37.33**	14.44**	48.91**	41.67**	9.68**
	P10	39.53**	20.00**	0.00	39.53**	20.00**	0.00	42.86**	25.00**	-3.23
P8 x	P9	38.69**	33.80**	5.56*	37.78**	34.78**	3.33	43.28**	39.13**	3.23
	P10	40.80**	23.94**	-2.22	46.34**	30.43**	0.00	41.46**	26.09**	-6.45*
P9 x	P10	60.00**	45.45**	6.67*	65.00**	50.00**	10.00**	61.34**	47.69**	3.23

recorded in case of 43 hybrids for heterobeltiosis and 10 hybrids for standard heterosis. Twenty one hybrids recorded significant negative standard heterosis at this location.

4.3.12 Grain yield

All the hybrids exhibited significant positive heterosis and heterobeltiosis at all locations (Table 6l).

At Rajendranagar, thirty two hybrids showed significantly positive standard heterosis, while only two hybrids recorded significant negative standard heterosis. Heterosis varied from 75.16 (P1xP8) to 201.67 (P2xP3), heterobeltiosis from 69.0 (P1xP4) to 191.47 (P2x P3) and standard heterosis from -14.84 (P1xP8) to 46.67 (P5xP7).

At Karimnagar thirty two hybrids showed significant performance in positive direction for standard heterosis and five hybrids in the negative direction. Range of variation was 75.95 (P2xP6) to 185.75 (P4xP8) for heterosis, 75.35 (P2xP6) to 171.55 (P3xP4) for heterobeltiosis and -11.78 (P1xP10) to 33.45 (P4xP8) for standard heterosis.

At Tandoor, heterosis varied from 91.45 (P4xP5) to 215.74 (P1xP3), heterobeltiosis from 58.94 (P3xP5) to 211.65 (P1xP3) and standard heterosis from -18.30 (P1xP9) to 36.36 (P5xP8). Twenty nine hybrids recorded significant positive standard heterosis, while nine hybrids were in significantly negative direction.

4.3.13 Oil percentage

At Rajendranagar, 27 hybrids exhibited significant positive heterosis, while it is in the negative direction in case of nine hybrids. The heterobeltiosis was significantly positive in case of 22 hybrids and 18 hybrids recorded significantly negative heterobeltiosis. Standard heterosis was

Table 6(f): Estimates of Heterosis, Heterobelliosis and Standard Heterosis at three locations

Hybrids	Grain yield								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Hetero-belliosis	Standard Heterosis	Heterosis	Hetero-belliosis	Standard Heterosis	Heterosis	Hetero-belliosis	Standard Heterosis
P1 x P2	191.14**	166.06**	28.18**	160.97**	128.80**	16.96**	175.93**	147.56**	16.73**
P1 x P3	169.16**	154.05**	22.39**	167.58**	166.36**	3.53	215.74**	211.65**	16.73**
P1 x P4	84.07**	69.00**	-2.64	176.05**	162.71**	12.01**	179.03**	163.04**	11.27**
P1 x P5	100.51**	95.53**	-0.88	119.73**	85.65**	3.65	93.32**	60.21**	-8.73**
P1 x P6	171.39**	163.39**	34.84**	146.97**	117.17**	10.25**	139.77**	112.50**	3.03
P1 x P7	117.23**	96.01**	17.36**	142.38**	109.84**	10.48**	148.57**	114.86**	10.42**
P1 x P8	75.16**	73.59**	-14.84**	109.76**	84.45**	-6.36**	131.90**	97.94**	4.85*
P1 x P9	125.16**	124.28**	8.05**	114.15**	95.94**	-9.07**	106.75**	96.50**	-18.30**
P1 x P10	135.12**	134.20**	12.83**	116.79**	105.77**	-11.78*	125.96**	107.59**	-7.15**
P2 x P3	201.67**	191.47**	24.65**	118.06**	91.94**	-1.88	154.20**	125.45**	6.30**
P2 x P4	143.10**	105.68**	18.49**	134.17**	114.75**	9.78**	125.20**	113.62**	0.73
P2 x P5	169.44**	140.69**	22.01**	96.47**	88.18**	5.06*	96.04**	79.15**	2.06
P2 x P6	100.28**	78.13**	-8.81**	75.95**	75.35**	-10.37**	91.63**	89.00**	-8.36**
P2 x P7	129.00**	90.76**	14.21**	119.30**	116.11**	13.78**	102.21**	93.87**	-0.36
P2 x P8	116.69**	96.41**	-3.65	114.80**	114.06**	9.42**	109.93**	98.40**	5.09*
P2 x P9	173.17**	150.53**	19.75**	114.25**	104.38**	4.48*	93.72**	82.26**	-14.06**
P2 x P10	129.84**	110.79**	0.75	115.79**	98.39**	1.41	103.43**	98.20**	-6.55**
P3 x P4	104.51**	78.17**	2.64	184.10**	171.55**	15.78**	176.62**	157.59**	8.97**
P3 x P5	144.15**	125.06**	14.09**	117.16**	84.18**	2.83	93.77**	58.94**	-9.45**
P3 x P6	149.26**	128.75**	17.11**	141.79**	113.46**	8.36**	153.07**	121.75**	7.52**
P3 x P7	113.24**	82.77**	9.43**	159.72**	125.73**	18.85**	176.14**	136.08**	21.33**
P3 x P8	166.30**	149.23**	22.26**	132.33**	105.10**	4.12	133.60**	97.25**	4.46*
P3 x P9	124.72**	112.89**	1.76	152.49**	131.98**	7.66**	192.55**	174.64**	14.18**
P3 x P10	116.39**	105.00**	-2.01	120.17**	109.89**	-10.01**	122.69**	102.17**	-9.58**
P4 x P5	110.69**	98.03**	14.09**	105.26**	81.01**	1.06	91.45**	66.81**	-4.97*
P4 x P6	80.12**	70.09**	-2.01	168.60**	147.10**	25.44**	172.36**	155.00**	23.64**
P4 x P7	135.97**	131.51**	38.62**	135.85**	113.42**	12.37**	127.68**	107.55**	6.67**
P4 x P8	142.45**	124.45**	29.31**	185.75**	162.88**	33.45**	183.21**	154.69**	34.91**
P4 x P9	120.05**	101.31**	15.97**	150.53**	140.36**	11.54**	177.46**	175.07**	16.36**
P4 x P10	147.97**	126.86**	30.69**	161.71**	160.99**	11.90**	159.05**	152.03**	12.73**
P5 x P6	126.42**	125.31**	15.35**	133.81**	123.20**	24.62**	131.72**	114.47**	22.18**
P5 x P7	165.30**	144.96**	46.67**	127.14**	120.67**	23.20**	113.42**	102.98**	15.64**
P5 x P8	154.98**	150.87**	27.17**	114.81**	105.06**	14.49**	148.07**	139.36**	36.36**
P5 x P9	94.13**	88.59**	-4.40	139.40**	119.20**	22.38**	151.17**	117.23**	23.76**
P5 x P10	149.04**	141.94**	22.64**	108.59**	84.38**	2.94	96.90**	75.74**	0.12
P6 x P7	87.77**	74.16**	4.28	113.67**	109.84**	10.48**	123.06**	116.75**	11.39**
P6 x P8	127.60**	122.85**	14.09**	119.03**	119.03**	11.19**	121.98**	112.59**	12.61**
P6 x P9	144.47**	136.36**	21.01**	116.24**	106.96**	5.06*	136.88**	120.00**	6.67**
P6 x P10	122.87**	115.48**	10.31**	139.25**	120.65**	12.01**	165.02**	154.75**	23.52**
P7 x P8	118.48**	98.74**	18.99**	105.47**	101.79**	6.24**	98.61**	95.65**	3.64
P7 x P9	110.75**	89.50**	13.46**	118.55**	105.59**	8.24**	144.59**	121.23**	13.70**
P7 x P10	103.97**	83.40**	9.81**	130.58**	109.17**	10.13**	122.45**	108.02**	6.91**
P8 x P9	131.69**	128.72**	12.20**	123.03**	113.46**	8.36**	136.67**	111.21**	11.88**
P8 x P10	169.87**	166.41**	30.69**	138.74**	120.19**	11.78**	109.93**	93.59**	2.55
P9 x P10	117.11**	117.11**	3.77	159.37**	149.49**	15.78**	175.84**	166.12**	19.03**

Table 6(m): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybride	Oil percentage								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis
P1 x P2	13.38**	3.97**	31.73**	10.46**	4.02**	26.18**	12.16**	7.37**	26.51**
P1 x P3	18.29**	10.76**	34.13**	13.46**	5.92**	30.90**	9.13**	3.62*	24.19**
P1 x P4	50.20**	38.73**	46.60**	44.18**	33.97**	43.55**	44.38**	34.82**	45.27**
P1 x P5	28.75**	20.62**	45.88**	27.24**	19.74**	45.44**	27.27**	20.01**	45.97**
P1 x P6	38.72**	30.05**	57.07**	35.54**	27.71**	54.72**	34.80**	27.65**	53.88**
P1 x P7	26.87**	11.60**	55.32**	28.05**	15.27**	54.32**	21.74**	10.20**	46.51**
P1 x P8	11.53**	-4.81**	42.29**	16.79**	2.91**	44.65**	10.95**	-2.30	38.29**
P1 x P9	-8.64**	-16.14**	11.27**	-7.13**	-13.58**	7.55**	-8.46**	-14.21**	5.74**
P1 x P10	22.99**	9.51**	48.20**	24.68**	14.06**	47.33**	24.74**	14.41**	47.75**
P2 x P3	1.29	-0.95	25.50**	4.53**	3.56**	27.99**	4.50*	3.62*	24.19**
P2 x P4	38.48**	18.17**	49.72**	38.22**	21.52**	47.41**	40.13**	25.66**	48.06**
P2 x P5	0.71	-1.58	24.70**	5.83**	5.76**	28.46**	3.98*	2.36	24.50**
P2 x P6	21.12**	18.30**	49.88**	25.10**	25.02**	51.65**	20.78**	19.42**	43.95**
P2 x P7	-18.34**	-22.00**	8.55**	-13.99**	-18.03**	9.75**	-15.67**	-20.47**	5.74**
P2 x P8	2.52**	-5.29**	41.57**	5.25**	-1.96**	37.81**	0.72	-7.72**	30.62**
P2 x P9	22.03**	19.28**	58.27**	29.56**	27.92**	59.20**	32.09**	29.18**	59.22**
P2 x P10	-5.74**	-8.74**	23.50**	6.21**	2.98**	33.02**	7.72**	3.00	33.02**
P3 x P4	16.20**	1.06	22.38**	27.43**	11.13**	37.34**	23.11**	9.57**	31.32**
P3 x P5	5.42**	5.35**	27.58**	-1.64*	-2.48**	20.52**	7.48**	6.69**	29.77**
P3 x P6	2.97**	2.84**	24.54**	4.27**	3.24**	27.59**	-1.00	-1.29	18.99**
P3 x P7	20.52**	12.69**	56.83**	19.88**	15.27**	54.32**	18.37**	12.54**	49.61**
P3 x P8	11.14**	0.59	50.36**	8.04**	1.51*	42.69**	10.44**	1.97	44.34**
P3 x P9	18.43**	13.25**	50.28**	23.80**	23.37**	53.54**	27.87**	26.10**	55.43**
P3 x P10	-7.11**	-11.99**	19.10**	-5.19**	-7.24**	19.81**	-3.30	-6.78**	20.39**
P4 x P5	21.84**	6.01**	28.22**	22.65**	7.77**	30.90**	20.50**	6.56**	29.61**
P4 x P6	42.30**	23.89**	49.64**	36.48**	20.05**	45.44**	37.85**	22.38**	47.52**
P4 x P7	32.05**	8.50**	51.00**	33.94**	12.98**	51.26**	19.48**	1.75	35.27**
P4 x P8	-2.54*	-22.09**	16.47**	2.03*	-15.60**	18.63**	4.16*	-13.53**	22.40**
P4 x P9	1.94	-14.64**	13.27**	7.01**	-6.95**	15.80**	9.80**	-3.46*	18.99**
P4 x P10	37.93**	14.59**	55.08**	36.72**	17.04**	51.18**	37.40**	18.43**	52.95**
P5 x P6	26.72**	26.64**	53.16**	22.29**	22.14**	48.35**	24.07**	23.52**	50.23**
P5 x P7	1.54	-5.11**	32.05**	4.68**	-0.18	33.65**	5.24**	0.76	33.95**
P5 x P8	-29.77**	-36.47**	-5.04**	-23.01**	-28.24**	0.86	-14.23**	-20.26**	12.87**
P5 x P9	-0.09	-4.52**	26.70**	-1.53	-2.72**	21.07**	3.39	2.70	26.59**
P5 x P10	11.92**	5.97**	43.41**	2.57**	-0.49	28.54**	7.20**	4.08*	34.42**
P6 x P7	1.48	-5.23**	31.89**	-1.36	-6.05**	25.79**	-3.73*	-8.22**	22.02**
P6 x P8	9.85**	-0.70	48.44**	6.04**	-1.29	38.76**	3.76*	-3.94**	35.97**
P6 x P9	-1.67	-6.08**	24.62**	4.61**	3.22**	28.46**	2.00	0.88	24.34**
P6 x P10	14.92**	8.74**	47.16**	17.02**	13.39**	46.46**	18.47**	14.53**	47.91**
P7 x P8	-4.29**	-7.59**	38.13**	-3.52**	-5.82**	32.39**	-1.61	-4.60**	35.04**
P7 x P9	-12.32**	-14.36**	19.18**	-6.63**	-9.92**	20.60**	-3.42*	-6.94**	23.72**
P7 x P10	6.23**	4.77**	45.80**	12.25**	10.28**	47.64**	9.32**	7.76**	43.26**
P8 x P9	1.76	-3.96**	43.57**	9.34**	3.08**	44.89**	9.31**	2.25	44.73**
P8 x P10	-0.36	-5.08**	41.89**	7.67**	3.30**	45.20**	8.71**	3.94**	47.13**
P9 x P10	-5.58**	-6.50**	26.54**	-5.83**	-7.55**	19.42**	-3.38*	-5.58**	21.94**

significant positive in 44 hybrids and it was significantly negative in one hybrid. Heterosis ranged from -29.77 (P5xP8) to 50.20 (P1x P4), heterobeltiosis from -36.47 (P5xP8) to -38.73 (P1xP4) and standard heterosis from -5.04 (P5xP8) to 58.27 (P2xP9) (Table 6m).

At Karimnagar, heterosis varied from -23.01 (P5xP8) to 44.18 (P1xP4), heterobeltiosis from -28.24 (P5xP8) to 33.97 (P1xP4) and standard heterosis from 0.86 (P5xP8) to 59.20 (P2xP9). Only 35 hybrids for heterosis, 29 hybrids for heterobeltiosis and 44 hybrids for standard heterosis showed significant positive values. Eight hybrids for heterosis and 13 hybrids for heterobeltiosis were significant in negative direction.

At Tandoor, heterosis varied from -15.67 (P2xP7) to 44.38 (P1xP4), heterobeltiosis from -20.47 (P2xP7) to 34.82 (P1xP4) and standard heterosis from 5.74 (P1xP9) to 59.22 (P2xP9). Thirty three hybrids exhibited significant positive heterosis, 23 heterobeltiosis and all hybrids for standard heterosis while significant negative heterosis and heterobeltiosis were observed in 6 and 12 hybrids respectively.

4.3.14 Protein per cent

At Rajendranagar, heterosis varied from -40.80 (P9xP10) to 55.03 (P5xP7), heterobeltiosis from -47.47 (P6xP9) to 46.22 (P5xP7) and standard heterosis from -14.27 (P6xP9) to 81.83 (P1xP2). As many as 19 hybrids for heterosis, 9 for heterobeltiosis and 32 for standard heterosis performed well with significant positive values. On the other hand, 22 hybrids for heterosis, 32 for heterobeltiosis and 3 for standard heterosis showed significantly negative values (Table 6n).

At Karimnagar, heterosis varied from -41.71 (P9xP10) to 51.31 (P4xP7), heterobeltiosis from -45.55 (P2xP3) to 40.97 (P5xP7) and standard heterosis from -11.37 (P6xP9) to 76.18 (P1xP2). Heterosis in 19 hybrids,

Table 6(n): Estimates of Heterosis, Heterobeltiosis and Standard Heterosis at three locations

Hybrids	Protein per centage								
	Rajendranagar			Karimnagar			Tandoor		
	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis	Heterosis	Heterobeltiosis	Standard Heterosis
P1 x P2	36.90**	30.62**	81.83**	36.91**	31.04**	76.18**	38.51**	32.00**	80.49**
P3	-17.95**	-29.99**	25.26**	-20.24**	-31.93**	18.35**	-15.22**	-26.78**	24.72**
P4	-6.69**	-19.30**	2.02	-6.87**	-18.82**	-0.22	-8.43**	-20.63**	-1.68
P5	22.04**	13.88**	43.97**	16.92**	10.30**	35.57**	16.36**	11.65**	38.32**
P6	-16.36**	-16.89**	5.07**	-18.86**	-20.25**	-1.98	-16.95**	-17.07**	2.74**
P7	31.34**	29.84**	64.15**	31.61**	30.80**	60.77**	31.10**	30.38**	63.31**
P8	-28.15**	-33.85**	-0.58	-29.30**	-35.20**	-4.39**	-29.33**	-35.98**	-2.30
P9	12.70**	0.00	63.21**	12.92**	-0.35	60.12**	16.05**	0.98	69.01**
P10	-29.00**	-37.10**	3.05	-33.35**	-42.50**	-2.58	-34.41**	-44.22**	-1.41
P2 x P3	-38.91**	-45.69**	-2.83	-38.59**	-45.55**	-5.34**	-35.41**	-41.78**	-0.84
P4	-16.19**	-30.33**	-3.01	-16.82**	-30.14**	-6.07**	-14.65**	-28.96**	-2.87**
P5	11.94**	0.00	39.21**	10.24**	-0.19	34.19**	11.28**	1.97	39.43**
P6	32.88**	26.01**	75.41**	37.67**	29.60**	74.25**	27.06**	20.92**	65.34**
P7	22.01**	15.15**	60.30**	25.37**	19.28**	60.38**	26.09**	20.79**	65.17**
P8	3.95**	0.12	50.47**	5.50**	0.82	48.75**	3.51**	-1.88	49.76**
P9	-36.69**	-41.34**	-4.26*	-34.95**	-40.26**	-4.01**	-35.51**	-41.41**	-1.94
P10	-6.91**	-13.91**	41.05**	-9.75**	-19.06**	37.12**	-12.56**	-22.46**	37.04**
P3 x P4	26.41**	-4.21**	71.38**	31.87**	0.59	74.89**	30.22**	-0.16	70.07**
P5	11.49**	-10.13**	60.79**	11.63**	-9.19**	57.88**	10.64**	-7.70**	57.22**
P6	0.71	-14.52**	52.94**	1.34	-14.74**	48.23**	5.80**	-8.74**	55.45**
P7	17.35**	-0.80	77.48**	17.97**	0.17	74.16**	20.09**	4.20**	77.48**
P8	-6.81**	-14.27**	53.39**	-4.70**	-11.91**	53.14**	-6.63**	-11.48**	50.77**
P9	-35.56**	-38.39**	10.23**	-35.50**	-37.95**	7.88**	-33.90**	-34.47**	11.61**
P10	-1.36	-5.52**	69.04**	-4.53**	-5.75**	63.87**	-3.85**	-5.60**	66.84**
P4 x P5	-1.22	-9.01**	-0.36	-5.52**	-13.16**	-5.34**	-3.73**	-13.45**	-1.46
P6	38.11**	20.09**	49.89**	38.09**	22.21**	45.05**	42.30**	23.48**	52.54**
P7	52.60**	33.26**	64.65**	51.31**	32.60**	60.98**	54.53**	33.31**	66.98**
P8	13.61**	-8.33**	37.77**	11.54**	-9.69**	33.25**	13.84**	-9.20**	38.59**
P9	18.02**	-7.64**	50.74**	18.16**	-7.32**	48.92**	28.33**	-1.00	65.70**
P10	7.22**	-16.21**	37.28**	3.04**	-20.69**	34.37**	3.55**	-21.61**	38.54**
P5 x P6	19.89**	12.54**	40.47**	18.93**	14.08**	35.40**	16.79**	12.22**	38.63**
P7	55.03**	46.22**	80.66**	48.56**	40.97**	71.15**	48.82**	42.05**	77.92**
P8	9.13**	-5.67**	41.77**	9.12**	-5.14**	39.97**	5.86**	-7.58**	41.06**
P9	-9.56**	-24.44**	23.33**	-11.40**	-25.65**	19.47**	-10.99**	-25.22**	25.17**
P10	1.00	-15.74**	38.04**	-2.83**	-20.16**	35.27**	-4.65**	-21.61**	38.54**
P6 x P7	-20.52**	-20.92**	-1.30	-18.28**	-19.19**	-1.89	-21.60**	-22.14**	-2.47
P8	-23.35**	-29.85**	5.43**	-24.04**	-31.47**	1.12	-27.07**	-34.02**	0.71
P9	-40.47**	-47.47**	-14.27**	-36.55**	-44.84**	-11.37**	-43.48**	-50.88**	-17.79**
P10	-29.62**	-38.01**	1.57	-32.50**	-42.60**	-2.76*	-33.86**	-43.82**	-0.71
P7 x P8	-12.29**	-20.09**	20.10**	-14.78**	-22.33**	14.60**	-13.50**	-21.26**	20.18**
P9	-23.00**	-32.35**	10.41**	-21.95**	-31.49**	10.08**	-25.77**	-35.11**	8.61**
P10	-26.54**	-35.57**	5.56**	-31.26**	-41.00**	-0.04	-34.77**	-44.27**	-1.50
P8 x P9	-38.52**	-40.96**	-3.63*	-39.33**	-41.81**	-6.50**	-38.82**	-41.52**	-2.12
P10	-37.02**	-39.62**	-1.08	-36.14**	-40.26**	1.21	-39.65**	-43.77**	-0.62
P9 x P10	-40.80**	-40.91**	-3.19	-41.71**	-43.21**	-3.79**	-43.70**	-45.19**	-3.13*

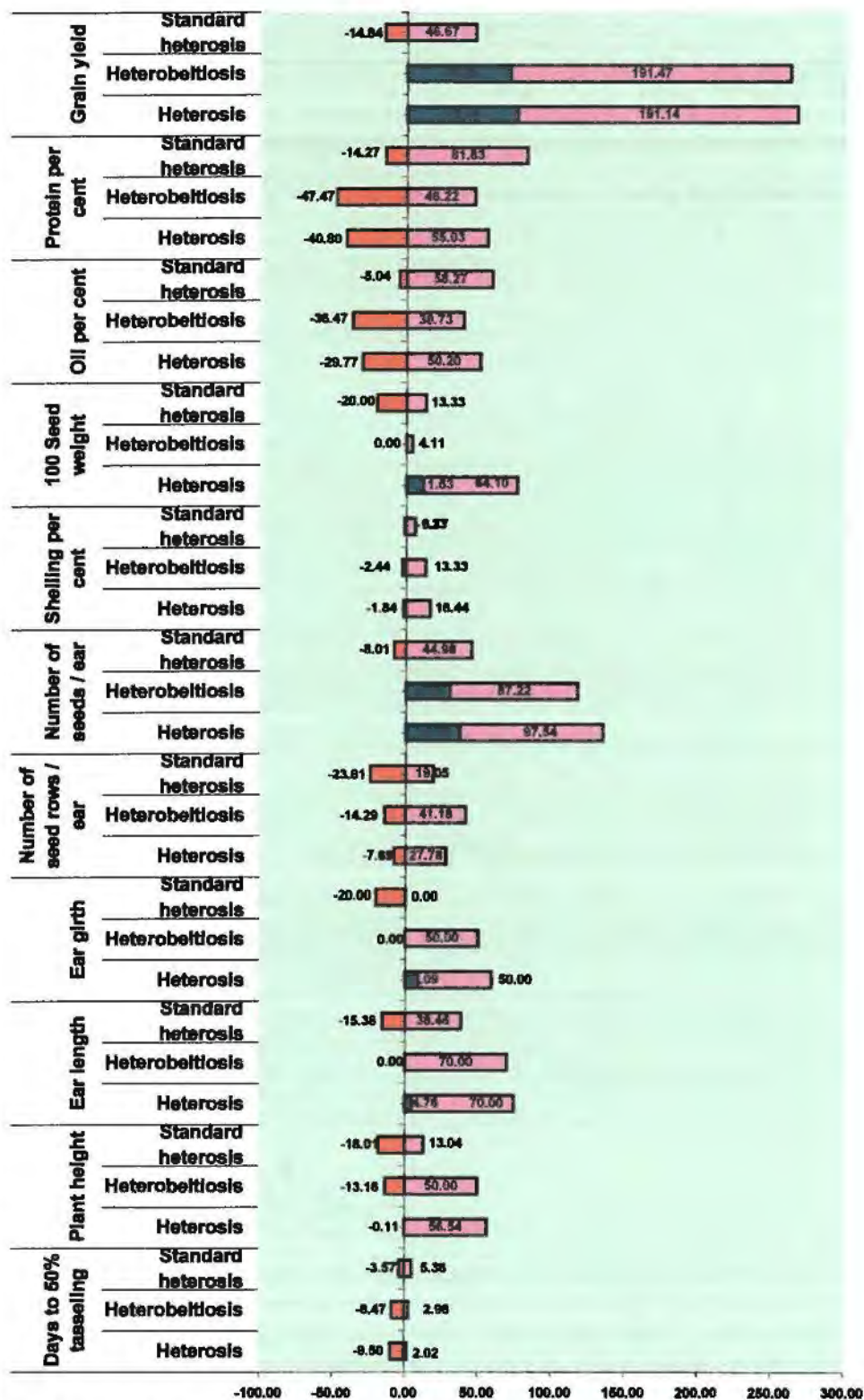


Fig. 2. Range of heterosis, Heterobeltiosis and Standard heterosis for yield and yield components for 45 hybrids at Rajendranagar

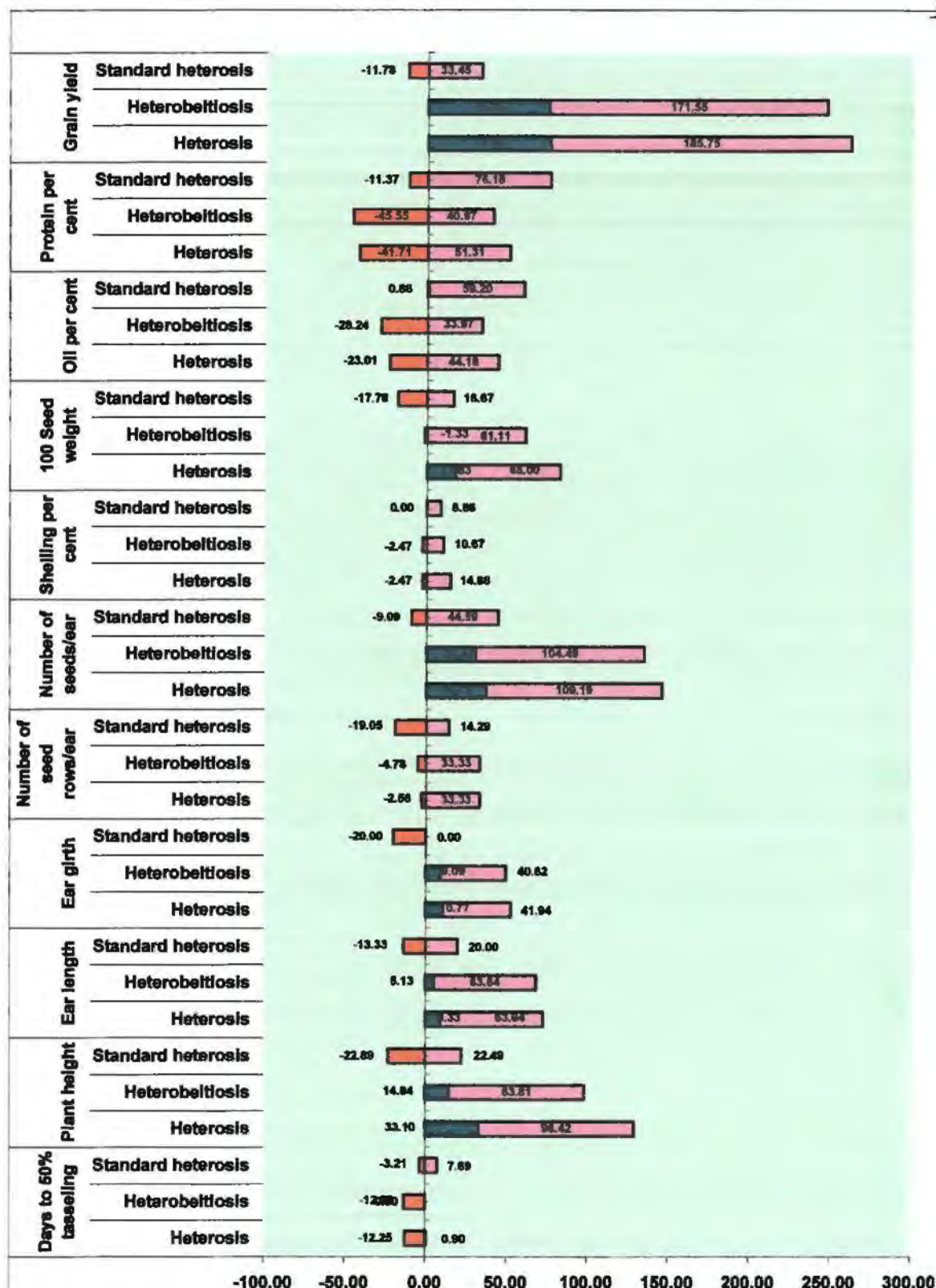


Fig. 3. Range of Heterosis, Heterobeltiosis and Standard heterosis for yield and yield components for 45 hybrids at Karimnagar

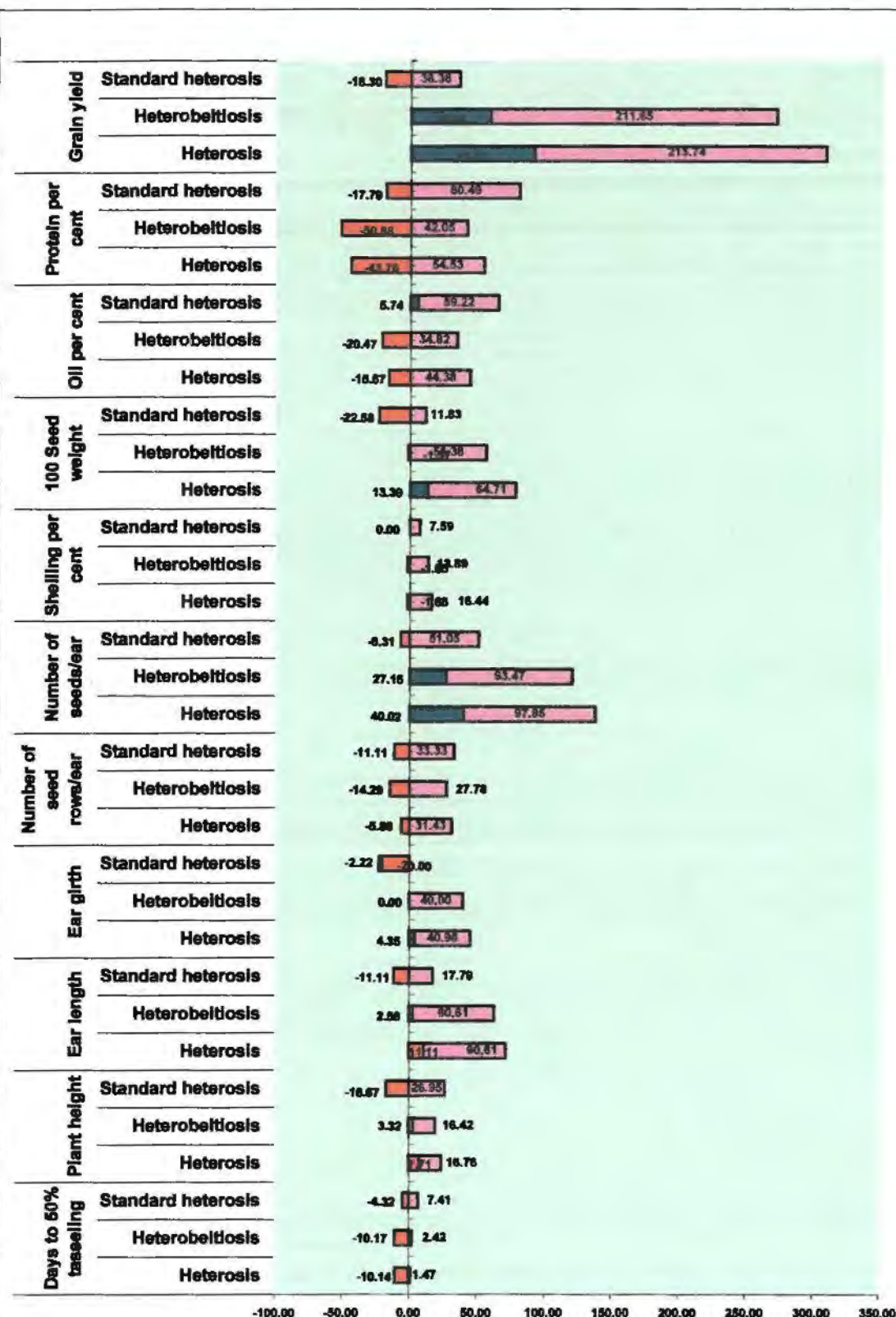


Fig. 4. Range of Heterosis, Heterobeltiosis and Standard heterosis for yield and yield components for 45 hybrids at Tandoor

heterobeltiosis in 9 hybrids and standard heterosis in 29 hybrids was found to be significant and in positive direction. On the other hand, 25 hybrids for heterosis and 31 hybrids for heterobeltiosis and nine hybrids for standard heterosis was found with significant values in the negative direction indicating their reduced protein content.

At Tandoor, heterosis varied from -43.70 (P9xP10) to 54.53 (P4xP7), heterobeltiosis from -45.19 (P9xP10) to 42.05 (P5xP7) and standard heterosis from -17.79 (P6xP9) to 80.49 (P1xP2). Twenty hybrids for heterosis, 23 for heterobeltiosis and 39 for standard heterosis registered significant positive values.

4.4 STABILITY PARAMETERS FOR GRAIN YIELD AND YIELD COMPONENTS

4.4.1 Grading of environments

The genotype x environment interaction was estimated in parental lines and their possible crosses and was presented in Table 7. The pooled analysis of variance for 14 characters over three locations viz., Rajendranagar, Karimnagar and Tandoor revealed significant differences among genotypes. Environment (Linear) were also significant for all characters except ear height, number of seed rows per ear and grain yield. The magnitude of environment (linear) was higher for all characters except number of seed rows per ear. The Genotype X Environment interaction was significant for all characters except days to 50 per cent silking, ear height, ear girth, number of seeds per ear, shelling percentage, protein percentage and grain yield. Pooled deviation were significant days to 50 per cent brown husk, ear height, number of seeds per ear shelling per cent, oil per cent, protein per cent and grain yield.

Table 7 . Pooled analysis of variance for grain yield and its components involving 55 maize genotypes over three environments

Source	df	50% Tasseling (days)	50% Silking (days)	50% Brown husk (days)	Plant height (cm)	Ear height (cm)
Genotypes	54	6.593**	6.102**	12.546**	1454.30**	388.006**
Environment(Linear)	1	219.131**	82.008**	92.866**	422.60**	33.58**
Genotype x Env(Linear)	54	1.568**	0.880**	0.842*	150.65**	12.616
Pooled deviation	55	0.367	0.477	0.297	30.91	10.848
Pooled error	330	0.554	0.546	0.364	18.56	3.414
SE(b) $\pm$		0.303	0.565	0.594	2.005	4.216

Table 7 contd...

Source	df	Ear length (cm)	Ear girth (cm)	No.of seed rows / ear	No. of seeds / ear	Shelling percentage
Genotypes	54	10216**	4.636**	4.261**	24084.789**	25.821**
Environment(Linear)	1	45.526**	0.791*	0.4088	5683.129*	10.376**
Genotype x Env(Linear)	54	1.288**	0.254	0.4754**	692.75	0.560
Pooled deviation	55	0.2371	0.193	0.1238	1111.118**	1.389**
Pooled error	330	0.4329	0.231	0.2801	142.375	0.312
SE(b) $\pm$		0.535	3.665	4.077	3.279	2.713

Table 7 contd...

Source	df	100 Seed weight (g)	Grain yield (kg)	Oil Percentage	Protein Percentage
Genotypes	54	58.176**	1.491**	1.195**	14.217**
Environment(Linear)	1	2.341**	0.115	0.233**	0.950**
Genotype x Env(Linear)	54	0.424**	0.042	0.031**	0.029
Pooled deviation	55	0.236	0.068**	0.013**	0.052**
Pooled error	330	0.335	0.002	0.002	0.007
SE(b) $\pm$		2.359	5.700	1.975	1.734

* Significant (P<0.05)

** Significant (P<0.01)

The mean values and environmental index for grain yield and its components under each environment in the present study at Rajendranagar, Karimnagar and Tandoor were presented in table 8.

A comparative study of environmental mean with grand mean helped to grade the environment. Among the three environments Karimnagar was graded as more favourable environment for grain yield as indicated by highest positive environmental index value. The characters viz., days to 50 per cent tasseling, days to 50 per cent silking, days to 50 per cent brown husk, plant height, ear height and number of seeds per ear were found to express fully at Rajendranagar. The Karimnagar location was also found to be good for ear length, ear girth, shelling percentage, 100 seed weight and protein percentage as evidenced by higher positive environmental index compared to other locations. Tandoor location was found to be unfavourable for the yield and yield contributing characters except oil percentage.

4.4.2 Estimates of stability parameters of ten parents

The estimates of the stability parameters viz., mean, regression coefficient and deviation from regression are presented in table 9.

4.4.2.1 Days to 50 per cent tasseling

The parental lines P5, P6 and P7 possessed lower means, unit regression and non-significant deviation from regression estimates for days to 50 per cent tasseling.

4.4.2.2 Days to 50 per cent silking

The parental lines P5 and P7 were also stable for days to 50 per cent silking. The parent P6 was early for days to 50 per cent silking and possessed significant regression coefficient but S^2_{di} was non-significant.

Table 8: Mean and environmental index for grain yield and its components under each environment

Characters		Environments			
		Rajendranagar	Karim Nagar	Tandoor	Grand mean
1.Days to 50%tasselling	$\bar{X}$	57.05	54.24	55.86	55.71
	I_j	1.335	-1.476	0.141	
2.Days to 50% silking	$\bar{X}$	60.6	58.87	59.61	59.69
	I_j	0.900	-0.820	-0.080	
3.Days to 50% brown husk	$\bar{X}$	89.26	87.43	88.2	88.29
	I_j	0.961	-0.868	-0.092	
4.Plant height	$\bar{X}$	156.14	152.32	153.46	153.97
	I_j	2.165	-1.652	-0.513	
5.Ear height	$\bar{X}$	61.35	60.49	60.32	60.72
	I_j	0.630	-0.230	-0.400	
6.Ear length	$\bar{X}$	13.97	15.24	14.44	14.55
	I_j	-0.581	0.690	-0.109	
7.Ear girth	$\bar{X}$	12.93	13.09	12.96	12.99
	I_j	-0.060	0.097	-0.036	
8.Number of rows per ear	$\bar{X}$	13.22	13.1	13.15	13.15
	I_j	0.064	-0.056	-0.008	
9.Number of seeds per ear	$\bar{X}$	480.35	474.15	466.02	473.51
	I_j	6.846	0.640	-7.486	
10.Shelling percentage	$\bar{X}$	81.24	81.38	80.8	81.14
	I_j	0.103	0.242	-0.345	
11.100 seed weight	$\bar{X}$	27.89	28.18	28.05	28.04
	I_j	-0.151	0.139	0.012	
12.Grain yield	$\bar{X}$	2.71	2.77	2.65	2.71
	I_j	-0.002	0.059	-0.057	
13.Oil percent	$\bar{X}$	5.59	5.63	5.68	5.63
	I_j	-0.046	0.001	0.045	
14.Protein percent	$\bar{X}$	9.85	10.03	9.99	9.95
	I_j	-0.104	0.073	0.031	

$\bar{X}$ = Mean I_j = Environmental index

Table 9 . Estimates of stability parameters of 10 Parents

S.No	Parent	Days to 50% Tasseling			Days to 50% Silking			Days to 50% Brown husk		
		Mean	bi	s ² di	Mean	bi	s ² di	Mean	bi	s ² di
1	B-57 (P1)	57.44	0.95	-0.542	60.89	1.61	0.323	87.44	1.43	-0.175
2	WRGL - 22 (P2)	58.67	-0.34	-0.335	61.67	0.05	0.116	88.67	-0.57	-0.243
3	MMH-9607 (P3)	58.67	0.37	-0.435	61.44	1.58	-0.393	88.67	0.51	-0.143
4	Med-9 (P4)	57.00	0.71	-0.539	61.67	1.21	-0.057	87.00	1.08	-0.349
5	WRGL-34 (P5)	56.00	0.71	-0.539	60.22	0.79	-0.507	86.00	1.08	-0.349
6	PARB-96 (P6)	56.44	0.68	-0.111	59.56	-0.42*	-0.291	86.22	0.95	-0.034
7	Med-5 (P7)	55.44	0.45	-0.164	59.67	0.11	0.990	86.22	0.89	-0.306
8	DMR-110 (P8)	59.00	0.00	-0.554	63.44	0.15	-0.058	89.00	0.00	-0.364
9	P 8326 (P9)	59.78	0.48	-0.518	63.56	-0.04**	-0.252	89.67	0.57	-0.242
10	CM 595 (P10)	58.33	0.34	-0.335	61.78	-0.13**	0.392	88.89	2.17	-0.031
Mean of bi			1.00			0.99			1.00	
SE of bi			0.30			0.57			0.59	

* : Significant (P<0.05)

** : Significant (P<0.01)

Table 9. (Contd.)

S.No	Parent	Plant height (cm)			Ear height (cm)			Ear length (cm)		
		Mean	bi	s ² di	Mean	bi	s ² di	Mean	bi	s ² di
1	B-57 (P1)	109.33	15.20**	115.262**	41.11	18.93**	1.867	10.67	0.70	-0.175
2	WRGL - 22 (P2)	121.56	14.90**	40.057*	45.56	11.49*	-0.750	12.00	-1.54	-0.389
3	MMH-9607 (P3)	122.33	8.36**	233.356**	45.11	3.26	12.380	12.56	0.94	0.025
4	Med-9 (P4)	103.22	2.87	-8.005	45.11	2.60	0.527	11.00	-0.00	-0.432
5	WRGL-34 (P5)	136.11	10.13**	111.978**	49.11	7.20	4.328	10.67	-0.83	-0.343
6	PARB-96 (P6)	98.22	5.53*	127.671**	35.00	0.19	-0.548	11.44	0.79	-0.432
7	Med-5 (P7)	85.56	3.71	100.618**	30.56	-0.63	-1.804	11.33	2.37	-0.424
8	DMR-110 (P8)	128.89	4.10	-17.585	40.44	1.00	-3.061	12.56	2.28	0.233
9	P 8326 (P9)	123.56	-2.48	-18.181	49.78	-1.26	3.027	10.33	-0.51	-0.428
10	CM 595 (P10)	123.78	-6.45	-9.852	43.78	-1.73	4.615	11.56	2.28	-0.233
Mean of bi			0.99			1.00			0.99	
SE of bi			2.01			4.21			0.54	

* : Significant (P<0.05)

** : Significant (P<0.01)

Table 9. (Contd.)

S.No	Parent	Ear girth (cm)			No of seed rows/ear			No of seeds/ear		
		Mean	bi	s ² di	Mean	bi	s ² di	Mean	bi	s ² di
1	B-57 (P1)	11.67	-6.73	-0.218	12.00	-0.00	-0.280	302.22	2.90	102.885
2	WRGL - 22 (P2)	10.67	1.12	0.639	11.78	-5.79	-0.233	305.56	-0.34	-139.664
3	MMH-9607 (P3)	11.00	0.00	-0.231	11.11	5.07	-0.174	291.11	1.57	148.436
4	Med-9 (P4)	11.00	-1.40	2.628*	14.00	-0.00	-0.280	348.44	-0.85	537.946*
5	WRGL-34 (P5)	11.44	-11.22	-0.193	12.00	0.00	-0.280	313.78	-0.43	57.204
6	PARB-96 (P6)	10.44	-5.05	-0.080	12.00	0.00	-0.280	293.56	0.15	-93.589
7	Med-5 (P7)	10.00	0.00	-0.231	11.33	0.00	-0.280	288.33	-1.50	50.039
8	DMR-110 (P8)	10.22	4.49	-0.225	11.56	0.30	-0.174	321.56	1.25	19.536
9	P 8326 (P9)	10.00	0.00	-0.231	11.11	1.19	-0.092	286.67	2.29	46.928
10	CM 595 (P10)	10.56	1.96	0.231	11.56	0.30	-0.223	343.33	0.64	-80.412
Mean of bi			1.00			0.99			0.99	
SE of bi			3.67			4.07			3.27	

* : Significant (P<0.05)

** : Significant (P<0.01)

Table 9. (Contd.)

S.No	Parent	Shelling percentage			100 Seed weight(g)			Grain yield (kg)		
		Mean	bi	s ² di	Mean	bi	s ² di	Mean	bi	s ² di
1	B-57 (P1)	72.33	2.76	10.913**	18.56	-1.38	0.101	1.13	0.45	0.027**
2	WRGL - 22 (P2)	71.00	-0.00	-0.312	21.00	0.00	-0.335	1.27	1.37	0.060**
3	MMH-9607 (P3)	73.00	-0.00	-0.312	18.11	0.10	-0.262	1.08	0.80	-0.001
4	Med-9 (P4)	81.00	-0.00	-0.312	16.00	0.00	-0.335	1.30	0.28	0.074**
5	WRGL-34 (P5)	81.33	0.55	0.296	24.44	3.37	-0.301	1.73	2.27	0.206**
6	PARB-96 (P6)	80.44	0.67	0.121	23.33	3.28	-0.126	1.38	0.89	-0.004
7	Med-5 (P7)	75.67	-0.55	0.298	24.67	-0.28	0.327	1.50	0.62	0.008
8	DMR-110 (P8)	80.00	-0.00	-0.312	23.22	-2.37	-0.279	1.40	-0.13	0.010
9	P 8326 (P9)	76.44	4.09	-0.281	21.89	-0.09	-0.262	1.24	1.44	0.004
10	CM 595 (P10)	76.00	0.74	1.584	18.00	0.00	-0.335	1.24	0.16	-0.004
Mean of bi			0.99			1.00			1.00	
SE of bi			2.71			2.36			3.64	

* : Significant (P<0.05)

** : Significant (P<0.01)

Table 9. (Contd.)

S.No	Parent	Oil percentage			Protein percentage		
		Mean	bi	s ² di	Mean	bi	s ² di
1	B-57 (P1)	4.53	2.48	-0.002	9.42	0.44	0.003
2	WRGL - 22 (P2)	5.16	-2.36	-0.001	10.36	0.23	-0.004
3	MMH-9607 (P3)	5.15	1.14	0.010*	13.20	-0.09	0.183**
4	Med-9 (P4)	3.88	3.13	-0.002	6.93	0.95	0.008
5	WRGL-34 (P5)	5.14	2.04	-0.002	8.39	2.10	0.025
6	PARB-96 (P6)	5.12	1.61	-0.001	9.26	-0.27	0.001
7	Med-5 (P7)	5.73	-0.94	0.002	9.34	1.42	0.001
8	DMR-110 (P8)	6.09	-1.60	0.024**	11.37	1.72	0.009
9	P 8326 (P9)	5.37	-2.54	0.010*	12.40	2.24	0.038*
10	CM 595 (P10)	5.56	-0.98	0.007	12.88	6.10	0.118**
Mean of bi			1.00			1.00	
SE of bi			1.97			1.73	

* : Significant (P<0.05)

** : Significant (P<0.01)

4.4.2.3 Days to 50 per cent brown husk

The parental lines P5, P6 and P7 possessed lower means, unit regression and non-significant S^2di estimates.

4.4.2.4 Plant height

In respect of plant height, P4, P8, P9 and P10 possessed non-significant bi and S^2di estimates.

4.4.2.5 Ear height

The parental lines P5 and P9 possessed higher ear height with non-significant stability parameters. The parents P3 and P4 with 45.1cm ear height were found to possess unit regression and non-significant estimate of deviation from regression.

4.4.2.6 Ear length

In respect of ear length, all the parental lines were found to be stable; However, P3 and P8 possessed highest ear length of 12.56cm.

4.4.2.7 Ear girth

The parental lines P1, P5 and P3 possessed higher mean values ranging from 11.00cm to 11.67cm ear girth with non-significant bi and S^2di estimates. The other parents were also stable for this character.

4.4.2.8 Number of seed rows per ear

In respect of number of seed rows per ear, all the parental lines exhibited stable performance across the locations; However, P4, P5, P6 and P1 possessed higher mean values from 12 to 14 seed rows per ear.

4.4.2.9 Number of seeds per ear

The parent P4 had highest number of seeds per ear (348.44) with unit regression and significant S^2_{di} estimates. Among the others, P8, P5 and P2 possessed desirable higher mean values with stable performance as indicated by non-significant b_i estimates.

4.4.2.10 Shelling percentage

In respect of shelling percentage, all the parental lines exhibited stable performance across the locations but P1 exhibited significant S^2_{di} . Among the parents, P5, P4 and P8 possessed higher mean values from 80.44 to 81.33 per cent.

4.4.2.11 100 seed weight

All the parental lines showed stable performance across the locations. However the parents, P7, P5, P6, and P8 possessed higher mean values from 23.22 to 24.44g.

4.4.2.12 Grain yield

The parent P5 exhibited higher mean value (1.73) but S^2_{di} was significant. The parents P7 and P8 showed higher mean values, unit regression and non-significant deviation from regression estimates (Fig.7).

4.4.2.13 Oil per cent

In respect of oil per cent the parent P8 recorded higher mean value but S^2_{di} estimates was significant. However, the parents P7 and P10 possessed higher mean values, b_i and S^2_{di} estimates were non-significant (Fig.8).

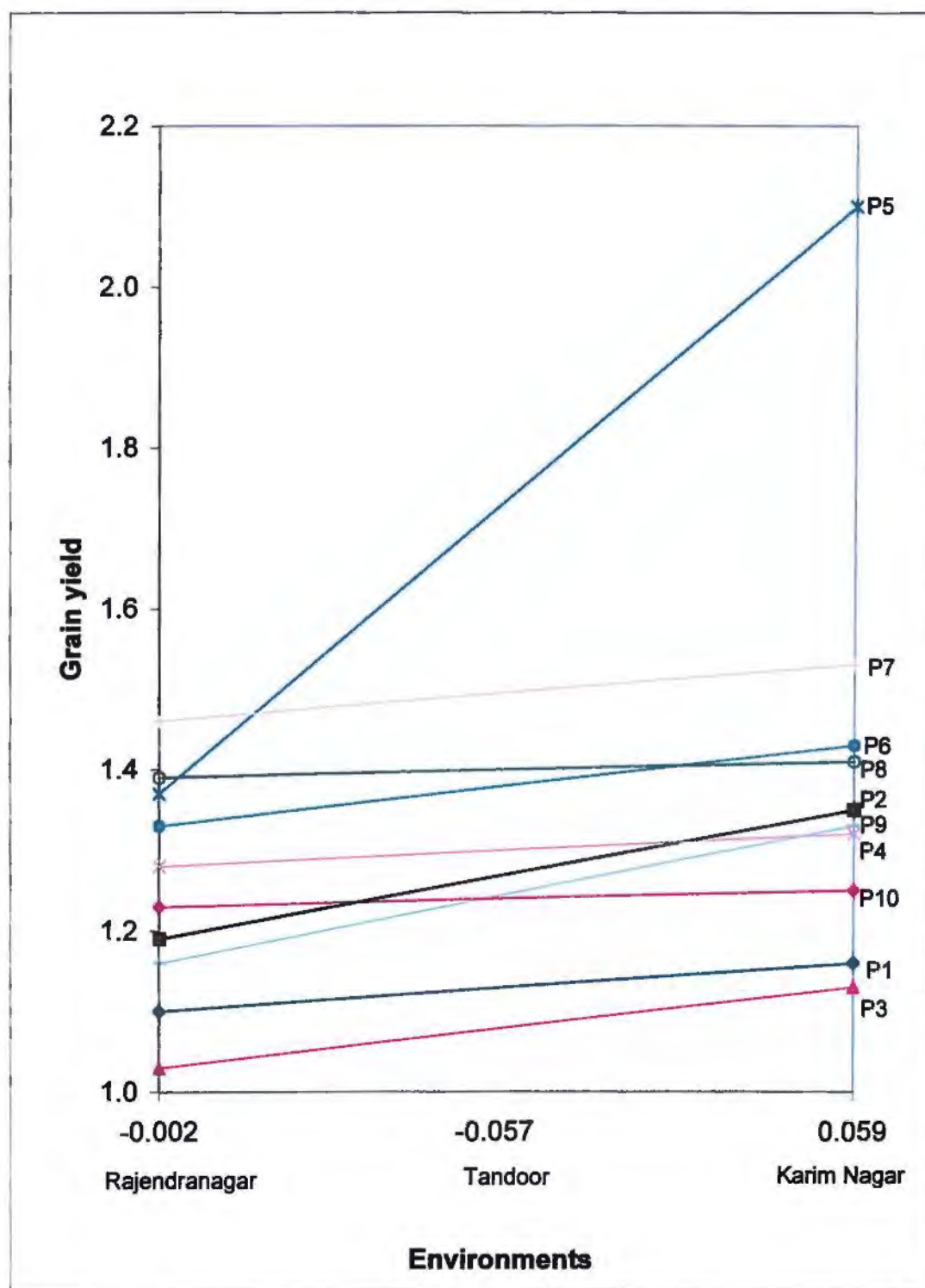


Fig. 7: Stability performance of parents on grain yield

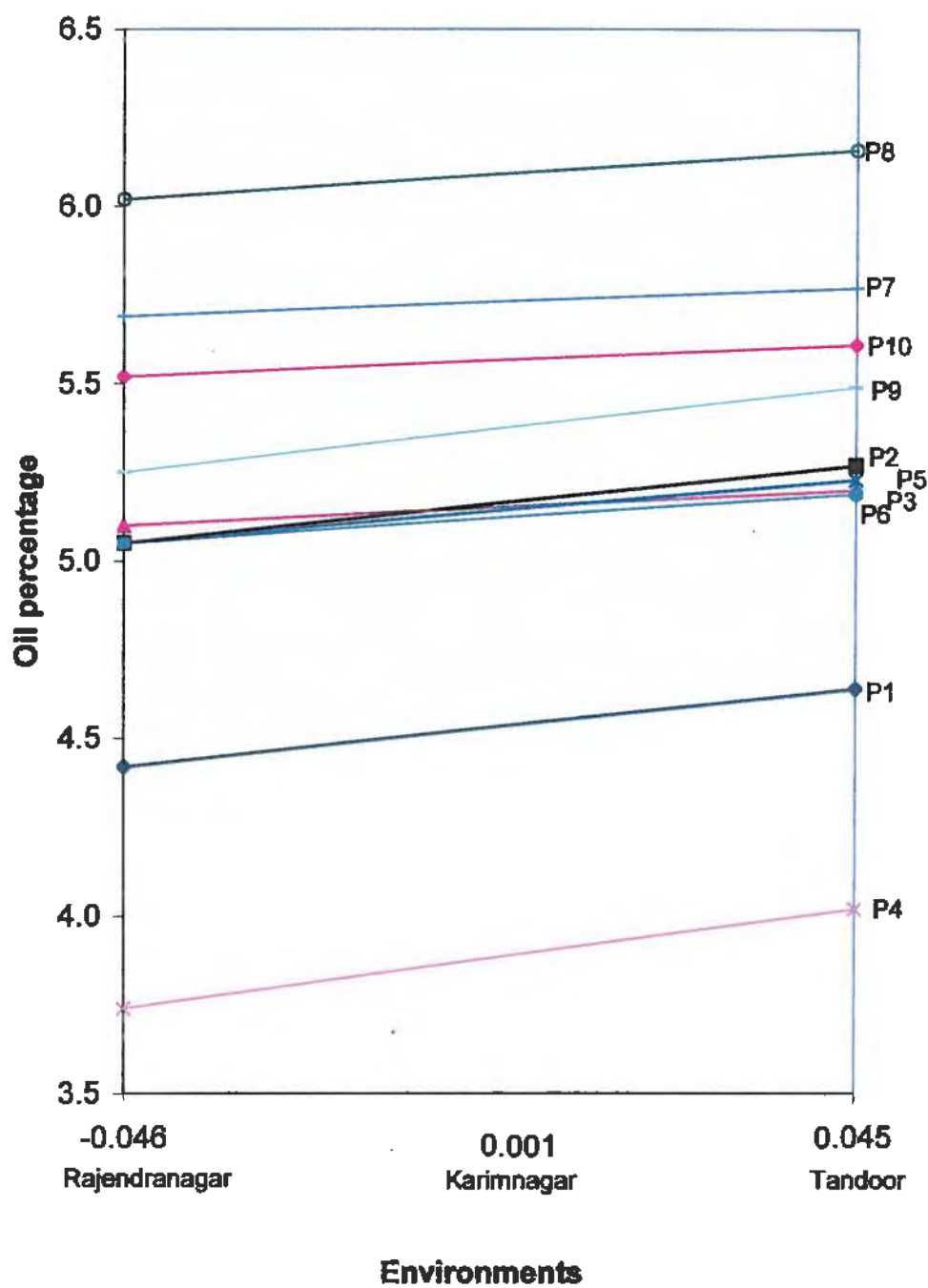


Fig. 8: Stability performance of parents on oil percentage

4.4.2.14 Protein per cent

The parents P3, P10 and P9 possessed higher mean values but deviation from regression estimates was significant. However, the parent P8 possessed higher mean (11.37) per cent, non-significant bi and S^2_{di} estimate (Figs 9).

4.4.3 Estimates of stability parameters of crosses

The data on mean of three locations and stability parameters of 45 crosses are given in Table 10.

4.4.3.1 Days to 50 per cent tasseling

In respect of days to 50 per cent tasseling 35 hybrids executed stable performance across the locations. Eight hybrids possessed more than unit regression while 6 less than one. The crosses P4xP10, P1xP2, P3xP9, P3xP10 and P5xP6 had low mean values and stable performance.

4.4.3.2 Days to 50 per cent silking

Out of 45 hybrids only four possessed more than unit regression and one hybrid had significant S^2_{di} estimate. Among the 41 stable hybrids, P3xP9, P3xP10, P5xP6, P6xP7 and P5xP8 had less than 58 days for 50 per cent silking.

4.4.3.3 Days to 50 per cent brown husk

The mean over locations ranged from 82.67 to 91.78 days, Thirty four hybrids exhibited unit regression and non-significant S^2_{di} estimates, for this character. The hybrids P4xP10, P5xP6 and P5xP7 were early to 50 per cent brown husk with less than 84.89 days.

4.4.3.4 Plant height

Average plant height of the hybrids ranged from 137.57cm to 196.67cm. Only 17 crosses exhibited unit regression and non significant S^2_{di}

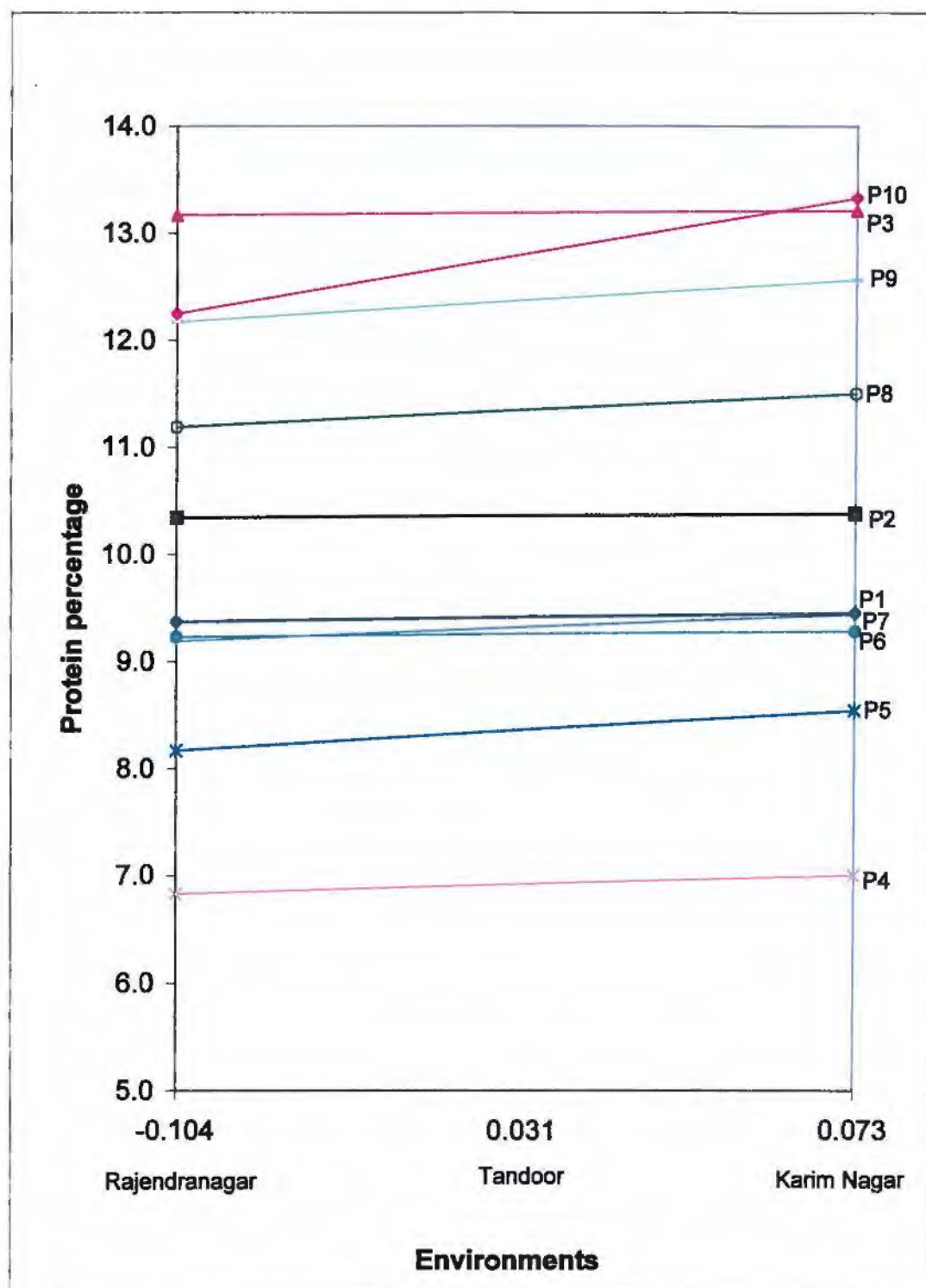


Fig. 9: Stability performance of parents on protein percentage

Table 10 . Estimates of stability parameters of 45 cross of maize

Cross	Days to 50% Tasseling			Days to 50% Silking			Days to 50% Brown husk		
	Mean	bi	s ² di	Mean	bi	s ² di	Mean	bi	s ² di
P1 x P2	53.67	0.67	0.321	59.00	1.15	-0.532	89.67	0.72	-0.355
P3	54.44	1.15	1.003	58.89	0.95	-0.492	89.22	0.89	-0.306
P4	56.00	0.00	-0.554	59.89	0.29	1.399	90.00	-0.05**	0.296
P5	57.56	1.06	-0.553	61.78	1.91	-0.332	91.78	1.79	-0.137
P6	55.11	-0.12**	-0.541	59.00	-0.00	-0.545	89.00	0.00	-0.364
P7	54.67	1.38	0.566	59.11	1.79	0.058	89.11	1.69	0.215
P8	54.56	1.77*	-0.526	59.00	1.81	0.554	89.56	1.67	-0.122
P9	56.44	1.05	-0.452	60.67	2.36*	-0.204	91.44	1.18	1.153*
P10	56.22	1.44	-0.466	61.00	1.65	1.393	91.11	1.37	1.195*
P2 x P3	54.33	2.02**	-0.550	58.00	1.15	-0.532	88.11	0.91	-0.365
P4	56.11	1.42	-0.554	60.22	0.79	-0.507	90.22	0.74	-0.330
P5	54.67	0.10**	-0.372	58.33	0.60	-0.423	88.22	0.74	-0.327
P6	54.44	1.32	-0.349	58.22	0.79	-0.506	89.33	0.72	-0.358
P7	55.89	0.83	-0.553	59.33	0.60	-0.423	89.89	0.59	0.016
P8	55.89	1.04	0.770	59.89	0.84	0.471	90.67	0.83	2.020*
P9	54.44	0.45**	-0.164	58.78	0.04	-0.252	89.56	-0.50*	0.183
P10	55.33	1.45	-0.231	60.00	3.46**	-0.427	91.44	1.64	-0.362
P3 x P4	56.11	2.26**	-0.471	59.89	2.11*	-0.426	90.00	1.24	-0.061
P5	55.89	1.30	-0.546	59.40	1.46	2.109*	89.89	1.21	2.783**
P6	56.00	0.71	-0.539	59.30	0.60	-0.423	89.67	0.72	-0.355
P7	55.67	1.08	-0.505	60.56	0.73	-0.163	90.89	0.48	0.658
P8	56.00	0.71	-0.539	59.89	1.17	-0.521	90.22	1.10	-0.342
P9	53.33	0.34	-0.335	56.67	0.05	0.116	87.33	0.26	1.072
P10	53.67	1.48	1.353	56.78	1.19	-0.363	87.56	1.16	0.557
P4 x P5	55.78	1.09	-0.311	59.22	1.12	-0.113	89.89	0.32	-0.020
P6	55.89	0.39*	0.233	59.44	0.42	-0.290	89.67	0.57	-0.242
P7	53.78	2.03**	-0.445	58.56	0.73	-0.162	89.22	0.38	-0.310
P8	55.33	1.45	-0.231	59.56	0.95	-0.492	90.00	1.08	-0.349
P9	57.00	1.55	-0.534	60.56	1.50	-0.063	90.56	1.26	-0.287
P10	52.11	1.39	0.065	56.67	0.55	-0.330	82.67	2.07	0.621
P5 x P6	53.67	0.67	0.321	57.67	0.05	0.116	84.67	0.93	-0.271
P7	54.11	0.72	-0.532	58.0	0.66	0.807	84.89	1.10	-0.342
P8	55.44	1.73*	0.042**	59.78	2.29	-0.295	85.67	2.42*	3.305**
P9	56.44	1.05	-0.452	60.33	0.60	-0.423	86.78	1.69	0.216
P10	56.11	1.69*	0.082	60.33	1.76	-0.490	86.33	2.42*	3.303**
P6 x P7	55.00	-0.06**	0.584	57.89	0.18	-0.521	86.11	-0.49*	3.079**
P8	56.00	2.12**	-0.419	60.33	1.87	0.464	88.33	1.14	0.107
P9	54.78	1.39	0.065	59.44	1.14	-0.396	86.00	1.81	-0.323
P10	54.44	1.72*	1.022	59.33	1.48	0.389	85.11	1.90	0.953
P7 x P8	55.78	1.79**	-0.417	59.44	1.91	-0.331	86.56	1.98	-0.233
P9	55.33	0.34*	-0.335	58.56	0.24	-0.112	86.11	0.34	-0.269
P10	56.00	0.71	-0.539	60.33	1.10	0.316	86.44	1.22	0.312
P8 x P9	56.00	0.71	-0.539	60.78	0.75	-0.425	86.67	0.51	-0.143
P10	57.22	1.57	-0.086	60.67	1.70	-0.211	87.44	2.16*	-0.095
P9 x P10	55.11	1.52	-0.393	59.0	1.54	-0.522	85.67	2.17*	-0.303
Mean of bi		1.00			0.99			1.00	
SE of bi		0.30			0.57			0.59	

Table 10. (contd.)

Cross		Plant height (cm)			Ear height (cm)			Ear length (cm)		
		Mean	bl	s ² dl	Mean	bl	s ² dl	Mean	bl	s ² dl
P1 x	P2	155.67	-3.74	-7.988	47.00	-2.26**	0.368	14.56	1.07	-0.415
	P3	157.78	7.89**	43.654	68.78	9.00	46.366**	14.00	-0.00	-0.432
	P4	155.00	3.91	-7.266	62.11	3.92	7.728	16.00	3.08**	-0.260
	P5	157.22	5.02*	2.941	55.67	7.14	12.330	13.78	0.47	-0.318
	P6	157.67	2.19	-9.041	68.33	4.23	3.661	13.67	3.78**	0.419
	P7	151.00	2.19	-9.039	45.44	1.66	-1.470	16.67	0.13	0.219
	P8	163.78	0.71	-0.135	74.22	2.00	-2.003	15.78	-1.45**	0.123
	P9	153.00	3.45	-18.264	61.33	4.32	1.402	14.22	2.42**	-0.302
	P10	159.22	4.97	-1.030	62.00	2.64	24.993**	15.00	-0.00	-0.432
P2 x	P3	137.56	5.64**	-18.380	55.44	6.83	0.669	14.56	0.75	-0.376
	P4	165.44	2.91	-12.552	68.22	3.79	-3.204	16.78	-0.10	0.521
	P5	160.56	-2.45**	-17.410	64.22	-3.35**	-2.631	13.89	1.26	-0.338
	P6	166.33	-0.36**	18.661	72.33	1.03	2.829	14.44	-2.28**	-0.233
	P7	139.00	-3.33*	-17.772	58.33	-4.89**	0.685	14.11	-0.23**	-0.404
	P8	161.56	-1.35**	-16.100	59.22	0.98	12.073*	16.00	1.54	-0.389
	P9	158.33	1.49	-8.136	65.44	3.07	-3.296	14.22	2.42**	-0.302
	P10	174.11	-4.40**	-15.624	72.67	-7.74**	282.926**	16.56	0.75	-0.376
P3 x	P4	165.44	-0.79**	-8.797	67.67	-1.69**	-3.153	14.33	2.37*	-0.424
	P5	160.11	-1.07**	-17.886	67.67	-1.41**	-2.627	13.78	3.16**	-0.417
	P6	147.78	-2.12**	5.088	59.11	-1.73**	4.616	13.11	1.17	0.283
	P7	159.89	1.25	-18.462	62.89	1.63	-2.959	15.22	1.45	0.123
	P8	170.33	1.10	28.173*	77.11	3.44	1.452	15.44	3.29**	0.433
	P9	155.33	1.84	-0.406	75.11	3.72	-2.457	14.44	0.79	-0.432
	P10	171.67	0.03**	-15.692	68.22	-0.15**	-0.686	14.00	1.92	0.743
P4 x	P5	160.67	1.39	-18.568	57.33	1.97	-2.900	14.78	1.63	-0.323
	P6	161.22	-4.02*	-14.434	64.44	-4.45**	2.582	14.14	1.11	-0.273
	P7	153.78	-3.12*	11.733	60.67	-1.79**	-0.697	17.00	1.54	-0.389
	P8	173.89	-2.44**	-8.865	79.56	-0.25**	-3.156	17.33	-0.70**	-0.175
	P9	173.56	-3.04*	0.243	69.44	-3.23**	7.179	15.78	1.30	-0.431
	P10	155.56	-0.04**	-5.172	65.44	0.72	-0.097	15.56	0.94	0.025
P5 x	P6	162.33	-0.25**	-13.471	66.44	1.48	1.996	15.22	1.45	0.123
	P7	181.00	-0.76*	-16.800	72.22	-0.72**	-2.768	17.78	0.28	-0.423
	P8	166.67	0.32	-11.118	70.11	1.38	-3.388	16.00	-0.00	-0.432
	P9	182.67	-0.73*	-3.961	72.11	0.81	-3.303	15.56	0.75	-0.376
	P10	162.78	-7.52	-17.966	58.44	-6.41**	-3.119	14.67	1.67	-0.073
P6 x	P7	148.22	1.88	-16.068	59.78	1.47	-3.326	15.89	1.58	-0.429
	P8	176.11	1.17	-16.380	68.11	2.98	4.129	15.89	1.58	-0.429
	P9	172.78	-0.14**	62.247**	77.44	-1.16**	-3.269	14.00	1.54	-0.389
	P10	157.89	-2.71**	-18.562	54.11	-2.66**	-2.773	16.11	1.30	-0.431
P7 x	P8	148.11	-3.42*	-18.534	51.78	-3.60**	-1.477	16.67	1.67	-0.072
	P9	162.33	0.96	-8.733	63.00	0.66	0.540	15.67	0.70	-0.175
	P10	164.67	-0.44*	49.484**	58.89	-1.28**	-3.013	16.44	2.14*	-0.364
P8 x	P9	171.00	0.19	169.374**	68.56	2.83	25.534**	16.67	1.35	-0.379
	P10	180.67	-3.36*	-11.870	64.67	-3.01**	-2.703	16.33	-0.70**	-0.175
P9 x	P10	196.67	-6.45**	32.628*	73.00	-7.97*	4.702	14.22	-0.34**	0.880
Mean of bl		0.99			1.00			0.99		
SE of bl		2.01			4.21			0.54		

Table 10. (contd.)

Cross		Ear girth (cm)			No of seed rows/ear			No of seeds/ear		
		Mean	bi	s ² di	Mean	bi	s ² di	Mean	bi	s ² di
P1 x	P2	13.78	-1.40	-0.185	14.00	-0.00	-0.280	521.22	-0.76	497.833
	P3	13.33	-4.21	0.179	13.33	-0.00	-0.280	540.56	1.70	5106.928**
	P4	13.89	-2.24	-0.230	15.56	20.99	0.293	569.11	2.33	10.580
	P5	14.00	0.00	-0.231	13.33	-0.00	-0.280	494.89	2.44	1002.672*
	P6	14.33	3.65	-0.201	15.33	-10.86	-0.268	471.11	-2.07	1423.602**
	P7	13.33	3.65	-0.201	12.44	0.72	0.012	523.78	5.83	645.315*
	P8	13.67	-3.65	-0.201	13.33	10.85	-0.268	553.33	2.43	5952.981**
	P9	13.33	3.65	-0.201	13.33	-10.86	-0.268	449.00	1.35	4064.371**
	P10	12.11	2.24	-0.230	13.78	5.06	-0.174	508.89	5.21	3563.941**
P2 x	P3	12.56	-5.89	-0.213	12.89	16.64	-0.268	470.89	-0.26	636.787*
	P4	14.22	7.58	-0.095	14.00	-0.00	-0.280	570.67	7.47	-126.811
	P5	13.67	2.53	0.343	13.33	10.85	-0.268	484.89	3.58	764.713*
	P6	13.67	2.53	0.343	13.33	10.85	-0.268	459.78	7.91	2891.839**
	P7	12.89	0.84	-0.167	15.56	5.79	-0.233	477.33	-3.00	5768.167**
	P8	12.67	4.21	0.179	12.89	-11.58	-0.093	494.00	1.53	-142.255
	P9	13.11	13.19	0.004	14.00	-4.34	0.468	523.78	4.55	2114.515**
	P10	13.00	3.09	-0.146	13.78	5.06	-0.174	514.44	5.76	33.640
P3 x	P4	14.00	0.00	-0.231	14.00	-4.34	0.468	551.89	-3.12	1136.343**
	P5	14.00	0.00	-0.231	13.56	5.79	-0.233	454.00	2.84	-49.441
	P6	14.00	-3.09	-0.146	14.22	-5.07	-0.175	455.56	0.46	-6.617
	P7	13.33	3.65	-0.201	12.67	4.34	0.468	477.89	-2.01	-211.351
	P8	12.89	-2.24	-0.230	11.56	5.79	-0.233	437.33	1.12	184.438
	P9	14.33	-4.21	0.179	13.78	5.06	-0.174	497.44	4.26	739.464
	P10	13.11	2.24	0.230	12.44	0.72	0.012	446.44	2.11	-50.630
P4 x	P5	13.89	0.84	-0.167	13.33	10.85	-0.268	522.44	-0.22	-138.115
	P6	13.22	4.49	-0.225	12.89	-11.58	-0.093	519.56	-3.78	2059.505**
	P7	12.67	4.21	0.179	12.22	-5.07	-0.174	499.78	-2.64	1330.739**
	P8	13.44	1.68	0.023	14.00	-0.00	-0.280	667.56	-0.46	-141.532
	P9	14.78	-1.40	-0.185	15.78	5.06	-0.174	618.00	1.64	706.401*
	P10	14.00	0.00	-0.231	15.11	-5.79	-0.233	594.67	-0.31	-135.151
P5 x	P6	14.44	-1.96	0.231	14.22	16.64	-0.268	519.78	1.25	186.030
	P7	14.11	2.24	-0.230	13.78	-5.79	-0.233	547.11	0.56	2336.084**
	P8	13.89	-2.24	-0.230	13.33	10.85	-0.268	536.67	0.40	6615.468**
	P9	14.00	0.00	-0.231	12.44	-5.79	-0.233	512.33	-1.34	120.304
	P10	13.48	6.45	0.131	14.00	-0.00	-0.280	554.33	-3.13	-28.907
P6 x	P7	13.44	-1.96	0.231	12.89	-5.07	-0.174	455.11	2.41	50.918
	P8	13.44	-1.96	0.231	14.89	-5.07	-0.174	534.89	-2.79	-95.793
	P9	14.11	-0.84	-0.167	13.78	0.72	0.012	486.00	2.08	-75.367
	P10	13.22	1.40	-0.186	13.11	15.92	-0.092	523.44	-0.31	696.413*
P7 x	P8	12.44	5.89	-0.213	10.89	-5.07	-0.174	453.33	1.15	2105.470**
	P9	13.11	2.24	-0.230	12.00	-0.00	-0.280	456.89	0.13	39.269
	P10	13.22	4.49	-0.225	12.00	-0.00	-0.280	503.78	0.94	225.942
P8 x	P9	13.89	8.70	0.086	12.67	-10.86	-0.268	478.44	-1.28	295.852
	P10	12.44	8.98	-0.207	13.33	-17.37	0.140	499.44	1.51	-105.887
P9 x	P10	13.22	4.49	-0.225	12.22	-0.72	0.012	516.78	1.87	542.857*
Mean of bi			1.00			0.99			0.99	
SE of bi			3.67			4.07			3.27	

Table 10 . (contd.)

Cross		Shelling percentage			100 Seed weight (gram)			Grain yield (kg)		
		Mean	bi	s ² di	Mean	bi	s ² di	Mean	bi	s ² di
P1 x	P2	81.67	0.19	4.348*	30.67	-3.28**	-0.125	3.31	0.82	0.008
	P3	80.44	0.43	-0.272	29.00	0.00	-0.335	3.13	-2.44	0.014*
	P4	82.33	3.66	-0.176	27.78	-2.18**	-0.242	2.94	1.09	0.184**
	P5	81.67	1.09	2.130	27.00	6.84	-0.325	2.69	3.65	0.000
	P6	82.00	1.48	7.275**	30.22	2.19	-0.242	3.18	2.29	0.238**
	P7	82.33	4.40	0.699	31.00	0.00	-0.335	3.09	0.76	-0.004
	P8	85.67	1.83	-0.277	26.11	4.37	0.037	2.60	-1.85	0.172**
	P9	79.56	-0.67	0.118	26.11	-4.18	0.995*	2.56	2.67	0.063**
	P10	82.00	2.38	0.621	26.00	6.84	-0.325	2.69	-0.62	0.138**
P2 x	P3	79.33	0.55	0.296	30.78	-0.19**	-0.041	3.00	-1.38	0.130**
	P4	83.22	0.86	-0.156	26.67	-1.00**	-0.155	3.01	2.82	0.025*
	P5	81.22	0.06	0.204	30.00	0.00	-0.335	3.00	1.33	0.076**
	P6	84.56	-1.71	0.316	30.00	0.00	-0.335	2.49	0.18	0.004
	P7	82.00	1.64	5.181*	28.89	1.19	-0.321	3.00	4.09	-0.003
	P8	82.67	4.21	1.015	30.44	4.37	0.036	2.85	1.89	0.121**
	P9	85.00	-0.00	-0.312	24.78	4.66	-0.294	2.83	4.93	0.181**
	P10	85.00	-0.00	-0.312	27.89	-0.38**	0.843	2.70	2.58	-0.004
P3 x	P4	81.44	-1.16	0.397	26.56	3.47	-0.328	3.00	2.51	0.107**
	P5	82.33	-0.19	4.345*	29.11	1.09	-0.312	2.81	3.50	0.869
	P6	79.67	-1.28	0.043	33.11	-1.19**	-0.321	3.04	0.91	0.001
	P7	83.00	4.75	3.424	34.22	4.47	-0.220	3.20	0.355	0.130**
	P8	82.00	2.38	0.621	32.89	5.75	-0.333	3.02	0.54	0.069**
	P9	82.67	1.09	2.130	31.67	7.41	1.995	2.96	-0.69	0.101**
	P10	81.00	-0.74	1.584	28.89	-0.09**	-0.262	2.54	0.49	-0.001
P4 x	P5	80.22	1.89	-0.027	24.89	-1.09**	-0.312	2.83	2.03	0.052**
	P6	83.33	2.92	2.741	32.00	0.00	-0.335	3.18	1.53	0.505**
	P7	80.89	0.31	1.078	38.67	3.56	-0.209	3.26	1.94	0.254**
	P8	83.00	3.11	-0.143	27.44	-2.18**	-0.242	3.64	0.66	0.061**
	P9	82.00	0.74	1.584	26.11	-3.47**	-0.328	3.14	-0.34	0.003
	P10	81.11	0.43	-0.274	26.00	0.00	-0.335	3.24	0.48	0.069**
P5 x	P6	80.67	-2.02	3.582*	33.22	-1.09**	-0.312	3.31	1.54	0.093**
	P7	84.00	2.38	0.621	29.67	2.57	0.273	3.52	2.47	0.205**
	P8	83.67	-0.55	0.298	33.56	-0.09**	-0.262	3.45	-4.33	0.008
	P9	81.44	0.67	0.120	33.33	-3.56**	-0.208	3.13	0.77	0.533**
	P10	83.11	4.88	-0.069	24.67	6.55	0.503	2.97	1.25	0.113**
P6 x	P7	81.00	-0.00	-0.312	34.22	0.19	-0.040	2.98	0.64	0.068**
	P8	82.00	3.11	-0.143	27.67	3.56	-0.209	3.09	0.46	0.002
	P9	80.44	0.67	0.121	30.67	3.56	-0.209	3.04	0.27	0.038**
	P10	81.44	-1.40	-0.264	31.22	7.03	-0.141	3.16	-1.84	0.084**
P7 x	P8	82.33	-1.83	-0.279	32.56	-7.65	0.806	3.00	1.28	0.030**
	P9	81.78	1.96	1.259	34.11	1.09	-0.312	3.07	-0.52	0.001
	P10	81.22	-0.92	0.936	30.33	0.00	-0.335	2.99	1.55	0.004
P8 x	P9	83.33	1.28	0.041	31.56	-2.09**	-0.003	3.04	-0.06	0.002
	P10	84.33	2.02	3.580*	29.44	2.09	-0.003	3.15	2.81	0.149**
P9 x	P10	81.67	1.83	-0.277	32.33	3.28	0.126	3.10	0.18	0.179**
Mean of bi			0.99			1.00			1.00	
SE of bi			2.71			2.36			3.64	

Table 10. (contd.)

Cross		Oil percentage			Protein percentage		
		Mean	bi	s'di	Mean	bi	s'di
P1 x	P2	5.43	-0.58	0.006*	13.59	0.75	-0.006
	P3	5.49	-2.76	0.002	9.29	-0.42	0.023*
	P4	6.15	1.46	0.003*	7.58	0.33	0.236*
	P5	6.18	2.11	-0.002	10.54	-1.32	-0.001
	P6	6.58	0.73	-0.002	7.72	-1.02	0.001
	P7	6.44	-1.92	0.013**	12.32	1.29	-0.005
	P8	6.00	0.16	0.022**	7.39	0.04	-0.006
	P9	4.58	-1.01	-0.001	12.43	2.27	0.105**
	P10	6.26	1.90	-0.002	7.55	-0.88	0.002
P2 x	P3	5.33	1.17	0.010*	7.34	0.39	0.013
	P4	6.29	1.35	-0.001	7.27	0.50	-0.003
	P5	5.33	1.68	0.016**	10.42	0.51	0.006
	P6	6.29	-0.64	0.027**	13.00	0.93	0.482**
	P7	4.58	0.23	0.006*	12.26	3.15	0.011
	P8	5.79	-3.12	0.002	11.33	1.64	0.002
	P9	6.73	2.70	-0.001	7.32	1.87	-0.005
	P10	5.50	6.23	0.025**	10.48	0.33	0.026*
P3 x	P4	5.52	5.94	0.130**	13.04	3.60	0.149**
	P5	5.34	2.83	0.074**	12.01	1.02	0.042*
	P6	5.24	-0.82	0.041**	11.52	1.14	0.044**
	P7	6.51	-1.16	-0.001	13.36	1.63	-0.007
	P8	6.18	-0.69	0.021**	11.54	1.92	0.072*
	P9	6.49	4.55	-0.001	8.32	1.11	0.001
	P10	5.07	2.30	-0.002	12.61	0.59	-0.004
P4 x	P5	5.49	2.48	0.003*	7.39	-0.26	-0.001
	P6	6.25	1.13	0.008*	11.29	1.07	0.052**
	P7	6.18	-5.22	0.083**	12.34	1.64	0.017
	P8	5.05	4.44	-0.001	10.34	0.73	0.010
	P9	4.92	4.29	-0.002	11.75	3.75	0.680**
	P10	6.48	1.20	0.006	10.35	1.32	0.000
P5 x	P6	6.38	0.80	0.009	10.46	0.24	-0.007
	P7	5.64	2.77	-0.001	13.37	-0.73	0.005
	P8	4.36	9.74	0.008*	10.67	1.48	0.001
	P9	5.29	1.74	0.033**	9.29	0.87	0.023*
	P10	5.74	-2.19	0.120**	10.40	1.27	-0.006
P6 x	P7	5.36	-2.76	-0.001	7.43	1.16	0.010
	P8	5.97	-3.74	0.010*	7.75	-0.44	0.023*
	P9	5.33	1.65	0.018**	6.48	1.79	0.169**
	P10	6.24	2.44	-0.001	7.52	-0.18	-0.006
P7 x	P8	5.73	0.51	0.017**	8.96	0.04	0.015
	P9	5.13	3.82	-0.001	8.31	1.34	0.029*
	P10	6.17	0.88	0.010*	7.67	-1.19	0.057*
P8 x	P9	6.12	2.59	-0.001	7.26	0.74	0.010
	P10	6.13	4.48	-0.001	7.56	2.33	0.021*
P9 x	P10	5.19	-0.36	0.023**	7.32	1.29	0.003
Mean of bi			1.00			1.00	
SE of bi			1.97			1.73	

estimates. The crosses P6xP8 and P5xP8 were tall and stable while P1xP7 and P1xP9 were comparatively dwarf and exhibited less than unit regression and non significant deviation from regression.

4.4.3.5 Ear height

The mean over the locations ranged from 45.44cm (P1xP7) to 79.56cm (P4xP8). The estimates of b_i and S^2_{di} indicated 23 hybrids as stable. The crosses P2xP3, P1xP5 and P4xP5 had intermediate ear height with desired stability parameters.

4.4.3.6 Ear length

The length of the ear ranged from 13.67cm (P1xP6) to 17.78cm (P5xP7). Thirty one hybrids showed unit regression and non significant S^2_{di} estimates. The crosses P5xP7, P4xP7, P2xP4 and P1xP7 recorded higher mean ear length and were found to be stable.

4.4.3.7 Ear girth

Average ear girth of the crosses ranged from 12.11 cm (P1xP10) to 14.78 cm (P4xP9). Ten hybrids exhibited unit regression and non-significant S^2_{bi} estimates. The crosses P4xP9, P5xP6, P3xP9 and P2xP4 recorded higher mean (above 14 cm) and non-significant deviation from regression.

4.4.3.8 Number of seed rows per ear

The number of seed rows per ear ranged from 10.89 (P7xP8) to 15.78 (P4xP9). The responsiveness of hybrids was more for this character and in most cases the trend was for the better environment. In the present case, at Rajendranagar location, only 14 hybrids possessed regression around unity. Among these, P4xP9, P1xP2, P2xP4 and P4xP8 possessed 14 to 15.8 number of seed rows and non significant estimates of stability parameters.

4.4.3.9 Number of seeds per ear

The mean number of seeds per ear varied from 437.33 (P1xP8) to 667.56 (P4xP8). The crosses differed widely for their non linear component of stability while linear component was non-significant for any of the hybrid. Twenty four hybrids exhibited stability. Among these P4xP8 and P4xP10 possessed higher means and turned out to be stable for this character.

4.4.3.10 Shelling percentage

The mean over the locations ranged from 79.56 (P1xP9) to 85.67 (P1xP8) per cent. Shelling per cent did not show significant bi estimates. As many as 39 crosses showed stability. The crosses P1xP8, P2xP9, P2xP10 and P2xP6 possessed higher means with non significant stability parameters.

4.4.3.11 100 seed weight

The test weight varied from 24.78 (P2xP9) to 38.67 (P4xP7), few crosses exhibited significant linear component of stability but all the crosses had non significant S^2_{di} estimates.

4.4.3.12 Grain yield

The average grain yield of the hybrids across the locations ranged from 2.49 (P2xP6) to 3.64kg per plot (P4xP8). Only 15 hybrids exhibited unit regression and significant S^2_{di} estimates. The high yielding hybrids viz., P4xP8 and P5xP7 had significant estimates of deviation from regression. The cross combinations P5xP8, P1xP2, P1xP7, P4xP9 and P6xP8 possessed higher means and bi estimates around unity with non significant S^2_{di} estimates (Fig. 10).

4.4.3.13 Oil per cent

The oil per cent in hybrids ranged from 4.36 (P5xP8) to 6.73 per cent (P2xP9) (Fig. 11). The bi estimate of stability parameter was non significant for all

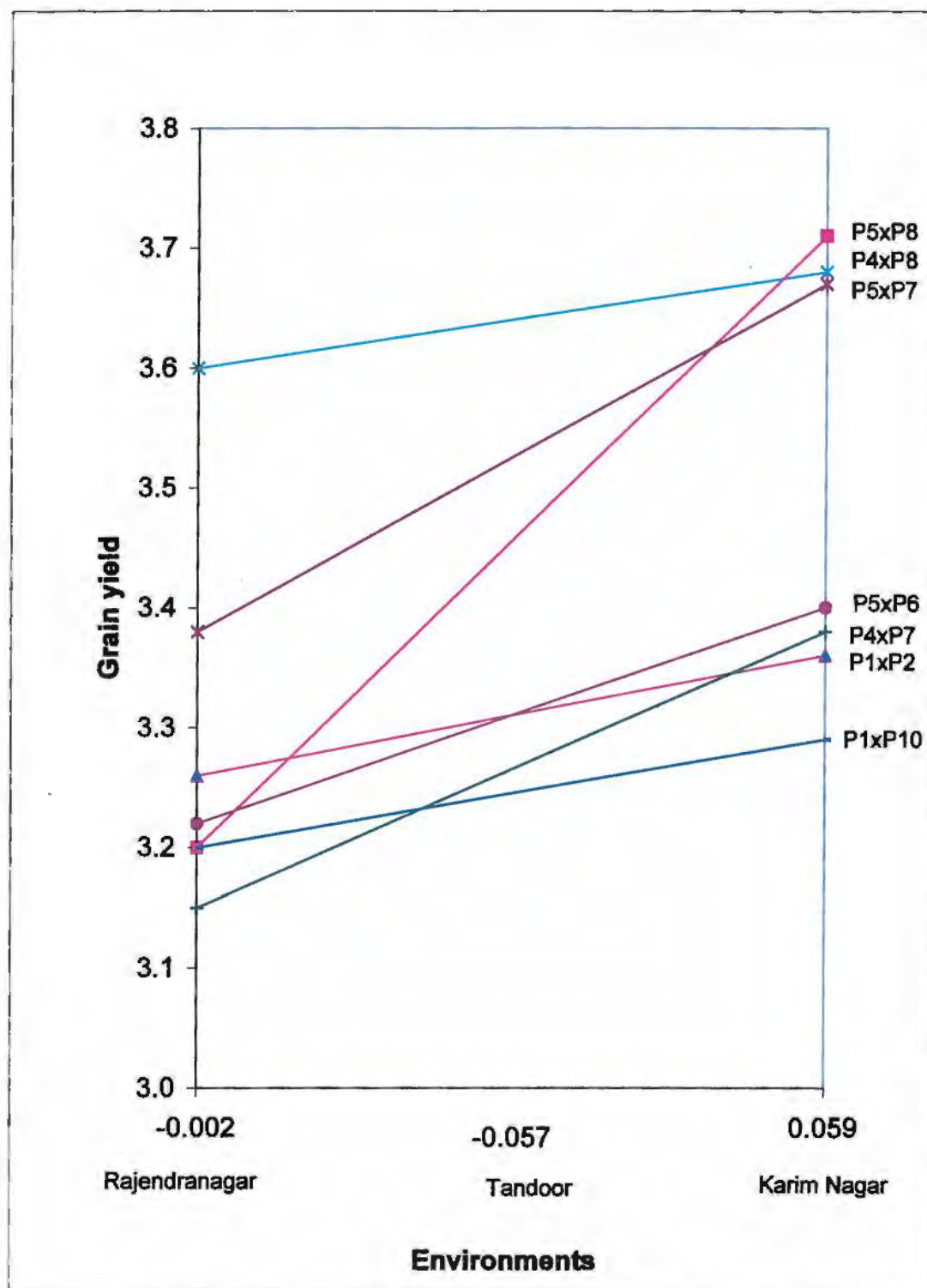


Fig. 10: Stability performance of promising crosses on grain yield

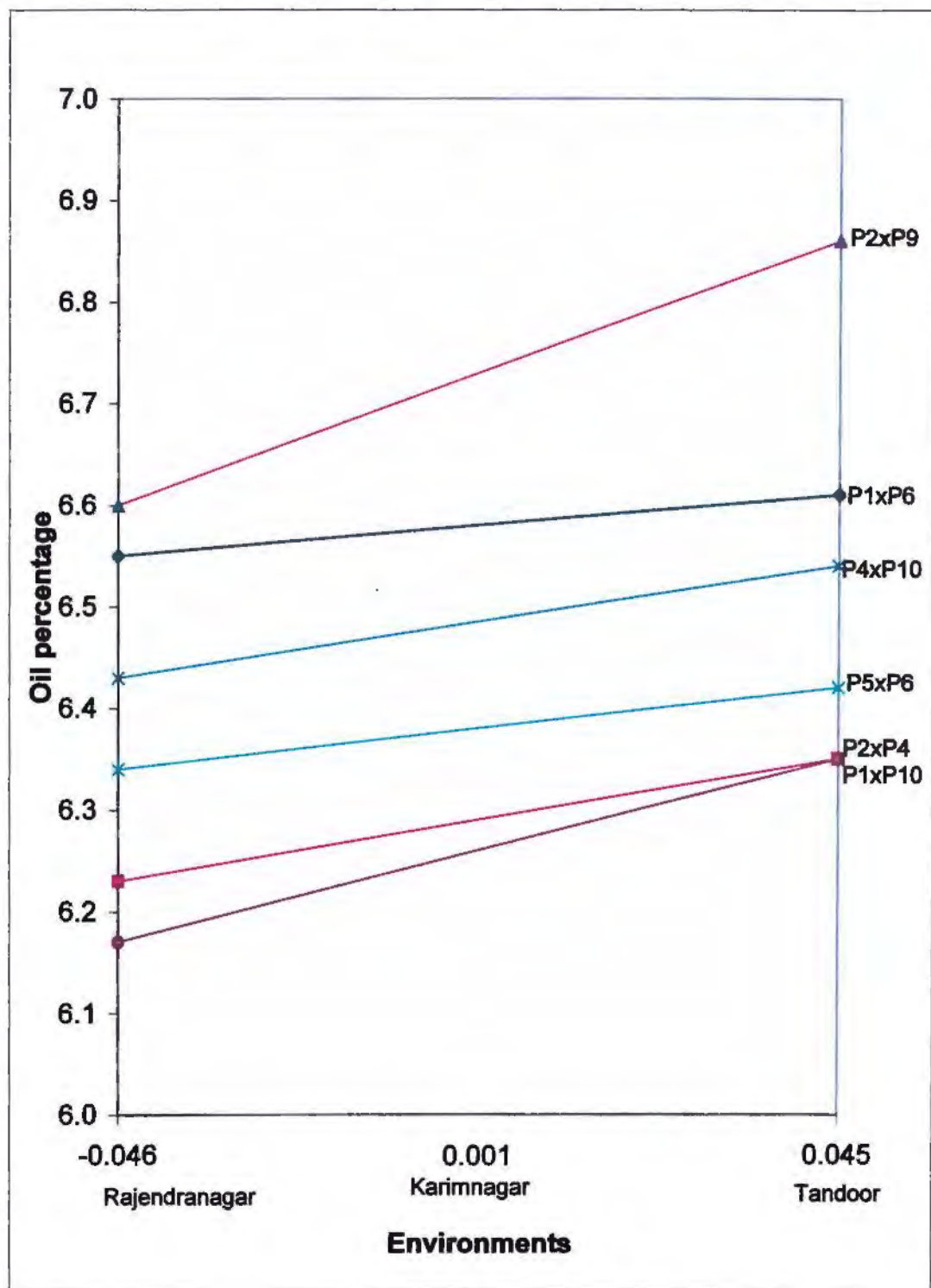


Fig. 11: Stability performance of promising crosses on oil percentage

the hybrids whereas S^2_{di} found to be non significant for 21 hybrids. The cross combinations P2xP9, P1xP6, P4xP10, P5xP6 and P2xP4 possessed higher mean oil per cent and were stable over the environments (Rajendranagar, Karimnagar and Tandoor).

4.4.3.13 Protein per cent

There was a wide difference among the hybrids for protein per cent, varying from 7.27 (P2xP4) to 13.59 (P1xP2) per cent (Fig. 10). The linear component GXE interaction for this character was non-significant. Twenty eight cross combinations exhibited stability with unit regression and non significant S^2_{di} estimates. The crosses P5xP7, P3xP7 and P3xP10 had higher mean protein per cent and were stable over the locations.

4.5 ESTIMATES OF GENETIC PARAMETERS

The estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), and heritability (b) and genetic advance as per cent of mean were estimated for all the characters at three locations and are presented in Table 11.

The differences between GCV and PCV were wider for the characters viz., days to 50 per cent tasseling, days to 50 per cent silking, plant height, ear length, ear girth and number of seed rows per ear. These differences were narrow for days to 50 per cent brown husk, ear height, number of seeds per ear, shelling per cent, 100 seed weight, grain yield, oil and protein per cent. The heritability estimates ranged from 46.47 for 50 per cent tasseling at Tandoor to 99.7 per cent (protein) at Tandoor. High heritability was observed for the characters plant height, ear height, number of seeds per ear, shelling percentage, 100 seed weight, grain yield, oil and protein per cent. However, these estimates were moderate for days to 50 per

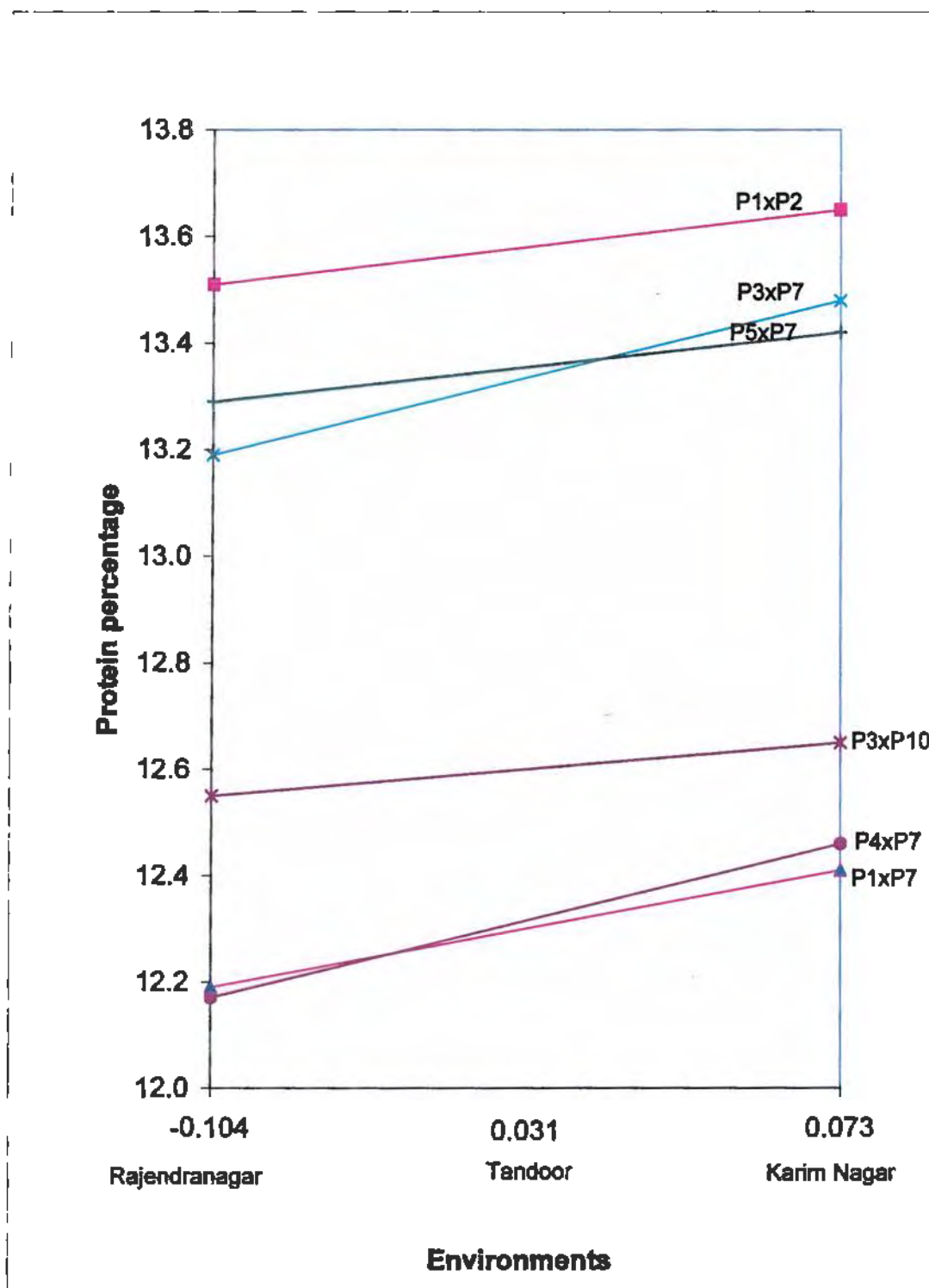


Fig. 12: Stability performance of promising crosses on protein percentage

Table 11: Estimates of genotypic (gcv), phenotypic (pcv) coefficient of variance heritability (b) and genetic advance as per centage of mean for 14 characters at three locations

	50%Tasseling (days)			50%Silking (days)			50%Brown husk (days)		
	Rajendranagar	Karim Nagar	Tandoor	Rajendranagar	Karim Nagar	Tandoor	Rajendranagar	Karim Nagar	Tandoor
GCV	2.22	3.41	2.54	2.41	2.28	2.51	2.14	2.63	2.29
PCV	3.03	4.05	3.73	3.18	3.01	3.19	2.44	2.84	2.61
h^2	53.18	71.06	46.47	57.19	57.20	61.81	76.95	85.46	77.02
GA % of mean	3.34	5.93	3.57	3.75	3.55	4.06	3.87	5.01	4.14

Table 11 contd...

	Plant height (cm)			Ear height (cm)			Ear length (cm)		
	Rajendranagar	Karim Nagar	Tandoor	Rajendranagar	Karim Nagar	Tandoor	Rajendranagar	Karim Nagar	Tandoor
GCV	11.30	16.99	13.48	33.72	18.83	17.79	13.05	12.55	10.54
PCV	12.42	17.60	14.02	35.09	19.72	18.20	14.81	14.01	13.70
h^2	82.82	93.09	92.36	92.36	91.16	95.51	77.68	80.23	59.25
GA % of mean	21.20	33.76	26.68	66.77	37.23	35.82	23.99	23.16	16.72

Table 11 contd...

	Ear girth (cm)			No. of seed rows/ear			No of seeds/ear		
	Rajendranagar	Karim Nagar	Tandoor	Rajendranagar	Karim Nagar	Tandoor	Rajendranagar	Karim Nagar	Tandoor
GCV	9.65	9.56	7.55	9.28	8.41	8.13	5.48	17.81	18.07
PCV	11.28	10.80	10.51	10.88	10.92	11.24	6.44	18.42	18.49
h^2	73.19	78.32	51.59	72.72	59.20	52.37	72.43	93.46	95.51
GA % of mean	17.01	17.43	11.17	16.30	13.32	12.13	29.61	35.47	36.38

Table 7 contd...

	Shelling%			100 Seed weight (g)			Grain yield (kg)		
	Rajendranagar	Karim Nagar	Tandoor	Rajendranagar	Karim Nagar	Tandoor	Rajendranagar	Karim Nagar	Tandoor
GCV	3.98	3.49	3.45	14.83	14.48	15.01	24.40	23.88	24.67
PCV	4.09	3.71	3.67	15.21	14.86	15.40	24.56	24.11	24.78
h ²	94.46	88.55	88.68	95.13	94.90	95.09	98.73	98.11	99.07
GA % of mean	7.97	6.72	6.69	29.81	29.06	30.15	49.92	48.72	50.54

Table 7 contd...

	Oil percentage			Protein percentage		
	Rajendranagar	Karim Nagar	Tandoor	Rajendranagar	Karim Nagar	Tandoor
GCV	12.41	11.12	10.64	23.82	22.16	22.39
PCV	12.46	11.15	10.81	23.88	22.19	22.42
h ²	99.20	99.51	96.85	99.52	99.65	99.70
GA % of mean	25.46	22.86	21.58	48.95	45.56	46.06

cent tasseling, days to 50 per cent silking, days to 50 per cent brown husk, ear girth and number of seed rows per ear.

The estimates of genetic advance as per cent of mean were found to vary from 3.34 for days to 50 per cent tasseling at Rajendranagar to 66.77 per cent for ear height at Rajendranagar. Genetic advance was very low (3.3 to 5.0 per cent) for days to 50 per cent tasseling, silking and was moderate for ear girth, number of seed rows per ear, oil per cent, shelling percentage and ear length. The Genetic advance was high for number of seeds per ear, 100 seed weight, grain yield and protein.

4.6 CHARACTER ASSOCIATION

In general, correlation studies reveal the nature and magnitude of the association between any two characters. Correlation coefficient refers to the measure of the relationship of two variables for two characters. Correlation coefficients will serve as a tool to determine the superior lines.

4.6.1 Phenotypic and genotypic correlation

Phenotypic and genotypic correlation coefficients were estimated between yield, its components and oil and protein contents, in 45 hybrids at Rajendranagar, Karimnagar and Tandoor and were presented in table 12A, 12B and 12C respectively. In general, genotypic correlations were of slightly higher magnitude than the corresponding phenotypic values, and hence only the genotypic correlations are discussed here under.

4.6.1.1 Days to 50 per cent tasseling

Days to 50 per cent tasseling was significant and positively correlated with 50 per cent silking, and 50 per cent brown husk, while it had significant negative association with all the other characters except protein content at

Table 12a: Phenotypic and genotypic correlations for 14 characters at Rajendranagar location

Variables		50% Tasseling	50% Silking	50% Br husk	Plant height	Ear height	Ear length	Ear girth	No of seed rows/ear	No of seeds/ear	Shelling percent	100 Seed weight	Oil percent	Protein percent	Grain yield
50% Tasseling	P	1.0000	0.7748**	0.4674**	-0.1667	-0.2624**	-0.1228	-0.3149**	-0.2260*	-0.2428**	-0.2487**	-0.3938**	-0.2074*	0.0528	-0.3726**
	G	1.0000	0.9504**	0.3701**	-0.1985*	-0.3348**	-0.2444**	-0.5614**	-0.2961**	-0.3557**	-0.3803**	-0.5423**	-0.2700**	0.0802	-0.4821**
50% Silking	P		1.0000	0.5433**	-0.1021	-0.2153*	-0.117	-0.3285**	-0.2216*	-0.2192*	-0.1838*	-0.3835**	-0.2287*	0.1093	-0.3525**
	G		1.0000	0.4561**	-0.1018	-0.2794**	-0.1884*	-0.5109**	-0.2880**	-0.3038**	-0.2610**	-0.5148**	-0.3003**	0.1417	-0.4546**
50%Brown husk	P			1.0000	0.1007	0.1102	0.0641	0.0577	0.1046	0.1929*	0.1778	-0.0931	0.0234	0.3080**	0.0442
	G			1.0000	0.1659	0.1507	0.0701	0.0610	0.1891*	0.2191*	0.2076*	-0.1068	0.0284	0.3532**	0.0568
Plant height	P				1.0000	0.8463**	0.5457**	0.6137**	0.2305*	0.6699**	0.4445**	0.4622**	0.2060*	-0.1259	0.5613**
	G				1.0000	0.8520**	0.6869**	0.7438**	0.2557**	0.7362**	0.5087**	0.5416**	0.2273*	-0.1438	0.6235**
Ear height	P					1.0000	0.4686**	0.6517**	0.3829**	0.6703**	0.4939**	0.4316**	0.1170	-0.1577	0.5677**
	G					1.0000	0.5561**	0.7661**	0.4281**	0.7033**	0.5316**	0.4734**	0.1222	-0.1657	0.5956**
Ear length	P						1.0000	0.4607**	0.1544	0.7183**	0.5586**	0.4780**	0.2091*	-0.0938	0.5990**
	G						1.0000	0.5207**	0.2109*	0.7945**	0.6137**	0.5625**	0.2357*	-0.1049	0.6802**
Ear girth	P							1.0000	0.5616**	0.7080**	0.4624**	0.5241**	0.1112	-0.0463	0.6365**
	G							1.0000	0.6773**	0.8021**	0.5503**	0.6852**	0.1313	-0.1547	0.7551**
No of seed rows/ear	P								1.0000	0.5472**	0.3298**	0.0697	-0.0174	-0.0878	0.4014**
	G								1.0000	0.6200**	0.4145**	0.1162	-0.0158	-0.1124	0.7330**
No of seeds/ear	P									1.0000	0.6224**	0.4462**	0.2289*	-0.1521	0.7351**
	G									1.0000	0.6497**	0.4905**	0.2331**	-0.1557	0.7539**
Shelling percent	P										1.0000	0.5081**	0.2976**	-0.0809	0.5712**
	G										1.0000	0.5352**	0.1302**	-0.0825	0.5928**
100 Seed weight	P											1.0000	0.2346*	-0.0276	0.6596**
	G											1.0000	0.2433**	-0.0278	0.6833**
Oil percent	P												1.0000	-0.0618	0.2492**
	G												1.0000	-0.0613	0.2519**
Protein percent	P													1.0000	-0.0618
	G													1.0000	-0.0633
Grain yield	P														1.0000
	G														1.0000

P-Phenotypic

G-Genotypic

* : Significant (P<0.05)

** : Significant (P<0.01)

Rajendranagar (Table 12A). Similar association of characters was found at Karimnagar and Tandoor.

4.6.1.2 Days to 50 per cent silking

Days to 50 per cent silking showed significant positive association with only one character i.e., 50 per cent brown husk. On the other hand it showed significant negative association with all other characters except 50 per cent tasseling and 50 per cent silking at all locations. It had non significant positive association with protein content at Rajendranagar and Karimnagar and oil and protein contents at Tandoor.

4.6.1.3 Days to 50 per cent brown husk

Days to 50 per cent brown husk has shown significant positive association with number of seed rows per ear, number of seeds per ear, shelling per cent and protein content at Rajendranagar, protein content at Karimnagar and Tandoor.

4.6.1.4 Plant height

The association of plant height was significant and positive with all characters except protein content with which it was non significant at Rajendranagar, Karimnagar and Tandoor. While it showed significant negative association at Rajendranagar, 50 per cent tasseling and 50 per cent silking at Karimnagar and Tandoor.

4.6.1.5 Ear height

Ear height revealed significant positive association with plant height, ear length, ear girth, number of seed rows per ear, number of seeds per ear, shelling per cent 100 seed weight and yield. It had significant negative association with 50 per cent tasseling, and 50 per cent silking at Rajendranagar.

Table 12b: Phenotypic and genotypic correlations for 14 characters at Karimnagar location

Variables		50% Tasseling	50% Silking	50% Br husk	Plant height	Ear height	Ear length	Ear girth	No of seed rows/ear	No of seeds/ear	Shelling percent	100 Seed weight	Oil percent	Protein percent	Grain yield
50% Tasseling	P	1.0000	0.8107**	0.3180**	-0.4883**	-0.4690**	-0.4553**	-0.4558**	-0.2387*	-0.5104**	-0.4643**	-0.4641**	-0.1988*	0.0678	-0.5656**
	G	1.0000	0.9728**	0.2537**	-0.5621**	-0.5404**	-0.5381**	-0.6229**	-0.3803**	-0.6405**	-0.5698**	-0.5596**	-0.2482**	0.0724	-0.6778**
50% Silking	P		1.0000	0.3368**	-0.4086**	-0.4126**	-0.4248**	-0.4272**	-0.2071*	-0.4308**	-0.3534**	-0.4565**	-0.1509	0.1039	-0.5113**
	G		1.0000	0.2637**	-0.5174**	-0.5449**	-0.5617**	-0.6632**	-0.3727**	-0.6096**	-0.4726**	-0.6275**	-0.2032*	0.1260	-0.6838**
50%Brown husk	P			1.0000	-0.0470	0.0123	-0.0200	0.0169	0.0908	0.0542	0.0040	-0.1372	0.1467	0.2918**	-0.0479
	G			1.0000	-0.0342	0.0365	0.0068	0.0189	0.1462	0.0555	-0.0077	-0.1503	0.1555	0.3123**	-0.0481
Plant height	P				1.0000	0.8435**	0.6367**	0.7524**	0.3146**	0.7487**	0.6557**	0.6243**	0.2723**	0.0032	0.8118**
	G				1.0000	0.8705**	0.7459**	0.8724**	0.4379**	0.7993**	0.7314**	0.6672**	0.2689**	0.0050	0.8496**
Ear height	P					1.0000	0.5064**	0.6722**	0.3416**	0.6301**	0.5785**	0.5374**	0.2047*	-0.0438	0.6867**
	G					1.0000	0.6013**	0.7832**	0.4721**	0.6889**	0.6447**	0.5704**	0.2175*	-0.0432	0.7239**
Ear length	P						1.0000	0.6267**	0.2617**	0.7264**	0.5325**	0.5364**	0.3893**	-0.0707	0.7468**
	G						1.0000	0.7963**	0.3685**	0.7968**	0.6308**	0.6262**	0.4415**	-0.0780	0.8213**
Ear girth	P							1.0000	0.4905**	0.7926**	0.5542**	0.5611**	0.3379**	-0.0599	0.8067**
	G							1.0000	0.6798**	0.9150**	0.6948**	0.6560**	0.3781**	-0.0688	0.9170**
No of seed rows/ear	P								1.0000	0.5765**	0.3872**	0.0901	0.0830	-0.0855	0.4222**
	G								1.0000	0.7198**	0.5242**	0.1616	0.1058	-0.1118	0.5421**
No of seeds/ear	P									1.0000	0.6161**	0.4445**	0.3228**	-0.0447	0.8831**
	G									1.0000	0.6795**	0.5115**	0.3359**	-0.0474	0.8992**
Shelling percent	P										1.0000	0.4835**	0.3357**	-0.1928*	0.6413**
	G										1.0000	0.5338**	0.3545**	-0.2009*	0.6903**
100 Seed weight	P											1.0000	0.3285**	-0.0646	0.8052**
	G											1.0000	0.3378**	-0.0676	0.8317**
Oil percent	P												1.0000	-0.0914	0.3698**
	G												1.0000	-0.0916	0.3753**
Protein percent	P													1.0000	-0.0460
	G													1.0000	-0.0472
Grain yield	P														1.0000
	G														1.0000

P-Phenotypic

G-Genotypic

* : Significant (P<0.05)

** : Significant (P<0.01)

In addition, ear height also showed significant positive association with oil content at Karimnagar and Tandoor.

4.6.1.6 Ear length

Ear length showed significant positive association with plant height, ear height, ear girth, number of seed rows per ear, number of seeds per ear, shelling per cent 100 seed weight, oil content and grain yield at Rajendranagar, Karimnagar and Tandoor except number of seed rows per ear at Tandoor.

4.6.1.7 Ear girth

Ear girth had significant positive correlation with plant height, ear height, ear length, number of seed rows per ear, seeds per ear, shelling per cent, 100 seed weight and yield at Rajendranagar, Karimnagar and Tandoor. In addition, it had significant positive association with oil content at Karimnagar and Tandoor.

4.6.1.8 Number of seed rows per ear

The association of number of seed rows per ear was significant and positive with plant height, ear height, ear length, ear girth, number of seeds per ear, shelling per cent and yield at Rajendranagar and Karimnagar. At Tandoor, it also had significant positive association with 100 seed weight.

4.6.1.9 Number of seeds per ear

Number of seeds per ear is an important yield contributing trait and showed significant positive correlation with plant height, ear height, ear length, ear girth, number of seed rows per ear, shelling per cent, 100 seed weight, oil content and yield. While it had significant negative association with 50 per cent tasseling, 50 per cent silking and 50 per cent brown husk at Rajendranagar, Karimnagar and Tandoor except its non significant association with 50 per cent brown husk at Karimnagar and Tandoor.

Table 12c: Phenotypic and genotypic correlations for 14 characters at Tandoor location

Variables		50% Tasseling	50% Silking	50% Br husk	Plant height	Ear height	Ear length	Ear girth	No of seed rows/ear	No of seeds/ear	Shelling percent	100 Seed weight	Oil percent	Protein percent	Grain yield
50% Tasseling	P	1.0000	0.5572**	0.4258**	-0.2594**	-0.2850**	-0.2639**	-0.3325**	-0.1773	-0.3549**	-0.3307**	-0.3987**	-0.2572**	0.1225	-0.4297**
	G	1.0000	0.9604**	0.4691**	-0.3429**	-0.4087**	-0.5072**	-0.6505**	-0.4582**	-0.5523**	-0.5563**	-0.5976**	-0.4002**	0.1863*	-0.6397**
50% Silking	P		1.0000	0.3927**	-0.2572**	-0.3668**	-0.2464**	-0.3214**	-0.1197	-0.2804**	-0.2943**	-0.3940**	-0.0809	-0.0141	-0.3769**
	G		1.0000	0.4132**	-0.3163**	-0.4558**	-0.3981**	-0.6388**	-0.3075**	-0.3716**	-0.3725**	-0.5075**	-0.1098	-0.0239	-0.4838**
50%Brown husk	P			1.0000	0.0308	0.0345	-0.0027	0.0147	0.1055	0.0321	-0.0143	-0.1075	0.0045	0.2278*	-0.0532
	G			1.0000	0.0326	0.0275	-0.0258	-0.0151	0.1396	0.0514	0.0007	-0.1378	-0.0065	0.2615**	-0.0564
Plant height	P				1.0000	0.8658**	0.5817**	0.5465**	0.2986**	0.7100**	0.6050**	0.6140**	0.3035**	-0.0664	0.7643**
	G				1.0000	0.8770**	0.7777**	0.7649**	0.4717**	0.7669**	0.6693**	0.6415**	0.3247**	-0.0694	0.7984**
Ear height	P					1.0000	0.5202**	0.5782**	0.3836**	0.7062**	0.5855**	0.5698**	0.2453**	-0.1240	0.7394**
	G					1.0000	0.6791**	0.7977**	0.5515**	0.7427**	0.6436**	0.5899**	0.2580**	-0.1265	0.7586**
Ear length	P						1.0000	0.4096**	0.2427**	0.6492**	0.5058**	0.5446**	0.3320**	-0.0506	0.6970**
	G						1.0000	0.7767**	0.1586	0.8531**	0.6880**	0.7275**	0.4526**	-0.0648	0.9043**
Ear girth	P							1.0000	0.4501**	0.6248**	0.4451**	0.4698**	0.1828*	-0.0691	0.6348**
	G							1.0000	0.8220**	0.8837**	0.6383**	0.6529**	0.2457**	-0.0929	0.8794**
No of seed rows/ear	P								1.0000	0.5949**	0.3648**	0.0911	0.1157	-0.1105	0.4199**
	G								1.0000	0.7133**	0.5024**	0.2253*	0.1706	-0.1388	0.5474**
No of seeds/ear	P									1.0000	0.6078**	0.4812**	0.2944**	-0.1120	0.8840**
	G									1.0000	0.6568**	0.5402**	0.3089**	-0.1140	0.8966**
Shelling percent	P										1.0000	0.5209**	0.3782**	-0.1706	0.6344**
	G										1.0000	0.5772**	0.4066**	-0.1799	0.6789**
100 Seed weight	P											1.0000	0.3277**	-0.0567	0.8289**
	G											1.0000	0.3364**	-0.0602	0.8516**
Oil percent	P												1.0000	-0.1600	0.3438**
	G												1.0000	-0.1630	0.3501**
Protein percent	P													1.0000	-0.0928
	G													1.0000	-0.0938
Grain yield	P														1.0000
	G														1.0000

P-Phenotypic

G-Genotypic

* : Significant (P<0.05)

** : Significant (P<0.01)

4.6.1.10 Shelling per cent

It showed significant positive correlation, with 50 per cent brown husk, plant height, ear height, ear length, ear girth, number of seed rows per ear, number of seeds per ear, 100 seed weight, oil content and yield but it showed significant negative association with 50 per cent tasseling and 50 per cent silking at Rajendranagar, Karimnagar and Tandoor. At Karimnagar protein content also showed significant negative association with shelling. The association of shelling per cent and 50 per cent brown husk was non significant at all locations.

4.6.1.11 100 seed weight

This character had significant positive correlation with plant height, ear height, ear length, ear girth, number of seeds per ear, shelling per cent, oil content and yield while it had shown significant negative correlation with 50 per cent tasseling and 50 per cent silking at Rajendranagar, Karimnagar and Tandoor. In addition, it showed significant positive association with number of seed rows per ear at Tandoor.

4.6.1.12 Oil content

Oil content had shown significant positive association with plant height, ear length, number of seeds per ear, shelling per cent, 100 seed weight and yield. While it had significant negative association with 50 per cent tasseling and 50 per cent silking at Rajendranagar.

At Karimnagar, it has shown significant positive association with plant height, ear height, ear length, ear girth, number of seed rows per ear, number of seeds per ear, shelling per cent 100 seed weight and yield.

At Tandoor plant height, ear height, ear length, ear girth, number of seeds per ear, shelling per cent, 100 seed weight and yield had significant

positive association. Days to 50 per cent tasseling and 50 per cent silking had shown significant negative association with oil content at Rajendranagar and Karimnagar but at Tandoor oil content and 50 per cent tasseling had significant negative correlation.

4.6.1.13 Protein content

It showed significant positive correlation with 50 per cent brown husk at all locations. In addition, it had significant positive association with 50 per cent tasseling at Tandoor.

4.6.1.14 Grain yield

All the characters except 50 per cent brown husk and protein content had shown significant positive association with yield at all locations.

4.6.2 Path Coefficient Analysis

Direct and indirect phenotypic and genotypic path coefficients are presented in Table 13a, 13b and 13c. Genotypic path coefficients are of higher magnitude than the phenotypic coefficients demonstrating that the observed relationships among various characters were due to genetic causes.

At Rajendranagar, days to 50 per cent tasseling showed positive direct effect and positive indirect effect via, ear girth, ear height, shelling percentage, oil percentage, ear length and protein percentage resulting in negative correlation with grain yield (Table 13a). Days to 50 per cent silking had negative direct effect. The positive indirect effect through ear girth, ear height, oil per cent, protein per cent, ear length and shelling per cent resulted in positive correlation with yield. Days to 50 per cent brown husking had negative direct effect. It showed positive indirect effect via plant height, number of seed rows per ear, number of seeds per ear and protein per cent and revealed positive correlation with grain yield. Plant height had positive

Table 13a. Phenotypic and genotypic path coefficients for various characters at Rajendranagar location

Variables		50% Tasseling	50% Silking	50% Br husk	Plant height	Ear height	Ear length	Ear girth	No of seed rows/ear	No of seeds/ear	Shelling percent	100 Seed weight	Oil percent	Protein percent	r' with Grain yield
50% Tasseling	P	-0.053	-0.039	0.011	-0.003	-0.007	-0.011	-0.001	-0.027	-0.092	-0.001	-0.148	-0.006	0.002	-0.372
	G	0.056	-0.426	-0.001	-0.174	0.056	0.027	0.684	-0.220	-0.160	0.028	-0.406	0.027	0.014	-0.492
50% Silking	P	-0.041	-0.050	0.013	-0.002	-0.006	-0.011	0.001	-0.026	-0.083	-0.001	-0.144	-0.007	0.004	-0.352
	G	0.053	-0.448	-0.001	-0.089	0.047	0.021	0.623	-0.214	-0.137	0.014	-0.385	0.030	0.025	-0.454
50%Brown husk	P	-0.025	-0.027	0.024	0.002	0.003	0.006	0.000	0.013	0.073	0.001	-0.035	0.001	0.011	0.044
	G	0.021	-0.204	-0.001	0.145	-0.025	-0.008	-0.074	0.140	0.099	-0.015	-0.079	-0.003	0.063	0.057
Plant height	P	0.009	0.005	0.002	0.017	0.023	0.049	-0.001	0.028	0.253	0.001	0.174	0.006	-0.004	0.561**
	G	-0.011	0.046	0.000	0.875	-0.143	-0.075	-0.907	0.190	0.331	-0.038	0.405	-0.023	-0.026	0.623**
Ear height	P	0.014	0.011	0.003	0.014	0.027	0.042	-0.001	0.043	0.253	0.001	0.162	0.004	-0.005	0.567**
	G	-0.019	0.125	0.000	0.745	-0.168	-0.061	-0.934	0.317	0.316	-0.039	0.354	-0.012	-0.030	0.595**
Ear length	P	0.007	0.006	0.002	0.009	0.013	0.091	-0.001	0.018	0.271	0.002	0.180	0.006	-0.003	0.599**
	G	-0.014	0.084	0.000	0.601	-0.093	-0.110	-0.635	0.156	0.357	-0.046	0.421	-0.024	-0.019	0.680**
Ear girth	P	0.017	0.016	0.001	0.010	0.018	0.042	-0.002	0.067	0.267	0.001	0.197	0.003	-0.002	0.636**
	G	-0.031	0.229	0.000	0.651	-0.129	-0.057	-1.219	0.502	0.361	-0.041	0.512	-0.013	-0.010	0.755**
No of seed rows/ear	P	0.012	0.011	0.003	0.004	0.010	0.014	-0.001	0.119	0.206	0.001	0.026	-0.001	-0.003	0.401**
	G	-0.017	0.129	0.000	0.224	-0.072	-0.023	-0.826	0.742	0.279	-0.031	0.087	0.002	-0.020	0.733**
No of seeds/ear	P	0.013	0.011	0.005	0.011	0.018	0.065	-0.001	0.065	0.377	0.002	0.168	0.007	-0.005	0.735**
	G	-0.020	0.136	0.000	0.644	-0.118	-0.087	-0.978	0.460	0.449	-0.048	0.367	-0.024	-0.028	0.754**
Shelling percent	P	0.013	0.009	0.004	0.007	0.014	0.051	-0.001	0.039	0.235	0.003	0.191	0.009	-0.003	0.571**
	G	-0.021	0.117	0.000	0.445	-0.089	-0.067	-0.671	0.307	0.292	-0.074	0.400	-0.031	-0.015	0.593**
100 Seed weight	P	0.021	0.019	-0.002	0.008	0.012	0.043	-0.001	0.008	0.168	0.002	0.736	0.007	-0.001	0.659**
	G	-0.030	0.231	0.000	0.474	-0.079	-0.062	-0.835	0.086	0.220	-0.040	0.748	-0.025	-0.005	0.683**
Oil percent	P	0.011	0.011	0.001	0.003	0.003	0.019	0.000	-0.002	0.086	0.001	0.088	0.030	-0.002	0.249**
	G	-0.015	0.135	0.000	0.199	-0.021	-0.026	-0.160	-0.012	0.105	-0.023	0.182	-0.101	-0.011	0.252**
Protein percent	P	-0.003	-0.006	0.007	-0.002	-0.004	-0.009	0.000	-0.011	-0.057	0.000	-0.010	-0.002	0.034	-0.062
	G	0.005	-0.063	-0.001	-0.126	0.028	0.012	0.067	-0.083	-0.070	0.006	-0.021	0.006	0.178	-0.063

(values in boxes and bold are direct effects)

P- Phenotypic

G- Genotypic

direct effect. On the other hand, it had positive indirect effect via 100 seed weight, number of seeds per ear, number of seed rows per ear and 50 per cent silking and resulted in significant positive correlation with grain yield. Ear height shows negative direct effect and it had positive indirect effect through, plant height, 100 seed weight, number of seed rows per ear, number of seeds per ear and 50 per cent silking causing significant positive correlation with grain yield. Ear length indicated negative direct effect. On the other hand it had positive indirect effect via plant height, 100 seed weight, number of seeds per ear, number of seed rows per ear and 50 per cent silking resulting in significant positive correlation with grain yield. Ear girth had negative direct effect. Conversely, it had positive indirect effect through plant height, 100 seed weight, number of seed rows per ear, number of seeds per ear and 50 per cent silking indicating significant positive correlation with grain yield. 148

Number of seed rows per ear had direct positive effect. It had indirect effect through number of seeds per ear, plant height, days to 50 per cent silking, 100 seed weight and oil per cent resulting in significant positive correlation with grain yield. Number of seeds per ear had positive direct effect, on the other hand, it had positive indirect effect through plant height, number of seed rows per ear, 100 seed weight, days to 50 per cent silking and resulted in significant positive correlation with grain yield. Shelling per cent had negative direct effect. It had positive indirect effect through plant height, 100 seed weight, number of seed rows per ear, number of seeds per ear and days to 50 per cent silking and resulted in significant positive correlation with grain yield. 100 Seed weight had direct positive effect. On the other hand, it showed positive indirect effect through plant height, days to 50 per cent silking, number of seeds per ear, number of seed rows per ear and resulted in significant positive correlation with grain yield.

Oil per cent had direct negative effect and had positive indirect effect through plant height, 100 seed weight, 50 per cent silking, number of

Table 13b. Phenotypic and genotypic path coefficients for various characters at Karim Nagar location

Variables		50% Tasseling	50% Silking	50% Br husk	Plant height	Ear height	Ear length	Ear girth	No of seed rows/ear	No of seeds/ear	Shelling percent	100 Seed weight	Oil percent	Protein percent	r with Grain yield
50% Tasseling	P	0.017	0.004	-0.008	0.001	-0.001	0.003	0.000	0.000	-0.345	0.004	-0.242	0.001	0.001	-0.566
	G	0.269	-0.239	-0.007	-0.077	0.026	0.028	0.108	-0.010	-0.483	-0.008	-0.281	-0.007	0.002	-0.677
50% Silking	P	0.013	0.004	-0.009	0.000	-0.001	0.003	0.000	0.000	-0.291	0.003	-0.238	0.001	0.002	-0.511
	G	0.261	-0.245	-0.007	-0.071	0.026	0.029	0.115	-0.009	-0.460	-0.006	-0.315	-0.006	0.004	-0.683
50%Brown husk	P	0.005	0.002	-0.025	0.000	0.000	0.000	0.000	0.000	0.037	0.000	-0.072	-0.001	0.006	-0.048
	G	0.068	-0.065	-0.026	-0.005	-0.002	0.000	-0.003	0.004	0.042	0.000	-0.075	0.004	0.010	-0.048
Plant height	P	-0.008	-0.002	0.001	-0.001	0.002	-0.005	0.000	0.000	0.506	-0.006	0.326	-0.001	0.000	0.812**
	G	-0.151	0.127	0.001	0.138	-0.041	-0.039	-0.151	0.011	0.603	0.010	0.335	0.008	0.000	0.849**
Ear height	P	-0.008	-0.002	0.000	-0.001	0.002	-0.004	0.000	0.000	0.426	-0.005	0.280	-0.001	-0.001	0.686**
	G	-0.145	0.134	-0.001	0.120	-0.047	-0.031	-0.136	0.012	0.520	0.009	0.286	0.006	-0.001	0.724**
Ear length	P	-0.008	-0.002	0.001	-0.001	0.001	-0.007	0.000	0.000	0.491	-0.005	0.280	-0.002	-0.002	0.747**
	G	-0.145	0.138	0.000	0.103	-0.028	-0.052	-0.138	0.009	0.602	0.009	0.314	0.012	-0.002	0.821**
Ear girth	P	-0.008	-0.002	0.000	-0.001	0.001	-0.005	0.000	0.000	0.535	-0.005	0.293	-0.002	-0.001	0.807**
	G	-0.167	0.163	-0.001	0.120	-0.037	-0.041	-0.173	0.017	0.690	0.009	0.329	0.011	-0.002	0.917**
No of seed rows/ear	P	-0.004	-0.001	-0.002	0.000	0.001	-0.002	0.000	0.000	0.384	-0.004	0.047	0.000	-0.002	0.422**
	G	-0.102	0.092	-0.004	0.060	-0.223	-0.019	-0.118	0.025	0.543	0.007	0.081	0.003	-0.004	0.542**
No of seeds/ear	P	-0.008	-0.002	-0.001	-0.001	0.001	-0.005	0.000	0.000	0.675	-0.006	0.232	-0.001	-0.001	0.883**
	G	-0.172	0.150	-0.001	0.110	-0.033	-0.042	-0.159	0.018	0.754	0.009	0.257	0.009	-0.002	0.899**
Shelling percent	P	-0.008	-0.002	0.000	-0.001	0.001	-0.004	0.000	0.000	0.416	-0.009	0.252	-0.002	-0.004	0.641**
	G	-0.153	0.116	0.000	0.101	-0.030	-0.033	-0.120	0.013	0.512	0.014	0.268	0.010	-0.006	0.690**
100 Seed weight	P	-0.008	-0.002	0.004	-0.001	0.001	-0.004	0.000	0.000	0.300	-0.004	0.522	-0.001	-0.001	0.805**
	G	-0.150	0.154	0.004	0.092	-0.027	-0.033	-0.114	0.004	0.386	0.007	0.501	0.009	-0.002	0.832**
Oil percent	P	-0.003	-0.001	-0.004	0.000	0.000	-0.003	0.000	0.000	0.218	-0.003	0.171	-0.004	-0.002	0.369**
	G	-0.067	0.050	-0.004	0.040	-0.010	-0.023	-0.066	0.003	0.253	0.005	0.169	0.028	-0.003	0.375**
Protein percent	P	0.001	0.001	-0.007	0.000	0.000	0.001	0.000	0.000	-0.030	0.002	-0.034	0.000	0.021	-0.046
	G	0.020	-0.031	-0.008	0.001	0.002	0.004	0.012	-0.003	-0.036	-0.003	-0.034	-0.003	0.031	-0.047

(values in boxes and bold are direct effects)

P- Phenotypic

G- Genotypic

seeds per ear which resulted in significant positive correlation with grain yield. Protein per cent had direct positive effect. On the other hand, it shows positive indirect effect through ear height, ear length, 50 per cent tasseling, shelling per cent and oil per cent resulting in non-significant negative correlation with grain yield.

At Karimnagar, days to 50 per cent tasseling showed positive direct effect and positive indirect effect via ear girth, ear length, ear height and protein content resulting in non-significant negative correlation with grain yield (Table 13b). Days to 50 per cent silking had negative direct effect. The positive indirect effect through 50 per cent tasseling, ear girth, ear length, ear height, protein content resulting in non significant negative correlation with grain yield. Days to 50 per cent brown husking had negative direct effect. It had positive indirect effect via 50 per cent tasseling number of seeds per ear, protein content, number of seed rows per ear, oil per cent and ear length and revealed insignificant negative correlation with grain yield. Plant height had positive direct effect. On the other hand, it had positive indirect effect via number of seeds per ear, 100 seed weight, 50 per cent silking, number of seed rows per ear, shelling per cent, oil content, protein content and resulted in significant positive correlation with grain yield. Ear height had negative direct effect and it had positive indirect effect through number of seeds per ear, 100 seed weight, 50 per cent silking, plant height, number of seed rows per ear, shelling percentage, oil per cent causing significant positive correlation with grain yield. Ear length indicated negative direct effect. On the other hand it had positive indirect effect via number of seeds per ear, 100 seed weight, 50 per cent silking, plant height, oil per cent, shelling per cent, number of seed rows per ear resulted in significant positive correlation with grain yield. Ear girth had negative direct effect. Conversely, it had positive indirect effects through number of seeds per ear, 100 seed weight. Days to 50 per cent silking, plant height, number of seed rows per ear, oil per cent, shelling per cent indicating significant positive correlation with grain yield.

Number of seed rows per ear had direct positive effect. It had indirect effect through number of seeds per ear, days to 50 per cent silking, 100 seed weight, plant height, shelling per cent and oil per cent resulting in significant positive correlation with grain yield. Number of seeds per ear had positive direct effect. On the other hand, it had positive indirect effect through 100 seed weight, 50 per cent silking days to 50 per cent silking, plant height, number of seed rows per ear, shelling per cent and oil per cent and resulted in significant positive correlation with grain yield. Shelling per cent had positive direct effect. It had positive indirect effect through number of seeds per ear, 100 seed weight, 50 per cent silking, plant height, number of seed rows per ear and oil per cent resulting in significant positive correlation with grain yield. 100 Seed weight had direct positive effect. On the other hand, it showed positive indirect effect through number of seeds per ear, 50 per cent silking, plant height, oil per cent, shelling per cent and number of seed rows per ear and resulted in significant positive correlation with grain yield.

Oil per cent had direct positive effect and had positive indirect effect through number of seeds per ear, 100 seed weight, 50 per cent silking, plant height, and number of seed rows per ear which resulted in significant positive correlation with grain yield. Protein content had direct positive effect. On the other hand, it showed positive indirect effect through 50 per cent tasseling, ear girth, ear length, ear height and plant height resulting in non significant negative correlation with grain yield.

At Tandoor, days to 50 per cent tasseling showed positive direct effect and positive indirect effect via shelling per cent, 50 per cent silking, plant height, ear girth, oil per cent and protein per cent resulted in non significant negative correlation with grain yield (Table 13c). Days to 50 per cent silking had positive direct effect. The positive indirect effect through 50 per cent tasseling, plant height, shelling per cent, number of seed rows per

Table 13c. Phenotypic and genotypic path coefficients for various characters at Tandoor location

Variables		50% Tasseling	50% Silking	50% Br husk	Plant height	Ear height	Ear length	Ear girth	No of seed rows/ear	No of seeds/ear	Shelling percent	100 Seed weight	Oil percent	Protein percent	r' with Grain yield
50% Tasseling	P	0.006	0.010	-0.012	0.004	-0.003	-0.002	0.002	0.000	-0.233	0.011	-0.216	0.002	0.001	-0.429
	G	0.030	0.014	-0.017	0.016	-0.010	-0.007	-0.012	0.004	-0.360	0.019	-0.321	0.001	0.002	-0.639
50% Silking	P	0.003	0.018	-0.011	0.004	-0.004	-0.002	0.002	0.000	-0.184	0.010	-0.214	0.001	0.000	-0.377
	G	0.029	0.015	-0.015	0.015	-0.011	-0.006	-0.012	0.003	-0.242	0.013	-0.273	0.000	0.000	-0.484
50%Brown husk	P	0.003	0.007	-0.029	0.000	0.000	0.000	0.000	0.000	0.021	0.001	-0.058	0.000	0.002	-0.053
	G	0.014	0.006	-0.036	-0.002	0.001	0.000	0.000	-0.001	0.034	0.000	-0.074	0.000	0.003	-0.056
Plant height	P	-0.002	-0.005	-0.001	-0.014	0.009	0.004	-0.004	0.001	0.466	-0.021	-0.333	-0.003	-0.001	0.764**
	G	-0.010	-0.005	-0.001	-0.047	0.021	0.011	0.014	-0.004	0.499	-0.023	0.345	-0.001	-0.001	0.798**
Ear height	P	-0.002	-0.006	-0.001	-0.012	0.010	0.004	-0.004	0.001	0.464	-0.020	0.309	-0.002	-0.001	0.739**
	G	-0.012	-0.007	-0.001	-0.041	0.024	0.010	0.015	-0.005	0.484	-0.022	0.317	-0.001	-0.002	0.758**
Ear length	P	-0.002	-0.004	0.000	-0.008	-0.005	0.007	-0.003	0.001	0.426	-0.017	0.296	-0.003	-0.001	0.697**
	G	-0.015	-0.006	0.009	-0.036	0.016	0.014	0.014	-0.005	0.555	-0.024	0.391	-0.001	-0.001	0.904**
Ear girth	P	-0.002	-0.006	0.000	-0.008	0.006	0.003	-0.007	0.001	0.410	-0.015	0.255	-0.002	-0.001	0.6354**
	G	-0.020	-0.010	0.001	-0.036	0.019	0.011	0.019	-0.008	0.575	-0.022	0.351	-0.001	-0.001	0.879**
No of seed rows/ear	P	-0.001	-0.002	-0.003	-0.004	0.004	0.002	-0.003	0.002	0.399	-0.012	0.049	-0.001	-0.001	0.419**
	G	-0.014	-0.005	-0.005	-0.022	0.013	0.008	0.015	-0.009	0.464	-0.017	0.121	-0.001	-0.002	0.547**
No of seeds/ear	P	-0.002	-0.005	-0.001	-0.010	0.007	0.005	-0.004	0.002	0.656	-0.021	0.261	-0.003	-0.001	0.884**
	G	-0.017	-0.006	-0.002	-0.036	0.018	0.012	0.016	-0.007	0.651	-0.023	0.290	-0.001	-0.001	0.896**
Shelling percent	P	-0.002	-0.005	0.000	-0.008	0.006	0.004	-0.003	0.001	0.399	-0.034	0.283	-0.004	-0.002	0.634**
	G	-0.017	-0.006	0.000	-0.031	0.016	0.010	0.012	-0.005	0.428	-0.035	0.310	-0.001	-0.002	0.679**
100 Seed weight	P	-0.003	-0.007	-0.003	-0.008	-0.006	0.004	-0.003	0.000	0.316	-0.018	0.543	-0.003	-0.001	0.829**
	G	-0.018	-0.008	0.005	-0.030	0.014	0.011	0.012	-0.002	0.352	-0.020	0.537	-0.001	-0.001	0.852**
Oil percent	P	-0.002	-0.002	0.000	-0.004	-0.003	0.002	-0.001	0.000	0.193	-0.013	0.178	-0.009	-0.002	0.344**
	G	-0.012	-0.002	0.000	-0.015	0.006	0.007	0.005	-0.002	0.201	-0.014	0.181	-0.003	-0.002	0.350**
Protein percent	P	0.001	0.000	-0.007	0.001	-0.001	0.000	0.001	0.000	-0.074	0.006	-0.031	0.002	0.011	-0.093
	G	0.006	0.000	-0.010	0.003	-0.003	-0.001	-0.002	0.001	-0.074	0.006	-0.032	0.001	0.012	-0.094

(values in boxes and bold are direct effects)

P- Phenotypic

G- Genotypic

ear, oil per cent and protein per cent resulted in non significant negative correlation with grain yield. Days to 50 per cent brown husking had negative direct effect. It had positive indirect effect via number of seeds per ear, 50 per cent tasseling, 50 per cent silking, protein per cent, ear height and revealed non significant negative correlation with grain yield.

Plant height had negative direct effect. On the other hand, it had positive indirect effect via number of seeds per ear, 100 seed weight, ear height and ear girth and resulted in significant positive correlation with grain yield. Ear height showed positive direct effect and it had positive indirect effect through number of seeds per ear, 100 seed weight and ear girth and ear causing significant positive correlation with grain yield. Ear length indicated positive direct effect. On the other hand it had positive indirect effect via number of seeds per ear, 100 seed weight, ear height, and ear girth resulting in significant positive correlation with grain yield. Ear girth had positive direct effect. Conversely, it had positive indirect effects through number of seeds per ear, 100 seed weight, ear height, ear length, and 50 per cent brown husk indicating significant positive correlation with grain yield.

Number of seed rows per ear had direct negative effect. It had indirect effect through number of seeds per ear, 100 seed weight, ear girth, ear height, and ear length resulting in significant positive correlation with grain yield. Number of seeds per ear had positive direct effect. On the other hand, it had positive indirect effect through 100 seed weight, ear height, ear girth, and ear length and resulted in significant positive correlation with grain yield. Shelling per cent had negative direct effect. It had positive indirect effect through number of seeds per ear, 100 seed weight, ear height, ear girth, ear length resulting in significant positive correlation with grain yield. 100 Seed weight had direct positive effect. On the other hand, it showed positive indirect effect through number of seeds per ear, ear height, ear girth, ear

length, and 50 per cent brown husk and resulted in significant positive correlation with grain yield.

Oil per cent had direct negative effect and had positive indirect effect through number of seeds per ear, 100 seed weight, ear length, ear height, ear girth and 50 per cent brown husk and resulted in significant positive correlation with grain yield. Protein content had direct positive effect. On the other hand, it showed positive indirect effect through 50 per cent tasseling, shelling per cent, plant height, number of seed rows per ear and oil per cent resulting in non-significant negative correlation with grain yield.

A graphic design featuring eleven ears of corn arranged in a circular pattern on a dark blue background. The corn cobs are a mix of yellow and red kernels. The word "Discussion" is written in a large, white, sans-serif font across the center of the image, partially overlapping the corn.

Discussion

CHAPTER V

DISCUSSION

Yield improvement in maize in India was mainly due to development of high yielding varieties, hybrids, (single cross, double cross and three way cross), synthetics and composites. There is a continuous thrust on population improvement. In the recent years, though double cross hybrids have shown wider coverage, theoretically exploitation of high level heterosis is possible through single cross hybrids only (Hallauer and Miranda, 1988; Vasal, 1995). Hence the focus of maize breeders was shifted to develop high yielding single cross hybrids in India. For the production of commercially viable hybrids, suitable inbreds need to be produced.

Pandey and Gardener (1993) successfully used tropical maize to improve temperate maize. The tropical and subtropical introgression will be helpful in broadening of maize germplasm base. With this objective 180 inbreds of tropical and subtropical types were top crossed and evaluated at two locations viz., Rajendranagar and Tandoor. Finally, five best performing inbreds each from tropical and subtropical types were selected based on general combining ability and are crossed in diallel fashion. The resulting 45 hybrids with parents and three popular checks were evaluated at three locations viz., Rajendranagar, Karimnagar and Tandoor. The data were collected on grain yield, oil per cent, protein per cent and 11 yield contributing characters. The results obtained are discussed congenitly under different heads.

5.1. NATURE OF GENE ACTION AND COMBINING ABILITY FOR GRAIN YIELD COMPONENTS, OIL AND PROTEIN PER CENT

Knowledge of genetic architecture of yield and yield components will help to demarcate the better crosses. Ever since Sprague and Tatum (1942) had given the concept of combining ability in crop breeding, it has

attained paramount importance in breeding experiments for isolating potential parental lines and superior performing hybrids. These concepts facilitate in determination of the type of gene action controlling particular character which ultimately helps the breeder to formulate suitable breeding programme in exploiting heterosis for higher yields.

Average performance of parental line in a series of cross combinations is generally referred to as general combining ability and is mainly attributed to additive and additive x additive gene effects which is mainly an intra allelic interaction and indicate part of inter allelic interaction also. However, deviation in the performance of a cross expected on the basis of average performance of parental lines is mainly attributed to dominant and epistatic effects and is termed as specific combining ability ie., non additive part. Additive component of genetic variance is fixable through normal selection procedures, whereas non-additive component is not fixable, and its presence for controlling traits necessitates exploitation of hybrid vigour through heterosis breeding.

In the present investigation, the genotypic differences for grain yield and its 13 components were significant at Rajendranagar, Karimnagar and Tandoor indicating enough variation among the genotypes. Cross (1977) and Han *et al* (1991) observed additive and dominance gene effects depending on either parents are open pollinated or inbred lines. The combining ability analysis revealed significant mean squares due to general and specific combining ability indicating that both additive and non-additive gene actions were important in the inheritance of these characters. Alika (1994) reported widely predominant role of additive genetic variance for ear length, ear girth and 100 seed weight except shelling per cent. The relative importance of additive and non additive gene action was reported by Mukherjee *et al* (1971), Nawar and Hosary (1984) and Muthiah *et al* (1989). They also observed

predominant role of specific combining ability for plant height, height upto ear, ear length, ear girth, number of seeds per ear and number of seeds per row.

The magnitude of GCA to SCA variance was less than unity for all the characters indicating predominant role of non additive gene action in governing these characters. These results are in concurrence with earlier investigations carried out by Nawar and El Hosary 1984, Guo *et al* (1986), Crossa *et al* (1990), Paul and Duara (1991) and Appunu (2002) for earliness, Mukherjee *et al* (1974), Dhillon and Singh (1977 c), Mathur and Bhatnagar (1995) and Malvar *et al*, (1996) for ear height. In respect of plant height, primary action of non additive gene action was reported by Dudley (1976), Ivanovic (1979) and Mahmoud *et al*. (1990). Similar results were also reported by Martin and Hallauer (1976), Mathur and Bhatnagar (1995) for ear characters, Khristova *et al*. (1983), Kimani (1984), Debnath and Sarkar (1990), Nagda *et al*. (1995) reported for 100 seed weight. Predominant role of non additive gene action for grain yield was reported by Hull (1952), Matzinger *et al*. (1959), Wright *et al*. (1971), Darrah and Hallauer (1972), Murthy *et al*. (1981), Malvar *et al*. (1996), Joshi *et al*. (1998), Choudhary *et al*. (2000), Zelleke (2000) and Appunu (2002). Under these circumstances, for exploiting non additive gene action and to improve these characters one has to resort to the breeding procedures which lead to non-homozygous end products such as recurrent selection.

The parental lines P6 and P7 possessed low *per se* means and turned out to be good general combiners for days to 50 per cent tasseling, silking and brown husk and contributed maximum favourable genes for earliness at all the three locations. Thus, they can be used as potential donors for inducing earliness.

The crosses P4xP10 and P3xP9 were the best specific combiners at all the three locations with significant negative SCA effects for earliness. These crosses are not having good general combiners in parentage and are resultant of non additive gene action which can be improved through suitable population improvement in addition to utilizing them in heterosis breeding.

In respect of plant height, P5, P8 and P9 parents were found to be taller at all the three locations. These parents possessed significant GCA effects and recorded as good general combiners. An examination of SCA effects of the crosses at all the locations indicated that P9xP10, P6xP8 and P5xP9 were best specific crosses. First two crosses possesses one of the parent as good combiner and gene action is primarily non additive. However, the cross combination P5xP9 possess both parents as good general combiners and gene action is due to additive x additive which is fixable in nature. Desirable medium tall segregants can be spotted from segregating progeny of this cross following pedigree selection. The relative importance of additive gene action for plant height was reported by Salem *et al* (1986), Hallauer and Miranda (1988) Lima *et al* (1995) and Zelleke (2000).

For ear height, P9, P5 and P4 possessed higher mean values but only P9 and P4 were good combiners for this character in addition to P8 at all the locations. Thus these parents can be used in breeding programmes aimed at improving the ear height. The best specific crosses are P5xP7, P4xP8, P6xP9 and P3xP8. All these crosses, except P4xP8 have one good general combiner in parentage. Hence, they can be used in heterosis breeding, whereas selection can be effectively practiced in the cross P4xP8 to isolate true breeding genotypes from the subsequent generations.

Ear length varied from 10 to 14 cm at different locations and higher length was observed in P8, P2 and P3. Among the parents, both tropical types

P8 and P7 contributed maximum favourable genes and they can be used as donors for increasing ear length. The cross combinations P5xP7, P2xP10, P6xP10, P8xP9 and P4xP7 were the best specific crosses and consistent over the locations. In the cross P7xP8, both tropical parents are good combiners and did not exhibit significant SCA effect and can be considered for recombination breeding as it is likely to throw desirable recombinations with lengthy ears having favourable genes from both parents. Muthiah *et al.* (1989) also reported that ear length and number of grains are the major yield components and improvement in these characters will directly lead to higher yield.

In respect of ear girth, P1, P5 and P3 had higher *per se* performance and only P5, a tropical type turned out to be good combiner at all the three locations. Another tropical parent P4 contributed maximum favourable genes for ear girth at Karimnagar and Tandoor locations. The cross P4xP9 was best specific cross at all the locations, while P3xP9, P5xP6 and P2xP4 were best at Rajendranagar and Karimnagar, P1xP6, P3xP10, P6xP9 and P8xP9 were best at Tandoor only. None of these crosses have additive gene action and therefore heterosis breeding and recurrent selection is suggested to improve these characters.

Inter population improvement can be initiated with two populations, one having larger ears and the other with thicker ears to maximise the heterotic response (Hallauer and Miranda, 1988).

Number of seed rows per ear and number of seeds per ear have exhibited significant positive correlations with grain yield and the parental performance was also stable. Among the parents, though P4, P10 and P8 had higher *per se*, only P4 was found to be good general combiner at all the three locations. Among the crosses, P4xP9, P6xP8 and P4xP10 were best specific

crosses at all the locations. These crosses also possessed better *per se* performance.

The parental lines P5, P4 and P8 had more than 80 per cent shelling outturn considering the three locations. The tropical parents P5 and P4 contributed maximum favourable genes for shelling per cent at three locations and P8 at Karimnagar and Tandoor locations. All these three lines are tropical ones and extensive testing of tropical lines for increasing shelling per cent will be worthwhile, till then these lines can be used to exploit the additive genetic variance. The best specific crosses for this character are P1xP8, P2xP9, P2xP10, P5xP7 and P2xP6, which are resultant of non additive gene action and cannot be fixed by selection. Hybrid breeding with several cross combinations can be tried with these lines. Further these crosses can be used for the exploitation of heterosis alone, so that shuffling of genes takes place, linkages can be broken and desirable genotypes can be isolated in the passing generations through selection programme.

Three tropical parents P5, P7 and P8 and two sub tropical parents P6 and P9 were good combiners for 100 seed weight at all the locations. These parental lines can be used in a series of multiple crosses to combine gene and gene complexes into a gene pool. Many crosses exhibited significant SCA effects but the crosses P5xP6, P5xP8, P5xP9, P6xP7, P7xP9 and P8xP9 which are derived from good combiners can be profitably used in improving the seed weight by exploiting the additive gene action.

With global acceptance of maize oil, it can be concentrated as a rich source of nutritive oil with least detrimental effect on human health. Attention has been diverted to high oil rate of maize (Pal and Prodhan, 1994). Therefore to identify potential parents and best crosses, oil content was evaluated. Among the parents, the best combiners for oil per cent were P6, P8

and P10 at all the locations, and P1, P7 at Rajendranagar and Karimnagar locations. These parents possessed higher oil content and therefore can be used in improving oil percentage. The crosses P3xP9, P5xP6, P4xP10, P4xP7, P4xP6 and P6xP10 were best specific crosses at all the locations. The cross P6xP8 has both the parents as good general combiners and SCA effects are non significant at Karimnagar and Tandoor. Therefore there is a good scope for selection from segregating generations in isolating progenies with high oil per cent. Such improvement in oil content has been reported by Alexander (1999) in temperate maize.

The protein content of maize has nutritional value and it was demonstrated that protein per cent can be increased by breeding (Woodworth *et al*, 1952). In the present investigation it was interesting to note that the sub tropical parents P3, P10 and P9 possessed higher protein per cent but only P3 contributed maximum favourable genes for protein per cent. The tropical parents P2, P5 and P7 were also good combiners and these can be inter crossed with P3 to obtain higher protein content by pooling the genes from tropical and subtropical types. Considering three locations, 22 crosses got the status of best specific crosses. Out of these P3xP5, P3xP7, P2xP7 and P5xP7 are the best specific combinations, where both the parents are good combiners. These can be used in recombination breeding to isolate pure breeding progenies with higher protein content. These crosses can also be used in population improvement to increase frequency of desirable alleles.

Grain yield is a complex character and is influenced by number of its components apart from biotic and abiotic stress. Among the ten parental lines, five each are from tropical and sub tropical type. The tropical lines viz., P4, P5, P7 and P8 registered higher grain yield at Rajendranagar, Karimnagar and Tandoor locations. Among these, P4, P5 and P7 are the good combiners as evidenced by their significant GCA effects. P8 found to be a good

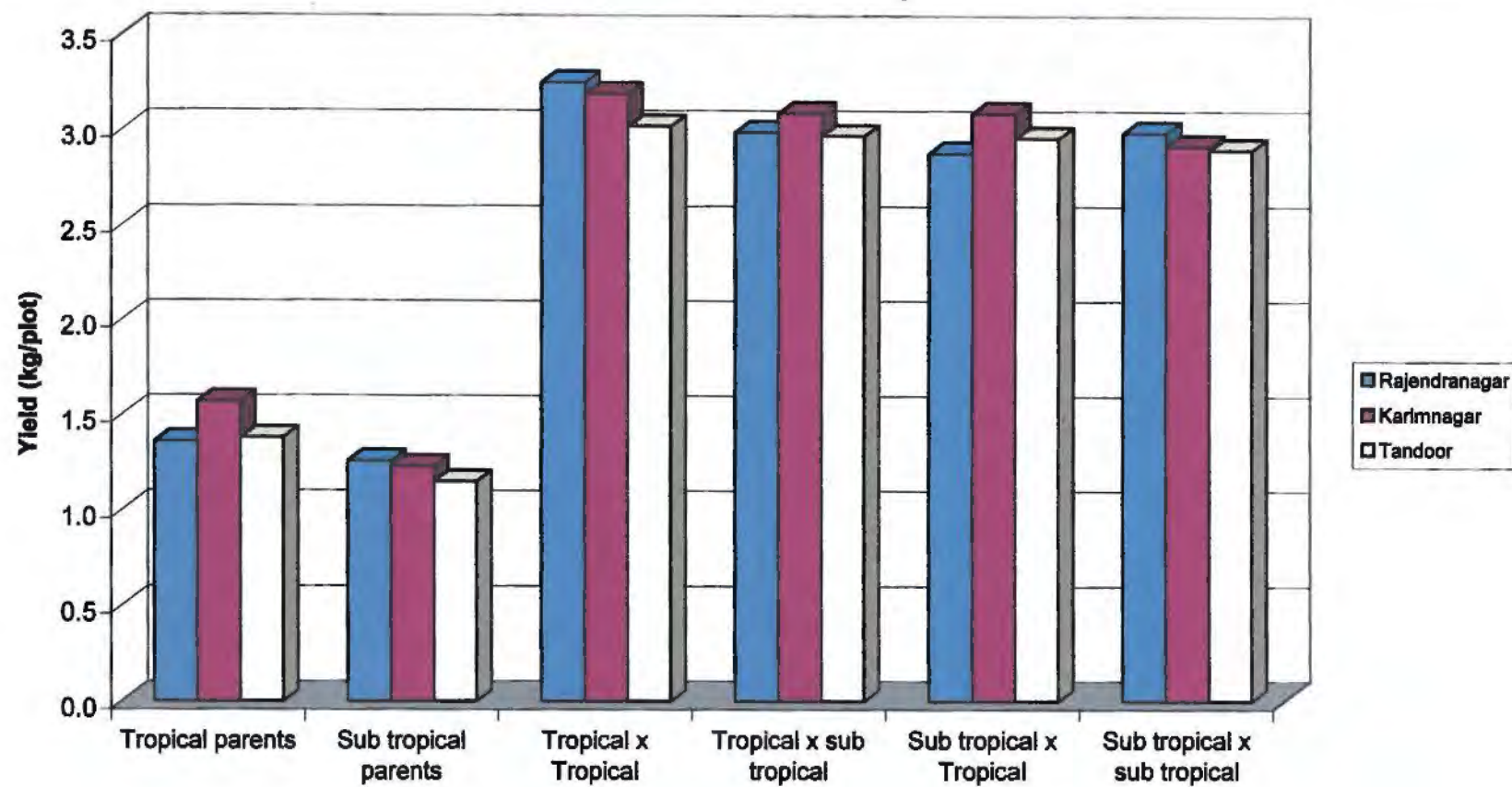


Fig. 1. Relative performance of tropical and subtropical parents and their hybrids

combiner at Karimnagar and Tandoor only. From present investigation it is suggested that for improving the grain yield tropical types will have key role (Fig.1). Such good combiners can also be inter crossed to develop high yielding composites. As many as 29 crosses exhibited significant SCA effects at all the locations. The best specific combinations for high yield are P5xP7, P4xP8, P5xP8, P5xP6, P1xP2 and P4xP7. These crosses exhibited 19.2 to 32.5 per cent superiority of grain yield over the best check hybrid. These hybrids were also superior to double cross hybrid and a three way cross hybrid used as check in the present study. Therefore, these hybrids are of considerable practical importance as they proved to be superior over popular commercial hybrids.

The cross combinations P5xP7, P5xP8, P4xP7 and P4xP8 are derivatives of high x high combiners and selection in these crosses may throw useful transgressive segregates for high yield in the future generations. Yield improvement can be sought from these crosses by pedigree or simple selection procedure. Lonnquist (1949) and Prasad *et al* (1988) advocated production of synthetics with lines having good combining ability. In the present study also these hybrids have parents with good combining ability and greater progress can be achieved in production of synthetics.

The other hybrids viz., P5xP6, P1xP2 and P4xP7 can be exploited by production of single cross hybrids in realizing their high yield potential.

The final selection of parents is mostly influenced by results on grain yield and other characters, which have direct bearing on yield (Venkatesh *et al*. 2001). Arunachalam and Bandhyopadhyay (1979) and Venkatesh *et al*. (2001) suggested that the general picture of the combining ability of parents over all the characters is useful to decide the combining ability status of parents. Considering all the locations and the yield

	50% tasseling	50% silking	50% brown huek	Plant height	Ear height	Ear length	Ear girth	Seeds per row	Seeds per cob	Shelling %	100 seed wt.	Oil %	Protein %	Yield	Good combiners for characters
P1							×								1
P2													✱		1
P3					×								✱		2
P4					✱		×	✱	✱	✱				✱	6
P5	×	×	×	✱	×		✱			✱	✱		✱	✱	10
P6	×	×	×								✱	✱		×	6
P7						✱					✱	×		✱	4
P8				✱	✱	✱			×	×	✱	✱		×	8
P9				✱	✱						✱				3
P10			×	×					×			✱			4

×	Significant at two locations
✱	Significant at three locations

Fig: Pictorial presentation of GCA effects of parental lines as good combiners at three locations

contributing characters, the tropical types P5, P7 and P4 can be given the status of good general combiners and genetically worthy parents, as they contributed maximum favourable genes for yield and yield components. The parental line P5 was good general combiner for ear girth, shelling per cent, 100 seed weight, protein per cent and also for earliness. P7 was good combiner for ear length, 100 seed weight, protein per cent and earliness, whereas P4 was good combiner for number of seeds per ear and shelling per cent (Fig.13). Hence, these high yielding parents with good attributes for different yield components may be inter crossed to pool the genes in desirable direction to improve the yield potential. Prasad *et al* (1988) also suggested that grain yield in maize can be improved by improving component characters viz., grain weight, kernel rows per cob and cob girth.

5.2 HETEROSIS

Shull (1952) gave the inbred-hybrid method of producing hybrid maize and with this, a new era started. He outlined a plan using inbreeding to establish pure lines and crossing these to produce uniformly productive hybrids. The hybrid maize became extensively popular in United States Corn belt during 1930's. This documented phenomenon of heterosis was widely used by maize breeders and there after many workers reported varying levels of heterosis in relation to mid parent, superior parent and standard check. In the present investigation also heterotic behaviour of 45 hybrids was estimated as heterosis (over mean of the parent), heterobeltiosis (over superior parent) and standard heterosis (over high yielding check) in three locations viz., Rajendranagar, Karimnagar and Tandoor.

Maximum range of heterosis was obtained for grain yield, number of seeds per ear, ear length, 100 seed weight, plant height, protein per cent, ear girth and shelling per cent (Fig 2, 3 and 4). The extent of heterosis was less for days to 50 per cent tasseling. The same trend of results was observed in all the locations.

Days to 50 per cent tasseling, days to 50 per cent silking, days to 50 per cent brown husk indicates the earliness of a genotype in maize. Earliness is a desirable character as it requires less moisture that too for a short period. It also facilitates multi-cropping systems, Heterosis for earliness was reported by Mukherje *et al.* (1971), Daniel and Bajbay (1976) Dhillon and Singh (1977a) Hassaballa *et al.* (1980) Crossa *et al.* (1990), Mandal (1996), Satyanarayana and Sai Kumar (1996) and Venkatesh (1997). In the present investigation also many crosses exhibited heterosis for days to 50 per cent tasseling and silking but were not consistent and also not significant. However, the cross combinations P4xP10, P3xP9 and P2xP9 registered significant level of heterosis and heterobeltiosis. These hybrids were earlier than the early parent and will be useful under rainfed cultivation. In respect of days to 50 per cent brown husk, only P4xP10 found to excel significantly even over early parent and standard check at all the locations.

Heterosis and heterobeltiosis for plant height was found to be positively significant in crosses P5xP7 and P6xP9, recording a mean height of 181cm and 171cm respectively over the locations. They were also superior for height over standard check (CM119 X CM211). The parental lines P5, P8, P10 and P9 were medium tall and most of the cross combinations with these parents exhibited heterosis. Thus in breeding for medium tall hybrids, inclusion of at least one medium tall parent is desirable. It is possible to have more fodder in addition to grain yield with medium tall stature. Increase in plant height of hybrids was also reported by Mabo (1977), Todorov (1981), Crossa *et al* (1987), Beck *et al* (1990) and Bhantnagar *et al* (1993).

Verma and Singh (1980), Nawar and Khamis (1983), Lin and Chen (1986), Tomov and Min (1990) and Venkatesh (1997) reported heterosis for ear length. In present investigation also all the hybrids possessed higher ear length even compared to better parent. Out of 45 hybrids evaluated, 28 exhibited heterosis and heterobeltiosis (21.22 to 70 per cent) at all the

locations. Increase in ear length is useful to have higher number of grains per ear resulting in higher yield as it has got significant genotypic correlation of 0.68**, 0.82** and 0.76** at Rajendranagar, Karimnagar and Tandoor respectively. Only two hybrids P5xP7 and P5xP9 were found to possess standard heterosis at all locations even though 14 hybrids exhibited standard heterosis at Rajendranagar and Karimnagar locations.

Ear girth is an important character which accommodates more number of rows on the ear and more number of seeds per ear. This is also evident from the significant correlation at genotypic and phenotypic level at all the three locations.

Thirty one crosses exhibited heterosis and heterobeltiosis at all the locations however, none of them could exceed standard check. Maximum level of heterosis was observed in cross combinations P4xP9, P5xP6 and P5xP7. They also had higher *per se* performance. Such heterotic crosses for ear girth has also been reported by Yurankova *et al* (1989), Mandal (1996) and Venkatesh (1997).

Number of seed rows per ear and number of seeds per ear is one of the important component of grain yield and for this, all the hybrids (except seed rows per ear) exhibited heterosis in positive direction. Among the crosses, P4xP9 and P4xP10 possessed more number of seed rows per ear varying from 15.33 to 16.00 and 14.67 to 15.33 seed rows per ear at all the three locations. They possessed on an average 595 to 642 and 591 to 596 seeds per ear. The hybrid P4xP9 not only recorded heterosis and heterobeltiosis but also recorded 14.29 and 33.33 per cent standard heterosis for seed rows per ear at Rajendranagar and Tandoor. The hybrids viz., P4xP9 and P4xP8 exhibited high heterosis of 90.20 to 109.19 per cent for number of seeds per ear at Karimnagar and they were also heterotic at Rajendranagar and Tandoor locations. P4xP10 has also exhibited high heterosis of three types. The crosses, P4xP9 and P4xP10 involves one tropical parent (P4) and other two parents (P9

and P10) are of sub-tropical type. Considering three locations they possessed significant standard heterosis of 28.86 per cent at Karimnagar to 51.05 per cent at Tandoor.

In respect of shelling per cent which gives per cent shelled grains per ear, twelve hybrids exhibited varying levels of heterosis, heterobeltiosis and standard heterosis. The cross combinations, P1xP8, P2xP9, P2xP10, P5xP7 and P2xP6 recorded an average of 84 to 85.7 per cent of shelling. Their shelling out turn in terms of standard heterosis was significant and ranged from 2.47 to 6.17 at Rajendranagar, 3.38 to 8.86 at Karimnagar and 2.53 to 7.59 per cent at Tandoor.

The mean of 100 seed weight ranged from 24.00 to 34.00 grams at Rajendranagar, 24.67 to 35.00 grams at Karimnagar and 24.00 to 34.67 grams at Tandoor. The hybrids P5xP9, P7xP9, P3xP7, P5xP8 and P3xP8 had higher *per se* performance at all the locations ranging from 32.00 to 35.00 grams. The heterosis and heterobeltiosis was in positive direction but many hybrids recorded negative standard heterosis. The above five hybrids registered significant heterosis and exceeded their superior parent and standard check hybrid at all the locations. These crosses involved one parent having higher seed weight and resultant of tropical and sub tropical cross combinations. This implies that in breeding for higher individual grain weight, at least one divergent parent with superior *per se* must be included as one of the parent.

The cross combinations P5xP7, P4xP8, P5xP8, P5xP6 and P1xP2 had higher grain yield *per se* performance ranging from 3.06 to 3.89 kg/plot at Rajendranagar, 3.31 to 3.78 kg/plot at Karimnagar and 3.18 to 3.75 kg/plot at Tandoor (Figs.5, 6a and 6b). All the hybrids exhibited their superiority over the mean of their parents and better parent. The cross P4xP8 (tropical x tropical) recorded maximum standard heterosis of 46.67, per cent at Rajendranagar, 33.45 per cent at Karimnagar and 36.36, per cent at Tandoor. The other two best hybrids P5xP7 and P5xP8 were also resultants of tropical x

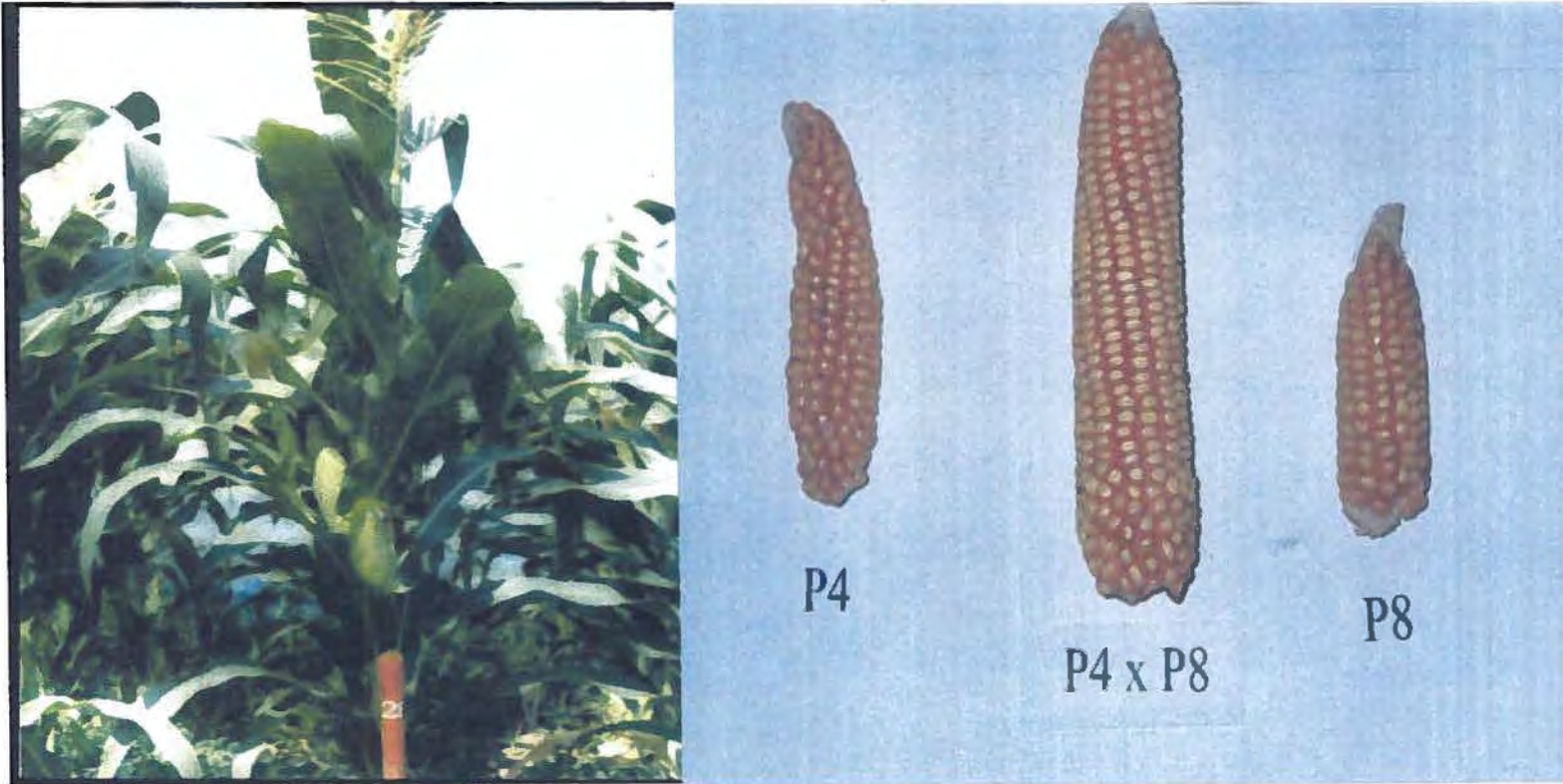


Fig. 5. Top performing hybrid plant, ear and ears of its parents

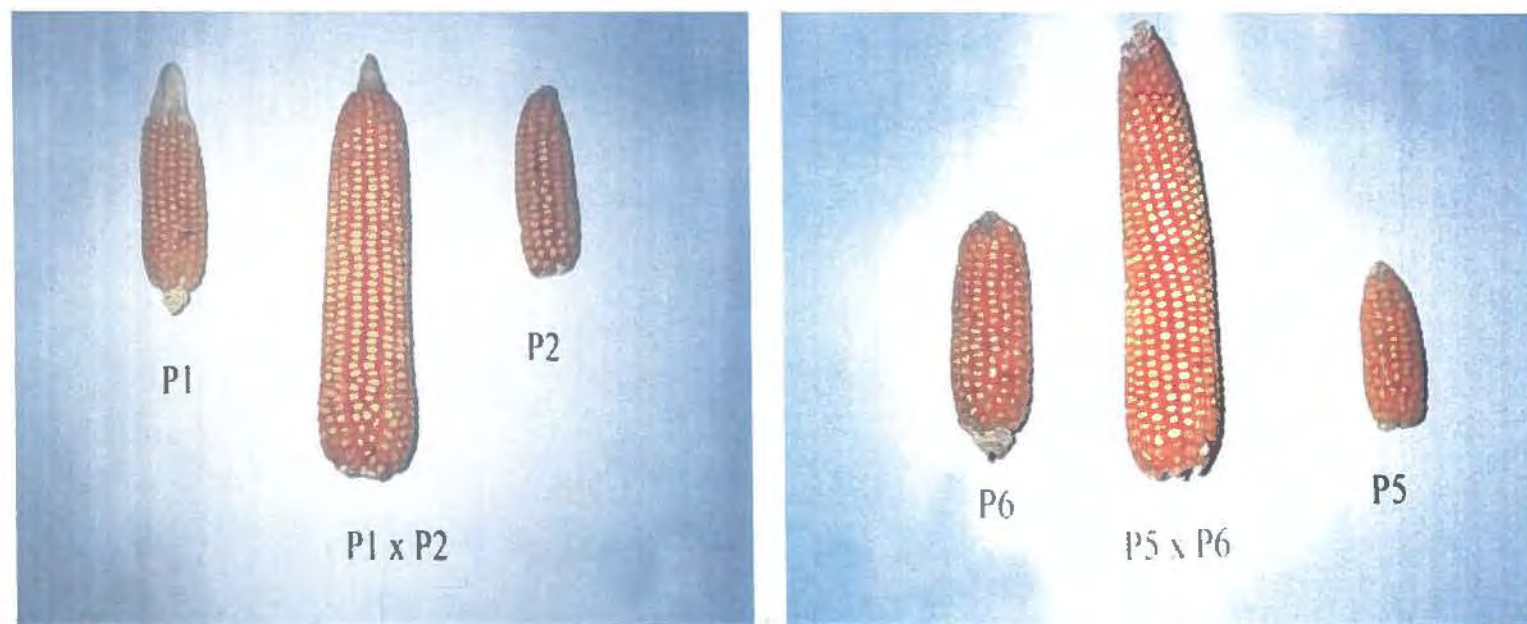


Fig. 6a. Ears of best performing hybrids and their parents

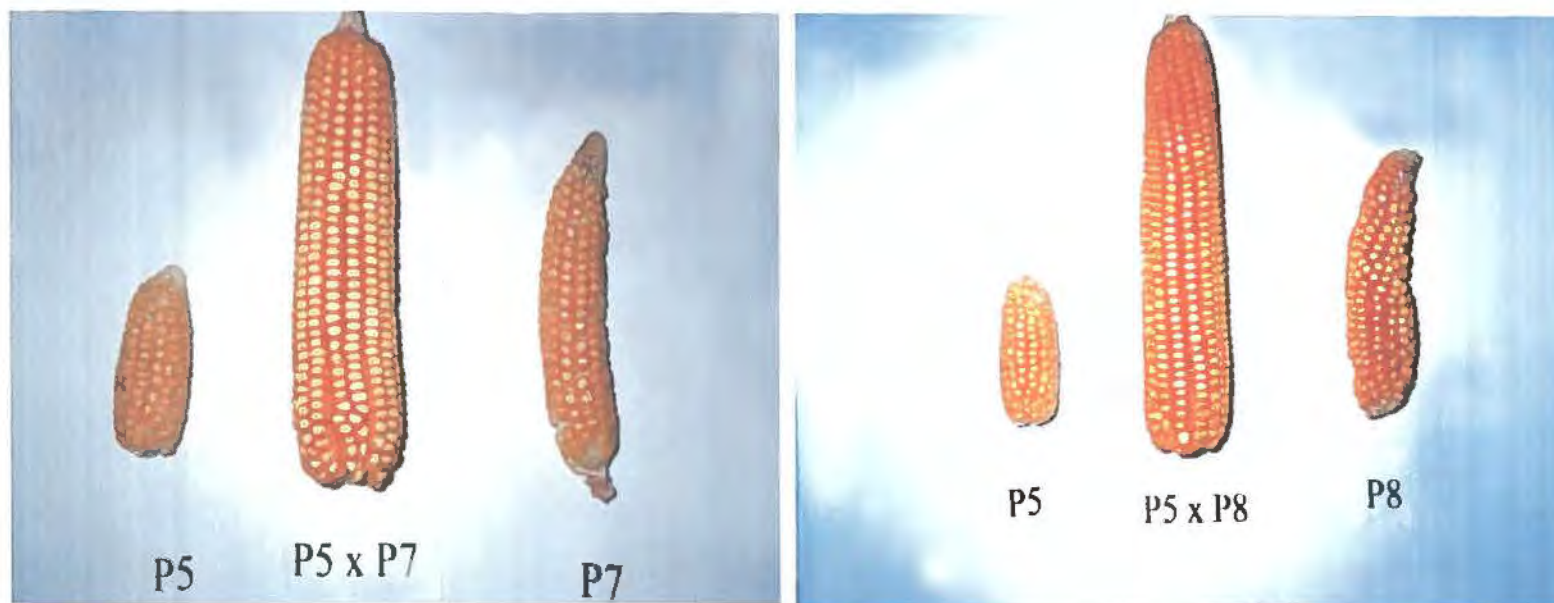


Fig. 6b. Ears of best performing hybrids and their parents

tropical crosses and have 28.5 and 26.0 per cent higher yield over the standard check. The tropical x subtropical hybrids P5xP6 and P1xP2 can also be considered as promising, as they had significant performance over better parent and standard check. Varying levels of heterosis was reported by Krowlinowski (1971), Mabo (1977), Verma and Singh (1980), Younis *et al* (1987), Debnath and Sarkar (1990), Murali Krishna and Patil (1992), Joshi *et al* (1998) and Appunu (2002).

In general, the oil per cent in maize ranges from 4.0 to 5.0 (Kumar *et al* 1997). But in the present investigation, the hybrids exhibited wide range of oil per cent ranging from 3.96 to 6.60 at Rajendranagar, 4.28 to 6.75 per cent at Karimnagar and 4.55 to 6.85 at Tandoor. Heterosis in both negative and positive directions was observed in the crosses. The crosses P1xP6, P2xP9, P3xP7, P4xP10 and P5xP6 recorded more than 6.41 per cent oil and turned out to be best heterotic crosses exceeding their better parent. For considering the hybrid superiority, the performance of hybrid in relation to standard check is essential. Kumar *et al* (1997) reported standard heterosis of 13.4 to 21.6 per cent for oil content at all the locations. In the present study P5xP6 at Karimnagar and P2xP9 at Tandoor exhibited standard heterosis of 48.35 (P5xP6) to 59.22 per cent (P2xP9). Breeding for higher protein increases the nutritional value of maize and this possibility was demonstrated by Woodworth (1952). Thereafter many workers reported heterotic performance of hybrids for protein. Recently heterosis for protein content was reported by wang *et al* (1998) and Konark *et al* (1999). Generally protein per cent ranges from 7.2 to 10.1 (Singh, 2000). In the present study the protein per cent of hybrids ranged from 6.37 to 13.19 per cent at Rajendranagar, 6.86 to 13.64 at Karimnagar and 6.21 to 13.63 at Tandoor. The crosses P5xP7, P1xP2, P3xP4 and P2xP6 recorded higher protein content ranging from 12.48 (P2xP6 at Tandoor) to 13.54 per cent (P3xP4 at Karimnagar). Nine crosses exhibited all the three types of heterosis at three locations. An average of 79.5 per cent in P5xP7 and 71.6 per cent of heterosis in P2xP6 was observed. Hybrids with

higher protein content are useful and essential to overcome the problem of malnutrition.

Considering the three locations, the crosses P4xP8, P5xP7, P5xP8, P5xP6, P1xP2 and P4xP7 were the high yielders and recorded high levels of heterosis, heterobeltiosis and standard heterosis. A perusal of heterotic performance for other characters revealed that heterosis for yield was accomplished with heterosis for ear length, ear girth, number of seeds per ear and 100 seed weight in P4xP8 cross. While in P5xP7, heterosis was also observed for number of seed rows per ear, shelling per cent and protein per cent. In cross P1xP2, contribution for high yield was due to ear girth, number of seed rows per ear, number of seeds per ear, shelling per cent, 100 seed weight, oil and protein per cent. High yield with protein and oil per cent was observed in the cross combinations P5xP6, P1xP2 and P4xP7.

5.3 PHENOTYPIC STABILITY FOR YIELD AND YIELD COMPONENTS

A desirable hybrid should possess stability in performance besides high yield. The high yielding ability and response to environmental changes are the two independent attributes of a genotype and are governed by separate gene system (Finley and Wilkinson, 1963; Liu, 1992). A stable phenotypic expression of a character is the result of interaction between its genotype and the environment in which it develops. Therefore, the ability of some crop varieties to perform well under wide range of environmental conditions has long been appreciated. Although plant breeders are aware of important genetic differences in adaptability, they have not been able to exploit their full potentiality on account of difficulties in defining and measuring either adaptability itself or the complexity of environments. In recent times many models have been developed of which Eberhart and Russell (1966) has been widely adopted. They emphasized the need to study

both linear (bi) and non-linear ($S^2 di$) components of $G \times E$ interactions in the estimation of stability.

Linear regression is a measure of response of a particular genotype to the different environments. Stability is reflected by deviation from regression components where the mean performance of a genotype along with both these parameters represent a measure of adaptability of genotype.

In the present investigation, 45 hybrids along with 10 parents were evaluated for stability over three environments viz., Rajendranagar, Karimnagar and Tandoor following Eberhart and Russell (1966) model.

Grading of environment indicated that the Karimnagar location was best for grain yield and most of the yield components. Pooled analysis of variance revealed the presence of genetic variability among the genotype for all the characters indicating differential response of genotype in different environments and exhibited their indifferent nature of genetic system in controlling the stability performance.

Environment linear was also significant for all characters except ear height, number of seed rows per ear and grain yield. Significant effect of environment was also reported by Cardoso *et al.* (1997), Gentinetta *et al* (1988) and Gautam *et al* (1998).

Pal and Prodhan (1994) reported significant $G \times E$ interaction for yield and yield components except ear diameter, number of rows per ear and oil content. In the present study, $G \times E$ (linear) was found to be significant for days to 50 per cent tasseling, 50 per cent brown husk, plant height, ear length, number of seeds per ear, 100 seed weight and oil per cent. Thus prediction for most of the genotypes will be feasible for these traits across locations. However, the $G \times E$ linear interaction was non significant for 50 per cent silking, ear height, ear girth, number of seeds per ear, shelling percentage,

protein per cent and grain yield indicating that only non linear component alone accounted for Genotype x Environment interaction.

Pooled deviation was significant for days to 50 per cent brown husk, ear height, number of seeds per ear, shelling percentage, oil and protein per cent and grain yield indicating that the parents and hybrids differed considerably for their stability. Mahajan and Khehra (1992) for grain yield, ear length and 100 seed weight, Kumar *et al.* (1997) observed both linear and non linear components of GxE interaction for maize oil.

Duration of a variety or a hybrid is an important attribute which qualifies them to fit in crop rotation system in order to increase crop intensity. It also helps in escaping terminal drought. Days to 50 per cent tasseling, silking and brown husk, indicates the earliness of a genotype in maize. Most of the hybrids and parental lines exhibited stable performance for earliness. However, the tropical parental lines P5 and P7 and cross combinations P4xP10, P3xP9 and P5xP6 were early and possessed desirable stability parameters.

In respect of plant height P8, P9 and P10 possessed intermediate height and did not exhibit both linear and non linear portion of Genotype x Environment interaction. The hybrids P6xP8, P5xP10 and P7xP9 possessed higher mean value and were stable as both bi and S²di estimates were not significant.

Stability for ear height was observed in parental lines P5 and P9 and hybrids P3xP8, P1xP8, P2xP6 and P5xP9 with desirable means. The parental lines P3, P8 and P2, among the hybrids, P4xP7, P5xP7, P2xP4 and P1xP7 possessed lengthy ears and both linear and non linear portion of Genotype x Environment interaction were absent.

In respect of number of seed rows per ear, the parent P4 and crosses P4xP9, P4xP8 and P2xP4 exhibited stable performance with higher mean

values for number of seeds per ear. P1 and P8 possessed higher mean and the hybrids P4xP8, P4xP10, P2xP4 and P1xP4 were found to be stable with unit regression and non significant S^2_{di} estimates.

In respect of shelling per cent, all the parents were found to be stable except P1. None of the hybrids exhibited linear G x E interaction. The cross combinations P1xP8, P2xP9 and P2xP10 had more than 85 per cent shelling out turn and stable performance.

The predictable portion of G x E interaction was found to be non significant for 100 seed weight and thus the performance of parents and hybrids can be predicted across the environment. The parents P5 and P7 had 24.5 and 24.6 grams of 100 seed weight and the hybrids P4xP7, P3xP7 and P7xP9 had 34.1 to 38.7 grams of 100 seed weight and exhibited stability for this character. The parent P7 was stable for 100 seed weight and also produced stable hybrids indicating that in breeding for stability, for this character, one of the parent must be stable.

Kumar *et al* (1997) reported G x E interaction and differential performance of the genotype under different environments for oil content. Considering three locations in the present study for oil content, P7 and P10 and hybrids P2xP9, P1xP6, P4xP10 and P5xP6 exhibited stable performance.

The linear response of genotype for protein per cent was non significant. P10 and P9 had higher protein per cent and among hybrids P5xP7, P3xP9 and P3xP10 had more than 12.6 per cent protein and were stable over the environments.

Among the parents, P5, P7 and P8, all belonging to tropical type registered high grain yield but P5 had significant S^2_{di} estimates and its performance cannot be predicted across the locations while tropical parents P7 and P8 exhibited stable performance with higher yield. The linear estimate of G x E interaction which gives the idea of responsive capacity of a particular

genotype was found to be non significant but the non linear component was significant for most of the hybrids. Some of the hybrids with high mean possessed significant S^2_{di} and their stable performance across locations is not possible. Eberhart and Russel (1966) characterized an ideal genotype to be stable should possess unit regression, lowest deviation from the regression and higher mean to have practical value. Accordingly, the hybrids P5xP8, P1xP2, P4xP9, P1xP7 and P6xP8 were found to be stable across the locations with unit regression and non significant deviation from regression. The hybrid combinations P5xP8 and P1xP2 also exhibited standard heterosis of 26 and 21.6 per cent respectively. And in many cross combinations involving at least one tropical parent, stable yield was recorded over locations viz., Rajendranagar, Karimnagar and Tandoor, indicating the usefulness of tropical parents in improvement of grain yield.

Stability for yield in P5xP8 was accomplished with stability in shelling percentage and ear length. In cross P1xP2 the stable performance for yield was due to its stability for 100 seed weight, number of seed rows per ear, number of seeds per ear and ear length.

5.4 GENETIC PARAMETERS AND CHARACTER ASSOCIATION

The variance component derived from further partitioning of genotypic differences into phenotypic, genotypic and environmental coefficient of variation and heritability is a good index of transmission of characters from parents to their off-springs (Falconer 1960). The estimates of heritability along with expected genetic advance are more useful in predicting the resultant effects on selecting the best individuals.

Singh *et al* (1998) observed high to moderate estimates of heritability and genetic advance for plant height, ear height, ear length, kernels per row, 100 kernel weight and grain yield. Shimpiger *et al*. (1996)

observed high heritability estimates for yield components except yield, while 178
Satyanarayana (1995) reported high heritability for yield and suggested recurrent selection for yield improvement.

In the present study heritability and genetic advance was low for days to 50 per cent tasseling, days to 50 per cent silking, low to average for days to 50 per cent brown husk, ear length, ear girth and number of seed rows per ear indicating predominant role of non additive gene action and environment in governing these characters and thus selection will not be effective.

Grain yield and its component characters viz., ear height, number of seeds per ear, 100 seed weight and protein content had high heritability coupled with high genetic advance therefore selection can be practiced for improving these characters. Heritability was high for plant height, oil and shelling per cent but the genetic advance was average which indicates that the selection will be effective with higher selection intensity.

The concept of path analysis was originally developed by Wright (1921) and this technique was first used in plant selection by Dewey and Lu (1959). There after many workers reported and utilized these techniques in crop improvement through selection. In maize hybrids of 12 parental diallel, Kumar *et al.* (1998) suggested selection for number of grains per row, number of rows per ear, ear diameter, ear length and days to 50 per cent maturity. Mathur *et al* (1997) observed least influence of environment on phenological characters and the pattern of association on number of rows, number of kernels, 100 kernel weight with grain yield remained consistent over environments.

In the present investigation also phenotypic, genotypic correlations and path analysis were studied. Satyanarayana (1995) observed significant

positive association of kernels per row, kernel rows per ear, ear length, ear girth, 100 seed weight with grain yield. Grain yield was significantly and positively associated with plant height, ear height, ear length, ear girth, number of seed rows per ear, number of seeds per ear, shelling per cent, 100 seed weight and oil per cent at Rajendranagar, Karimnagar and Tandoor, both at phenotypic and genotypic levels. These results were in conformity with findings of Jadhav *et al* (1995) and Devi *et al.* (2001).

The direct and indirect association through other characters by path analysis revealed that 100 seed weight, number of seed rows per ear, and number of seeds per ear directly influenced grain yield at Rajendranagar. Number of seeds per ear, plant height and days to 50 per cent silking indirectly contributed for 100 seed weight while plant height and number of seed rows per ear positively contributed for number of seed rows per ear and number of seeds per ear. Geetha and Jayaraman (2000) advocated selection for number of grains per row to improve the grain yield. At Karimnagar and Tandoor direct effects of only number of seeds per ear and 100 seed weight were observed on grain yield, in turn 100 seed weight was indirectly influenced by number of seeds per ear and number of seed rows per ear. Hence these characters can be exploited in selection for increasing the grain yield. Annapurna *et al.* (1998) also made similar recommendation while Satyanarayana *et al.* (1990) reported the role of test weight via ear length and ear girth.

Oil is one of the important characters and was found significantly associated with plant height, ear length, number of seeds per ear, shelling per cent and 100 seed weight at all the three locations. Kumar and Kumar (2000) also reported that late maturing and dwarf plants with lower number of seed rows, number of seeds per ear and 100 seed weight were desirable for improving oil content. Days to 50 per cent tasseling, exhibited significant negative association with oil per cent. The direct effect of oil content was on

negative side at Rajendranagar and Tandoor locations and positive side at Karimnagar.

Protein content showed positive association with only number of days to 50 per cent brown husk at all the three locations and did not exhibit any relationship with other characters.

In light of present investigation it is evident that tropical parents have higher ear length, ear girth, number of seeds per ear, oil content and grain yield. While sub tropicals have higher protein content.

The present study revealed the role of additive and non additive gene action in most of the yield and yield contributing characters. The preponderance of non-additive gene action is apperant. Hence, a breeder should coin the non-additive gene action through the exploitation of heterosis. To realise both the gene actions, recurrent selection process i.e., population improvement programmes should be followed to get the elite inbreds in the future breeding programmes and to pyramid the genes of tropicals and sub tropicals into certain individuals. So that it will act as fuel for future breeding programmes.

The tropical parents P4, P5 and P7 were good combiners for most of the characters including yield. These lines can be used as parental donors for yield improvement and thesis crosses can be exploited in pyramiding genes for higher yield. The crosses P5xP7, P5xP8, P4xP7 and P4xP8 were high yielding & exhibited 19.22 to 32.5 percent superiority over high yielding hybrid check. These crosses have tropical parents with good combining ability and can be used in production of synthesis.

Heterosis for most of the hybrids was accomplished for ear length, ear girth, number of seeds per ear and 100 seed weight. Hence, improvement in these characters ensures higher yield.

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From the limited material tested and evaluated, it is apparent that tropical types have high yield potential. Besides yield, protein content in the grain is also important. Sub tropical parents have higher protein content. The parents P3, (sub tropical) and P2,P5 (tropical) were good combiners and introgression of these tropical x subtropical types by developing new gene recombinations through recurrent selection in future breeding programmes will bring about changes in gene frequencies and may give better lines with higher level of protein content with yield.

Stability analysis was based on three diversified locations. It is better to test the high yielding hybrids over more locations and different agro climatic situations to find out the real worth of the hybrids before it is released for commercial cultivation.

Despite the importance of biotechnology and genetic engineering in changing further production methods in agriculture, these are going to neither take the place of traditional plant breeding research and breeding methodology nor diminish their value. Their impact on the future of maize breeding is unknown, but they most certainly will broaden the horizons in developing better lines and hybrids (Hallauer, 1990).



Summary

CHAPTER VI

SUMMARY

Present investigation entitled **"Genetic analysis of yield and its components in selected tropical and sub tropical maize (*Zea mays* L.) inbreds"** was carried at three locations viz., Rajendranagar, Karimnagar and Tandoor and the results obtained are summarized in this thesis. The study was aimed to understand the nature of gene action, amount of heterosis, genetic parameters, character association, genotype x environment interaction and stability of yield, yield components, oil and protein per cent. For this purpose 180 genotypes comprising of tropical and sub tropical types were top crossed and these top crosses were evaluated at Rajendranagar and Tandoor locations during 1999 *kharif*. Top 5 high yielding parents each from tropicals and sub tropicals were selected. These ten parents were crossed in diallel fashion (excluding reciprocals). The resulting 45 hybrids along with parents and three checks were grown during *kharif* 2001 at Rajendranagar, Karimnagar and Tandoor locations. The data was collected on days to 50 per cent tasseling, days to 50 per cent silking, days to 50 per cent brown husk, plant height, ear height, ear length, ear girth, number of seed rows per ear, number of seeds per ear, shelling per cent, 100 seed weight, grain yield, oil and protein per cent. The data was analyzed following Griffing (1956) model for diallel and Eberhart and Russell (1966) for stability.

The genotypic differences were significant for all the characters. The differences in tropical and sub tropical parents were also significant and magnitude of variation due to tropicals was higher for ear height, ear length, ear girth, number of seeds per ear, shelling per cent, 100 seed weight, grain yield and

oil per cent. The comparison of parents vs. hybrids was significant for all characters at all locations.

Combining ability analysis revealed importance of both additive and non additive gene action in governing most of the characters but non additive gene action was found to be predominant. Hence, recurrent selection was suggested to improve these characters. Days to 50 per cent tasseling, days to 50 per cent silking and days to 50 per cent brown husk, indicates earliness of a genotype. The parental lines P6 and P7 were early and contributed maximum favourable genes for these maturity characters. For plant height P5, P8 and P9, for ear length, P7 and P8 were good general combiners. Considering all the three locations, P5 for ear girth, P4 for number of seeds per ear and seed rows per ear turned out to be good combiners. The tropical parents P5 and P4 for shelling per cent, P7 and P8 for 100 seed weight had higher per se performance and contributed more favourable genes at all three locations. The tropical parents P7 and P8 and a sub tropical inbred P6 possessed high oil per cent and were good combiners. In general, the sub tropical parents possessed higher mean protein per cent. Among these P3 (sub tropical) and P2, P5, P7 (tropical) parents were found to be good combiners. In respect of grain yield P4, P5 and P7 (all tropical types) turned out to be good combiners at all the locations. They were good combiners for most of the other yield contributing characters and can be given the status of good general combiners.

Among the crosses P4xP10 and P3xP9 were early and exhibited significant SCA effects for earliness. The cross combinations P9xP10, P6xP8 and P5xP9 for plant height, P5xP7, P4xP8 and P6xP9 for ear height; P5xP7, P2xP4, P4xP7 and P2xP10 for ear length, P3xP9, P5xP6 and P5xP7 for ear girth (at Rajendranagar and Karimnagar) were the best specific crosses.

P4xP9, P6xP8 and P4xP10 found to be best crosses for number of seeds per ear, P1xP8, P2xP9, P2xP10 and P5xP7 for shelling per cent P5xP6, P5xP8, P5xP9 for 100 seed weight. In respect of oil per cent P6xP8, for protein per cent P3xP5, P3xP7, P2xP7, P5xP7 and for grain yield, P5xP7, P5xP8, P4xP7 and P4xP8 were the best specific crosses involving both parents as good general combiners and are expected to give good transgressive segregates. These crosses exhibited 19.2 to 32.5 per cent superiority over high yielding hybrid check.

Heterosis expressed over mean of parent, better parent (heterobeltiosis) and standard check (standard heterosis) in 45 hybrids exhibited wide range for all the characters. Maximum heterosis was observed for grain yield followed by number of seeds per ear. The hybrids P4xP10, P3xP9 and P2xP9 were early and exhibited maximum heterosis in negative direction. P5xP7 and P6xP9 were medium tall and exhibited heterosis for plant height. Though 14 hybrids exhibited heterosis for ear length, only one hybrid P5xP7 had standard heterosis over all the locations and it is also possessed heterosis for ear girth.

The cross combinations P4xP9 and P4xP10 had 15.33 to 16.00 and 14.67 to 15.33 seed rows per ear and possessed 595 to 642 and 591 to 596 seeds per ear and were heterotic for this character. For shelling per cent P1xP8, P2xP9, P2xP10, P5xP7 and P2xP6 registered 83.67 to 85.00 per cent shelling out turn and had 2.47 to 7.59 per cent standard heterosis. At different locations P5xP9, P7xP9, P3xP7, P5xP8 and P3xP8 possessed higher *per se* performance for 100 seed weight and turned out to be heterotic ones.

All the hybrids exhibited superiority over mean of parent and superior parent for grain yield. The heterosis ranged from 75.16% (P1xP8) to 201.67% (P2xP3) for grain yield at Rajendranagar, 75.95% (P2xP6) to 185.75% (P4xP8) at Karimnagar and from 91.45% (P4xP5) to 15.74% (P1xP3) at Tandoor. The mean

heterobeltiosis varied from 70.09 per cent (P4xP6) to 191.47 per cent (P2xP3) at Rajendranagar, 75.95 per cent (P2xP6) to 185.75 per cent (P4xP8) at Karimnagar and from 60.21 (P1xP5) to 211.65 per cent (P1xP3) at Tandoor. The average superiority of hybrids over standard high yielding check was from -14.84 per cent (P1xP8) to 46.67 per cent (P5xP7) at Rajendranagar, from -11.78% (P1xP10) to 33.45 per cent (P4xP8) at Karimnagar and from -18.30 (P1xP9) to 363.36 per cent (P5xP8) at Tandoor. On the average of the three locations, the cross P4xP8 exhibited 32.5 per cent standard heterosis followed by P5xP7 and P5xP8 to an extent of 28.5 and 26.0 per cent respectively. All these three crosses are derivatives of tropical x tropical types. The crosses P1xP6, P2xP9, P3xP7 and P4xP10 not only recorded more than 6.4 per cent oil but also heterotic and exceeded their parents. The protein content ranged from 12.48 to 13.53 per cent in crosses P5xP7, P1xP2, P3xP4 and P2xP6. Among the 9 standard heterotic crosses P5xP7 and P2xP6 recorded average standard heterosis of 76.5 and 71.6 per cent over the locations.

Heterotic performance for grain yield in P4xP8 was due to heterosis for ear length, ear girth, number of seeds per ear and 100 seed weight, while in P5xP7 for number of seed rows per ear, shelling per cent and protein per cent. High yield with high protein and oil contents were observed in P5xP6, P1xP2 and P4xP7.

High heritability with high genetic advance was observed for ear height, number of seeds per ear, 100 seed weight, grain yield and protein per cent. The grain yield was positively and significantly associated at genotypic and phenotypic level with number of seeds per ear, shelling per cent, number of seed rows per ear, ear girth, ear length, plant height, ear height and oil per cent at Rajendranagar, Karimnagar and Tandoor locations.

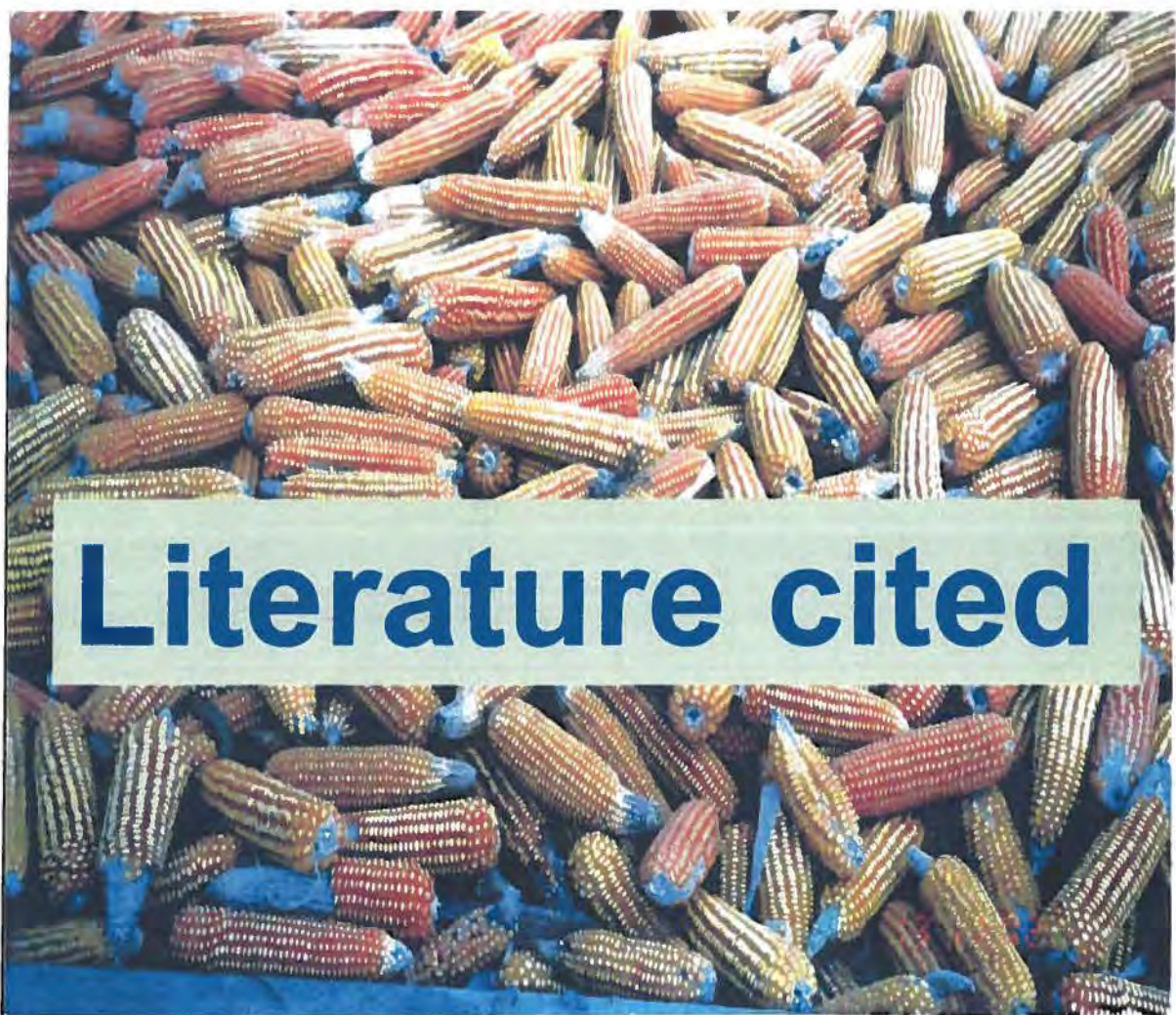
Path coefficient analysis has shown direct relationship of number of seed rows per ear, number of seeds per ear, 100 seed weight with grain yield. The indirect effect of these characters on yield was influenced much by 100 seed weight and number of seeds per ear. Therefore selection for these two characters will bring out desirable change for higher yield.

Genotype x Environment interaction studied at three locations viz., Rajendranagar, Karimnagar and Tandoor was found to be significant for days to 50 per cent tasseling, brown husk, plant height, ear length, number of seed rows per ear, 100 seed weight and oil per cent. The environment linear was also significant for all characters except ear height, number of seed rows per ear and grain yield. Pooled deviation was significant for ear height, number of seeds per ear, shelling per cent and grain yield indicating non linear component of GxE interaction alone accounting for variation in these characters.

The parental lines P5 and P7, both of tropical type, exhibited stable performance for earliness and 100 seed weight; P3 and P8 for ear length, P1 and P5 for ear girth and P4 for number of seeds per ear possessed higher means and non significant b_i and S^2d_i estimates. For shelling per cent the tropical parents P4, P5 and for 100 seed weight P5 and P7 were stable. In respect of oil, P7 and P10 and for protein, P8 possessed unit regression and least deviation from regression.

Two tropical parents P7 and P8 recorded higher grain yield at all three locations and were found to be stable. The responsiveness of a genotype measured by linear estimate (b_i) was not significant for all the hybrids while the non linear components (S^2d_i) were significant for most of the hybrids for grain yield. Among the hybrids P5xP8, P1xP2, P4xP9 and P1xP7 possessed higher mean and were stable for grain yield. The hybrid combinations P5xP8 and P1xP2

- Sub-tropical parents P3, P10 and P9 possessed higher protein per cent. P3 contributed maximum favourable genes for protein per cent. The tropical parents P2, P5 and P7 were also good combiners and these can be intercrossed with P3 to obtain higher protein content.



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