GENETIC ANALYSIS OF PRODUCTIVITY IN RELATION TO MATURITY IN BUNCH GROUNDNUT

BY

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DECLARATION

I hereby declare that this thesis entitled "Genetic analysis of productivity in relation to maturity in bunch groundnut" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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LIST OF TABLES

LIST OF FIGURES

CONTENTS

INTRODUCTION

INTRODUCTION

The groundnut plant originated in the Bolivian region (Gregory and Gregory,1976). The crop is now generally distributed in the tropical, sub tropical and warm temperate zones of the world. However, the limits of present commercial production are between latitudes 40° N and 40° S.

In India, groundnut was adopted as an agricultural crop only during the late 19th century. But the country has already become a major groundnut producer accounting for nearly one third of the world's production. Groundnut accounts for 45 per cent of the total area and 55 per cent of the total production of oilseeds in the country.

The edible oil economy in India is primarily dependent upon groundnut production. The major portion of the groundnut in India is utilised for oil extraction. Up to 1979-80, India was exporting groundnut oil. About 12,000 tonnes was exported during 1979-80 earning Rs. 91 million. However, export of groundnut oil was discontinued since then in view of the higher demand within the country and to check the rising price in the internal market (Patel,1988).

Though, India ranks first in area and production of groundnut, the present productivity is less than the world average. This is mainly because of the fact that the crop continues to be grown mostly in drylands, often subject to the vagaries of the weather. Up to 1970-71 groundnut was grown only during the Kharif season. Thereafter groundnut cultivation started on a large scale in rabi and summer also. This has opened up new areas in the southern and central parts of the country and there is considerable scope for increasing productivity also, since the yield of groundnut in rabi and summer is double than that of Kharif.

For most parts of the country, in order to suit the rainfall patterns, rotation systems and availability of water in the irrigation sources, early maturing groundnut varieties are required. Nigam et al. (1980) indicated that groundnut which mature earlier and possess higher yield potential together with good quality will be extremely useful in the areas of the semi-arid tropics which have short growing season, where an early maturing crop may escape stress situations. There is also good scope for fitting early maturing groundnuts in the relay or sequential cropping systems, particularly in South-East Asia by utilizing the residual moisture after the harvest of the rice crop (Gibbons, 1980).

In Kerala , the rice-rice-groundnut sequence in double cropped wetlands has opened out new vistas in the production of groundnut. It is projected that about two lakh hectares of rice fallows can be brought under groundnut during summer season (Anon., 1978a). Nair (1978) emphasized the urgent need for evolving short duration varieties of groundnut for rice fallows. The crop sequence trials conducted at the Rice Research Station, Kayamkulam (Kerala) had proven that groundnut can be grown profitably as a third crop in the rice fallows of Onattukara (Anon., 1979). The trials in farmers fields conducted by the Kerala Agricultural University through the village adoption programme had demonstrated the possibility for extensive cultivation of groundnut as a commercial crop in the rice fallows. The trials conducted under the National demonstrations have also exposed similar possibilities (Anon., 1978b).

The major constraint in extending the groundnut crop to the summer rice fallows is the lack of an extra early variety maturing in 80-90 days with synchronized pod maturity and moderate yield potential.

The present study undertaken with the following activities has relevance in this context.

i) Estimation of genetic parameters like components of variance, heritability and genetic advance in extra early, early and medium maturing bunch types of groundnut.

ii) Computation of correlations between oil yield and its components and path analysis for pod yield and oil yield and their components in the above three maturity groups.

iii) Assessment of combining ability in the parents selected for recombination breeding.

iv) Study of the nature of gene action involving the inheritance of earliness.

v) Identification of types with high yield coupled with early maturity.

An understanding of the genetic basis of earliness in relation to productivity traits will help the breeder to have a more rational approach in breeding for the trait. Among the parents tested for combining ability, good combiners for earliness could be isolated. Moreover, promising recombinants (high yield coupled with early maturity) selected could be used for further testing and selection.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The success of breeding a self pollinated crop like groundnut mainly depends on the choice of the best parents for hybridization and the ideal selection scheme adopted in the early generations. Genetic information about the nature of combining ability and the type of gene action governing the inheritance of important economic traits is a prerequisite in fixing the suitable parents and designing the appropriate breeding procedures. A review of the reported results on variability, heritability, genetic advance, correlation, path analysis, combining ability, gene action, heterosis and genotype x environment interaction in groundnut are presented hereunder.

2.1 Variability

Basu and AshokaRaj (1969) recorded high genotypic coefficient of variation for number of days to flower. Moderate to high genotypic coefficient of variation for days to 50 per cent flowering was observed by Kushwaha and Tawar (1973). However, Kuriakose (1981) reported low values for duration up to flowering under both kharif uplands and summer rice fallows.

Low value for genotypic coefficient of variation for spread of flowering was reported by Pushkaran (1983). But, Patil and Bhapkar (1987) recorded high value for the character.

Kushwaha and Tawar (1973) recorded low values of genotypic coefficient of variation for days to maturity. Similar result was obtained by Pushkaran (1983). However, Patil and Bhapkar (1987) recorded high value for the trait.

High value of genotypic coefficient of variation was reported for number of immature pods per plant by Kulkarni and Albuquerque (1967) and Radhika (1984). Patra (1975) registered a moderate value for the trait. Lakshmaiah (1978) obtained high value during kharif and a moderate value in rabi. Pushkaran (1983) recorded a moderate value for the trait during kharif and a low value during rabi.

Kulkarni and Albuquerque (1967) reported moderate value of genotypic coefficient of variation for number of mature pods per plant. Low values of genotypic coefficient of variation were recorded by Majumdar <u>et</u> <u>al</u>. (1969), Sangha (1973b) and Patra (1975). Values ranged from low to moderate for the spreading group and low for the bunch group (Dixit et al. 1971). High values of genotypic coefficient of variation was reported by Dixit et al. (1970) and Pushkaran (1983). Lakshmaiah (1978) recorded low and moderate values in two different seasons.

Basu and AsokaRaj (1969) reported high genotypic coefficient of variation for haulms weight per plant. Moderate to high genotypic coefficient of variation estimate was recorded for dry weight of fodder by Kushwaha and Tawar (1973). Pushkaran (1983) reported low genotypic coefficient of variation for the character in both kharif uplands and summer.

Low values of genotypic coefficient of variation was reported by Basu and AsokaRaj (1969) and Majumdar et al. (1969) for dry pod yield. On the other hand Dixit et al. (1970) obtained high values for the trait. The genotypic coeficient of variation was low in the bunch group whereas, it ranged from low to moderate in the spreading group (Dixit et al., 1970). Sangha (1973b) and Deshmukh et al. 1986) obtained low values for dry pod yield whereas, Patra (1975) recorded a high value for the character. Moderate genotypic coefficient of variation was recorded in kharif and a high value in rabi for the trait

(Lakshmaiah, 1978). Pushkaran (1983) reported low values in both kharif and summer seasons. Patil and Bhapkar (1987) obtained high value for the trait.

Kushwaha and Tawar (1973) registered low genotypic coefficient of variation for 100 pod weight, while Kuriakose (1981) recorded a high value. Pushkaran (1983) obtained low values for the trait during both kharif and summer seasons.

Mohammed et al. (1973) recorded high genotypic coefficient of variation for shelling percentage in semi-spreading and spreading types. Natarajan et al. (1978) concluded from their study that variation in shelling percentage was the highest in prostrate varieties in comparison to semi-spreading varieties. High genotypic coefficient of variation for the trait was recorded by Rao (1980), while Kuriakose (1981) obtained a low value. Pushkaran (1983) reported low values for the character in two seasons.

In both semi-spreading and spreading types, Mohammed et al. (1973) reported high genotypic coefficient of variation for kernel weight. Sangha (1973b) and Patil and Bhapkar (1987) obtained high values for 100 kernel weight. In a study with both semi-spreading and spreading varieties, Natarajan *et al*. (1978) recorded moderately high variation in kernel weight. Kuriakose (1981) reported high genotypic coefficient of variation for the trait, while Pushkaran (1983) recorded low estimates both in kharif and summer.

Low estimates of genotypic coefficient of variation for oil content were reported by Kushwaha and Tawar (1973), Kuriakose (1981) and Pushkaran (1983). Shany (1977) in a study with nine varieties and five crosses registered considerable variation in oil content. Norden (1980) recorded a wide range in oil content in different types studied.

2.2 Heritability and Genetic Advance

High estimate of heritability for days to first flowering was obtained by Basu and AshokaRaj (1969), Majumdar *et al*. (1969), Kushwaha and Tawar (1973) and Ramanathan (1980). However, Kuriakose (1981) recorded high heritability but, low genetic advance for days to 50 per cent flowering. In a two season study Pushkaran (1983) obtained high heritability but low genetic advance for duration up to flowering.

High heritability estimate was reported for period of flowering by Majumdar et al. (1969). Pushkaran (1983) obtained high heritability coupled with moderate genetic advance for the trait during kharif season, while during summer season high heritability along with high genetic advance was observed.

Days to maturity showed high heritability estimates in studies conducted by Majumdar et al. (1969) and Kushwaha and Tawar (1973). High heritability but low genetic advance was noticed in both kharif and summer seasons (Pushkaran, 1983).

Kulkarni and Albuquerque (1967) reported high heritability and low genetic advance for number of immature pods per plant, while Patra (1975) reported moderate heritability with higher genetic advance. In a two season study by Lakshmaiah (1978) an higher heritability estimate was recorded in the rabi season compared to the kharif. But, the genetic advance values were lower in both seasons. Pushkaran (1983) reported low heritability values for the trait in both kharif and summer seasons but the genetic advance values were moderate.

Kulkarni and Albuquerque (1967) reported high heritability estimate for number of mature pods per plant, but the genetic advance was low. Majumdar et al. (1969) recorded low heritability coupled with low genetic advance for the trait. Dixit et al. (1970) reported moderate heritability and moderate genetic advance for this character. In a study with bunch as well as spreading group, Dixit et al. (1971) recorded low heritability, but moderate genetic advance for number of mature pods per plant. High heritability coupled with high genetic advance was obtained by Sangha (1973b). Patra (1975) recorded low heritability, but high genetic advance for the character. High heritability with high genetic advance was estimated by Sivasubramanian et al. (1977). Lakshmaiah (1978) reported low heritability and low genetic advance in kharif season whereas, in the rabi season the heritability estimate was high but the genetic advance value was moderate. Moderate heritability and genetic advance was reported by Pushkaran (1983). Reddy et al. (1987) indicated that the percentage of mature pods to flowers had high heritability coupled with high genetic advance and should be given greater attention when selecting for improved yield.

Moderate heritability values for haulms yield was reported by Basu and AsokaRaj (1969). Dixit et al. (1970) recorded moderate heritability estimate but a low genetic advance for the character. Kuriakose (1981) recorded low heritability and genetic advance values for haulms yield. Pushkaran (1983) reported moderate heritability but high genetic advance values during kharif, while during summer heritability estimate was low and the genetic advance was moderate.

High heritability estimates for pod yield were reported by Reddy (1968), Dixit et al. (1970), Raman and SreeRangasamy (1970) and Sandhu and Khehra (1976). Moderate heritability values were recorded by Basu and AsokaRaj (1969), Majumdar et al. (1969), Sangha (1973a) and Cahaner (1978). Dixit et al. (1971) reported a wide range of heritability in spreading types compared to the bunch types in three environments. Low genetic advance for the trait was recorded by Basu and AsokaRaj (1969), Majumdar et al. (1969), Dixit et al. (1970), Sangha (1973b), Dixit et al. (1971) and Lakshmaiah (1978). Moderate value for genetic advance was recorded by Raman and SreeRangasamy (1970), while Patra (1975) reported very high value. Low values of heritability and genetic advance were reported for the trait by Kuriakose (1981). Pushkaran (1983) recorded low values of heritability and genetic advance for the character during summer, while during kharif season both the values were moderate. Basu et al. (1986a) registered a moderate narrow sense heritability value for pod yield. Krishnamurthy et al. (1986) stressed that selection for total biomass and pod yield per plant with high heritability will be effective in increasing groundnut productivity. Reddy et al. (1987) recorded high heritability coupled with high genetic advance for pod yield.

Bernard (1960) reported that weight per pod has high heritability value. That 100 pod weight had high heritability value was observed by Basu and AsokaRaj (1969), Majumdar et al. (1969), Dixit et al. (1970), Kushwaha and Tawar (1973), Cahaner (1978), Dorairaj et al. (1979) and Kuriakose (1981). Pushkaran (1983) reported high heritability and fairly high genetic advance for the character.

High heritability estimate for shelling percentage was recorded by Bernard (1960) and Kushwaha and Tawar (1973) while, Basu and AsokaRaj (1969), Majumdar et al. (1969) and Dixit et al. (1970) reported moderate values. Though Kuriakose (1981) also recorded high heritability for shelling percentage the value for genetic advance was low. Pushkaran (1983) in a two season study found high heritability and low genetic advance for the trait during Kharif season while, during the summer season the heritability value was moderate with low genetic advance. Reddy *et al*. (1987) observed high heritability but moderate genetic advance for shelling percentage.

Badwal *et al*. (1967) reported high heritability estimate for kernel weight. Badwal and Gupta (1968) recorded high heritability coupled with high genetic advance for the character. Similar findings were reported by Dixit *et al*. (1970), Sangha (1973b), Sangha and Sandhu (1975a) and Kumar and Yadav (1979). High heritability with moderate genetic advance was reported by Pushkaran (1983) and Deshmukh *et al*. (1986).

Kushwaha and Tawar (1973) reported low heritability estimate for oil content. Pushkaran (1983) in a two season study recorded moderate heritability and low genetic advance values during both kharif and summer seasons.

2.3 Correlation

Kushwaha and Tawar (1973) recorded positive correlation between days to flowering and 100 kernel weight. Nagabhushanam (1981) reported significant negative association between days to first flowering and pod yield. Kuriakose (1981) reported negative correlation between pod yield and days to 50 per cent flowering. Pushkaran (1983) also reported significant negative association of pod yield with duration up to flowering. He also observed positive correlation between duration up to flowering and oil content. Yadav et al. (1984) observed significant positive correlations of pod yield and pod number with days to first flowering. They also noted correlation of days to first flowering with days to maturity and shelling percentage. Deshmukh et al. (1986) recorded negative association between pod yield and days to 50 per cent flowering. Significant positive association between duration of flowering and pod yield was reported by Kuriakose (1981).

Mohammed (1977) in a regression study of F_3 on F_2 indicated that maturity (lateness) was positively correlated with seed yield. Kumar and Yadav (1978) in their studies with bunch varieties reported strong positive association of days to maturity with pod yield. Pushkaran

(1983) recorded moderate positive correlation of days to maturity with pod yield. Wu (1983) observed negative correlation of maturity date with yield. Alam *et al*. (1985) reported positive association between pod yield per plant and days to maturity.

Patra (1980) observed significant positive correlation of number of immature pods per plant with pod yield.

Significant positive correlations of number of mature pods per plant to pod yield were reported by Dorairaj (1962) in both spreading and bunch varieties, Jaswal and Gupta (1966), Chandra mohan *et al*. (1967), Khangura and Sandhu (1972) in spreading varieties, Badwal and Singh (1973) in semi-spreading and erect types, Chandola *et al*. (1973), Kushwaha and Tawar (1973), Sangha (1973b), Shettar (1974), Patra (1980), Kuriakose (1981), Nagabhushanam (1981), Lakshmaiah (1983) and Deshmukh *et al*. (1986).

Comstock and Robinson (1952), Moustafa and Sayid (1971), Lin *et al*. (1969), Bhargava *et al*. (1970), Phadnis *et al*. (1973), Dholaria *et al*. (1972), Nair (1978), Singh *et al*. (1979), Venkateswaran (1980), Yadava *et al*. (1981) and Alam *et al*. (1985) reported significant and positive association of number of pods per plant to pod yield.

Kushwaha and Tawar (1973) reported significant and positive association of number of mature pods with number of immature pods per plant. Yadava *et al*. (1981) found positive and significant association of number of pods with days to first flowering.

Nevano (1924) and Lin (1954) reported strong correlation between total number of pods and dry pod weight. Pushkaran (1983) found significant negative association of number of mature pods with 100 kernel weight.

Lin *et al*. (1969) indicated positive association between number of pods per plant and shelling percentage. Kushwaha and Tawar (1973) reported significant and positive correlation between number of mature pods per plant and shelling percentage.

Pushkaran (1983) reported significant negative association of number of mature pods per plant with 100 kernel weight.

Samooro (1975) observed positive correlation between number of pods and seed maturity.

Chandramohan *et al.* (1967) found that weight of plant (haulm) had high positive correlation with yield. Nair (1978) reported that yield of haulms was significantly and positively correlated with yield. Pushkaran (1983) recorded that haulms yield had significant and positive correlation with duration upto flowering and maturity, 100 pod and kernel weights.

Nevano (1924) recorded strong association between dry pod weight and total pod number. Syakudo and Kawabata (1965) observed significant and positive association between pod and kernel weights. Coffelt (1974) and Coffelt and Hammons (1974) observed highly significant correlations of pod weight with seed number and seed weight. Nair (1978) and Radhika (1984) reported that 100 pod weight was significantly and positively correlated with pod yield. Kuriakose (1981) reported positive association of pod yield with 100 pod weight. Pushkaran (1983) obtained high positive correlation between 100 pod weight and 100 kernel weight. Deshmukh *et al.* (1986) in a study with Virginia bunch genotypes indicated that pod yield had significant and positive association with 100 pod weight.

Raman *et al*. (1970) reported high positive genotypic and phenotypic correlation coefficients between yield and shelling percentage. Khangura and Sandhu (1972) observed strong positive association of pod yield with shelling percentage. Similar findings were reported by Dholaria *et al*. (1972) and Kumar and Yadav (1979). Kushwaha and Tawar (1973) observed significant negative correlations of shelling percentage with 100 pod weight and, 100 kernel weight. Shettar (1974) noted that pod yield was negatively correlated with shelling percentage. Venkateswaran (1980) observed significant and positive correlation of yield with shelling percentage in bunch varieties. Patra (1980) stressed the importance of shelling percentage as an effective yield component for selection. Ramanathan (1980) observed significant positive correlation between shelling percentage and pod weight. Kuriakose(1981) reported positive association of shelling percentage with pod yield.

Significant positive association of 100 seed weight with pod yield was reported by Dholaria *et al*. (1972), Sangha (1973b), Kudupley (1977), Singh *et al*. (1979), Rao (1978/79), Labana *et al*. (1980), Kuriakose (1981), Nagabhushanam (1981), Raju *et al*.(1981), Singh *et* al. (1984), Kataria et al. (1984), Radhika (1984), Yadava et al.(1984) and Deshmukh et al. (1986). Venkateswaran (1980) noted significant positive correlation of yield with kernel weight in spreading type of groundnut. According to him, kernel yield was more steady and reliable than yield of pods. However, Sangha and Sandhu (1975) reported negative association of 100 seed weight with the number of pods.

Elsaeed (1967) observed that coefficient of correlation between oil content and kernel weight was negative. Kushwaha and Tawar (1973) reported negative but non-significant associations of percentage of oil content with days to maturity and 100 pod weight. Kudupley (1977) reported nonsignificant but, positive association between yield and oil percentage. Shany (1977) observed highly significant negative correlation between oil content and percentage of mature pods and positive correlations between oil content and number of pods per plant, and mean seed weight. Layrisse et al. (1980) indicated significant associations of pod yield seed yield with oil content. Kuriakose (1981) also reported significant positive correlation of pod yield with oil content. Pushkaran (1983) recorded negative correlation between oil content and 100 kernel weight.

2.4 Path analysis

Wright (1921) developed standardized partial regression analysis known as path coefficient analysis. It analyses the cause-effect relationship. The path coefficient analyses attempted in groundnut are reviewed hereunder.

Khangura and Sandhu (1972) in a study with 30 spreading varieties of groundnut observed that the regression of pod yield on the number of mature pods was highly significant. They inferred that number of mature pods was an effective selection aid for improvement of pod yield in spreading groundnut.

Path coefficient analysis by Badwal and Singh (1973) indicated that the number of mature pods in semi-spreading and erect types and 100 kernel weight in spreading types had significant direct effect on yield. Shelling percentage in general had indirect effects towards pod yield. The individual contribution by various component traits to pod yield varied from one group to the other.

Chandola *et al*. (1973) recorded that the number of pods per plant had a high direct effect on yield.

In a study with semi-spreading x bunch and semi-spreading x semi-spreading crosses of groundnut, Sandhu and Khehra (1977a) indicated that number of mature pods had high direct contribution on pod yield. The contribution of other traits was largely indirect through pod number.

That direct or indirect influence of the number of mature pods was more pronounced on pod yield was reported by Raju (1978) in his work with cultivars and their 10 hybrids. Days to flowering had negative direct effect but, it affected pod yield indirectly via. days to maturity.

That pod number had high positive direct effect on yield followed by 100 kernel weight and days to maturity was indicated in a study with 16 bunch groundnut cultivars by Yadava *et al*. (1984). They also observed that pod number affected pod yield via. days to maturity.

Path analysis at the genotypic level by Singh *et al*. (1984) indicated that shelling percentage was an important yield component. 100 kernel weight showed high indirect effect on pod yield via. other traits.

High positive direct effect of mature pods, 100 pod weight, 100 kernel weight and percentage of sound matured kernel on pod yield was observed by Deshmukh et al. (1986). They also suggested that characters showing negative correlation with pod yield also exhibited negative direct effects for days to first flowering.

Jaswal and Gupta (1967) in their studies with 59 erect varieties over two seasons suggested number of mature pod per plant as an important selection criterion.

Dholaria et al. (1973) observed that branch number was more important in spreading type , while pod number was more important in bunch types for selection for improved yield.

Selection for characters viz., the number of mature pods, pod weight, mature seed weight either individually or in combination could aid in improvement for increased mature seed yield per plant (Nigam et al., 1984).

2.5 Combining ability and gene action

In a six parent diallel cross (without

reciprocals) Wynne *et al.*(1975) estimated combining ability in the F_2 generation. The parents included Valencia, Virginia and Spanish botanical types. Estimates of gca were of greater magnitude than sca for all the characters except percentage of sound mature kernels.

Garet (1976) evaluated the F_1 hybrid progeny from a complete diallel of five cultivars, four of them African and one from U.S.A.. Estimates of gca were significant for pod and seed yields per plant, the number of pods and seeds per plant, 100 pod weight, 100 seed weight, oil content and shelling outturn. Sca and reciprocal effects were also significant for all the traits except oil content. The gca estimates were larger than sca estimates for all the characters except shelling outturn. It was concluded that the major part of the total genetic variability was additive for all traits except shelling outturn.

Sandhu and Khehra (1976) indicated from their studies that non-additive effects were more important than additive effects for pod yield per plant and number of mature pods per plant, whereas additive effects were more important for 100 kernel weight.

Oraby *et al*. (1977) found that seed weight was controlled by one or two major genes with few minor genes, and additive effects were more important for this trait.

In a study with two crosses at two sites, Sandhu and Khehra (1977a) concluded that shelling percentage was controlled by predominance of non-additive components of variance.

Gibori *et al*. (1978) in a diallel analysis study found that yield per plant and days to flowering were due to dominance.

In F_2 and F_3 generations of a study, Mohammed *et al*. (1978) found that additive effects were significant for all traits and non-additive for yield and pod size.

In a six parent half-diallel cross of diverse groundnut cultivars, Isleib *et al*.(1978) evaluated the progeny from F_1 to F_5 generations for the presence of epistatic effects. For all the traits measured, estimates of epistatic variance were larger than those of dominance variance. In an analysis of the F_2 generation of diallel crosses, Cahaner *et al*. (1979) found duplicate gene interactions for the weight of pods per plant.

In a five parent diallel study, Raju *et al.* (1979) indicated that the sca variance was greater than the gca in magnitude for all the traits studied, which showed the predominance of non-additive gene action.

Significant gca estimates were obtained in both F_1 and F_2 generations for resistance to early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Cercosporidium personatum*) indicating additive genetic effects for minimal leaf defoliation (Kornegey *et al.* 1980).

Layrisse *et al.* (1980) observed that variation due to both general and specific combining abilities was significant for yield and oil characters while the sca estimates were significant for protein percentage. However the component of variation due to gca was larger than that of sca for all the characters studied.

In a six parent diallel analysis involving four Virginia and two Spanish types, Singh and Labana (1980) studied combining ability for nine vegetative and pod characters. The mean squares due to gca and sca were significant for all the characters. They suggested bi-parental progeny approach for the improvement of pod yield and its components.

Sridharan and Marappan (1980) indicated that pod yield and 100 kernel weight were influenced by additive gene effects.

Gan *et al*. (1981) in a diallel study found that gca and sca effects and reciprocal effects were highly significant for all the 15 traits studied. High heritability was indicated by the close correlation of estimated gca values with the parental values. The maternal inheritance component of genetic variance was significant in some varieties.

Hamid *et al*. (1981) in a six parent full diallel analysis found that sca effects were more important than gca effects for percentage protein content and shelling percentage. The reverse was true for other traits studied. Both the gca and sca effects were approximately equal for percentage oil content.

A ten parent half diallel study conducted by Labana *et al*. (1981) indicated greater sca variance for pods per plant and pod yield per plant while gca variance was greater for 100 seed weight.

In a five parent diallel including three Valencia and two Spanish types, Reddy (1982) observed preponderance of additive genetic variance for 100 kernel weight. Other traits such as number of mature pods, number of immature pods, number of kernels, total kernel weight, weight of sound matured kernels, shelling percentage and 100 kernel weight showed significant difference for mean squares due to both gca and sca. Estimates of components of variance indicated preponderance of non-additive gene action for these traits. Sca variance was highly significant for pod yield. Both additive and non-additive genetic variances were of equal importance for days to first flowering.

In a line x tester analysis involving four males and five females, Raju (1982) observed that there was no preponderance of either gca or sca for most of the characters, sca effects were more predominant than gca. The resistance to rust had very high gca variance compared to that of sca suggesting a preponderance of additive genetic variance.

In a study on the influence of plant density on combining ability, Reddy (1983) found that lower plant densities could be utilized for the estimation of combining ability under limited seed supply and valid inferences could be drawn even from small F_2 populations. Predominance of non-additive gene action was indicated for kernel yield, yield of pods and weight of haulms.

Khanorkar et al. (1984) in a line x tester analysis using six early maturing Spanish bunch varieties as female parents and three rust resistant Valencia strains as male parents, found that sca variance was greater than gca variance for traits such as mature pods, immature pods and rust infection indicating a predominance of non-additive gene action.

In another line x tester study involving seven females and three males, Manoharan et al. (1985) observed additive gene action for 100 pod weight, shelling percentage and pod yield and non-additive gene action for pod number.

In a line x tester analysis, Basu et al. (1986b) found 'Chico' to be the best general combiner for days to 50 per cent flowering and days to maturity. The highest negative heterosis for the above two traits was exhibited by the cross combination TMV 2 x Chico.

In a eight parent diallel analysis, Basu *et al*. (1987) reported that traits such as days to 50 per cent flowering, days to maturity, mature pods, pod yield, 100 kernel weight and shelling percentage were controlled predominantly by additive gene action.

2.6 Heterosis

Stokes and Hull (1930) were the first to study heterosis for different traits in groundnut. In a diallel study, Syakudo and Kawabata (1963) observed marked heterosis for the top weight in Virginia x Spanish or Virginia x Valencia combinations.

Parker *et al*. (1970) in their study obtained F_1's which exceeded mid-parent means by 20 to 40 per cent for several seedling traits which included days to flowering. They also found that greater heterotic responses were for Valencia x Virginia crosses than for Valencia x Spanish or Virginia x Spanish crosses.

Wynne *et al*. (1970) observed that greater heterosis for yield and pod characters was given by Valencia x Spanish crosses.

Hammons (1973) observed heterotic responses for pod yield in F_1 hybrids resulting from crosses between the subspecific groundnut groups.

Studies by Wynne et al. (1975) indicated genotypic x environment interaction in the expression of heterosis.

In a five parent diallel study, Garet (1976) obtained a good heterotic response over better parent for 100 pod weight, 100 kernel weight, pod and seed number per plant and shelling percentage. Crosses involving Virginia and Spanish type as parents manifested the best heterosis.

Heterosis over the superior parent for yield components such as number of mature pods (20.05 per cent), two seeded pod (20.8 per cent) and pod yield per plant (37.02 per cent) were obtained by Raju (1978).

High gca x low gca crosses produced greater heterosis than high x high or low x low crosses in studies by Arunachalam et al. (1980), Prasad (1981) and Arunachalam et al. (1982).

Muralidharan and Raman (1980) observed positive heterosis for days to flowering, number of two seeded pods and pod yield per plant in the hybrids produced by crossing bunch types with *Arachis monticola*.

Sridharan and Marappan (1980) reported positive heterosis over better parent on all the hybrids studied for number of mature pods and pod yield per plant. Heterosis ranged from 23.33 to 87.50 per cent over mid-parent and from 6.22 to 38.40 per cent over better parent for number of mature pods and from 37.44 to 95.33 per cent over mid-parent and from 4.20 to 70.30 per cent over better parent for pod yield. For 100 pod weight and 100 kernel weight, heterosis ranged form 6.38 to 30.20 per cent over mid-parent.

Gregory *et al*. (1980) in a diallel study found heterosis in crosses between different subspecies. Most F_2 means were equal to mid-parental values although some F_2 means were exceptionally high or low.

Positive heterosis for number of mature pods and yield per plant was observed by Kumar (1981) in a study with 28 hybrids obtained from four established cultivars and seven pollen parents of wider genetic base.

Wynne and Gregory (1981) reviewed the phenomenon of heterosis in groundnut and arrived at the following conclusions. Heterosis is most often observed in crosses between the sub specific groups. There is difference in gene action in crosses made within and those made between botanical varieties. In crosses made between parents chosen from a single botanical variety, additive genetic variance appeared to be of prime importance, but in crosses made between parents from different botanical varieties both additive and non-additive genetic variances may be significant.

Raju (1982) indicated that heterosis for economic yield may be obtained in both intraspecific and intra-subspecific crosses, unlike most of the previous reports where yield heterosis was thought to be prevalent in inter-subspecific crosses only.

Reddy (1982) observed that heterosis percentages in crosses between Spanish x Spanish and Valencia x Valencia were equally good and comparable to the best cross which involved Spanish and Valencia parents for several traits.

Isleib and Wynne (1983) found that a significant portion of the variability in heterotic effects were attributable to differences among the parental groups, with generally higher levels expressed in inter - subspecific crosses. Dominance was the most important source of non-additive genetic variation for traits like pod yield and seed yield, while epistasis was more important for pod and seed numbers. For characters manifesting more dominance, the relationship of heterosis to divergence between parents was linear and increasing, while the relationship was curvilinear for characters largely controlled by epistasis.

Presence of an optimum level of genetic divergence between parents to obtain heterosis was indicated in studies of Arunachalam et al . (1984).

2.7 Genotype x Environment interaction

Joshi et al. (1972) studied the stability of bunch cultivars at seven environments in Gujarat. Cultivars showed stability in all environments for yield, one of them performed consistently well in both poor and good environments.

Singh *et al*. (1975) studied eight promising spreading varieties of groundnut under four environments. Pooled analysis of variance for pod yield showed that the mean differences between the genotype and genotype x environment interaction component were highly significant. Both the environment (linear) and genotype x environment (linear) components of variation for stability were highly significant. The differences in stability were mainly due to linear regression.

Sangha and Jaswal (1975) tested 12 groundnut varieties for two years at four locations. The performance of varieties in different years was quite uniform but was inconsistent at different locations. The small and non-significant variety x year interaction indicated that the performance of different varieties in different years was quite similar and suggested that little would be gained by testing the varieties for more than two years.

Significant genotype x environment interaction was obtained for pod yield and 100 seed weight but not for number of mature pods in an evaluation study conducted by Sandhu and Khehra (1977b).

In a two year yield trial, Tai and Hammons (1978) obtained large and significant cultivar x location x year interactions and small year x cultivar and location x cultivar interactions in respect of pod yield, percentage of sound matured kernels, 100 kernel weight, extra large kernels and fancy sized pods.

Williams et al. (1978) opined that cultivars were sensitive to changes in the environment before the pod filling than during the actual pod filling phase.

Yadava and Kumar (1978a) tested 11 varieties in three environments for phenotypic stability of pod yield, shelling percentage, 100 seed weight and oil content. The magnitude of the linear component of the genotype x environment interaction was high for pod yield, 100 seed weight and oil content.

Yadava and Kumar (1978b) studied 17 genotypes under four environments and found that the linear and non-linear portions of the genotype x environment interactions were significant for 100 kernel weight, oil content and shelling percentage. Genotype x environment interactions were significant for these three traits. It was also found that the stability parameters for the different characters were governed by apparently independent genetic systems.

Significant genotype x environment interaction (linear) was obtained for number of days to maturity and pod yield in a study conducted by Yadava and Kumar (1979) with 13 varieties in four different years. The non-linear portion of genotype x environment interaction was significant only for the number of days to maturity. In a study with 17 cultivars grown at four locations in 1971-72 and at three locations in 1972-73, Mercer - Quarshie (1980) recorded that variety x year x locality interaction effects were significant for traits like pod yield, number of pods per plant, seed yield, shelling outturn and 100 seed weight. The variety x year interaction was significant only for 100 seed weight and the variety x location interaction was significant for seed yield and 100 seed weight. It was inferred that testing in several locations was more important than testing during the several years.

Wynne and Gregory (1981) opined that although genotype x environment interactions vary with the material tested and the site chosen for testing, genotype x environment interactions in groundnut appear to be similar to those in several other autogamous species. The yield of a groundnut cultivar in each individual experiment if unique, the environmental conditions differentiating the tests cannot be grouped according to years or locations. This is not surprising considering the indeterminate nature of the groundnut plant.

Pod yield and four yield related characters were studied in 12 spanish bunch genotypes under three environmental by Kumar et al. (1984). G x E interactions were significant for all the traits. Non linear-components had higher values for all the traits except pod yield and days to maturity. For pod yield non-linear component of the interaction was significant whereas, for the four other traits, linear components were significant.

Norden et al. (1986) found that genotype x environment interactions were highly significant for pod yield, fancy pods percentage, shelling percentage, 100 kernel weight and S.M.K yield in a study with four multi line populations along with their component lines over four years in two locations. Large differences were not present for the traits between sib-lines. However differences were found in stability estimates from regression coefficients and deviation from regression of multilines compared to the component lines.

Vindhiya Varman et al. (1989) worked out phenotypic stability estimates both under stress and stress free environments, for three consecutive years involving seven groundnut genotypes. The phenotypic responsiveness and stability were estimated for productivity and kernel quality characters. The genotype RSHY 1 exhibited high mean performance for yield and quality characters indicating the average unit responsiveness across the environments. However, the stability was poor. JL 24 produced bold kernels even under stress conditions. All other genotypes exhibited similar pattern of stability and responsiveness.

In their study on genotype x environment interaction, Veerabadran et al. (1990) indicated that the larger the interaction, the lesser were the chances of progress under selection in a breeding programme. The variety Co 1 was considered to possess stability under favourable environment and the genotype Dh-3-20 was found to be specially suited for unfavourable environment.

2.8 Breeding for earliness

Earliness is an important objective in groundnut breeding. Nigam *et al*. (1980) indicated that groundnuts which mature earlier than the current cultivars and possessing high yield potential together with good quality will be extremely useful in the areas of semi-arid tropics which have short growing seasons or where an early maturing crop may escape certain pests and diseases.

Good scope for fitting early maturity groundnuts into relay and sequential cropping systems, particularly in South - East Asia by utilizing residual moisture after the harvest of the rice crop was suggested by Gibbons (1980).

Tiwar (1983) pointed out that summer varieties should, in addition to high yield and superior quality posses early maturity, responsiveness to fertilizer application and fresh seed dormancy.

Donald (1984) opined that earliness coupled with good kernel yield would ensure stable production in poor rainfall areas.

In order to identify early maturing genotypes it is quite essential to determine their time of optimum maturity. Groundnut is unique compared to other crops in that it has indeterminate growth habit. Pod maturation, a cumulative and subterranean process, makes determination of time of optimum maturity difficult. Soil and atmospheric factors further complicate the maturity determination. For determination of the time of optimum maturity, staggered system of harvesting was suggested, wherein the lines under evaluation are harvested at pre-defined intervals from randomized and replicated field plots (Rao and Gibbons 1984). Thereafter, the components associated with crop maturity are analysed and time of optimum maturity determined at that point of time when the various maturity related characters attained their peak values.

Studies conducted by Rao and Gibbons (1984) indicated that early maturity varieties unless harvested early in a staggered harvesting approach did not exhibit any significant advantage in yield. They also recorded that a variety that gave maximum yield at 90 days after sowing may also show superiority when harvested at 75 days after sowing.

Arunachalam and Bandyopadhyay (1984) opined that decision made jointly on a number of dependent characters were more representative than those drawn from a direct observation on the final pod yield alone. Rao and Gibbons (1984) suggested the traits viz., pod yield, sound mature kernel yield, 100 pod weight, 100 kernel weight, shelling percentage and sound mature kernel percentage as important ones for determination of physiological maturity in groundnut.

Gupton and Emery (1970) estimated heritability of maturity as measured by the percentage of light transmitted through oil expressed from kernel. This gave the oil index.

Tai and Young (1977) registered high values of broad sense heritability for the level of free arginine in groundnut cultivars. Thus, the use of Arginine Maturity Index as a measure of maturity was indicated.

Studies on the genetic control of maturity in groundnut indicated that earliness was recessive to late maturity and was controlled by a single factor (Badami, 1923; Patel et al., 1936 and Hassan, 1964). Holbrook et al. (1988) in a study with F_1 and F_2 plants from reciprocal crosses involving early maturity chico and extremely late PI 383421 observed that maturity was under the control of four to six genes, with a tendency towards earliness. No reciprocal differences in maturity were observed.

Breeding programmes have been launched at the International crop Research Institute for Semi-Arid Tropics, Hyderabad and at various AICORPO groundnut centres for incorporation of earliness into present popular varieties. Chico, Robut 33-1, 91176, TGE 1 and TGE 2 have been identified as sources of earliness. Chico is very early, small poded and small kernelled spanish genotype from Russia. TGE 1 considered to be as early as chico, but superior in pod yield, shelling percentage and oil content, possess foliaceous stipules as a genetic marker (Mouli and Kale, 1982).

Observations on the flowering pattern of groundnut in relation to crop duration have indicated that early maturity genotypes like chico, ICGS (E) 52 and Gangapuri flowered at a rapid rate up to 44 to 47 days after sowing and further produced flowers at a slower rate up to 65 to 70 days after sowing after which they ceased to flower (Anon., 1985).

Basu *et al*. (1986b) used Gangapuri, MH 2, chico and Robut 33-1 as donor of earliness in crossing programme with four Spanish bunch types by the line x tester method. They recommended chico, Robot 33-1 and Gangapuri as parents for breeding early maturing, high yielding varieties.

MATERIALS AND METHODS

MATERIALS AND METHODS

3.1. MATERIALS

3.1.1. Preliminary Evaluation

The genetic material consisted of 63 bunch types of groundnut maintained under the oilseeds project of the Department of Plant Breeding. The source of these types are presented in table 1.

3.1.2. Choice of parents for hybridization

The material comprised of six extra early types (chico, ISKN 8827, ICGS 35-1, Dh(E) 20, Dh(E) 32 and IES 883) and three high productive types (TG 3, TMV 2 and JL 24) selected from the preliminary evaluation programme(Figures 1 & 2).

3.1.3. Combining ability study

The study involved six lines, three testers and their 18 hybrids as detailed in table 2.

Table 1. SOURCE OF TYPES

Sl.No.	Type	Original source
1.	Chico	Russia
2.	IGG(FDRS) 43	ICRISAT
3.	ICG 44-1	do
4.	ICGS 35-1	do
5.	ICGSE 21	do
6.	ICGSE 52	do
7.	ICGSE 121	do
8.	ICGV 86010	do
9.	ICGV 86011	do
10.	ICGC 86012	do
11.	ICGV 86013	do
12.	IES 883	do
13.	ISKN 8827	do
14.	ISKN 8828	do
15.	ISKN 8829	do
16.	ISKN 8830	do
17.	ISKN 8831	do
18.	ISKN 8832	do
19.	ISKN 8833	do
20.	ISKN 8834	do
21.	ISKN 8835	do
22.	ISKN 8836	do
23.	ISKN 8837	do
24.	ISKN 8839	do
25.	ISKN 8840	do
26.	ISKN 8844	do
27.	ISKO 8802	do
28	ISKO 8803	do
29.	ISKO 8804	do
30.	ISKO 8805	do
31.	ISKO 8806	do
32.	ISKO 8807	do
33.	ISKO 8808	do
34.	ISKO 8809	do
35.	ISKO 8810	do
36.	ISKO 8811	do
37.	ISKO 8812	do
38.	ISKO 8813	do
39.	ISKO 8814	do

Table 1. Cont'd.

Sl.No.	Type	Original source
40.	ISKO 8815	ICRISAT
41.	ISKO 8816	do
42.	ISKO 8821	do
43.	ISKO 8823	do
44.	ISKO 8824	do
45.	ISKO 8825	do
46.	TG 3	BARC, Trombay
47.	TG 14	do
48.	PGN 1	Ludhiana
49.	RG 192	do
50.	BPG 521	Bapatla
51.	JL 24	Jalgaon
52.	TMV 2	Tindivanam
53.	VG(E) 55	Vridhachalam
54.	VG 77	do
55.	Dh(E) 20	Dharvad
56.	Dh(E) 32	do
57.	MC 3	Vellayani
58.	MC 11	do
59.	MC 18	do
60.	MC 21	do
61.	MC 22	do
62.	MC 29	do
63.	MC 33	do

Figure 1. Selected six lines and three testers.

Lines		Testers
Chico	(L1)	TG 3 (T1)
ISKN 8827	(L2)	TMV 2 (T2)
Dh (E) 20	(L3)	JL 24 (T3)
Dh (E) 32	(L4)	
ICGS 35-1	(L5)	
IES 883	(L6)	

Figure 1.

Figure 2. Pods of selected six lines and three testers

Lines		Testers
Chico	(L1)	TG 3 (T1)
ISKN 8827	(L2)	TMV 2 (T2)
Dh (E) 20	(L3)	JL 24 (T3)
Dh (E) 32	(L4)	
ICGS 35-1	(L5)	
IES 883	(L6)	

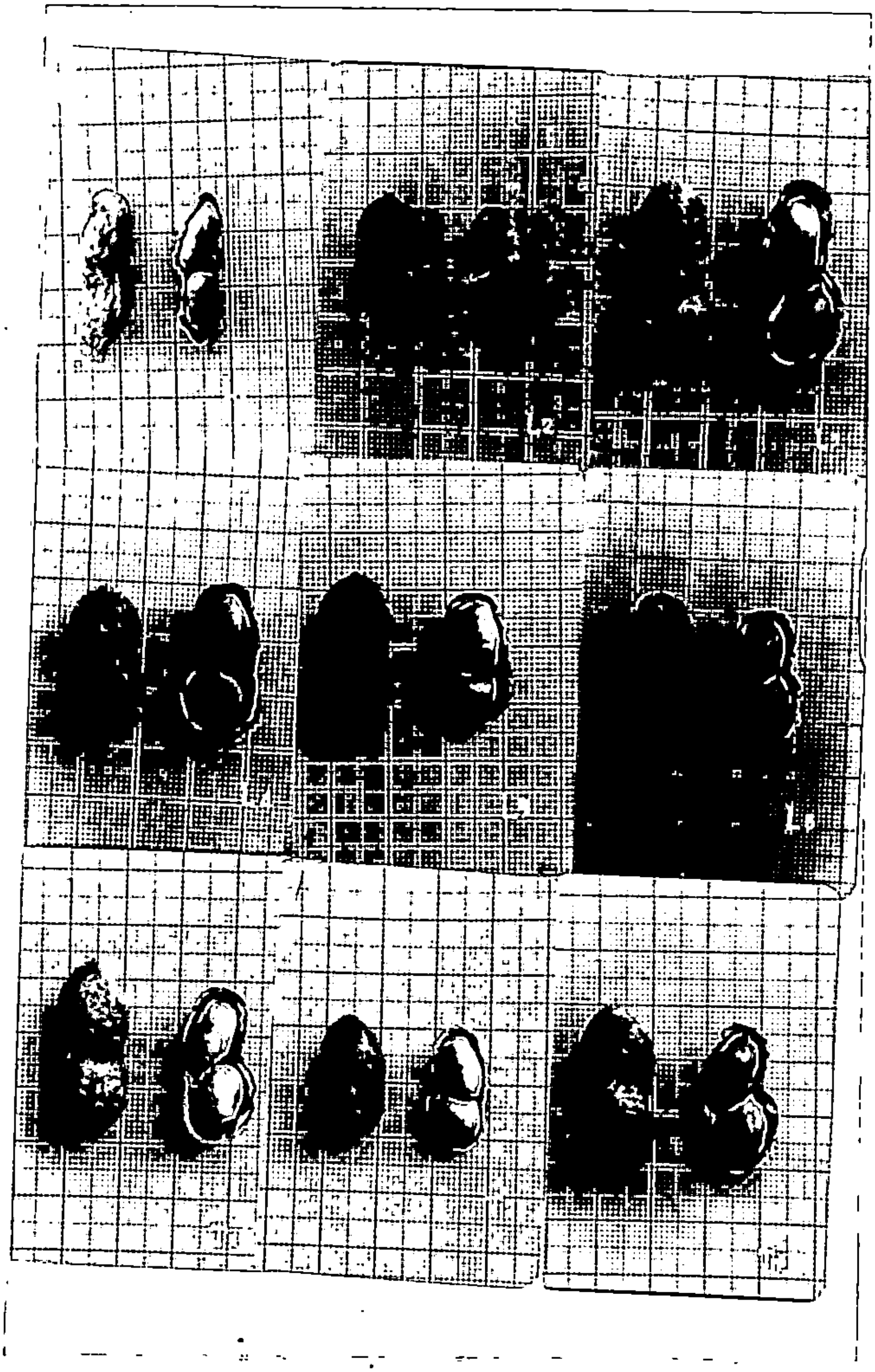


Figure 2.

Table 2. DETAILS OF SELECTED TYPES AND THEIR HYBRIDS

Sl.No.	Types/Hybrids	Code No.
1.	Chico	L1
2.	ISKN 8827	L2
3.	ICGS 35-1	L3
4.	Dh(E) 20	L4
5.	Dh(E) 32	L5
6.	IES 883	L6
7.	TG 3	T1
8.	TMV 2	T2
9.	JL 24	T3
10.	Chico X TG 3	L1 X T1
11.	Chico X TMV 2	L1 X T2
12.	Chico X JL 24	L1 X T3
13.	ISKN 8827 X TG 3	L2 X T1
14.	ISKN 8827 X TMV 2	L2 X T2
15.	ISKN 8827 X JL 24	L2 X T3
16.	ICGS 35-1 X TG 3	L3 X T1
17.	ICGS 35-1 X TMV 2	L3 X T2
18.	ICGS 35-1 X JL 24	L3 X T3
19.	Dh(E) 20 X TG 3	L4 X T1
20.	Dh(E) 20 X TMV 2	L4 X T2
21.	Dh(E) 20 X JL 24	L4 X T3
22.	Dh(E) 32 X TG 3	L5 X T1
23.	Dh(E) 32 X TMV 2	L5 X T2
24.	Dh(E) 32 X JL 24	L5 X T3
25.	IES 883 X TG 3	L6 X T1
26.	IES 883 X TMV 2	L6 X T2
27.	IES 883 X JL 24	L6 X T3

3.1.4 Study of F_2 generation

The genetic material consisted of the 18 F_2 populations (families) derived from the hybrids listed in table 2.

3.1.5. Genotype x environment interaction

The material for the study consisted of the six lines (Chico, ISKN 8827, ICGS 35-1, Dh(E) 20, Dh(E) 32, and IES 883) and three testers (TG 3, TMV 2 and JL 24) selected in the preliminary evaluation.

3.2. Methods

3.2.1. Experimental procedure

3.2.1.1. Preliminary Evaluation

The 63 types were evaluated in rice fallows during summer 1989 (January to April) at the Rice Research Station, Kayamkulam. The experiment was laid out in a split plot design with three stages of maturity as the main plot and the 63 types in the sub plot, with three replications. Each sub plot comprised of a single three meter row with plants spaced at 20 cm. Staggered harvesting of the main plots was done at three stages of maturity, viz.,80, 95 and 110 days after sowing. Data on the following traits were recorded taking all the 14 plants, except the border plants of a variety in each replication as the sample.

i) Number of immature pods per plant
ii) Number of mature pods per plant
iii) Haulms yield per plant
iv) Pod yield per plant
v) 100 pod weight
vi) Shelling percentage
vii) 100 Kernel weight
viii) Oil content

3.2.1.1.1. Estimation of genetic parameters

Genetic parameters such as co-efficients of variation, heritability and genetic advance as percentage of mean were estimated for the eight characters recorded.

3.2.1.1.2. Maturity index

A maturity index was computed by taking into consideration six traits such as ratio of number of mature to immature pods per plant (instead of the characters as such), pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content.

3.2.1.1.3. Maturity groups

Based on the maturity index, the 63 types were classified into three groups namely, extra early, early and medium. In each of the three maturity groups, mean performance of the constituent types for the eight traits recorded were studied.

3.2.1.1.4. Correlation

In each of the three maturity groups, phenotypic and genotypic coefficients of correlation were estimated between the different characters which included, number of immature pods per plant, number of mature pods per plant, haulms yield per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight, oil content and oil yield per plant. Oil yield per plant was calculated as follows:

Oil yield per plant (g.) =

$$\frac{\text{Pod yield per plant(g.)} \times \text{shelling \%} \times \text{oil content(\%)}}{10,000}$$

3.2.1.1.5. Direct and indirect effects

Direct and indirect effects on pod yield and oil yield per plant in each of the three maturity groups were worked out. The components of pod yield included, number of immature pods per plant, number of mature pods per plant, haulms yield per plant, 100 pod weight, shelling percentage and 100 kernel weight. The components of oil yield included, number of immature pods per plant, number of mature pods per plant, haulms yield per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content.

3.2.1.2. Choice of parents and hybridization

The nine selected types were crossed in the line x tester model keeping the six extra early types as the lines (L1 to L6) and the three high productive bunch varieties as testers (T1 to T3). The lines were used as the ovule parents. They were grown at the College of Agriculture, Vellayani during Kharif 1989 (May to October) in basin pots kept on raised platforms to facilitate easy accessibility to flowers. The crossing technique suggested by Reddy et al. (1970) was followed. In order to avoid marking of each crossed flower, a particular cross combination was confined to plants in a labelled pot. The flowers which were not used for crossing however, were removed daily. The sowing of the lines for crossing was staggered to keep the flowering phase protracted over a long period to facilitate large number of crosses. At harvest, the mature pods were collected, cross wise, dried and stored.

The parental types were grown separately and selfed pods were collected, dried and stored.

3.2.1.3. Combining ability

The six lines, three testers and their eighteen hybrids were raised adopting a Randomized Block Design with three replications in the rice fallows during summer 1990 at the Rice Research Station, Kayamkulam. Each plot comprised of a single four meter row with plants spaced at 20 cm. The off type plants from the parental types and selfed plants from the hybrids were marked out and excluded. Data on the following characters were recorded from five plants selected at random from the remaining genuine plants in each treatment per replication.

i) days to first flowering

ii) Spread of flowering

iii) days to maturity

iv) number of immature pods per plant

v) number of mature pods per plant

vi) haulms yield per plant

vii) pod yield per plant

viii) 100 pod weight

ix) shelling percentage

x) 100 kernel weight

xi) oil content

3.2.1.4. Study of F_2 generation

The 18 F_2 populations (families) were raised in three randomized blocks at the College of Agriculture, Vellayani during Kharif 1990. The plants were harvested at 80 days after sowing. Ten high yielding extra early recombinants with high mature to immature pod ratio were selected from each family in every replication. Observations on the following characters were recorded on these plants.

i) Number of immature pods per plants
ii) Number of mature pods per plants
iii) Pod yield per plant
iv) Kernel yield per plant
v) Shelling percentage

3.2.1.5. Genotype x environment interaction

Genotype x environment interaction was studied by utilising the data relating to the nine types selected as parents from the preliminary evaluation in three enviornments.

First environment(summer, 1989): The data obtained by the nine types in the preliminary evaluation for the different traits such as number of immature pods per plant, number of mature pods per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight, and oil content in their respective maturity groups were considered.

Second environment(summer, 1990): The data obtained by the nine types in the combining ability evaluation for the traits detailed above were considered.

Third environment(kharif, 1990): The nine types were raised in a simple Randomized Block Design with three replications at the Collage of Agriculture Vellayani. Each plot consisted of three rows of 15 plants each at a spacing of 30 x 10 cm.

The Bartletts test was used to judge the homogenity of error variances of the three different environments. The genotype x environment interactions were analysed following the Eberhart and Russel (1966) model for the traits exhibiting homogenity of error variances.

3.2.1.6. Details of characters studied and estimations made

i) Days to first flowering : The number of days from sowing to the appearance of the first flower on each observational plant.

ii) Days to last flowering : The number of days from sowing to the ceasation of flowering on each observational plant.

iii) Days to maturity : The number of days from sowing to maturity of each observational plant. In arriving at maturity, the appearance of plants, senescence of leaves, nature of pods, shell characters, pod filling, kernel characters and the inside colour of the shell were considered at harvest.

iv) Number of immature pods per plant: The number of immature pods in each observational plant at harvest.

v) Number of mature pods per plant : The number of visibly mature pods per plant at harvest on each observational plant.

vi) Haulms yield per plant : The fresh haulms yield of each observational plant after removing mature and immature pods at harvest.

vii) Pod yield per plant : The mature pods of individual observational plants were sun dried and weight recorded.

viii) 100 pod weight : A random sample of 100 dry pods was drawn from each type per replication and weighed.

ix) Shelling percentage : A random sample of 200g. of dry pods per type per replication was shelled. Shelling percentage was estimated as a percentage of the weight of kernels to the weight of pods.

x) 100 kernel weight : Hundred kernels were selected at random from a sample of dry kernels in each type per replication and weighed.

xi) Oil content : A random sample of kernels of each type per replication was drawn and oil content was estimated by using the OXFORD 4000 NMR analyser at the Tamil Nadu G.D. Naidu Agricultural University, Coimbatore.

xii) Reaction to major pests : There was no significant incidence of pest attack.

xiii) Reaction to major diseases : The plants were scored for their reaction to the incidence of rust disease at 80 days after sowing. Scoring for rust caused by *Puccinia arachidis* was done employing the 1 to 9 scale suggested by Subramanyan *et al*. (1980).

Where, 1 = no infection.

9 = 50 to 100 per cent foliage destroyed by rust.

xiv) Spread of flowering : The difference between the days to the first and the last flower in each observational plant was taken as the spread of flowering.

xv) Ratio of number of mature to immature pods per plant : The ratio was obtained by dividing the number of mature pods in each observational plant by the number of immature pods.

3.2.2. Statistical analysis

3.2.2.1. Preliminary evaluation

The data collected were tabulated and subjected to statistical analysis for estimation of the coefficients of variation, heritability and genetic advance.

3.2.2.1.1. Coefficients of variation

The analysis of variance of the split plot experiment is presented in table 3. The genotypic, phenotypic and enviromental coefficients of variations were estimated as follows.

$$\text{Genotypic coefficient of variation, G.C.V.} = \frac{\sqrt{\sigma^2 g}}{\text{mean}} \times 100$$

$$\text{where, } \sigma^2 g = \frac{MSv - MSe}{r}$$

$$\text{Phenotypic coeffcient of variation, P.C.V.} = \frac{\sqrt{\sigma^2 p}}{\text{mean}} \times 100$$

$$\text{where, } \sigma^2 p = \sigma^2 g + \sigma^2 e$$

$$\sigma^2 e = MSe$$

$$\text{Enviornmental coefficient of variation, E.C.V.} = \frac{\sqrt{\sigma^2 e}}{\text{mean}} \times 100$$

3.2.2.1.2. Heritability

Heritability in the broadsense (H^2) expressed as percentage was estimated as per the formula suggested by Hanson *et al*. (1956).

i.e., $$H^2 = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

3.2.2.1.3. Genetic advance

Expected genetic advance under selection was estimated according to Allard (1960) as;

$$\text{Genetic advance due to selection} = \frac{K \times H^2 \times \sigma p}{\text{mean}}$$

where, K = selection differentiial.

Table 3. ANALYSIS OF VARIANCE (ANOVA)

Source	df	Ms	F
Replication	r - 1	MS_r	MS_r / MS_{e1}
Stage of harvest	s - 1	MS_s	MS_s / MS_{e1}
Error 1	(s-1) (r-1)	MS_{e1}	
Type	(v-1)	MS_v	MS_v / MS_{e2}
Type x stage of harvest interaction	(v-1) (s-1)	MS_{vs}	MS_{vs} / MS_{e2}
Error 2	s(v-1) (r-1)	MS_{e2}	
Total	svr - 1	MS_t	

3.2.2.1.4. Maturity index

Based on the critical difference (C.D.) values of the treatment combinations obtained from the above split plot experiment, the 63 types were scored for the maturity traits namely, ratio of number of mature to immature pods per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content. The different scores were 3,2, and 1. The score 3 was given to those types whose mean values at 80 days harvest was significantly higher than that at 95 and 110 days harvest, and also to those types whose mean values at 95 and /or 110 days harvest were on par with that at 80 days harvest. The score of 2 was awarded to those types whose mean values at 95 days harvest were significantly higher than that at 80 and 110 days harvest, and to those types whose mean values at 95 and 110 days harvest did not differ significantly. The score of 1 was given to those types whose mean values at 110 days harvest were significantly higher than that at 80 and 95 days harvest. For each type, the total score was calculated by adding the scores obtained for the six different traits.

On the basis of the standard error (S.E). values the 63 types were classified into three groups namely, extra-early(>Mean + S.E.), early (Mean +/- S.E.) and medium(<Mean - S.E.).

3.2.2.1.5. Correlations

In each of the above three maturity groups, correlations between different traits were worked out both at genotypic and phenotypic levels.

Table 4. Analysis of co-variance

Source of variation	df	Mean sum of products (X_i, X_j)	
		Observed	Expected
Between replications	r - 1	MSP_r	
Between types	v - 1	MSP_v	$r\sigma v_{ij} + \sigma e_{ij}$
Error	(r-1) (v-1)	MSP_e	σe_{ij}

From the analysis of co-variance (Table 4), the genotypic, phenotypic and environmental co-variances where estimated as :

i) Genotypic co-variance, $\sigma g_{ij} = \frac{MSP_v - MSP_e}{r}$

ii) Environmental co-variance, σe_{ij} = MSP_e

iii) Phenotypic co-variance, $\sigma p_{ij} = \sigma g_{ij} + \sigma e_{ij}$

These co-variance components were substituted in the following formula to calculate the genotypic (r_g) and phenotypic(r_p) correlation coefficients:

The genotypic correlation coefficient between characters x_i and x_j,

$$r_{g_{ij}} = \frac{\sigma g_{ij}}{\sqrt{\sigma^2 g_i \times \sigma^2 g_j}}$$

where, $\sigma^2 g_i$ = genotypic variance of character x_i

$\sigma^2 g_j$ = genotypic variance of character x_j

Phenotypic correlation coefficient between character x_i and x_j,

$$r_{p_{ij}} = \frac{\sigma p_{ij}}{\sqrt{\sigma^2 p_i \times \sigma^2 p_j}}$$

where, $\sigma^2 p_i$ = phenotypic variance of character x_i

$\sigma^2 p_j$ = phenotypic variance of character x_j

The significance of correlation coefficients were tested by using the student's `t' test with degrees of freedom, equal to that of error.

3.2.2.1.6. Direct and indirect effects

The estimates of direct and indirect effects of the productivity traits on pod yield and on oil yield were estimated through path analysis technique in the three maturity groups as suggested by Wright (1921) and elaborated by Dewey and Lu (1959) using the model,

$$Y = a1x1 + a2x2 + a3x3 + - - - - - - - + akxk$$

Where, Y and X are the standardized variables corresponding to yield and the 1 to K traits respectively. The solutions to the simultaneous equations formed was given as,

$$R_{k \times k}\ \underline{P}_{i \times k} = \underline{R}_{y\ i.k}$$

where, $R_{k \times k}$ is the intercorrelation matrix of the k dependent variables X_i. $\underline{P}_{i \times k}$ is the vector of correlation between the dependent and independent variables (X_i). The residual factor (R) which measures the influence of those characters, if any not included in the causal scheme and that of the environment was estimated as,

$$R^2 = 1 - \Sigma^k_{i=1} \; r_{ij} P_i$$

where, r_{ij}, $i = 1, \ldots k$ is the correlation of the dependent variable with the independent variable and P_i, $i = 1 \ldots k$, the path coefficient which meausres the direct effect of the independent variable on the dependent variable. The indirect effect of the X_i variables on Y through x_j was estimated as $r_{ij}P_i$, r_{ij} being the correlation between X_i X_j.

3.2.2.2. Combining ability

3.2.2.2.1. Line x Tester analysis

Analysis of variance:

Analysis of variance was done for all the characters and test of significance of differences among the types including parents and crosses was performed (Table 5).

Estimation of combining ability:

For estimating the general and specific combining ability effects, the method described by Kempthorne (1957) was adopted. In this method, the co-variance of full sibs and half sibs in terms of mean squares due to lines (M_l), tester (M_t), line x tester (M_{lt}) were obtained, from which the variance due to general combining ability and specific combining ability were estimated.

Table 5. ANOVA for line x tester including parents

Source	df	MS
Replication	(r - 1)	
Parents	(l + t -1)	
Parents vs crosses	1	
Crosses	(lt - 1)	
Lines	(l - 1)	M_l
Testers	(t - 1)	M_t
Line x Tester	(l-1) (t-1)	M_{lt}
Error	(r-1) (lt -1)	M_e
Total	(r lt - 1)	

where, l = number of lines

t = number of testers

r = number of replications

The significance of lines and testers are tested against mean square due line x tester, while the significance of line x tester is tested against mean square for error (Singh and Chaudhary, 1977).

The genetic components were estimated as:

$$\text{Cov. H.S.(line)} = \frac{M_l - M_{lt}}{rt}$$

$$\text{Cov. H.S.(testers)} = \frac{M_t - M_{lt}}{rl}$$

$$\text{Cov. H.S.(average)} = \frac{1}{r(2lt-l-t)} \left[\frac{(l-1)\ M_l + (t-1)\ M_t}{l+t-2} \right] - M_l$$

$$\text{Cov. F.S.} = \frac{(M_l - M_e) + (M_t - M_e) + (M_{lt} - M_e)}{3r} + \frac{6r\ \text{Cov. H.S} - rl+t\ \text{Cov.H.S.}}{3r}$$

$$\sigma^2 \text{ gca} = \text{Cov. H.S. (average)}$$

$$\sigma^2 \text{ sca} = \frac{M_{1t} - M_e}{r}$$

When, $F=0$, $\sigma^2 D = 4\ \sigma^2$ sca

$F=1$, $\sigma^2 D = \sigma^2$ sca

Where, F is the inbreeding coefficient.

Estimation of gca and sca effects:

The model used to estimate the gca and sca effects of ijk^{th} observation was as follows,

$$X_{ijk} = \mu + \hat{g}_i + \hat{g}_j + \hat{S}_{ij} + \hat{e}_{ijk}$$

where,

μ = population mean

$\hat{g}_i$ = gca effects of i^{th} --- line

$\hat{g}_j$ = gca effects of j^{th} --- tester

$\hat{S}_{ij}$ = sca effects of ij^{th} combination

$\hat{e}_{ijk}$ = error associatted with ijk^{th} observation

i = number of lines

j = number of testers

k = number of replications

The individual effects were estimated as follows

1. Mean $= \frac{X\ldots}{ltr}$

2. gca effects of lines $\hat{g}_i = \frac{X_{i..}}{tr} - \frac{X\ldots}{ltr}$

3. gca effects of testers $\hat{g}_j = \frac{X_{.j.}}{lr} - \frac{X\ldots}{ltr}$

4. sca effects in combinations

$$\hat{S}_{ij} = \frac{X_{ij}}{r} - \frac{X_{i..}}{tr} - \frac{X_{.j.}}{lr} + \frac{X\ldots}{ltr}$$

where,

$X\ldots$ = total of all hybrid combinations.

$X_{i..}$ = total of i^{th} line over 't' testers and 'r' replications.

$X_{.j.}$ = total of j^{th} tester over 'l' lines and 'r' replications.

X_{ij} = total of the hybrid between i^{th} line and

j^{th} tester over 'r' replications.

The standard error pertaining to gca effects of lines and testers and sca effects in different combinations were calculated as given below.

$$\text{S.E. } (\hat{g}_i) \text{ Lines} = \sqrt{\frac{M_1}{rt}}$$

$$\text{S.E. } (\hat{g}_j) \text{ testers} = \sqrt{\frac{M_t}{rl}}$$

$$\text{S.E. } (\hat{S}_{ij}) \text{ in combinations} = \sqrt{\frac{M_e}{r}}$$

Proportional contribution of lines, testers and line X tester to total variance :

$$\text{Contribution of lines} = \frac{SS\ (l) \times 100}{SS\ (\text{crosses})}$$

$$\text{Contribution of testers} = \frac{SS\ (t) \times 100}{SS\ (\text{crosses})}$$

$$\text{Contribution of (lxt)} = \frac{SS\ (lxt) \times 100}{SS\ (\text{crosses})}$$

Where, SS (1) = sum of squares due to lines

SS (t) = sum of squares due to testers

SS (lxt) = sum of squares due to line x tester

3.2.2.2.2. Heterosis

Relative heterosis (di):

Relative heterosis was estimated as,

$$\frac{F1 - MP}{MP} \times 100$$

where, F1 was the mean value of the hybrid and MP was the mean mid - parental value. It was expressed as percentage.

Heterobeltiosis (dii):

Heterobeltiosis was estimated as,

$$\frac{F1 - BP}{BP} \times 100$$

where, F1 was the mean value of the hybrid and BP was the mean value of the better parent in the cross, expressed as percentage.

Standard heterosis (diii):

Standard heterosis was estimated as,

$$\frac{F1 - SP}{SP} \times 100$$

where, F1 was the mean value of the hybrid and SP was the mean value of the standard type, expressed as percentage.

Significance for the three types of heterosis was tested by using the C.D. values calculated as,

C.D. value for relative heterosis $= t_{df(e)} \sqrt{\frac{3\ M_e}{2r}}$

C.D. value for heterobeltiosis and standard heterosis $= t_{df(e)} \sqrt{\frac{2M_e}{r}}$

3.2.2.3. Genotype x Environment interaction

The data obtained from three seasons viz., summer 1989, summer 1990 and Kharif 1990, were subjected to location-wise analysis of variance followed by pooled analysis. Pooled analysis of variance was performed to investigate the consistency of the types over environment. The split up of the degrees of freedom for various sources of variation is given below (Singh & Chaudhary, 1977).

Table 6. POOLED ANOVA

Source	df	M.S.
Types(G)	t-1	MS_G
Environment (E)	s-1	MS_E
G x E	(t-1) (s-1)	$MS_{G \times E}$
Pooled Error	st(r-1)	MS_{E1}

The mean sum of squares due to genotype x environment interaction was tested against mean sum of squares for pooled error. The analysis for estimation of stability parameters was proceeded when the variance due to genotype x environment interaction was found significant.

The model of Eberhart and Russell (1966) was used for stability analysis with 't' types tested in 's' environments. The stability of types under different environments was computed as:-

$$Y_{ij} = m + b_i I_j + \delta_{ij} \quad (i=1,2,\ldots,t \text{ and } j=1,2,\ldots,s)$$

Where,

Y_{ij} = Mean of i^{th} type in j^{th} environment.

m = Mean of all the types over all the environments.

b_i = The regression coefficient of the i^{th} variety on the environmental index which measures the response of this type of varying environments.

I_j = The environmental index which is defined as the deviation of the mean of all the types at a given location from the overall mean.

$$= \frac{\sum_i Y_{ij}}{t} - \frac{\sum_{ij} Y_{ij}}{ts}, \qquad \sum_j I_j = 0$$

and δ_{ij} = The deviation from regression of the i_{th} type at j_{th} location.

Stability Parameters:

The two parameters of stability were calculated as:-

a) The regression coefficient which is the regression of the performance of each type under different environments on the environmental means over all the types. The regression coefficient (b_i) for each type is computed as:

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

Regression coefficient was tested by applying the 't' test,

$$t = \frac{|b-1|}{SE(b)}$$

where,

$$SE(b) = \sqrt{\frac{\text{MS due to pooled deviation from regression}}{\sum_j I_j^2}}$$

b) Mean square deviation ($\bar{S}^2_d$) from linear regression,

$$\bar{S}^2 d_i = \left[\sum_j \delta^2_{ij} \Big/ (s-2) \right] - (\bar{S}^2_e / r)$$

The significance of $\bar{S}^2_d$ is tested against pooled error ($\bar{S}^2_e$).

The analysis of variance for phenotypic stability is presented below in table 7.

Table 7. ANOVA FOR PHENOTYPIC STABILITY

Source		df	MS	F
Total		st-1		
Types		t-1	MS_1	MS_1/MS_3
Environment + (Type x Environment)		t(s-1)		
Environment (Linear)		1		
Type x Environment (Linear)		t-1	MS_2	MS_2/MS_3
Pooled deviation		t(s-2)	MS_3	
Type	1	s-2 = 1		
"	2	s-2 = 1		
"	3	s-2 = 1		
"	4	s-2 = 1		
"	5	s-2 = 1		
"	6	s-2 = 1		
"	7	s-2 = 1		
"	8	s-2 = 1		
"	9	s-2 = 1		
Pooled Error		s(t-1) (r-1)	MS_E	

RESULTS

RESULTS

The data collected from the different experiments were tabulated and were subjected to statistical analysis whereever required. The results obtained are interpreted and presented hereunder.

4.1. Preliminary evaluation

The analysis of variances for the eight characters studied in the 63 types in the split plot experiment are presented in table 8. For all the eight characters studied, significant differences were exhibited by the types. Moreover, type x stage of harvest interaction was also significant for all the characters.

4.1.1. Genetic parameters

Coefficients of variation, heritability and genetic advance were estimated for all the eight traits from the analysis of variance. The estimates are presented in table 9.

Table 8. ANOVA - Split plot experiment.

Source	df	M.S.S.: No. of immature pods per plant	No of mature pods per plant	Haulms yield per plant	Pod yield per plant	100 pod wt.	Shelling %	100 Kernel wt.	Oil content %
Replications	2	31.91	13.84	502.69	0.96	518.25	0.25	2.34	1.81
Stage of harvest (A)	2	268.54**	629.68**	38537.25**	1455.15**	60976.25**	22102.81**	3118.88**	265.56
Error 1	4	3.95	4.63	351.22	1.57	57.13	0.84	0.44	0.06
Type(B)	62	55.07**	43.69**	1101.34**	19.33**	690.62**	256.49**	159.77**	6.44**
(AXB)	124	24.65**	24.22**	475.69**	7.65**	391.83**	80.68**	33.75**	0.77**
Error 2	372	5.66	12.99	118.97	3.01	153.01	0.43	0.34	0.10

** Significant at 1% level

Table 9. COEFFICIENT OF VARIATION, HERITABILITY AND GENETIC ADVANCE

Sl. No.	Characters	Mean	Coefficient of variation			Heritability (%)	Genetic Advance of mean (%)
			Genotypic	Phenotipic	Environmental		
1.	No. of immature pods per plant	7.72	30.35	30.82	43.25	49.24	43.91
2.	No.of mature pods/plant	15.75	11.72	22.88	25.71	20.79	10.98
3.	Haulms yield / plant (g.)	55.58g.	18.70	19.52	27.03	47.85	26.65
4.	Pod yield/ plant (g.)	11.55g.	11.65	19.00	15.02	37.55	14.72
5.	100 pod weight(g)	69.25g.	11.16	21.06	17.86	28.08	12.19
6.	Shelling percentage	55.93	9.54	9.61	1.17	98.51	19.51
7.	100 kernel weight (g.)	31.69g.	13.28	13.41	1.84	98.12	27.11
8.	Oil content (%)	46.50%	1.84	1.96	0.68	87.95	3.55

For all the characters studied, phenotypic coefficient of variation (P.C.V.) values were higher than the respective genotypic coefficient of variation (G.C.V) values. The highest P.C.V. was showed by number of immature pods per plant (30.82), followed by number of mature pods per plant (22.88), 100 pod weight (21.06), haulms yield per plant (19.52) and pod yield per plant (19.00). Oil content registered the lowest value (1.96) for P.C.V.

The highest G.C.V. value was recorded by number of immature pods per plant (30.35) as in the case of P.C.V. This was followed by haulms yield per plant (18.70), 100 kernel weight (13.28), number of mature pods per plant (11.72), pod yield per plant (11.65) and 100 pod weight (11.16). As in the case of P.C.V., oil content showed the lowest value (1.84).

Environmental coefficient of variation (E.C.V.) was also the highest for number of immature pods per plant (43.25). This was followed by haulms yield per plant (27.03), number of mature pods per plant (25.71), 100 pod weight (17.86) and pod yield per plant (15.02). In this case also, oil content recorded the lowest value (0.68), followed by shelling percentage (1.17) and 100 kernel weight

(1.84). For the traits such as, number of immature pods per plant, number mature pods per plant, haulms yield per plant, pod yield per plant and 100 pod weight, the E.C.V. values were higher than their respective G.C.V. values.

Heritability estimates in the broad sense were either low, medium or high for the eight different traits. Highest estimate (98.51) was recorded by shelling percentage followed by 100 kernel weight (98.12) and oil content (87.95). The values were medium for number of immature pods per plant (49.24) and haulms yield per plant (47.85). The lowest estimate was showed by number of mature pods per plant (20.79).

Genetic advance expressed as percentage of mean was moderate to low for the eight different traits. It was maximum for number of immature pods per plant (43.91), followed by 100 kernel weight (27.11) and haulms yield per plant (26.65). Oil content recorded the minimum value (3.55).

High heritability estimates with moderate genetic advance was recorded by 100 kernel weight and shelling percentage. On the other hand, oil content had high heritability with very low genetic advance. Moderate estimates of both heritability and genetic advance were showed by number of immature pods per plant and haulms yield per plant. The traits such as number of mature pods per plant, pod yield per plant and 100 pod weight showed low estimates for both heritability and genetic advance.

4.1.2. Maturity index

A maturity index was formulated (Table 10) by taking into consideration the mean values for the six different traits namely, ratio of number of mature to immature pods per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content in each type at the three different stages of harvest viz., 80, 95 and 110 days after sowing (Table 11). On the basis of the critical difference (C.D.) values of the treatment combinations obtained from the split plot experiment, the 63 types were scored for the maturity traits. Based on the scores obtained, the types were classified into three groups namely, extraearly (>Mean + S.E. ie., >10.05), early (Mean ± S.E. ie., 10.05 to 9.69) and medium (< Mean-S.E. ie.,< 9.69).

Table 10. SCORE CHART FOR MATURITY INDEX

Type No.	Ratio of No. of mature to immature pods (C1)	Pod yield per plant (C2)	100 pod weight (C3)	Shelling percentage (C4)	100 kernel weight (C5)	Oil content (C6)	Total	Maturity Group
01	2	3	3	2	2	2	14	Extra early
02	3	2	2	1	1	1	10	Early
03	3	1	2	1	2	1	10	Early
04	3	3	2	2	2	2	14	Extra early
05	2	3	3	1	1	1	11	Extra early
06	1	1	3	1	1	1	8	Medium
07	3	2	2	1	2	1	11	Extra early
08	3	2	2	1	1	1	10	Early
09	1	2	1	1	3	1	9	Medium
10	3	2	2	1	2	1	11	Extra early
11	3	2	2	1	2	1	11	Extra early
12	2	3	3	1	1	3	13	Extra early
13	2	3	3	1	2	2	13	Extra early
14	2	2	1	1	1	1	8	Medium
15	3	2	2	1	1	1	10	Early
16	3	1	2	1	1	1	9	Medium
17	3	1	2	1	1	1	9	Medium
18	3	2	2	1	1	1	10	Early
19	2	1	2	1	2	1	9	Medium
20	3	1	2	1	1	1	9	Medium
21	3	2	2	1	1	1	10	Early
22	3	2	3	1	1	1	11	Extra early
23	3	2	2	1	2	1	11	Extra early
24	3	2	2	2	1	1	11	Extra early
25	3	1	2	1	1	1	9	Medium
26	1	1	2	1	2	2	9	Medium
27	1	2	2	1	1	1	8	Medium
28	1	1	1	1	1	1	6	Medium
29	3	2	2	1	1	1	10	Early
30	3	3	2	1	1	1	11	Extra early
31	3	2	2	1	1	1	10	Early

Table 10. Cont'd. SCORE CHART FOR MATURITY INDEX

Type No.	Ratio of No. of mature to immature pods (C1)	Pod yield per plant (C2)	100 pod Weight (C3)	Shelling percentage (C4)	100 kernel weight (C5)	Oil content (C6)	Total	Maturity Group
32	3	2	1	1	2	1	10	Early
33	3	2	1	1	1	1	9	Medium
34	2	2	2	1	1	1	9	Medium
35	3	2	1	1	1	1	9	Medium
36	3	2	2	1	1	1	10	Early
37	3	2	1	1	1	1	9	Medium
38	3	2	1	1	2	1	10	Early
39	3	2	2	1	1	1	10	Early
40	3	1	2	1	1	1	9	Medium
41	3	1	2	1	1	1	9	Medium
42	3	2	3	1	1	1	11	Extra early
43	3	2	1	1	1	1	9	Medium
44	3	2	1	1	2	1	10	Early
45	3	1	2	1	1	1	9	Medium
46	3	1	3	1	1	2	11	Extra early
47	2	2	2	1	1	1	9	Medium
48	3	1	3	1	1	1	10	Early
49	3	1	2	1	1	1	9	Medium
50	3	2	2	1	2	1	11	Extra early
51	1	2	2	1	1	1	8	Medium
52	1	2	3	1	1	2	10	Early
53	3	1	2	1	1	1	9	Medium
54	3	2	1	1	1	1	9	Medium
55	2	2	3	2	1	3	13	Extra early
56	2	2	3	1	1	3	12	Extra early
57	3	2	2	1	1	1	10	Early
58	1	2	2	1	1	1	8	Medium
59	3	1	2	1	1	1	9	Medium
60	3	1	2	1	1	1	9	Medium
61	3	1	2	1	1	1	9	Medium
62	3	1	2	1	1	1	9	Medium
63	3	1	2	1	1	1	9	Medium

Mean = 9.87 S.E = 0.18

Table 11. MEAN VALUES AT DIFFERENT HARVEST STAGES FOR DIFFERENT TRAITS.

(a) RATIO OF NUMBER OF MATURE TO IMMATURE PODS/PLANT (C_1)

Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3
1.	4.19	6.01	6.10	22.	2.01	2.72	3.36	43.	0.85	1.73	2.32
2.	3.27	1.98	2.58	23.	2.34	1.80	3.09	44.	2.30	1.99	2.82
3.	1.98	1.47	3.25	24.	1.49	1.62	3.13	45.	1.51	2.62	3.29
4.	3.55	3.33	4.12	25.	2.55	2.35	3.23	46.	1.82	2.76	3.32
5.	2.22	4.18	4.38	26.	2.05	1.48	4.00	47.	2.12	4.99	3.81
6.	2.79	1.72	4.96	27.	2.02	2.04	4.66	48.	1.93	2.15	3.10
7.	1.53	1.77	2.66	28.	2.21	1.62	4.22	49.	1.93	1.55	2.85
8.	0.97	0.85	2.36	29.	2.60	2.33	3.14	50.	2.50	2.85	3.14
9.	1.90	2.74	5.49	30.	1.77	1.43	2.32	51.	1.87	1.28	4.69
10.	1.81	2.05	3.19	31.	0.62	0.68	1.83	52.	2.27	1.51	4.75
11.	1.77	2.13	2.25	32.	2.56	1.67	2.32	53.	1.96	1.77	2.46
12.	3.50	5.73	5.80	33.	2.30	1.34	0.74	54.	3.01	2.25	3.27
13.	2.47	4.97	4.37	34.	0.25	2.41	2.15	55.	1.51	3.38	4.66
14.	0.21	2.13	2.11	35.	1.71	1.70	1.39	56.	2.78	4.60	4.61
15.	2.29	2.16	2.75	36.	1.54	1.35	3.02	57.	1.48	1.08	2.18
16.	2.33	1.78	0.53	37.	2.71	1.48	0.95	58.	2.05	2.48	4.28
17.	2.52	1.45	2.59	38.	2.64	1.52	3.08	59.	2.53	2.75	2.28
18.	2.38	1.24	2.63	39.	1.49	1.12	1.22	60.	2.85	2.66	1.36
19.	1.49	5.34	3.66	40.	3.36	4.09	3.05	61.	1.87	2.47	1.63
20.	1.68	2.03	1.67	41.	2.10	1.57	1.59	62.	2.16	1.34	1.94
21.	1.91	2.24	1.35	42.	3.00	1.88	2.32	63.	2.56	1.03	1.42

CD(AB) = 1.80 A_1 = Harvest at 80 D.A.S. A_2 = Harvest at 110 D.A.S.

Table 11. Cont'd. (b) POD YIELD / PLANT (C_2)

Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3
1.	6.69	6.92	6.51	22.	9.10	10.98	12.89	43.	8.80	11.86	14.45
2.	5.76	11.48	12.43	23.	7.82	10.79	10.76	44.	8.76	11.14	11.9
3.	7.93	12.26	16.91	24.	8.97	10.73	12.88	45.	7.35	12.53	15.5
4.	10.81	12.52	13.20	25.	8.82	10.38	14.02	46.	11.17	14.81	[illegible]
5.	8.38	8.02	10.53	26.	8.44	8.67	13.92	47.	8.42	11.35	12.9
6.	8.52	9.19	14.52	27.	7.45	13.45	15.97	48.	7.78	9.64	14.1
7.	7.00	9.97	11.74	28.	9.64	9.86	16.99	49.	9.51	8.95	14.96
8.	8.25	11.99	14.32	29.	8.14	14.31	16.34	50.	9.82	13.18	15.20
9.	0.27	12.65	13.14	30.	9.40	9.28	11.71	51.	10.89	14.98	17.15
10.	11.27	14.14	14.23	31.	8.04	14.00	14.84	52.	12.10	16.07	16.74
11.	9.77	11.44	12.31	32.	8.28	11.24	12.91	53.	8.28	11.08	15.44
12.	10.30	11.08	12.31	33.	8.89	12.28	12.89	54.	1.44	18.81	14.08
13.	12.30	13.09	14.38	34.	9.57	14.05	13.58	55.	9.46	10.38	11.05
14.	7.81	10.02	12.24	35.	8.11	12.86	14.36	56.	8.47	10.61	12.50
15.	7.43	11.32	14.09	36.	6.32	12.38	13.67	57.	9.73	11.74	12.95
16.	7.52	12.01	15.35	37.	9.32	14.12	12.54	58.	8.32	12.26	14.07
17.	6.74	12.04	15.89	38.	8.28	13.49	15.66	59.	8.24	12.73	15.96
18.	7.16	14.07	15.72	39.	7.67	9.40	11.21	60.	6.66	13.04	15.90
19.	7.89	12.22	16.16	40.	7.94	10.98	14.19	61	7.36	12.43	15.36
20.	7.75	11.46	15.09	41.	8.93	9.38	15.31	62.	9.79	12.78	15.64
21.	8.28	10.88	12.32	42.	9.34	10.67	12.57	63.	7.28	12.22	15.50

C.D. (AB) = 2.78

Table 11. Cont'd. (C) 100 POD HEIGHT (C_3)

Type No.	A_1	A_2	A_3	Type NO.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3
1.	32.96	36.56	47.55	22.	59.01	57.61	75.22	43.	43.63	51.68	100.60
2.	34.32	71.96	67.09	23.	45.48	43.15	97.64	44.	43.85	62.42	89.40
3.	51.49	70.89	78.07	24.	49.39	70.19	83.92	45.	61.70	100.25	118.28
4.	64.46	53.15	87.90	25.	45.08	54.75	68.44	46.	53.72	61.71	67.58
5.	53.33	72.59	75.46	26.	62.65	84.62	91.40	47.	34.24	57.67	76.56
6.	51.47	64.98	63.22	27.	57.91	95.89	107.33	48.	60.40	67.80	76.79
7.	46.92	68.20	75.70	28.	63.56	77.93	105.32	49.	71.95	81.75	97.43
8.	55.68	77.74	82.95	29.	43.32	78.05	96.91	50.	54.18	76.54	99.16
9.	50.00	72.76	97.42	30.	47.83	54.93	78.75	51.	66.11	100.58	101.62
10.	56.74	94.57	96.00	31.	42.98	85.76	93.28	52.	56.76	64.66	78.87
11.	58.47	79.08	83.17	32.	44.26	65.11	96.62	53.	55.33	95.84	106.54
12.	54.89	62.24	69.22	33.	42.18	72.73	94.65	54.	62.74	75.38	107.00
13.	56.05	74.30	75.27	34.	63.82	73.33	84.22	55.	73.51	68.83	78.57
14.	61.67	70.74	106.71	35.	43.58	63.86	115.99	56.	52.98	64.26	68.34
15.	46.22	79.59	94.31	36.	49.10	70.98	80.56	57.	52.10	77.23	92.81
16.	45.02	95.39	112.59	37.	45.49	75.04	102.67	58.	52.71	80.46	89.26
17.	50.10	76.37	81.46	38.	52.66	68.69	126.50	59.	50.20	86.96	94.34
18.	42.33	65.28	83.28	39.	50.10	65.89	80.03	60.	42.98	67.76	83.08
19.	59.55	87.69	94.06	40.	45.93	60.70	77.36	61.	34.15	83.15	90.95
20.	49.96	80.37	87.48	41.	51.18	60.60	62.69	62.	57.08	86.03	94.54
21.	59.13	83.30	85.85	42.	56.44	65.78	65.65	63.	42.33	59.85	75.11

CD (AB) = 19.80

Table 11. Cont'd. (d) SHELLING PERCENTAGE (C_4)

Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3
1.	55.37	56.24	57.10	22.	33.45	42.51	66.24	43.	35.73	46.16	65.31
2.	48.23	50.57	89.66	23.	55.63	59.96	69.08	44.	39.91	59.09	63.45
3.	41.78	47.97	80.41	24.	48.93	63.59	63.76	45.	41.50	59.69	67.13
4.	59.89	69.93	70.91	25.	49.34	59.55	68.10	46.	52.62	64.26	79.33
5.	55.28	57.73	67.95	26.	45.14	56.24	59.09	47.	45.42	52.38	61.19
6.	53.28	60.53	68.52	27.	43.38	51.64	61.73	48.	55.83	60.16	69.41
7.	58.35	65.51	70.61	28.	43.52	49.50	60.21	49.	44.58	52.19	69.10
8.	47.43	59.30	69.44	29.	43.70	50.49	63.53	50.	58.24	60.76	80.04
9.	40.42	52.28	62.46	30.	42.48	54.24	62.64	51.	40.57	53.65	75.45
10.	44.29	47.51	67.47	31.	26.00	51.75	62.29	52.	43.12	61.47	74.53
11.	41.56	47.80	66.39	32.	30.49	60.39	65.27	53.	46.92	52.12	80.16
12.	58.63	63.48	68.77	33.	30.85	49.39	59.51	54.	43.27	71.49	80.93
13.	55.43	66.68	68.39	34.	38.34	52.92	65.31	55.	51.77	62.01	60.36
14.	41.70	56.17	68.97	35.	47.70	63.43	71.04	56.	59.92	64.53	68.50
15.	43.70	54.57	59.99	36.	39.67	47.99	73.21	57.	43.64	55.42	68.50
16.	37.70	46.47	66.22	37.	34.55	45.38	58.01	58.	43.62	52.39	61.71
17.	37.53	46.90	57.86	38.	42.55	49.44	60.58	59.	53.57	58.67	63.95
18.	48.59	54.56	65.69	39.	38.78	51.56	67.14	60.	44.00	58.13	68.78
19.	44.84	54.75	65.37	40.	48.32	53.62	60.18	61.	55.87	58.23	65.74
20.	45.99	56.22	60.26	41.	39.65	45.19	60.33	62.	47.82	55.35	66.06
21.	46.94	55.37	68.66	42.	39.88	44.88	65.13	63.	43.85	55.27	64.15

CD (AB) = 1.05

Table 11. Cont'd. (e) 100 KERNEL WEIGHT (C_5)

Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3
1.	21.50	26.30	23.00	22.	21.17	26.34	41.97	43.	27.05	23.40	38.10
2.	24.43	25.80	32.47	23.	29.53	47.07	47.45	44.	39.43	49.63	29.47
3.	21.73	29.03	27.73	24.	26.42	25.40	34.63	45.	23.43	38.23	39.32
4.	30.60	31.27	33.58	25.	26.41	31.57	37.13	46.	20.12	24.80	34.60
5.	26.17	28.23	34.13	26.	29.35	30.01	30.10	47.	25.20	28.63	33.12
6.	32.27	42.42	47.30	27.	31.10	34.40	36.50	48.	31.63	31.67	35.38
7.	30.13	32.10	32.03	28.	36.75	38.53	42.70	49.	31.03	32.70	37.57
8.	26.50	33.20	37.63	29.	32.70	37.33	45.35	50.	26.10	34.57	34.80
9.	32.70	32.35	33.00	30.	27.73	33.13	39.45	51.	20.15	28.09	34.27
10.	26.29	30.02	30.20	31.	20.50	34.03	41.25	52.	28.50	31.70	32.80
11.	27.20	29.41	29.43	32.	29.51	30.19	33.00	53.	24.60	30.70	43.10
12.	26.30	27.15	29.43	33.	26.10	28.20	30.30	54.	36.07	44.70	48.37
13.	36.21	39.20	39.00	34.	20.00	30.10	32.58	55.	29.13	30.01	32.10
14.	31.20	36.50	38.28	35.	36.50	39.47	43.62	56.	31.25	32.25	33.48
15.	25.20	35.00	36.15	36.	29.30	33.33	38.93	57.	29.90	32.08	38.48
16.	26.97	35.23	39.17	37.	18.53	25.60	30.31	58.	24.43	27.47	32.13
17.	25.57	35.28	40.07	38.	25.36	27.32	27.57	59.	28.47	30.10	32.10
18.	29.67	31.16	37.30	39.	28.18	33.10	34.17	60.	25.17	29.25	34.10
19.	31.40	38.59	39.48	40.	27.83	28.13	32.37	61.	29.03	32.27	35.13
20.	21.37	24.60	36.77	41.	20.71	22.60	27.37	62.	24.30	39.42	36.07
21.	28.17	34.13	35.37	42.	23.37	28.37	36.95	63.	22.10	27.31	32.13

CD (AB) = 0.94

Table 11. Cont'd. (f) OIL CONTENT (C_6)

Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3	Type No.	A_1	A_2	A_3
1.	47.17	47.83	47.97	22.	43.30	46.00	46.88	43.	44.75	46.27	47.33
2.	45.17	46.17	48.33	23.	45.13	46.03	47.40	44.	44.85	46.12	47.27
3.	45.52	46.42	47.67	24.	44.35	46.13	47.03	45.	44.38	46.08	47.08
4.	47.25	47.83	48.02	25.	44.72	46.10	46.95	46.	47.17	48.17	48.67
5.	45.28	46.17	47.33	26.	45.60	46.23	46.47	47.	45.17	46.23	47.85
6.	45.20	46.30	47.08	27.	45.38	46.03	48.20	48.	45.07	46.07	47.35
7.	45.20	46.03	47.90	28.	45.08	46.12	48.17	49.	45.19	46.30	47.33
8.	45.13	46.47	48.15	29.	45.25	46.37	48.28	50.	45.05	46.42	48.42
9.	45.77	46.80	48.35	30.	45.22	46.12	48.17	51.	46.36	48.33	49.33
10.	45.17	46.20	48.23	31.	43.57	45.12	47.38	52.	48.33	49.17	48.67
11.	45.28	46.22	47.77	32.	45.17	46.30	47.95	53.	45.20	46.13	47.82
12.	48.93	49.02	48.98	33.	45.17	46.15	48.00	54.	46.48	47.07	48.27
13.	49.18	49.35	49.27	34.	45.25	46.05	47.98	55.	48.13	48.03	48.50
14.	44.72	45.76	47.43	35	45.07	46.17	48.03	56.	48.19	48.17	48.17
15.	44.35	46.20	47.17	36	44.88	46.27	48.07	57.	45.40	46.12	47.12
16.	44.10	46.12	47.42	37	42.62	45.07	47.18	58.	44.52	46.03	47.32
17.	44.38	45.90	47.38	38	45.15	46.33	47.83	59.	45.25	46.18	47.27
18.	45.58	46.33	47.23	39	45.52	46.28	47.20	60.	44.55	45.13	47.37
19.	45.03	46.08	47.53	40	45.35	46.18	47.22	61.	45.12	46.20	47.53
20.	43.80	46.02	47.07	41	45.95	46.23	47.32	62.	45.07	46.23	47.33
21.	44.22	46.33	47.00	42	44.78	46.05	47.29	63.	43.78	45.38	47.47

CD (AB) = 0.51

There were 17, 16 and 30 types in the three groups respectively. No type had the maximum score of 18. But the lowest score of six was obtained by the type No.28 included in the medium group. The type Nos. 1 and 4 in the extra-early group secured the highest score of 14, followed by type Nos. 12, 13 and 55 with a score of 13 and type No. 56 with 12.

4.1.3. Mean performance of types in the three maturity groups

The mean values for the different traits in the extra early group are presented in table 12 . The number of immature pods per plant ranged from 4.14 (type No. 42) to 10.80 (type No. 11). The number of mature pods per plant varied from 11.02 (type No.22) to 23.07 (type No. 1). Haulms yield per plant ranged from 26.90 (type No. 7) to 54.01 g. (type No.5). Mean pod yield per plant ranged from 6.96 to 12.30 g. The highest value was obtained by the type No. 13 and the lowest by type No.1. 100 pod weight ranged from 32.96 (type No.1) to 72.51 g. (type No.55). The range of shelling percentage was from 33.45 (type No.22) to 59.89 (type No. 4). 100 kernel weight varied from 20.12 (type No.46) to 36.21 g. (type No. 13). The range of oil content was from 43.30 (type No. 22) to 49.18 per cent

Table 12. MEAN VALUES FOR THE DIFFERENT TRAITS IN THE EXTRA EARLY GROUP

Sl. No.	Type No.	Number of immature pods / plant	Ratio of No. of mature to immature pods/plant	Haulms yield/ plant (g)	Pods yield/ plant (g)	100 pod weight (g)	Shelling percentage	100 kernel weight (g)	Oil content (%)
1.	01	5.50	23.07	34.26	6.69	32.96	55.37	21.50	47.17
2.	04	4.20	14.89	39.25	10.81	64.46	59.89	30.60	47.25
3.	05	7.39	16.37	54.01	8.38	53.33	55.28	26.17	45.28
4.	07	7.30	11.15	39.25	7.00	46.92	58.35	30.13	45.20
5.	10	7.63	13.83	38.71	11.27	56.74	44.29	26.29	45.17
6.	11	10.80	19.08	38.59	9.77	58.47	41.56	27.20	45.28
7.	12	4.60	16.11	43.51	10.30	54.89	58.63	26.30	48.93
8.	13	5.27	13.00	32.52	12.30	56.05	55.43	36.21	49.18
9.	22	5.48	11.02	30.84	9.10	59.01	33.45	21.17	43.30
10.	23	6.58	15.41	49.80	7.82	45.48	55.63	29.53	45.13
11.	24	8.63	12.63	41.96	8.97	49.39	48.93	26.42	44.35
12.	30	7.91	13.97	52.35	9.40	47.83	42.48	27.73	45.22
13.	42	4.14	12.43	34.47	9.34	56.44	39.88	23.37	44.78
14.	46	8.75	15.92	46.54	11.17	53.72	52.62	20.12	47.17
15.	50	5.11	12.77	36.50	9.82	54.18	58.24	26.10	45.05
16.	55	8.33	12.58	34.40	9.46	72.51	51.77	29.13	48.13
17.	56	5.29	14.72	43.53	8.47	52.98	59.92	31.25	48.19

(type No. 13).

In table 13, the mean values for the different traits included in the early group are presented. The number of immature pods per plant ranged from 6.20 (type No. 15) to 14.07 (type No. 52). The range of number of mature pods per plant was from 9.48 (type No. 31) to 21.27 (type No.52). Haulms yield per plant varied from 38.82 (type No.21) to 86.58 g. (type No.2). Pod yield per plant ranged from 9.40 (type No. 39) to 16.07 g. (type No. 52). The range of 100 pod weight was form 62.42 (type No. 44) to 85.76 g. (type No.31). Shelling percentage varied from 47.97 (type No.3) to 61.47 per cent (type No. 52). 100 kernel weight ranged from 25.80 (type No. 2) to 49.63 g. (type No.44). The range of oil content was from 45.12 (type No. 31) to 49.17 percent (type No. 52).

The mean values of the 30 types included in the medium group are presented in table 14. The range of number of immature pods per plant was from 2.47 (type No. 27) to 17.93 (type No. 60). The number of mature pods per plant varied from 10.77 (type No. 33) to 24.83 (type No. 41). Haulms yield per plant ranged from 48.13 (type No. 47) to 122.00 g. (type No. 34). Pod yield per plant varied from

Table 14. MEAN VALUES FOR THE DIFFERENT TRAITS IN THE MEDIUM GROUP

Sl. No.	Type No.	No.of immature pods/plant	No.of mature pods/plant	Haulms yield/ plant (g)	Pod yield/ plant(g)	100 pod weight (g)	Shelling percentage	100 kernel weight (g)	Oil content (%)
1.	06	4.27	21.20	52.05	14.52	63.22	68.52	47.30	47.08
2.	09	3.67	16.97	79.40	13.14	97.42	62.46	33.00	48.35
3.	14	6.90	14.57	63.76	12.24	106.71	68.97	38.28	47.43
4.	16	8.90	4.70	48.54	15.35	112.59	66.22	39.17	47.42
5.	17	7.60	19.67	73.38	15.89	81.46	57.86	40.07	47.38
6.	19	4.83	17.67	66.72	16.16	94.06	65.37	39.48	47.53
7.	20	11.40	19.00	53.44	15.09	87.48	60.26	36.77	47.07
8.	25	6.40	20.70	61.50	14.02	68.44	68.10	37.13	46.95
9.	26	3.77	15.07	67.67	13.92	91.40	59.09	30.10	46.47
10.	27	2.47	11.50	66.12	15.97	107.33	61.73	36.50	48.05
11.	28	3.57	15.07	66.50	16.99	105.32	60.21	42.70	48.20
12.	33	14.53	10.77	101.05	12.89	94.65	59.51	30.30	48.00
13.	34	7.89	16.97	122.00	13.58	84.22	65.31	32.58	47.98
14.	35	9.20	12.80	75.02	14.36	115.99	71.04	43.62	48.03
15.	37	13.23	12.60	78.54	12.54	102.67	58.01	30.31	47.18
16.	40	6.23	19.03	63.61	14.19	77.36	60.18	32.37	47.22
17.	41	15.57	24.83	89.49	15.31	62.69	60.33	27.37	47.32
18.	43	6.47	15.00	60.49	14.45	100.60	65.31	38.10	47.33
19.	45	4.17	13.73	60.49	15.52	118.28	67.13	39.32	47.08
20.	47	4.7	17.90	48.13	12.93	76.56	61.19	33.12	47.85
21.	49	5.47	15.57	66.37	14.96	97.43	69.10	37.57	47.33
22.	51	4.83	22.67	64.39	17.15	101.62	75.45	34.27	49.33
23.	53	7.20	17.73	77.09	15.44	106.54	80.16	43.10	47.82
24.	54	5.63	18.43	65.30	14.08	107.00	80.93	48.37	48.27
25	58	4.20	17.99	73.39	14.07	89.26	61.71	32.13	47.32
26.	59	6.57	14.97	48.80	15.96	94.34	63.95	32.10	47.27
27.	60	17.93	24.47	110.60	15.90	83.08	68.78	34.10	47.37
28.	61	13.60	22.20	86.68	15.36	90.95	65.74	35.13	47.53
29.	62	8.23	15.93	87.59	15.66	94.54	66.06	36.07	47.33
30.	63	15.83	22.53	67.06	15.50	75.11	64.15	32.13	47.47

12.24 (type No. 14) to 17.15 g. (type No. 51). The range of 100 pod weight was from 62.69 (type No. 41) to 118.28 g. (type No.45). Shelling percentage ranged from 57.86 (type No 17) to 80.93 per cent (type No. 54). 100 kernel weight varied from 27.37 (type No 41) to 48.37 g. (type No. 54). Oil content ranged from 46.47 (type No. 20) to 49.33 per cent (type No. 51).

4.1.4. Correlations

Phenotypic and genotypic correlations were estimated between nine characters including pod and oil yields in the three maturity groups separately.

4.1.4.1. Extra early group

The phenotypic and genotypic correlation coefficients are presented in table 15. At the phenotypic level, pod yield per plant showed highly significant and positive correlation with oil yield per plant. With 100 pod weight and oil content, its association was significant and positive. Number of mature pods per plant showed highly significant but negative relationship with 100 pod weight. 100 pod weight recorded positive and significant

Table 15. PHENOTYPIC AND GENOTYPIC COEFFICIENTS OF CORRELATION IN THE EXTRA EARLY GROUP.

	No. of immature pods per plant (X1)	No of mature pods per plant (X2)	Haulms yield per plant (X3)	Pod yield per plant (X4)	100 pod wt. (X5)	Shelling % (X6)	100 Kernel wt. (X7)	Oil content (X8)	Oilyield per plant (X9)
No. of immature pods per plant (X1)	...	0.21	0.15	0.04	0.01	-0.24	-0.05	-0.19	-0.17
No of mature pods per plant (X2)	0.08	...	0.13	-0.11	-0.51**	0.17	-0.23	0.24	0.04
Haulms yield per plant (X3)	0.31*	0.41**	...	-0.07	-0.21	0.11	-0.04	-0.01	0.01
Pod yield per plant (X4)	-0.10	-0.30*	0.10	...	0.33*	-0.09	0.17	0.28*	0.73**
100 pod wt. (X5)	0.14	-0.60**	-0.37**	0.54**	...	-0.10	0.27*	0.13	0.21
Shelling % (X6)	-0.33*	0.22	0.13	-0.11	-0.11	...	0.43**	0.61**	0.60**
100 Kernel wt. (X7)	-0.13	-0.30*	-0.06	0.21	0.29*	0.46**	...	0.41**	0.44**
Oil content (X8)	-0.30*	0.30*	-0.01	0.40**	0.15	0.62**	0.45	...	0.75**
Oil yield per plant (X9)	0.36**	-0.02	0.12	0.64**	0.30*	0.68**	0.51**	0.83**	...

* - Significant at 5% level
** - Significant at 1% level

Upper triangle - Phenotypic coefficient of correlation
Lower triangle - Genotypic coefficient of correlation

association with 100 kernel weight. Shelling percentage showed highly significant and positive association with 100 kernel weight, oil content and oil yield per plant. 100 kernel weight showed highly significant and positive relationship with oil content and oil yield per plant. Oil content recorded highly significant and positive association with oil yield per plant.

At the genotypic level, pod yield per plant recorded highly significant and positive relationship with oil content and oil yield per plant. With 100 pod weight the association was significant and positive but the relationship with number of mature pods per plant was significant and negative. Number of immature pods per plant also recorded highly significant negative association with oil yield per plant. With shelling percentage and oil content also the relationship was significant and negative. But with haulms yield per plant, the relationship was significant and positive. Number of mature pods per plant showed positive and highly significant relationship with haulms yield per plant and with oil content the association was significant and positive. But with 100 kernel weight, the relationship was significant and negative. Haulms yield per plant recorded highly significant and negative association with 100 pod weight. 100 pod weight showed significant and positive relationship with 100 kernel weight. Shelling percentage recorded highly significant and positive association with 100 kernel weight, oil content and oil yield per plant. 100 kernel weight showed significant positive association with oil yield per plant. The relationship of oil content with oil yield per plant was highly significant and positive.

4.1.4.2. Early group

At the phenotypic level (Table 16) pod yield per plant recorded highly significant and positive association with oil yield per plant. With oil content, the relationship was positive and significant. Number of mature pods per plant showed highly significant and positive correlation with oil content. Haulms yield per plant recorded significant, but negative relationship with shelling percentage. Shelling percentage showed significant and positive relationship with oil content and oil yield per plant. Oil content recorded significant and positive correlation with oil yield per plant.

At the genotypic level, pod yield per plant showed highly significant and positive association with

Table 16. PHENOTYPIC AND GENOTYPIC COEFFICIENTS OF CORRELATION IN THE EARLY GROUP

	No. of immature pods per plant (X1)	No of mature pods per plant (X2)	Haulms yield per plant (X3)	Pod yield per plant (X4)	100 pod wt. (X5)	Shelling % (X6)	100 Kernel wt. (X7)	Oil content (X8)	Oil yield per plant (X9)
No. of immature pods per plant (X1)	...	0.02	0.01	0.18	-0.12	-0.12	-0.18	0.26	0.16
No of mature pods per plant (X2)	-0.16	...	-0.07	0.23	-0.37	-0.05	0.06	0.49**	0.25
Haulms yield per plant (X3)	0.19	0.31*	...	0.15	0.10	-0.29*	-0.15	-0.09	0.01
Pod yield per plant (X4)	1.09**	0.47**	0.77**	...	0.13	-0.06	-0.05	0.40*	0.89**
100 pod wt. (X5)	—	—	—	—	...	-0.14	-0.01	-0.21	0.03
Shelling % (X6)	-0.27	-0.12	-0.40**	-0.12	—	...	0.26	0.37*	0.38*
100 Kernel wt. (X7)	-0.34*	0.05	-0.21	-0.09	—	0.26	...	-0.11	0.03
Oil content (X8)	0.41**	0.74*	0.06	0.55**	—	0.40**	-0.11	...	0.64**
Oil yield per plant (X9)	0.76**	0.41**	0.34*	0.78**	—	0.51*	0.04	0.82**	...

* - Significant at 5% level
** - Significant at 1% level
— - Not estimable

Upper triangle - Phenotypic coefficient of correlation
Lower triangle - Genotypic coefficient of correlation

number of immature pods per plant, number of mature pods per plant, haulms yield per plant and oil yield per plant. With oil content the association was positive and significant. Number of immature pods per plant recorded highly significant and positive relationship with oil content and oil yield per plant but it showed significant and negative association with 100 kernel weight. Number of mature pods rer plant recorded highly significant and positive association with oil content and oil yield per plant, and with haulms yield per plant the relationship was significant and positive. Haulms yield per plant showed significant and positive relationship with oil yield per plant but recorded highly significant and negative association with shelling percentage. Shelling percentage in turn recorded highly significant and positive correlation with oil content and oil yield per plant. Oil content showed highly significant and positive relationship with oil yield per plant.

4.1.4.3 Medium Group

The correlation coefficients furnished in table 17 indicate that at the phenotypic level, pod yield per plant showed highly significant and positive association with number of mature pods per plant and oil yield per plant. Number of immature pods per plant recorded highly

	No. of immature pods per plant (X1)	No of mature pods per plant (X2)	Haulms yield per plant (X3)	Pod yield per plant (X4)	100 pod wt. (X5)	Shelling % (X6)	100 Kernel wt. (X7)	Oil content (X8)	Oil yield per plant (X9)
No. of immature pods per plant (X1)	...	0.16	0.37**	0.01	-0.10	-0.06	-0.26**	-0.14	-0.02
No of mature pods per plant (X2)	0.25*	...	-0.02	0.46**	-0.60**	0.13	-0.10	0.02	0.45**
Haulms yield per plant (X3)	0.62**	0.35**	...	0.03	-0.07	-0.04	-0.24*	0.11	0.03
Pod yield per plant (X4)	0.10	0.18	0.21*	...	-0.01	0.10	0.01	0.33	0.90**
100 pod wt. (X5)	-0.22*	-0.87**	-0.16	-0.12	...	0.24*	0.26	0.23*	0.10
Shelling % (X6)	-0.10	0.30**	-0.04	0.21*	0.42**	...	0.60**	0.35**	0.52**
100 Kernel wt. (X7)	-0.31**	-0.17	-0.37**	0.01	0.44**	0.60**	...	0.16	0.24**
Oil content (X8)	-0.15	-0.04	0.22**	0.06	0.46**	0.40**	0.18	...	0.24*
Oil yield per plant (X9)	0.01	0.30**	0.13	0.80**	0.23*	0.79**	0.37**	0.39**	...

* - Significant at 5% level
** - Significant at 1% level

Upper triangle - Phenotypic coefficient of correlation
Lower triangle - Genotypic coefficient of correlation

significant and positive relationship with haulms yield per plant but recorded significant negative association with 100 kernel weight. Number of mature pods per plant showed highly significant positive relationship with oil yield per plant but with 100 pod weight the relationship was negative and highly significant. Haulms yield per plant recorded signifcant and negative association with 100 kernel weight. The relationship of 100 pod weight with traits such as shelling percentage, 100 kernel weight and oil content were significant and positive. Shelling percentage recorded highly significant and positive correlation with 100 kernel weight, oil content and oil yield per plant.

At the genotypic level, pod yield per plant showed highly significant and positive correlation with oil yield per plant and with traits such as haulms yield per plant and shelling percentage the relationship was significant and positive. Number of immature pods per plant recorded highly significant and positive relationship with haulms yield per plant and significant and positive association with number of mature pods per plant. On the contrary, its relationship with 100 kernel weight was highly significant and negative and with 100 pod weight it was significant and negative. Number of mature pods per plant recorded highly significant positive relationship with haulms yield per plant, shelling percentage and oil yield per plant but with 100 pod weight, the trait showed highly signifcant and negative relationship. Haulms yield per plant recorded significant and negative association with oil content but with 100 kernel weight, the relationship was highly significant and negative. 100 pod weight showed highly significant and positive correlation with shelling percentage, 100 kernel weight, oil content and oil yield per plant. Shelling percentage recorded highly significant relationship with 100 kernel weight, oil content and oil yield per plant. 100 kernel weight registered highly significant and positive association with oil yield per plant.

4.1.5. Direct and indirect effects

The direct and indirect effects of component characters on pod yield in the three maturity groups are presented in tables 18 to 20 and in figures 3 to 5. In the extra early group, among the six different components of pod yield, 100 pod weight showed the highest direct effect. Its indirect effects via. number of immature pods per plant and 100 kernel weight were low but positive. Its indirect effects via. number of mature pods per plant, haulms yield

Table 18. DIRECT AND INDIRECT EFFECTS OF THE COMPONENT CHARACTERS ON POD YIELD PER PLANT IN THE EXTRA EARLY GROUP

Components	Direct Effects	Indirect effects via.					
		No. of immature pods per plant (X1)	No of mature pods per plant (X2)	Haulms yield per plant (X3)	100 pod wt. (X5)	Shelling % (X6)	100 Kernel wt. (X7)
No. of immature pods per plant (X1)	-0.47	...	-0.04	-0.14	-0.06	0.16	0.06
No of mature pods per plant (X2)	0.12	0.01	...	0.05	-0.07	0.03	-0.03
Haulms yield per plant (X3)	0.51	0.16	0.21	...	-0.19	0.07	-0.03
100 pod wt. (X5)	0.78	0.11	-0.47	-0.28	...	-0.08	0.23
Shelling % (X6)	-0.35	0.12	-0.08	-0.04	0.04	...	-0.16
100 Kernel wt. (X7)	0.15	-0.02	-0.05	-0.01	0.04	0.07	...

Residual = 0.68

Table 19. DIRECT AND INDIRECT EFFECTS OF THE COMPONENT CHARACTERS ON POD YIELD PER PLANT IN THE EARLY GROUP

Components	Direct Effects	Indirect effects via.				
		No. of immature pods per plant (X1)	No of mature pods pe plant (X2)	Haulms yield per plant (X3)	Shelling % (X6)	100 Kernel wt. (X7)
No. of immature pods per plant (X1)	0.30	...	-0.20	0.25	-0.35	-0.44
No of mature pods per plant (X2)	0.52	-0.08	...	0.17	-0.06	0.03
Haulms yield per plant (X3)	0.60	0.12	0.19	...	-0.24	-0.12
Shelling % (X6)	0.45	-0.12	-0.05	-0.18	...	0.12
100 Kernel wt. (X7)	0.33	-0.11	0.02	-0.07	0.09	...

Residual = 0.78

Table 20. DIRECT AND INDIRECT EFFECTS OF THE COMPONENT CHARACTERS ON POD YIELD PER PLANT IN THE MEDIUM GROUP

Components	Direct Effects	Indirect effects via.					
		No. of immature pods per plant (X1)	No of mature pods per plant (X2)	Haulms yield per plant (X3)	100 pod wt. (X5)	Shelling % (X6)	100 Kernel wt. (X7)
No. of immature pods per plant (X1)	0.01	...	-0.01	-0.01	0.01	0.01	0.01
No of mature pods per plant (X2)	0.58	0.15	...	0.20	-0.50	0.15	-0.10
Haulms yield per plant (X3)	0.08	0.05	0.03	...	-0.01	-0.01	-0.03
100 pod wt. (X5)	0.45	-0.10	-0.39	-0.07	...	0.19	0.20
Shelling % (X6)	-0.14	0.01	-0.04	0.01	-0.06	...	-0.09
100 Kernel wt. (X7)	0.03	-0.01	-0.01	-0.01	0.01	0.02	...

Residual = 0.98

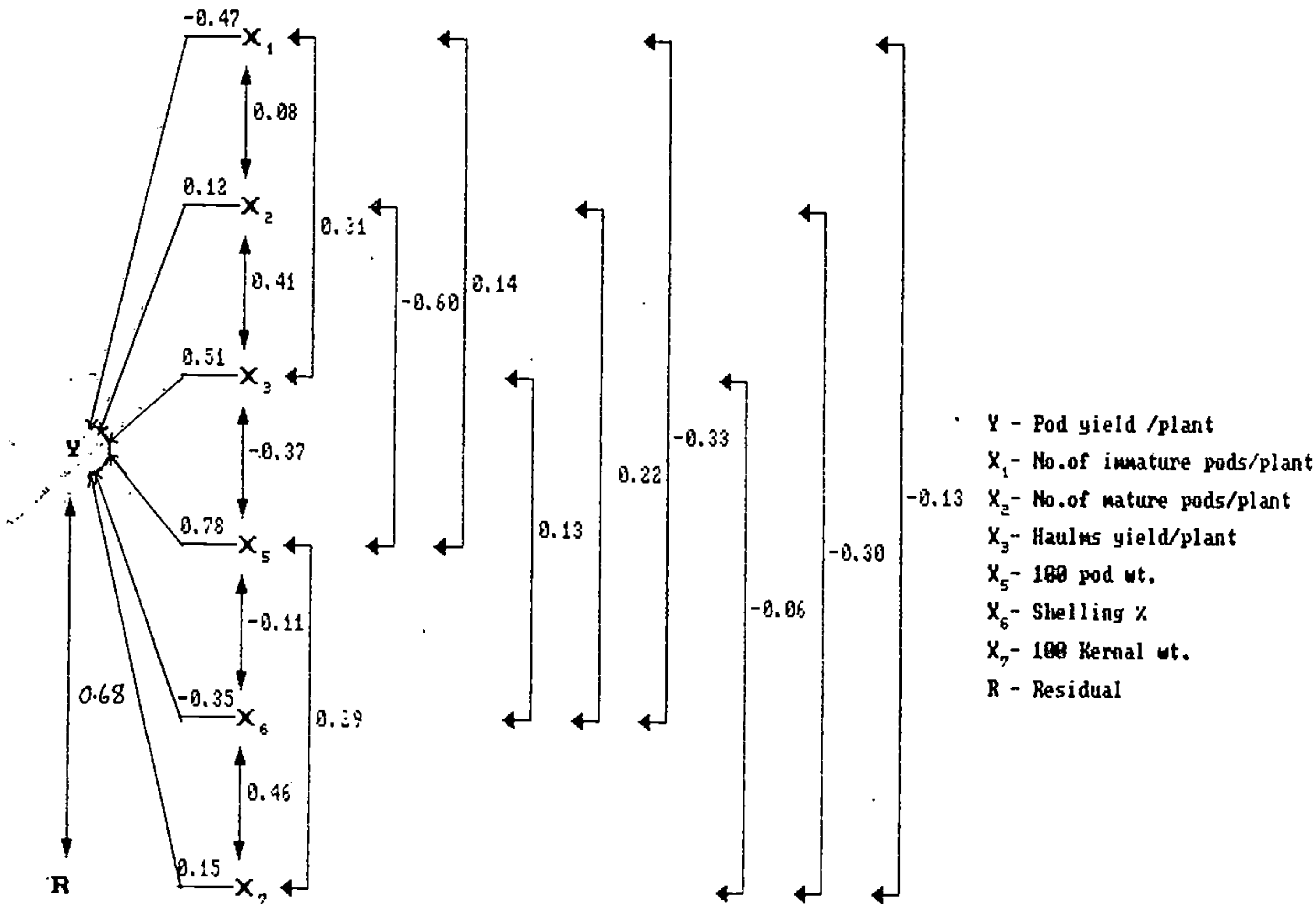


Figure 3. Path diagram showing the direct effects and inter - relationships of component characters on pod yield in the extra-early group.

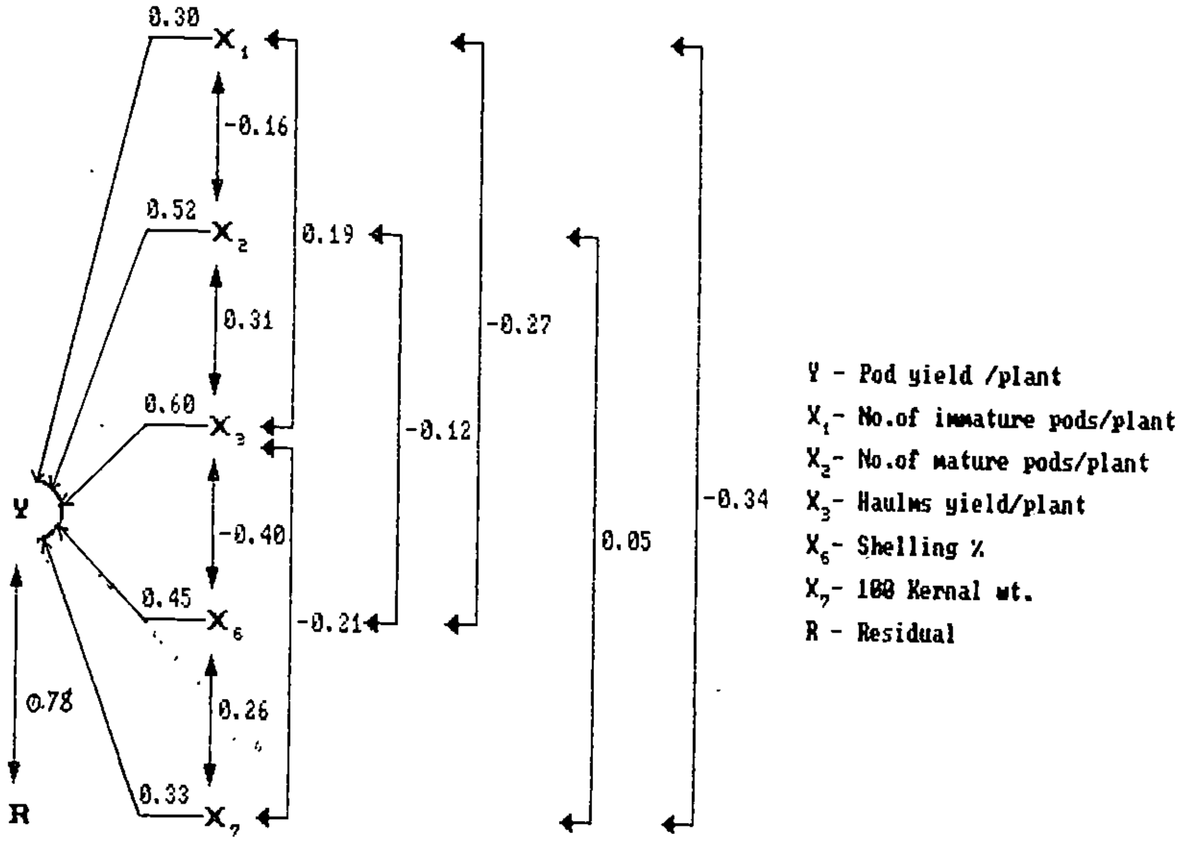


Figure 4. Path diagram showing the direct effects and inter - relationships of component characters on pod yield in the early group.

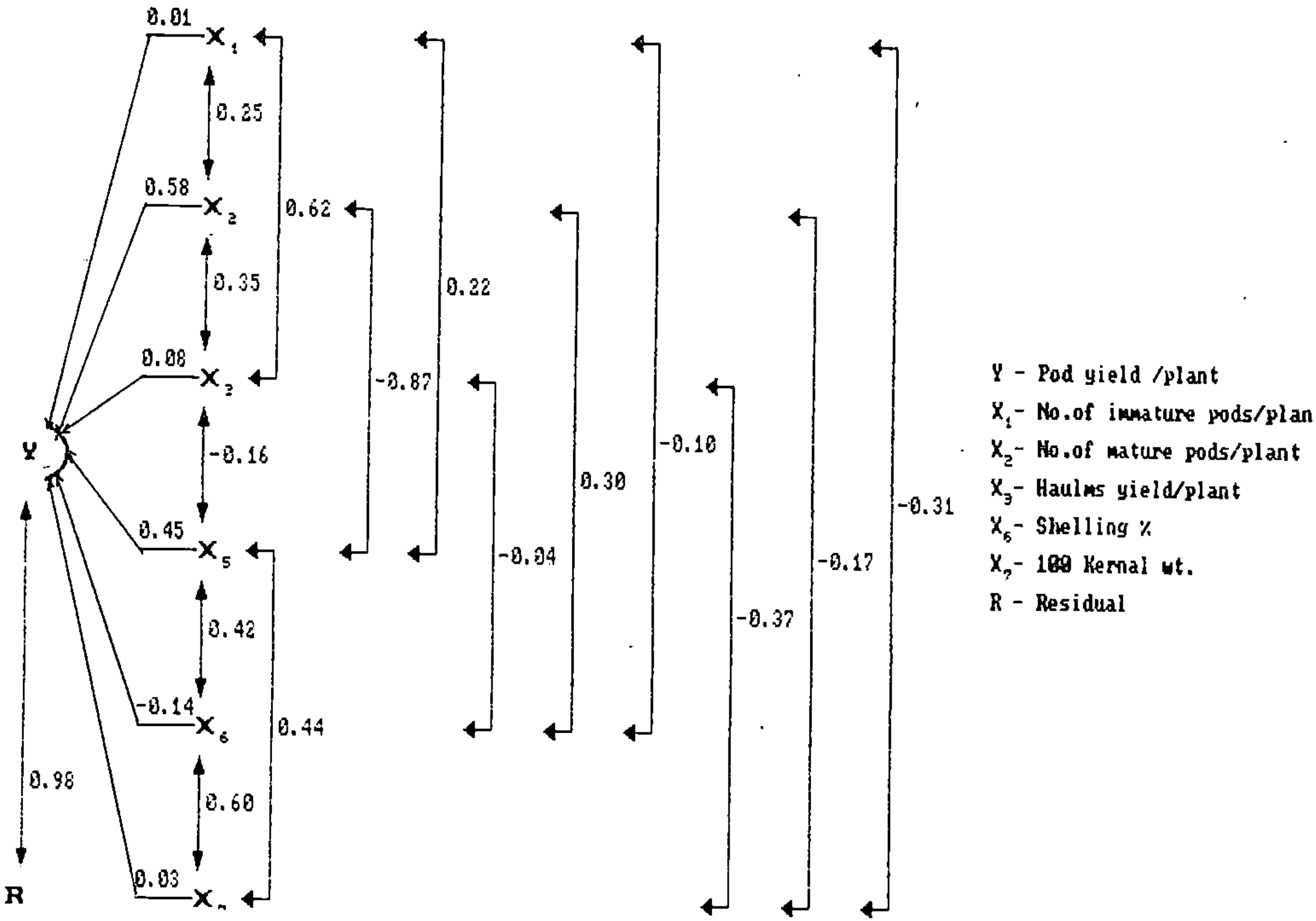


Figure 5. Path diagram showing the direct effects and inter - relationships of component characters on pod yield in the

per plant and shelling percentage were negative. Number of mature pods per plant, haulms yield per plant and 100 kernel weight showed positive direct effects on pod yield while number of immature pods per plant and shelling percentage recorded negative effects.

In the early group, maximum positive direct effect on pod yield was showed by haulms yield per plant. Its indirect effects via. number of immature and mature pods per plant were positive while via. shelling percentage and 100 kernel weight were negative. Characters such as number of immature pods per plant, number of mature pods per plant, shelling percentage and 100 kernel weight showed positive direct effects on pod yield.

In the medium group, maximum positive direct effect was recorded by number of mature pods per plant on pod yield. Its indirect effects via. number of immature pods per plant, haulms yield per plant and shelling percentage were positive whereas, via. 100 pod weight and 100 kernel weight were negative. Haulms yield per plant, 100 pod weight and 100 kernel weight recorded positive direct effects on pod yield while traits such as number of immature pods per plant and shelling percentage showed negative effects.

The direct and indirect effects of component characters on oil yield in the three maturity groups are presented in Tables 21 to 23 and in figures 6 to 8. In the extra early group, the maximum positive direct effect on oil yield was recorded by shelling percentage. Its indirect efffects via. number of immature pods per plant, number of mature pods per plant, haulms yield per plant, 100 kernel weight and oil content were positive but via. pod yield per plant and 100 pod weight were negative. The direct effect of pod yield per plant was close to the effect of shelling percentage. Its indirect effects via. haulms yeild per plant, 100 pod weight, 100 kernel weight and oil content were positive while via., number of immature pods per plant, number of mature pods per plant and shelling percentage were negative. Number of immature pods per plant, number of mature pods per plant and 100 kernel weight showed negative direct effects on oil yield per plant while, haulms yield per plant and 100 pod weight showed positive direct effects.

In the early group, the maximum positive direct effect on oil yield was recorded by pod yield per plant. Its indirect effects via. number of immature pods per plant, number of mature pods per plant, haulms yield per

Table 21. DIRECT AND INDIRECT EFFECTS OF THE COMPONENT CHARCTERS ON OIL YIELD PER PLANT IN THE EXTRA EARLY GROUP

Components	Direct effects	Indirect effects via.							
		No. of immature pods per plant (X1)	No of mature pods per plant (X2)	Haulms yield per plant (X3)	Pod yield per plant (X4)	100 pod wt. (X5)	Shelling % (X6)	100 Kernel wt. (X7)	Oil content (X8)
No. of immature pods per plant (X1)	-0.05	...	-0.01	-0.01	0.01	-0.01	0.02	0.01	0.01
No of mature pods per plant (X2)	-0.04	-0.01	....	-0.01	0.01	-0.01	0.01	-0.01	0.01
Haulms yield per plant (X3)	0.03	0.01	0.01	...	0.01	-0.01	0.01	0.01	0.01
Pod yield per plant (X4)	0.61	-0.06	-0.19	0.04	...	0.33	-0.07	0.13	0.25
100 pod wt. (X5)	0.01	0.01	-0.01	-0.01	0.01	...	-0.01	0.01	0.01
Shelling % (X6)	0.62	0.21	0.14	0.08	-0.07	-0.07	...	0.29	0.39
100 Kernel wt. (X7)	-0.01	0.01	0.01	0.01	-0.01	-0.01	-0.01	...	-0.01
Oil content (X8)	0.19	-0.06	0.06	-0.01	0.08	0.03	0.12	0.09	....

Residual= 0.01

Table 22. DIRECT AND INDIRECT EFFECTS OF THE COMPONENT CHARACTERS ON OIL YIELD PER PLANT IN THE EARLY GROUP

Components	Direct effects	Indirect effects via.						
		No. of immature pods per plant (X1)	No of mature pods per plant (X2)	Haulms yield per plant (X3)	Pod yield per plant (X4)	Shelling % (X6)	100 Kernel wt. (X7)	Oil content (X8)
No. of immature pods per plant (X1)	0.03	...	-0.01	0.01	0.03	-0.01	-0.01	0.01
No of mature pods per plant (X2)	0.10	-0.02	...	0.03	0.05	-0.01	0.01	0.07
Haulms yield per plant (X3)	-0.10	-0.02	-0.03	...	-0.03	0.04	0.02	0.01
Pod yield per plant (X4)	0.82	0.90	0.39	0.63	...	-0.10	-0.07	0.46
Shelling % (X6)	0.58	-0.16	-0.07	-0.23	-0.07	...	0.15	0.23
100 kernel wt. (X7)	-0.05	0.02	-0.01	0.01	0.01	-0.01	...	0.01
Oil content (X8)	0.04	0.02	0.03	-0.01	0.02	0.02	-0.01	....

Residual = 0.02

Table 23. DIRECT AND INDIRECT EFFECTS OF THE COMPONENT CHARACTERS ON OIL YIELD PER PLANT IN THE MEDIUM GROUP

Components	Direct effects	Indirect effects via.							
		No. of immature pods per plant (X1)	No of mature pods per plant (X2)	Haulms yield per plant (X3)	Pod yield per plant (X4)	100 pod wt. (X5)	Shelling % (X6)	100 Kernel wt. (X7)	Oil content (X8)
No. of immature pods per plant (X1)	-0.01	...	-0.01	-0.01	-0.01	0.01	0.01	0.01	0.01
No of mature pods per plant (X2)	-0.04	-0.01	...	-0.01	-0.01	0.03	-0.01	0.01	0.01
Haulms yield per plant (X3)	-0.01	0.01	0.01	...	0.01	-0.01	-0.01	-0.01	0.01
Pod yield per plant (X4)	0.61	0.06	0.11	0.13	...	-0.07	0.12	0.01	0.04
100 pod wt. (X5)	-0.04	0.01	0.04	0.01	0.01	...	-0.02	-0.02	-0.02
Shelling % (X6)	0.69	-0.05	0.18	-0.03	0.14	0.29	...	0.41	0.28
100 Kernel wt. (X7)	-0.05	0.02	0.01	0.02	-0.01	-0.02	-0.03	...	-0.01
Oil content (X8)	0.09	-0.01	0.01	0.02	0.01	0.04	0.04	0.02	...

Residual = 0.01

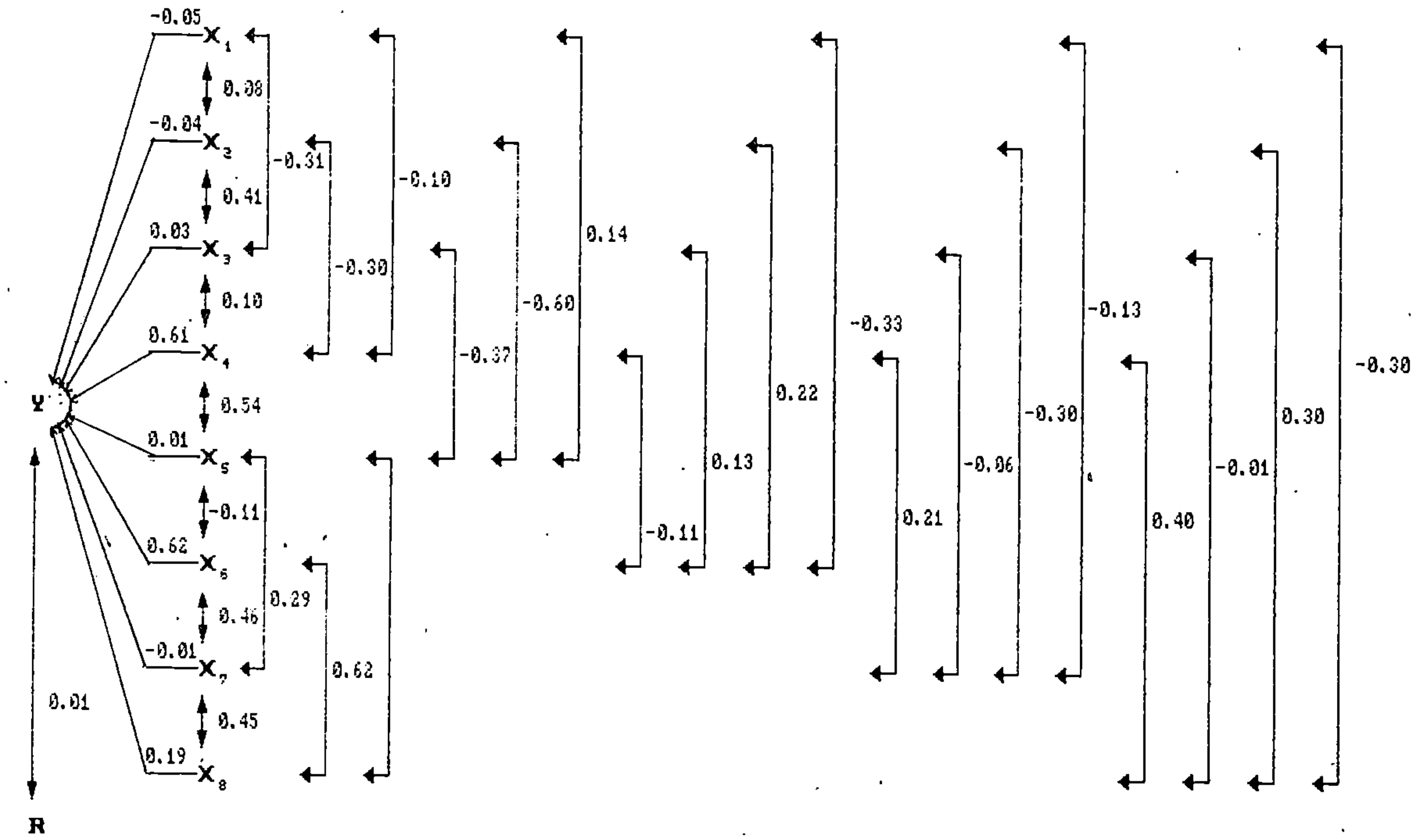


Figure 6. Path diagram showing the direct effects and inter - relationships of component characters on Oil yield in the extra early group.

Y - Oil yield /plant
X_1- No.of immature pods/plant
X_2- No.of mature pods/plant
X_3- Haulms yield/plant
X_4- Pod yield/plant
X_5- 100 pod wt.
X_6- shelling %
X_7- 100 kernel wt.
X_8- Oil coconut
R - Residual

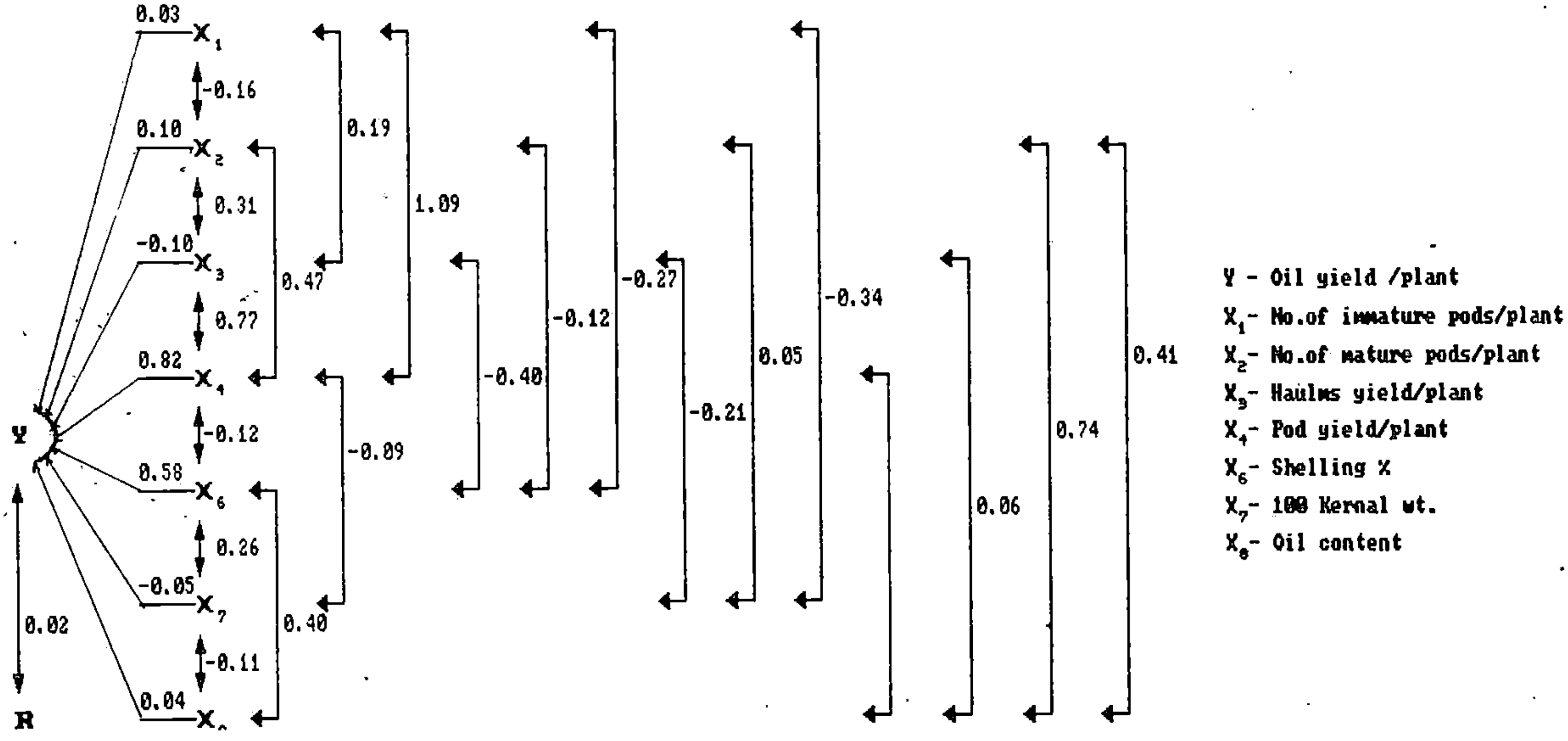


Figure 7. Path diagram showing the direct effects and inter - relationships of of component characters on Oil yield in the early group.

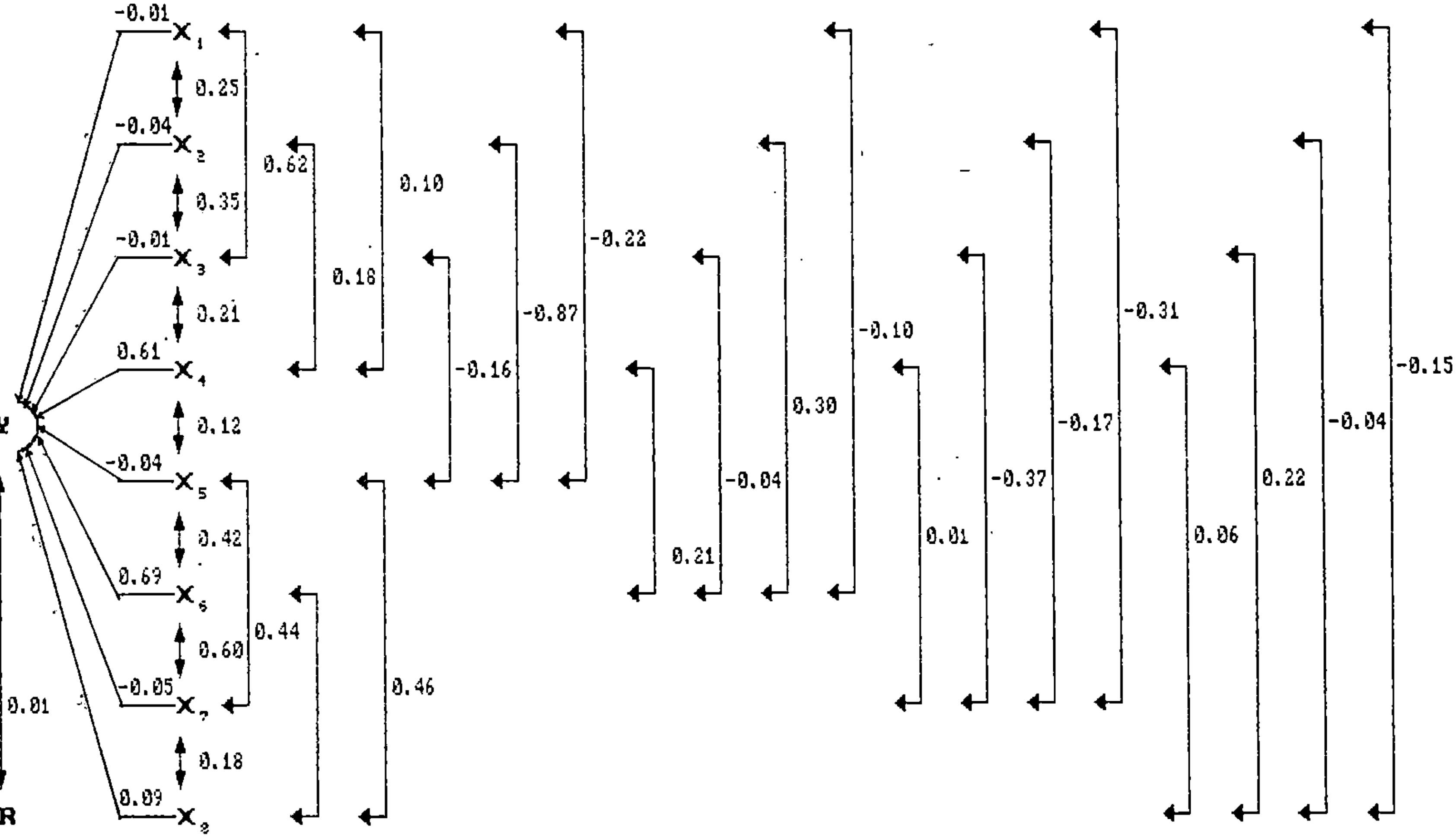


Figure 8. Path diagram showing the direct effects and inter - relationships of component characters on Oil yield in the medium group.

Y - Oil yield /plant

X_1- No.of immature pods/plant

X_2- No.of mature pods/plant

X_3- Haulms yield/plant

X_4- Pod yield/plant

X_5- 100 pod wt.

X_6- Shelling %

X_7- 100 Kernal wt.

X_8- Oil content

plant and oil content were positive but via. shelling percentage and 100 kernel weight were negative. Characters namely, number of immature pods per plant, number of mature pods per plant, shelling percentage and oil content recorded positive direct effects, while haulms yield per plant and 100 kernel weight showed negative effects.

In the medium group, all characters except pod yield per plant, shelling percentage and oil content, showed negative direct effects on oil yield per plant. The maximum contribution was made by shelling percentage. Its indirect effects via. number of mature pods per plant, pod yield per plant, 100 pod weight, 100 kernel weight and oil content were positive, where as via. number of immature pods per plant and haulms yield per plant it was negative. Direct effect of pod yield on oil yield was close to the effect of shelling percentage as in the case of the extra early group. Its indirect contribution via. all other traits except 100 pod weight were positive.

4.1.6. Reaction to incidence of rust.

The reaction of the 63 types to the incidence of rust is presented in table 24. The mean scores ranged from 1.2 to 8.6. The lowest score was obtained by ISKN 8832.

Table 24. REACTION OF THE 63 TYPES TO THE INCIDENCE OF RUST

Type No.	Mean Score	Type No.	Mean Score	Type No.	Mean Score
1.	2.1	22.	1.2	43.	2.3
2.	2.6	23.	3.1	44.	2.1
3.	8.5	24.	1.9	45.	1.4
4.	3.2	25.	3.2	46.	3.1
5.	2.4	26.	5.2	47.	2.6
6.	1.5	27.	8.3	48.	1.5
7.	2.3	28.	2.2	49.	8.4
8.	1.8	29.	8.6	50.	5.2
9.	1.9	30.	1.2	51.	5.1
10.	1.4	31.	1.7	52.	8.6
11.	8.4	32.	2.1	53.	3.1
12.	2.4	33.	1.8	54.	2.3
13.	2.3	34.	1.6	55.	2.1
14.	8.3	35.	5.2	56.	4.1
15.	2.4	36.	8.4	57.	2.3
16.	2.1	37.	1.9	58.	2.2
17.	5.6	38.	2.2	59.	2.4
18.	1.2	39.	3.4	60.	1.5
19.	3.4	40.	1.6	61.	1.4
20.	5.1	41.	1.3	62.	1.2
21.	5.3	42.	5.1	63.	1.4

The highest score was obtained by ISKO 8804 and TMV 2. Out of the 63 types, 39 of them recorded scores below 3.

4.2. Combining ability analysis:

4.2.1. Analysis of Variance:

The mean sum of squares for the 11 characters with the levels of significance indicated are presented in table 25. The types studied showed significant differences among themselves for all the traits. The variance of lines was significant for traits such as days to first flowering, days to maturity, haulms yield per plant, pod yield per plant, 100 pod weight and 100 kernel weight. The testers showed no significant variance for any of the characters studied. The variance for line x tester was significant for characters such as number of immature pods per plant, number of mature pods perplant, haulms yields per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content.

The data on mean performance, combining ability and heterosis estimates in respect of the 11 characters are presented below. In the estimation of standard

Table 25. ANOVA OF COMBINING ABILITY (LINE X TESTER ANALYSIS)

Source	df	M.S.S										
		Days to first flowering	Spread of flowering	Days to maturity	No. of immature pods per plant	No of mature pods per plant	Haulms yield per plant	Pod yield per plant	100 pod wt.	Shelling %	100 Kernel wt.	Oil content %
Replications	2	0.94	0.70	0.28	0.005	2.50**	31.63	0.48	819.00**	77.61**	37.48**	0.65
Treatments (Types)	26	1.39**	5.44**	117.76**	1.83**	11.45**	471.45**	47.15**	1260.77**	117.69**	279.42**	3.59**
Parents	8	2.58**	5.90**	123.46**	1.53**	10.63**	648.94**	44.03**	1347.90**	101.42**	256.45**	1.40**
Crosses	17	0.80**	0.82	87.15**	2.07**	11.63**	331.29**	49.54**	1251.23**	131.42**	303.62**	4.49**
Parents Vs Crosses	1	1.78*	80.22**	592.44**	0.16**	14.51**	1434.27**	31.42**	726.00**	14.43	51.76**	5.97**
Lines	5	2.15**	0.92	186.06**	2.93	11.80	944.64**	99.51*	3178.73**	232.47	826.87**	5.04
Testers	2	0.24	0.30	59.36	3.47	19.80	58.30	5.77	81.66	76.78	21.74	0.16
Line x Tester	10	0.24	0.87	43.26	1.36**	9.95**	79.22**	33.31**	521.39**	91.82**	98.38**	5.07**
Error	52	0.31	0.68	0.48	0.001	0.33	43.00	0.55	19.09	7.58	1.10	0.24

* Significant at 5% level

heterosis the type TG 3 was selected as the standard, bacause of its proven high yielding ability and prevalance in the region.

4.2.1.1. Days to first flowering

The mean performance of the lines, testers and hybrids are presented in table 26. The values ranged from 23.0 to 25.0 days for lines and from 24.67 to 25.00 days for testers. Among hybrids, the range was from 23.67 to 25.00 days. The values for lines, testers and hybrids did not differ appreciably.

The combining ability effects of the lines, testers and their combinations are presented in the table 27. All the lines except L1 showed positive gca effects but none of them was significant. The gca effect of L1 was significant, but negative. The gca effects of the testers were not significant. The sca effects of none of the cross combinations was significant. In several cases the values were negative.

The estimates of the three types of heterosis for the trait are presented in table 28 and figure 9. Relative heterosis (di) for the trait ranged from -2.68 to

Table 26. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - DAYS TO FIRST FLOWERING

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	24.67	25.00	25.00
Lines	Mean of lines	Mean of hybrids		
Chico (L1)	23.00	23.67	23.67	23.67
ISKN 8827 (L2)	25.00	25.00	24.33	25.00
Dh(E)20 (L3)	23.00	25.00	25.00	25.00
Dh(E)32 (L4)	25.00	24.33	25.00	25.00
ICGS 35-1 (L5)	25.00	25.00	24.33	25.00
IES 883 (L6)	23.33	24.67	25.00	25.00

Table 27. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - DAYS TO FIRST FLOWERING

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of Testers	-0.04	-0.09	0.13
Lines	sca of lines	sca of combinations		
Chico (L1)	-0.98*	0.04	0.09	-0.13
ISKN 8827 (L2)	0.13	0.26	-0.35	0.09
Dh(E) 20 (L3)	0.35	0.04	0.09	-0.13
Dh(E) 32 (L4)	0.13	-0.41	0.31	0.09
ICGS 35-1 (L5)	0.13	0.26	-0.35	0.09
IES 883 (L6)	0.24	-0.19	0.20	-0.02

C.D. LINE (5%) = 0.53

C.D. TESTER (5%) = 0.37

C.D. LINE X TESTER (5%) = 0.91

* Significant at 5% level

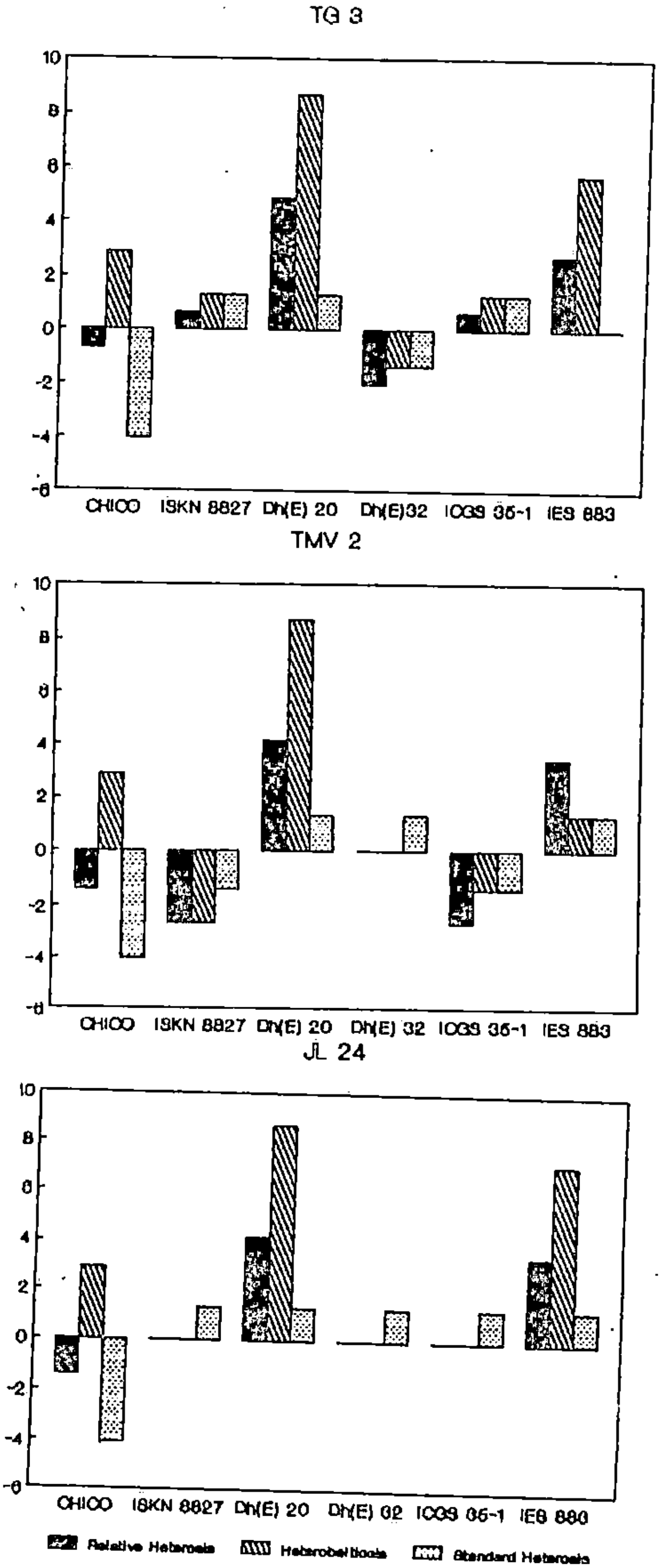
Table 28. HETEROSIS % - DAYS TO FIRST FLOWERING

Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
Lines	Relative heterosis (di)	Heterobeltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterobeltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterobeltiosis (dii)	Standard heterosis (diii)
Chico (L1)	-0.69	2.91**	-4.05**	-1.38**	2.91**	-4.05**	-1.38**	2.91**	-4.05**
ISKN 8827 (L2)	0.66	1.34**	1.34**	-2.68**	-2.68**	-1.38**	0.00	0.00	1.34**
Dh(E) 20 (L3)	4.89**	8.70**	1.34**	4.17**	8.70**	1.34**	4.17**	8.70**	1.34**
Dh(E) 32 (L4)	-2.03**	1.38**	-1.38**	0.00	0.00	1.34**	0.00	0.00	1.34**
ICGS 35-1 (L5)	0.66	1.34**	1.34**	-2.68**	-2.68**	-1.38**	0.00	0.00	1.34**
IES 883 (L6)	2.79**	5.74**	0.00	3.46**	7.16**	1.34**	3.46**	7.16**	1.34**

** Significant at 1% level

C.D. di (5%) = 0.90
C.D. dii (5%) = 0.78
C.D. diii (5%) = 0.78

Figure 9. HETEROSIS % - DAYS TO FIRST FLOWERING



4.89 per cent. ISKN 8827 X TMV 2 (L2 x T2) and ICGS 35-1 x TMV 2 (L5 xT2) recorded the maximum negative significant heterotic value. On the other hand Dh(E) 20 x TG 3 (L3 x T1) registered the maximum positive significant value.

Heterobeltiosis was estimated keeping the early flowering parent as the better parent, as earliness is the desired trait. The (dii) values ranged from -2.68 to 8.70 percent. The maximum negative significant values were showed by the combinations ISKN 8827 X TMV 2 (L2 X T2) and ICGS 35-1 X TMV 2 (L5 X T2) while the maximum positive significant values by Dh(E) 20 x TG 3 (L3 x T1), Dh (E) 20 x TMV 2 (L3 x T2) and Dh(E) 20 x JL 24 (L3 x T3).

Standard heterosis ranged from -4.05 to 1.34 per cent. The combinations namely chico x TG 3 (L1 x T1), chico x TMV 2 (L1 x T2) and chico x JL 24 (L1 x T3) recorded the maximum negative and significant heterotic value while eleven out of the eighteen combinations recorded the maximum positive and significant value.

4.2.1.2. Spread of flowering

In table 29, the mean performance of lines, testers and their hybrids are presented. The values ranged from 45.00 to 48.00 days among lines, from 48.33 to 49.00 days among testers, from 48.33 to 50.33 days among hybrids.

The combining ability effects of lines, testers and their combinations are presented in table 30. All the lines showed gca effects which were not significant. The gca effects of the testers were also not significant. None of the cross combinations showed significant sca effects.

In table 31 and figure 10, the estimates of the three types of heterosis are presented. Heterosis over mid - parental value (di) for the character ranged from 1.03 to 7.46 per cent. Dh(E) 32 x JL 24 (L4 x T3) recorded the maximum heterotic value for the trait while, IES 883 x JL 24 (L6 x T3) recorded the lowest value.

Heterosis over the better parent was estimated by keeping the type with compact spread of flowering as the better parent which is the desired trait. The (dii) values ranged from 2.77 to 11.84 per cent. Dh(E) 20 x JL 24 (L4 x T3) recorded the highest heterotic value, while the hybrids Dh(E) 20 x TG 3 (L3 x T1) and Dh(E) 20 x TMV 2 (L3

Table 29. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - SPREAD OF FLOWERING

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	49.00	48.33	48.67
Lines	Mean of Lines	Mean of hybrids		
Chico (L1)	45.33	48.33	49.33	49.67
ISKN 8827 (L2)	47.00	49.67	49.33	49.67
Dh(E) 20 (L3)	48.00	49.33	49.33	49.67
Dh(E) 32 (L4)	45.00	49.67	49.33	50.33
ICGS 35-1 (L5)	47.00	50.00	49.33	49.00
IES 883 (L6)	47.00	49.67	48.67	48.33

Table 30. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - SPREAD OF FLOWERING

	Testers	TG 3 T1	TMV 2 T2	JL 24 T3
	gca of Testers	0.07	-0.15	0.07
Lines	gca of lines	sca of Combinations		
Chico (L1)	-0.26	-0.85	0.37	0.48
ISKN 8827 (L2)	0.19	0.04	-0.07	0.04
Dh (E) 20 (L3)	0.07	-0.19	0.04	0.15
Dh(E) 32 (L4)	0.41	-0.19	-0.30	0.48
ICGS 35-1 (L5)	0.07	0.48	0.04	-0.52
IES 883 (L6)	-0.48	0.70	-0.07	-0.63

C.D. LINES (5%) = 0.78

C.D. TESTERS (5%) = 0.55

C.D. LINE X TESTER (5%) = 1.35

Table 31. HETEROSIS % - SPREAD OF FLOWERING

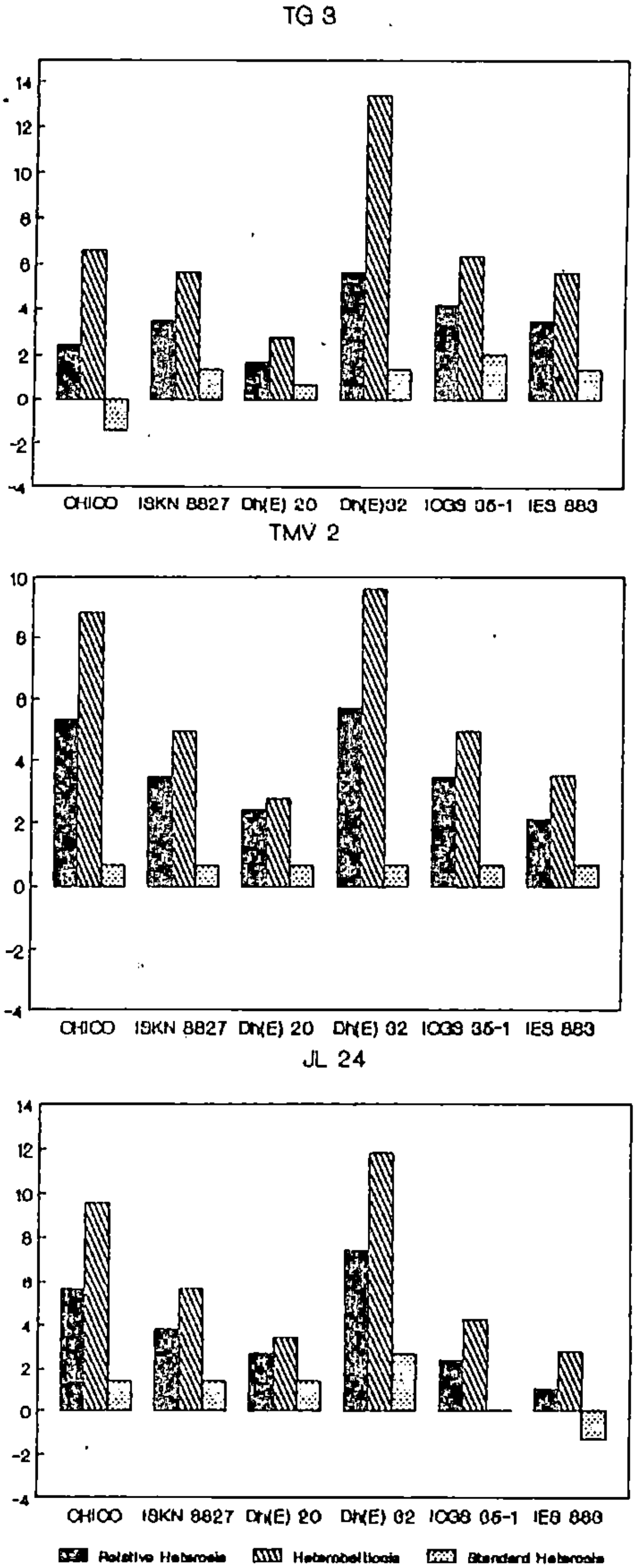
Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)
Chico (L1)	2.47**	6.62**	-1.37**	5.34**	8.82**	0.67ns	5.68**	9.57**	1.37*
ISKN 8827 (L2)	3.48**	5.68**	1.37*	3.49**	4.96**	0.67ns	3.84**	5.68**	1.37*
Dh(E) 20 (L3)	1.71*	2.77**	0.67ns	2.42**	2.77**	0.67ns	2.76**	3.48**	1.37*
Dh(E) 32 (L4)	5.68**	10.38**	1.37*	5.71**	9.62**	0.67ns	7.46**	11.84**	2.71**
ICGS 35-1 (L5)	4.17**	6.38**	2.04**	3.49**	4.96**	0.67ns	2.44**	4.26**	0.00ns
IES 883 (L6)	3.48**	5.68**	1.37*	2.11**	3.55	-0.67ns	1.03ns	2.83**	-1.37*

* Significant at 5% level

** Significant at 1% level

C.D. di (5%) = 0.90
C.D. dii (5%) = 0.78
C.D. diii (5%) = 0.78

Figure 10. HETEROSIS % - SPREAD OF FLOWERING



x T2) recorded the lowest value.

Heterosis over the standard parent (diii) ranged from -1.37 to 2.71 per cent. Dh(E) 32 x JL 24 (L4 xT3) showed the highest heterotic value while, the combinations chico x TG3 (L1 x T1) and IES 883 x JL 24 (L6 x T3) recorded the lowest value.

4.2.1.3. Days to maturity

The mean performance of lines, testers and their hybridsare presented in table 32. The mean values ranged from 77.33 to 95.67 days among lines. Among testers, the range was from 94.33 to 99.17 days. The range was from 81.17 to 99.00 days among the hybrids.

In table 33, the combining ability effects of lines, testers and their combinations are presented. The lines namely chico (L1), ISKN 8827 (L2) and Dh(E) 32 (L4) showed significant negative gca effects while, Dh(E) 20 (L3), ICGS 35-1 (L5) and IES 883 (L6) showed significant positive gca effects. Among the testers, TMV 2(T2) recorded significant negative gca effect while TG 3 (T1) recorded significant positive gca effect.

Table 32. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - DAYS TO MATURITY

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	95.17	94.33	99.17
Lines	Mean of Lines	Mean of hybrids		
Chico (L1)	77.33	82.83	85.00	82.67
ISKN 8827 (L2)	94.83	81.17	83.40	83.33
Dh(E) 20 (L3)	95.17	88.50	89.00	92.50
Dh(E) 32 (L4)	95.00	93.67	82.50	82.83
ICGS 35-1 (L5)	92.17	99.00	93.00	92.17
IES 883 (L6)	95.67	92.83	83.33	92.67

Table 33. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - DAYS TO MATURITY

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of Testers	1.87*	-1.76*	-0.11
Lines	gca of Lines	sca of combinations		
Chico (L1)	-4.30*	-2.53*	3.26*	-0.73
ISKN 8827 (L2)	-5.17*	-3.33*	2.53*	0.81
Dh(E) 20 (L3)	2.20*	-3.37*	0.76	2.61*
Dh(E) 32 (L4)	-1.47*	5.47*	-2.07*	-3.39*
ICGS 35-1 (L5)	6.92*	2.41*	0.04	-2.45*
IES 883 (L6)	1.81*	1.36*	-4.52*	3.16*

C.D. LINE (5%) = 0.67

C.D. TESTER (5%) = 0.46

C.D. LINE X TESTER (5%) = 1.14

* Significant at 5% level

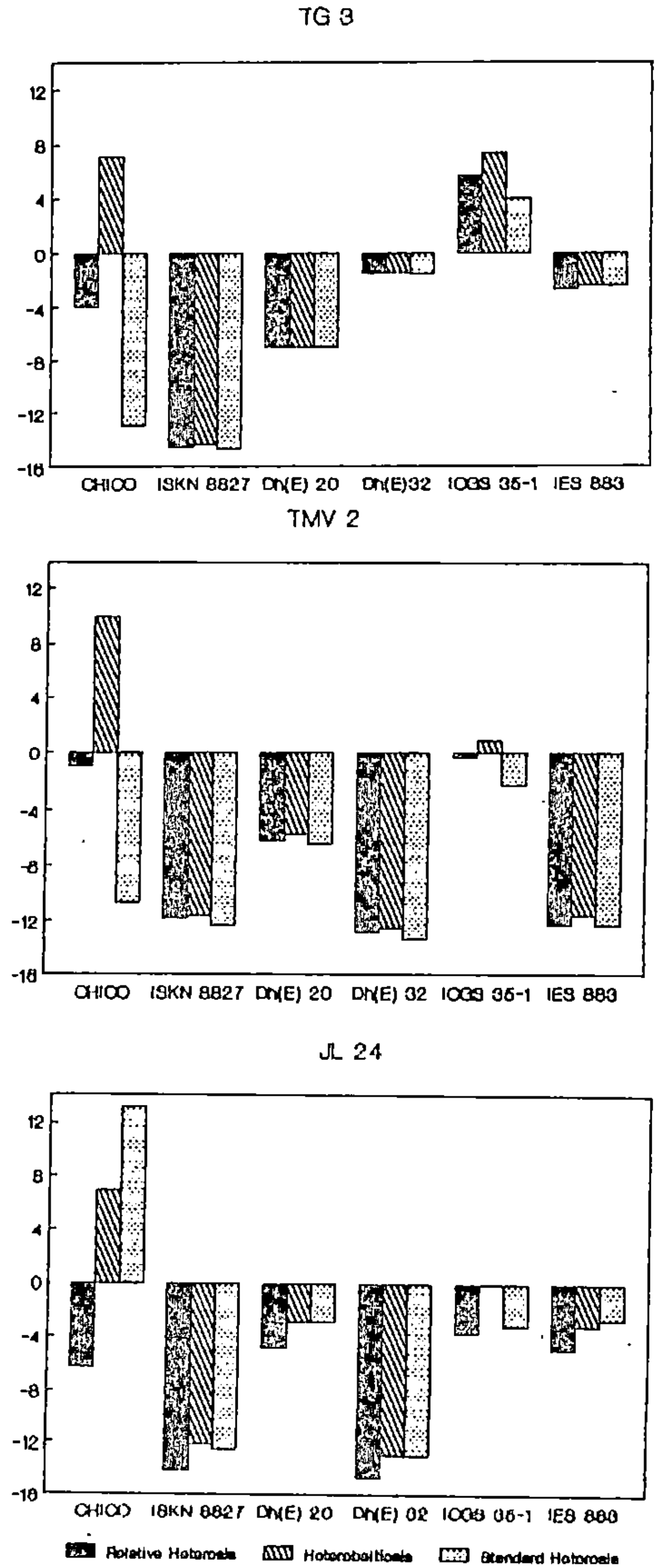
Table 34. HETEROSIS % - DAYS TO MATURITY

Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
Line	Relative heterosis (di)	Heterob- eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob- eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob- eltiosis (dii)	Standard heterosis (diii)
Chico (L1)	-3.97**	7.11**	-12.97**	-0.97NS	9.92**	-10.67**	-6.32**	6.91**	-13.13**
ISKN 8827 (L2)	-14.56**	-14.40**	-14.71**	-11.82**	-11.59**	-12.37**	-14.09**	-12.13**	-12.44**
Dh(E) 20 (L3)	-7.01**	-7.01**	-7.01**	-6.07**	-5.65**	-6.48**	-4.81**	-2.81**	-2.81**
Dh(E) 32 (L4)	-1.49**	-1.40**	-1.58**	-12.85**	-12.54**	-13.31**	-14.66**	-12.81**	-12.97**
ICGS 35-1 (L5)	5.69**	7.41**	4.02**	-0.27	0.90**	-2.28**	-3.66**	0.00	-3.15**
IES 683 (L6)	-2.71**	-2.46**	-2.46**	-12.28**	-11.66**	-12.44**	-4.88**	-3.14**	-2.63**

** Significant at 1% level

C.D di (5%) 1.15
C.D dii (5%) 0.40
C.D diii (5%) 0.40

Figure 11. HETEROSIS % - DAYS TO MATURITY



Out of the eighteen cross combinations, seven recorded significant negative sca effects. Among the remaining eleven combinations, seven showed significant positive sca effects.

In table 34 and figure 11, the estimates of the three types of heterosis are presented. Relative heterosis (di) for the trait ranged from -14.68 to 5.69. ICGS(E) 35-1 x TG 3 (L5 x T1) showed the maximum heterotic value while Dh(E) 32 x JL 24 (L4 x T3) showed the minimum value.

Heterobeltiosis was estimated by considering the early maturing parent as the better parent, because earlinessis the desired trait. The (dii) values ranged from -14.40 to 9.92. Chico x TMV 2 (L1 x T2) showed the highest heterotic value while ISKN 8827 X TG 3 (L2 x T1) showed the lowest value.

Standard heterosis (diii) ranged from -14.71 to 4.02. The combination ICGS 35-1 x TG 3 (L5 x T1) showed the maximum heterotic value while ISKN 8827 x TG 3 (L2 x T1) showed the minimum value (Figure 12).

Figure 12. Cross combination - ISKN 8827 (L2) X TG 3 (T1) showing the minimum value for standard heterosis - days to maturity

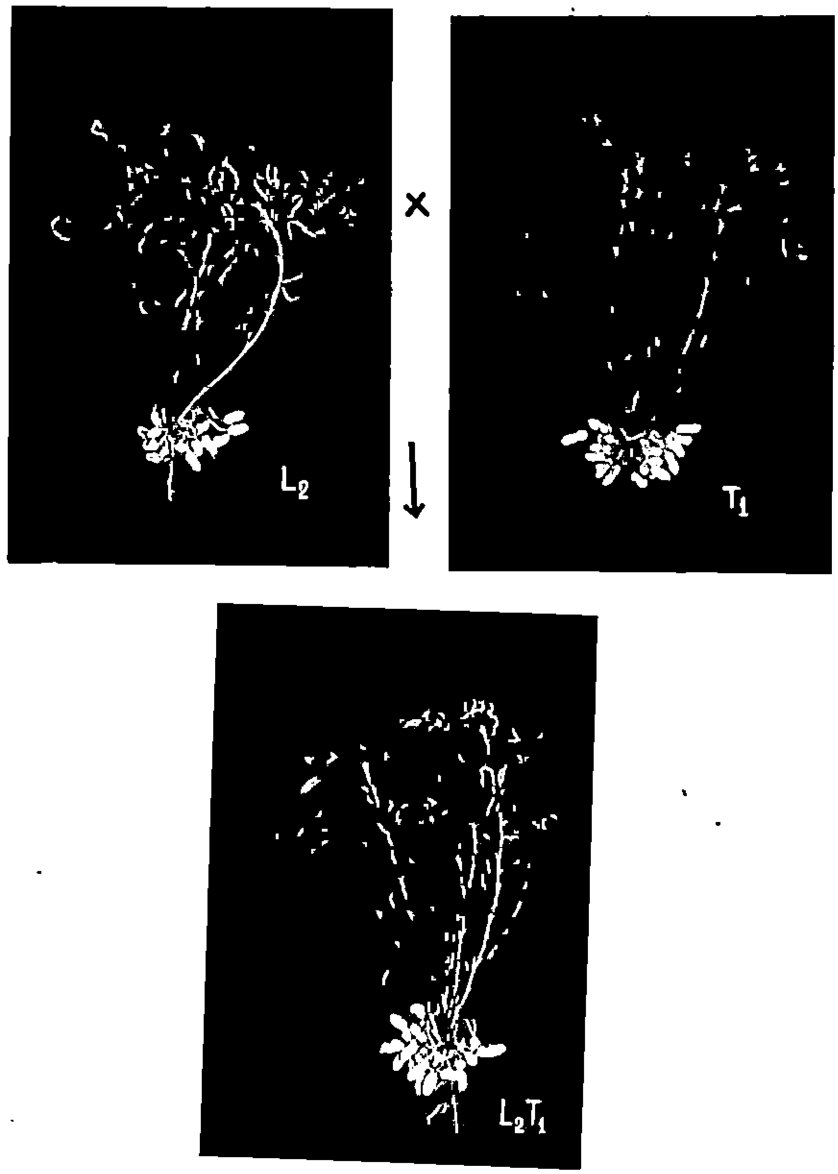


Figure 12.

4.2.1.4. Number of immature pods per plant.

In table 35 the mean performance of lines, testers and their hybrids are presented. Among lines, the mean number of immature pods per plant ranged from 1.35 to 3.19, while among testers it ranged from 2.24 to 3.50. The range was from 1.46 to 4.15 among the hybrids.

The combining ability effects of lines, testers and their combinations are presented in table 36. Among lines, Chico (L1), ISKN 8827 (L2) and Dh(E) 32 (L4) showed significant negative gca effects while Dh(E) 20 (L3), ICGS 35-1 (L5) and IES 883 (L6) showed significant positive effects. None of the testers recorded significant gca effects. Out of the eighteen cross combinations, eight combinations recorded significant negative sca effects and seven combinations recorded significant positive effects.

The estimates of the three types of heterosis are presented in table 37 and figure 13. Heterosis over the mid-parental value (di) ranged from -53.94 to 100.48. ICGS 35-1 X TG 3 (L5 x T1) recorded the highest heterotic value while Dh(E) 32 x TMV 2 (L4 x T2) recorded the lowest value.

Table 35. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - NUMBER OF IMMATURE PODS PER PLANT

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	2.64	3.50	2.24
Lines	Mean of Lines	Mean of hybrids		
Chico (L1)	1.35	2.84	2.12	1.75
ISKN 8827 (L2)	2.29	1.84	1.54	1.71
Dh(E) 20 (L3)	2.15	2.79	2.37	3.38
Dh(E) 32 (L4)	2.84	3.65	1.46	1.83
ICGS 35-1 (L5)	1.50	4.15	3.21	2.73
IES 883 (L6)	3.19	2.40	1.70	3.61

Table 36. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - NUMBER OF IMMATURE PODS PER PLANT

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of Testers	0.44	-0.44	0.003
Lines	gca of Lines	sca of Combimations		
Chico (L1)	-0.27*	0.16	0.33*	-0.49*
ISKN 8827 (L2)	-0.81*	-0.30*	0.28*	0.02
Dh-(E)-20 (L3)	0.35*	-0.50*	-0.04	0.54*
Dh-(E)-32 (L4)	-0.19*	0.90*	-0.42*	-0.48*
ICGS-35-1 (L5)	0.86*	0.35*	0.28*	-0.63*
IES- .883 (L6)	6.78*	-0.61	-0.43*	1.04*

C.D. LINE (5%) = 0.11

C.D. TESTER (5%) = 0.80

C.D. LINE X TESTER (5%) = 0.20

* Significant at 5% level

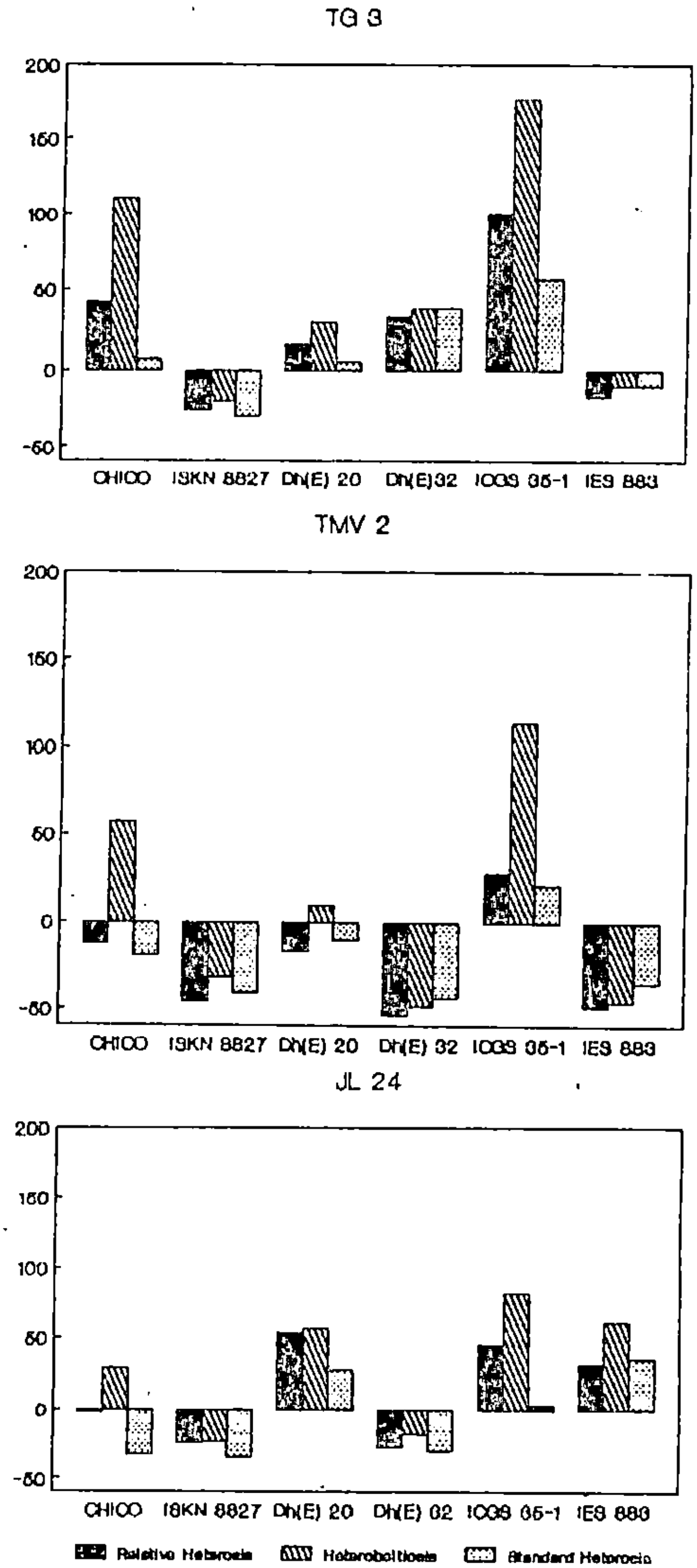
Table 37. HETEROSIS % - NUMBER OF IMMATURE PODS PER PLANT

Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
Lines	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)
Chico (L1)	42.36**	110.37**	7.58**	-12.58**	57.04**	-19.70**	-2.51**	29.63**	-33.71**
ISKN 8827 (L2)	-25.35**	-19.65**	-30.30**	-46.80**	-32.75**	-41.67**	-24.50**	-23.66**	-35.23**
Dh(E) 20 (L3)	16.49**	29.77**	5.68**	-16.11**	10.23**	-10.23**	53.99**	57.21**	28.03**
Dh(E) 32 (L4)	33.21**	38.26**	38.26**	-53.94**	-48.59**	-44.70**	-27.95**	-18.30**	-30.68**
ICGS 35-1 (L5)	100.48**	176.67**	57.20**	28.40**	114.00**	21.59**	45.99**	82.00**	3.41**
IES 883 (L6)	-17.67**	-9.09**	-9.09**	-49.18**	-46.71**	-35.60**	32.97**	61.16**	36.74**

** Significant at 1% level

C.D di (5%) 0.06
C.D dii (5%) 0.04
C.D diii (5%) 0.04

Figure 13. HETEROSIS % - NUMBER OF IMMATURE PODS PER PLANT



Heterosis over the better parent was estimated by keeping the parent with least number of immature pods per plant as the better parent. The (dii) value ranged from - 48.59 to 176.67. The highest value was recorded by the combination ICGS 35-1 X TG 3 (L5 x T1) and the lowest value by Dh(E) 32 X TMV 2 (L4 X T2).

Heterosis over the check type (diii) ranged from - 44.70 to 57.20. The highest value was showed by ICGS 35-1 X TG 3 (L5 X T1) and the lowest value by Dh(E) 32 x TMV 2 L4 X T2).

4.2.1.5. Number of mature pods per plant

In table 38, the mean performance of lines, testers and their hybrids for the trait are presented. The mean number of mature pods per plant ranged from 11.39 to 12.75 among lines, from 8.52 to 15.71 among testers and from 8.80 to 16.31 among hybrids.

The combining ability effects of lines, testers and their combinations for the trait are presented in table 39. Among lines, Dh(E) 20 (L3), Dh(E)32 (L4) and ICGS 35-1 (L5) recorded significant positive gca effects while,

Table 38. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS NUMBER OF MATURE PODS PER PLANT

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	11.28	15.71	8.52
Lines	Mean of Lines	Mean of hybrids		
Chico (L1)	11.48	12.74	12.55	11.54
ISKN 8827 (L2)	12.24	13.03	8.80	11.14
Dh(E) 20 (L3)	11.27	15.49	10.53	16.31
Dh(E) 32 (L4)	12.75	13.07	11.99	15.80
ICGS 35-1 (L5)	11.39	12.59	15.23	12.86
IES 883 (L6)	12.69	12.95	10.84	13.95

Table 39. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - NUMBER OF MATURE PODS PER PLANT

	Testers lines	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of Testers	0.46**	-1.20**	0.74**
Lines	gca of Lines	sca of Combinations		
Chico (L1)	-0.58*	0.009	1.47*	-1.48*
ISKN 8827 (L2)	-1.87*	1.58*	-0.99*	-0.59
Dh(E) 20 (L3)	1.26*	0.92	-2.38*	1.46*
Dh(E) 32 (L4)	0.76*	-1.00*	-0.43	1.44*
ICGS 35-1 (L5)	0.70*	-1.43*	2.87*	-1.44*
IES 883 (L6)	-0.28	-0.08	-0.54	0.62

C.D. LINE (5%) = 0.54

C.D. TESTER (5%) = 0.38

C.D. LINE X TESTER (5%) = 0.94

* Significant at 5% level

chico(L1) and ISKN 8827 (L2) recorded significant negative gca effects. Among testers, TG 3(T1) and JL 24 (T3) recorded significant positive gca effect and TMV 2 (T2), significant negative effect. Out of the eighteen cross combinations, five recorded significant positive sca effects while six recorded significant negative effects.

The three types of heterosis estimated are furnished in table 40 and figure 14. Relative heterosis (di) for the trait ranged from -37.03 to 48.57. The combination Dh(E)32 x JL 24 (L4 x T3) recorded the highest heterotic value while ISKN 8827 X TMV 2 (L2 x T2) recorded the lowest value.

Heterobeltiosis was estimated by considering the parent with greater number of mature pods as the better parent. The dii values for the trait ranged from -43.98 to 40.97. The hybrid Dh(E) 20 x JL 24 (L3 x T3) recorded the maximum heterotic value while the hybrid ISKN 8827 x TMV 2 (L2 x T2) the minimum value.

Standard heterosis (diii) for the trait ranged from -21.99 to 44.59. The highest value was recorded by Dh(E) 20 x JL 24 (L3 x T3) and the lowest value by ISKN 8827 x TMV 2 (L2 x T2).

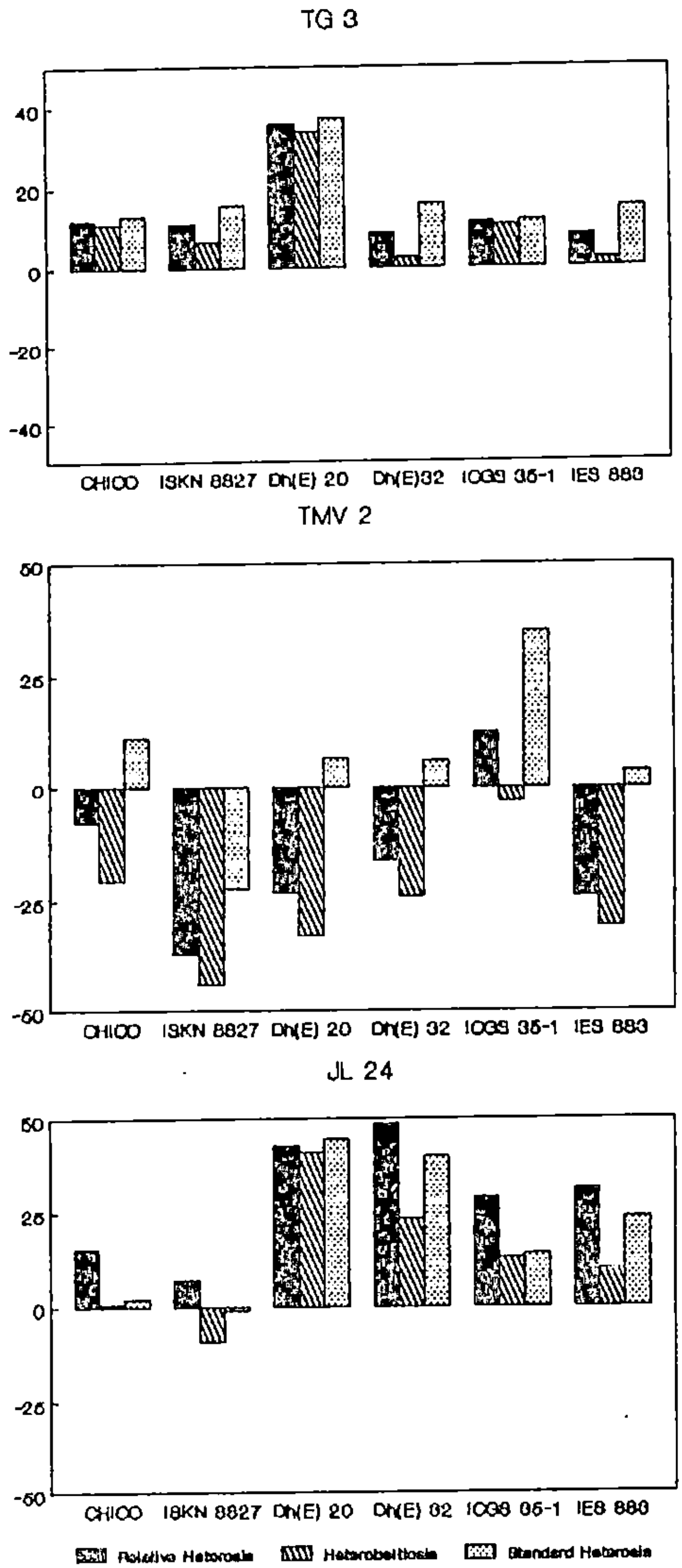
Table 40. HETEROSIS % - NUMBER OF MATURE PODS PER PLANT

Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
Lines	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)
Chico (L1)	11.96**	10.98**	12.94**	-7.69**	-20.11**	11.26**	15.40**	0.52	2.30**
ISKN 8827 (L2)	10.80**	6.45**	15.51**	-37.03**	-43.98**	-21.99**	7.32**	-8.99**	-1.24**
Dh(E) 20 (L3)	35.58**	33.88**	37.32**	-22.80**	-32.97**	6.65**	42.76**	40.97**	44.59**
Dh(E) 32 (L4)	8.78**	2.51**	15.87**	-15.74**	-23.68**	6.29**	48.57**	23.42**	40.07**
ICGS 35-1 (L5)	11.07**	10.54**	11.61**	12.40**	-3.06**	35.02**	29.18**	12.91**	14.01**
IES 883 (L6)	8.05**	2.05**	14.80**	-23.66**	-31.00**	3.90**	31.54**	9.93**	23.67**

** Significant at 1% level

C.D di (5%) 0.94
C.D dii (5%) 0.02
C.D diii (5%) 0.02

Figure 14. HETEROSIS % - NUMBER OF MATURE PODS PER PLANT



4.2.1.6. Haulms yield per plant

In table 41, the mean performance of lines, testers, and their hybrids for the trait are presented. The mean values ranged from 28.52 to 71.76 g. among lines, from 49.10 to 66.63 g. among testers and from 21.19 to 61.60 g. among hybrids.

The combining ability effects of lines, testers and their combinations are presented in table 42. ICGS 35-1 (L5) and IES 883 (L6) showed positive gca effects and chico (L1) showed significant negative gca effects among lines. None of the testers showed significant gca effects. Among the cross combinations none recorded significant sca effects.

The three types of heterosis estimates for the trait are presented in table 43 and figure 15. Heterosis over mid-parental value (di) ranged from -52.41 to 29.52 per cent. The highest heterotic value was registered by ICGS 35-1 x TMV 2 (L5 x T2) and the lowest value by chico x TMV 2 (L1 x T2).

Table 41. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - HAULMS YIELD PER PLANT

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	66.63	60.53	49.10
Lines	Mean of Lines	Mean of hybrids		
Chico (L1)	28.52	25.79	21.19	23.56
ISKN 8827 (L2)	45.22	38.36	40.94	41.73
Dh(E) 20 (L3)	48.49	44.00	39.87	40.72
Dh(E) 32 (L4)	37.71	34.82	39.27	31.02
ICGS 35-1 (L5)	34.59	41.83	61.60	43.53
IES 883 (L6)	71.76	52.70	50.81	52.67

Table 42. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - HAULMS YIELD PER PLANT

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of Testers	-0.66	2.04	-1.37
Lines	gca of Lines	sca of Combinations		
Chico (L1)	-16.73*	2.94	-4.36	1.42
ISKN 8827 (L2)	0.10	-1.33	-1.44	2.76
Dh(E) 20 (L3)	1.29	3.13	-3.70	0.56
Dh(E) 32 (L4)	-5.21	0.44	2.20	-2.64
ICGS 35-1 (L5)	8.74*	-6.49	10.58	-4.08
IES 883 (L6)	11.81*	1.30	-3.28	1.98

C.D. LINE (5%) = 6.21

C.D. TESTER (5%) = 4.39

C.D. LINE X TESTER (5%) = 10.76

* Significant at 5% level

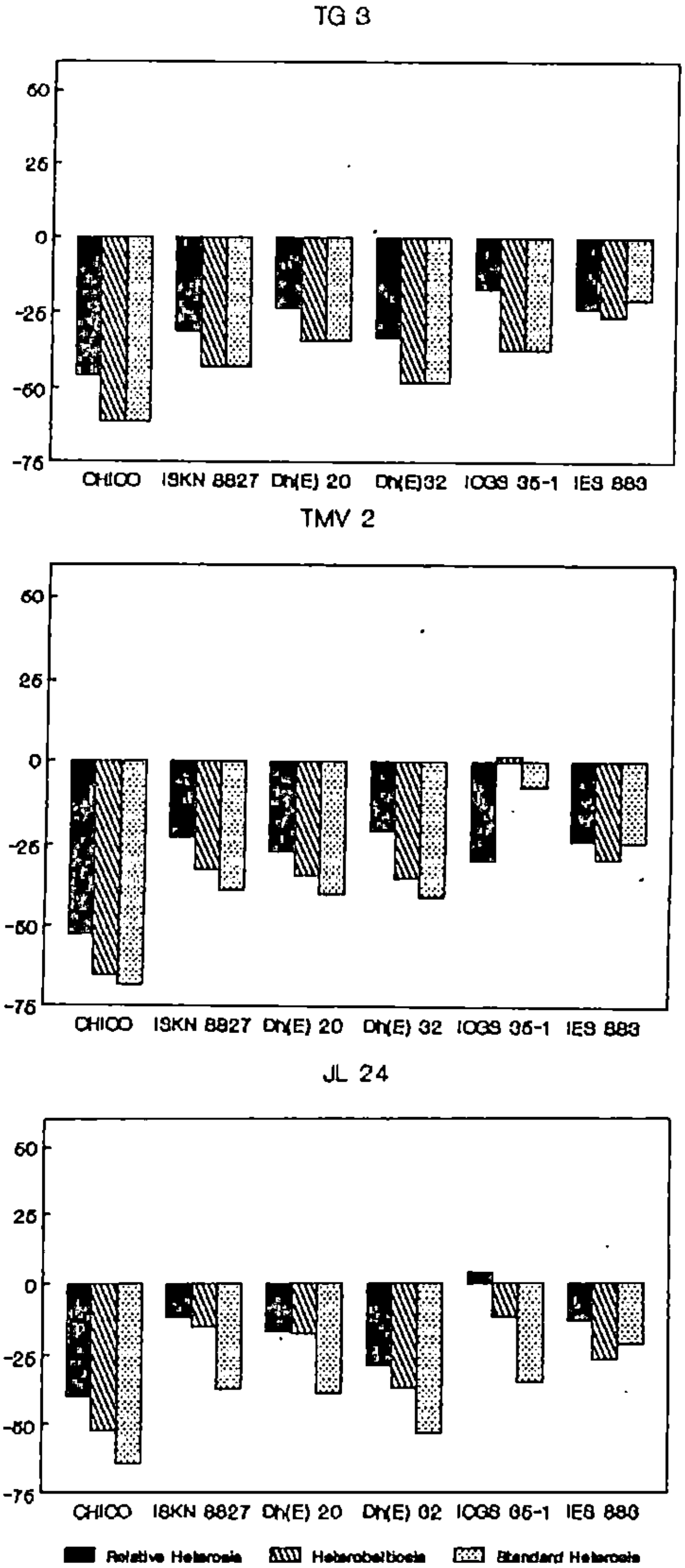
Table 43. HETEROSIS % - HAULMS YIELD PER PLANT

Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
Lines	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)
Chico (L1)	-45.79**	-61.29**	-61.29**	-52.41**	-64.99**	-68.23**	-39.29**	-52.02**	-64.64**
ISKN 8827 (L2)	-31.41**	-42.43**	-42.43**	-22.57**	-32.36**	-38.56**	-11.51*	-15.01**	-37.37**
Dh(E) 20 (L3)	-23.56**	-33.96**	-33.96**	-26.86**	-34.13**	-40.16**	-16.55**	-17.07**	-38.89**
Dh(E) 32 (L4)	-33.26**	-47.74**	-47.74**	-20.05**	-35.12**	-41.06**	-28.53**	-36.82**	-53.44**
ICGS 35-1 (L5)	-17.35**	-37.22**	-37.22**	29.52**	1.77	-7.55	4.03	-11.34*	-34.67
IES 883 (L6)	-23.84**	-26.56**	-20.91**	-23.18**	-29.19**	-23.74**	-12.84*	-26.60**	-20.95**

** Significant at 1% level

C.D di (5%) 10.75
C.D dii (5%) 9.33
C.D diii (5%) 11.95

Figure 15. HETEROSIS % - HAULMS YIELD PER PLANT



Heterobeltiosis was calculated by considering the parent with higher haulms yield per plant which is the desired trait as the better parent. Heterosis over the better parental value (dii) ranged from -64.99 to 1.77. The highest heterotic value was showed by ICGS 35-1 X TMV 2 (L5 x T2) and the lowest by chico x TMV 2 (L1 x T2).

Heterosis over the standard parent (diii) ranged from -68.23 to -7.55.The highest value was recorded by ICGS 35-1 x TMV 2 (L5 xT2) and the lowest value by chico x TMV 2 (L1 xT2).

4.2.1.7. Pod yield per plant

The mean performance of lines, testers and their hybrids for the trait are presented in table 44. The mean values ranged from 6.31 to 19.00 g. among lines, from 16.28 to 19.41 g. among the testers and from 7.00 to 18.87 g. among hybrids.

In table 45, the combining ability effects of lines testers and their combinations are presented. Among lines, ISKN 8827 (L2) Dh(E) 20 (L3) Dh(E) 32 (L4) and IES 883(L6) recorded significant positive gca effects and chico (L1) recorded significant negative gca effects. Among

Table 44. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - POD YIELD PER PLANT (g.)

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	19.41	16.62	16.28
Lines	Mean of Lines	Mean of hybrids		
Chico (L1)	6.31	7.00	9.76	7.57
ISKN 8827 (L2)	15.30	18.27	11.29	16.00
Dh(E) 20 (L3)	19.00	9.62	18.76	17.08
Dh(E) 32 (L4)	16.65	17.01	15.19	18.87
ICGS 35-1 (L5)	16.98	13.37	16.95	11.02
IES 883 (L6)	14.86	18.86	18.31	14.13

Table 45. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - POD YIELD PER PLANT

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of Testers	-0.37	0.65*	-0.28
Lines	gca of Lines	sca of Combinations		
Chico (L1)	-6.30*	-0.74	1.00	-0.26
ISKN 8827 (L2)	0.80*	3.45*	-4.55*	1.09
Dh-(E)-20 (L3)	0.76*	-5.16*	2.96*	2.20*
Dh-(E)-32 (L4)	2.63*	0.36	-2.48*	2.13*
ICGS-35-1 (L5)	-0.61	-0.04	2.52*	-2.48*
IES- .883 (L6)	2.71*	2.14*	0.57	-2.69*

C.D. LINE (5%) = 0.71

C.D. TESTER (5%) = 0.50

C.D. LINE X TESTER (5%) = 1.22

* Significant at 5% level

testers, significant positive gca effect was recorded by TMV 2 (T2). Six cross combinations showed significant positive sca effects and five showed significant negative sca effects.

The three types of heterosis estimates for the trait are presented in table 46 and figure 16. Relative heterosis (di) for the character ranged from -49.91 to 16.33 per cent. The highest heterosis value for the trait was recorded by IES 883 x TMV 2 (L6 x T2) (Figure 17)and the lowest value by Dh(E) 20 xTG 3 (L3 x T1).

Heterosis over the better parent was estimated by keeping the parent with higher pod yield per plant as the better parent. Heterobeltiosis (dii) for the character ranged from -63.94 to 10.17 . The highest value was recorded by IES 883 x TMV 2 (L6 x T2) (Figure 17) and the lowest value by hybrid, chico x TG 3 (L1 x T1).

Standard heterosis (diii) ranged from -63.94 to -2.78 per cent. The hybrid Dh(E) 32 X JL 24 (L4 x T3) (Figure 18) recorded the highest value while the hybrid chico x TG 3 (L1 x T1) recorded the lowest heterosis value.

Table 46. HETEROSIS % - POD YIELD PER PLANT

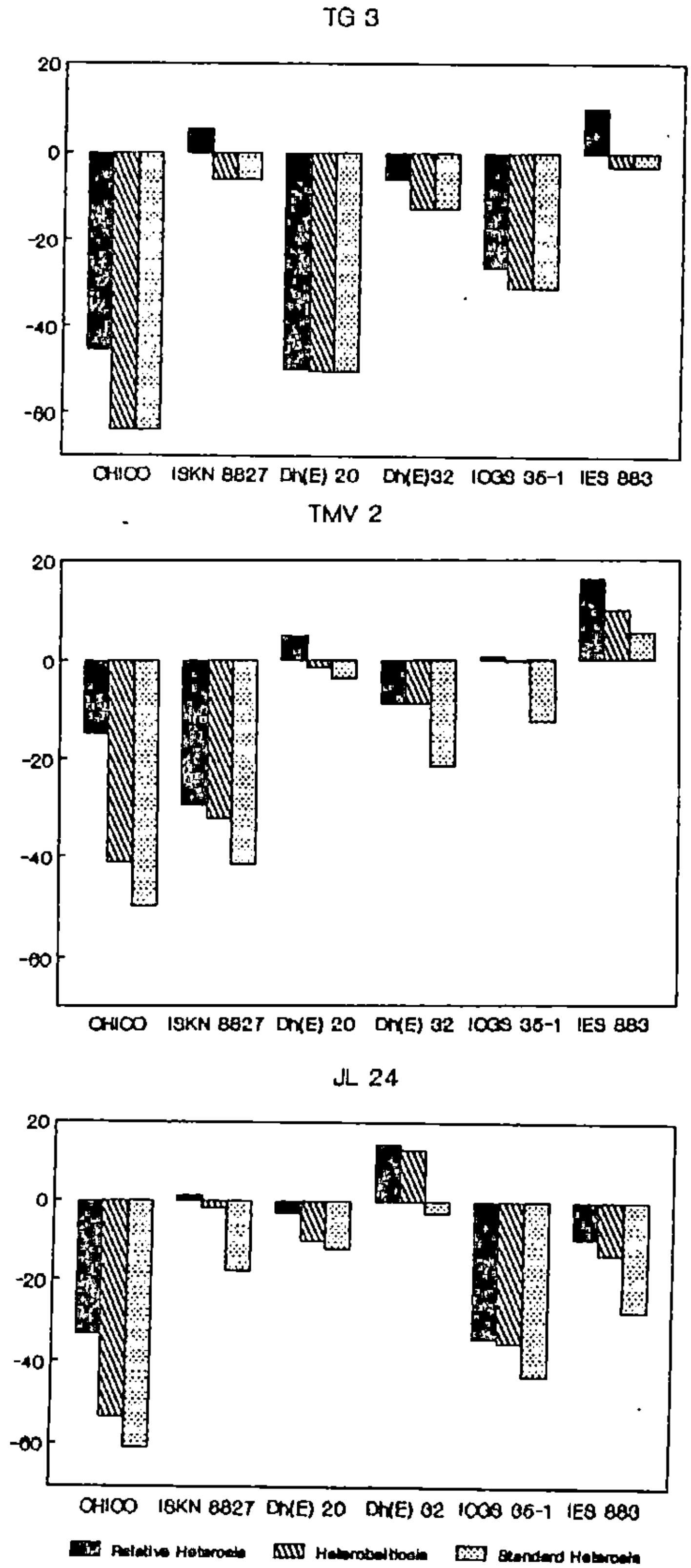
Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)
Chico (L1)	-45.57**	-63.94**	-63.94**	-14.87**	-41.28**	-49.72**	-32.98**	-53.50**	-61.00
ISKN 8827 (L2)	5.27**	5.87**	5.87**	-29.26**	-32.13**	-41.83**	1.33**	-1.72**	-17.57**
Dh(E) 20 (L3)	-49.91**	-50.44**	-50.44**	5.33**	-1.26**	-3.35**	-3.35**	-10.11**	-12.00**
Dh(E) 32 (L4)	-5.66**	-12.36**	-12.36**	-8.69**	-8.77**	-21.74**	14.61**	13.33**	-2.78**
ICGS 35-1 (L5)	-26.52**	-31.11**	-31.11**	0.89	-0.18	-12.67**	-33.73**	-35.10**	-43.23**
IES 883 (L6)	10.10**	-2.83**	-2.83**	16.33**	10.17**	5.67**	-9.25**	-13.21**	-27.20**

* Significant at 5% level

** Significant at 1% level

C.D. di (5%) 1.23
C.D. dii (5%) 1.05
C.D. diii (5%) 1.05

Figure 16. HETEROSIS % - POD YIELD PER PLANT



igure 17. Cross combination - IES 883 (L6) X TMV 2 (T2) showing the highest values for relative heterosis and heterobeltiosis - pod yield per plant.

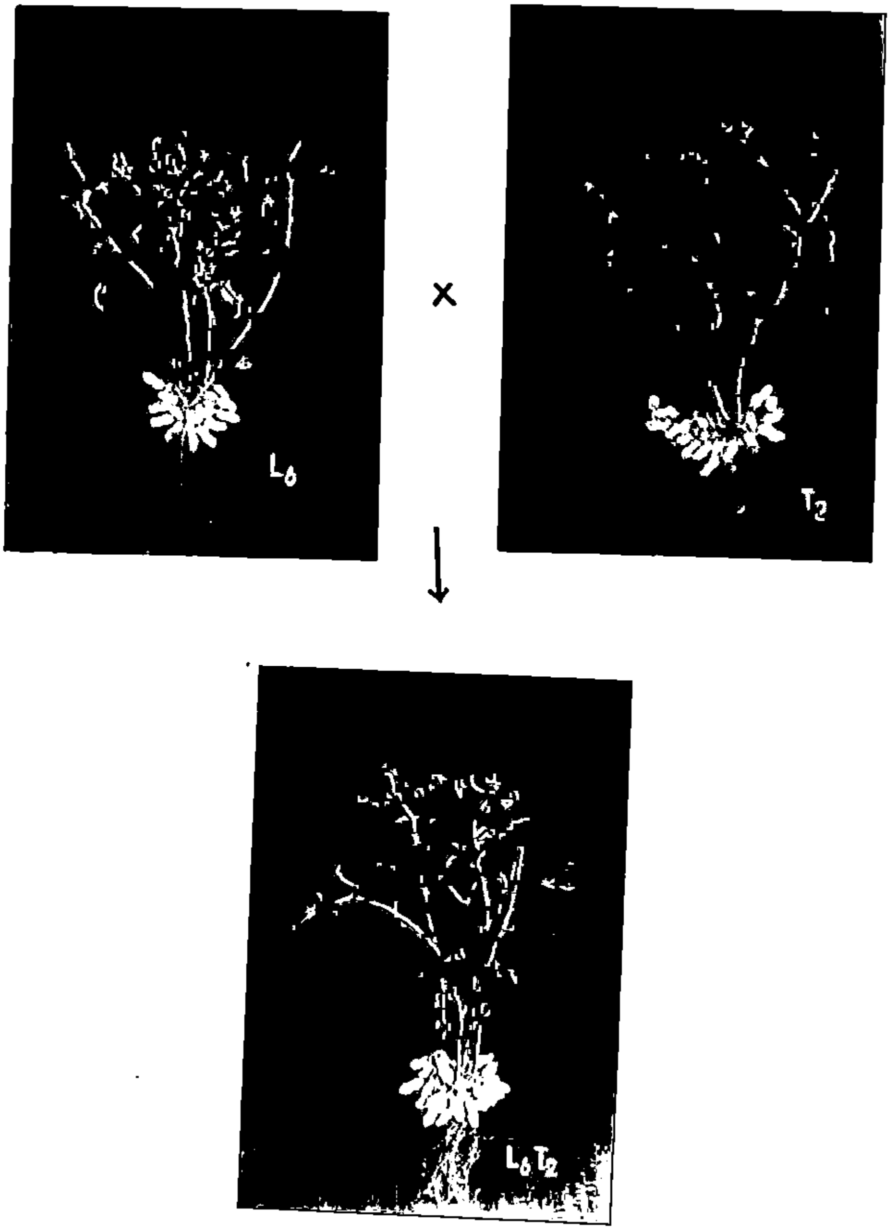


Figure 17.

Figure 18. Cross combination - Dh (E) 32 (L4) X jL 24 (T3) showing the highest value for standard heterosis - pod yield per plant

Figure 18.

4.2.1.8. 100 Pod Weight.

The mean performance of lines, testers and their hybrids are presented in table 47. Among lines, the mean values ranged from 45.04 to 99.06 g.. Among testers, the range was from 86.98 to 111.13 g.. The mean values ranged from 42.70 to 104.11 g. among hybrids.

In table 48, the combining ability effects of lines, testers and their combinations are presented. Among lines Dh(E) 20 (L3) and IES 883 (L6) recorded significant positive gca effects while, chico (L1) and ICGS 35-1 recorded significant negative gca effects. None of the testers showed significant gca effects. Seven cross combinations registered significant positive sca effects, while four combinations registered significant negative sca effects.

The three types of heterosis estimates for the trait are presented in table 49 and figure 19. Relative heterosis (di) ranged from -50.76 to 33.24 percent. The hybrid, Dh(E) 20 x TMV 2 (L3 x T2) recorded the highest value, while chico x JL 24 (L1 x T3) recorded the lowest value.

Table 47. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - 100 POD WEIGHT (g.)

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	99.19	86.98	111.13
Lines	Mean of Lines	Mean of hybrids		
Chico (L1)	45.04	42.70	55.90	38.45
ISKN 8827 (L2)	95.18	90.59	60.35	91.85
Dh(E) 20 (L3)	69.30	86.60	104.11	89.16
Dh(E) 32 (L4)	99.06	89.90	56.43	89.54
ICGS 35-1 (L5)	93.53	69.08	79.28	68.82
IES 883 (L6)	62.87	98.17	99.27	100.07

Table 48. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - 100 POD WEIGHT

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of Testers	1.16	-2.46	1.30
Lines	gca of Lines		sca of Combinations	
Chico (L1)	-32.66*	-4.14	12.68*	-8.54*
ISKN 8827 (L2)	2.58	8.50*	-18.12*	9.62*
Dh(E) 20 (L3)	14.94*	-7.85*	13.28*	-5.43
Dh(E) 32 (L4)	0.28	10.16*	-19.74*	9.62*
ICGS 35-1 (L5)	-5.96*	-4.47	9.34*	-4.87
IES- .883 (L6)	20.82**	-2.15	2.55	-0.40

C.D. LINE (5%) = 4.14

C.D. TESTER (5%) = 2.93

C.D. LINE X TESTER (5%) = 7.17

* Significant at 5% level

Table 49. HETEROSIS % - 100 POD WEIGHT

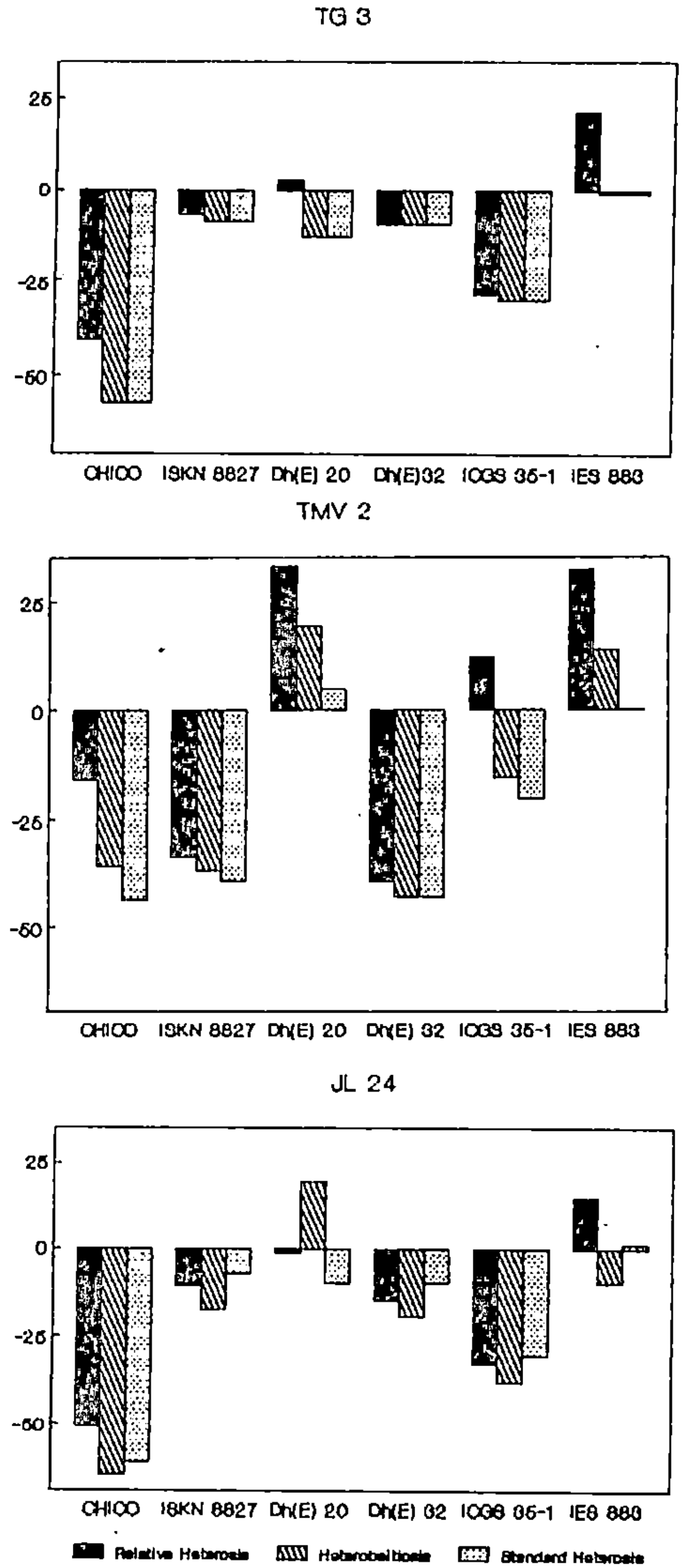
Testers	TG 3 (T1)			TMV 3 (T2)			JL 24 (T3)		
	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)
Chico (L1)	-40.79**	-56.95**	-56.95**	-15.32**	-35.73**	-43.64**	-50.76**	-65.40**	-61.24**
ISKN 8827 (L2)	-6.79	-8.67**	-8.67**	-33.74**	-36.59**	-39.16	-10.96**	-17.35**	-7.40*
Dh(E) 20 (L3)	2.80	-12.70**	-12.70**	33.24**	19.69**	4.96	-1.17	19.77**	-10.11**
Dh(E) 32 (L4)	-9.31**	-9.37**	-9.37**	-39.34**	-43.03**	-43.11	-14.80**	-19.43**	-9.73**
ICGS 35-1 (L5)	-28.31**	30.36**	-30.36**	-12.16**	-15.24**	-20.07	-32.75**	-38.07**	-30.62**
IES 883 (L6)	21.15**	-1.03	-1.03	32.49**	14.13**	0.08	15.02**	-9.95**	0.89

* Significant at 5% level

** Significant at 1% level

C.D. di (5%) 7.18
C.D. dii (5%) 6.21
C.D. diii (5%) 6.21

Figure 19 HETEROSIS % - 100 POD WEIGHT



Heterobeltiosis (dii) was calculated by considering the parent with higher 100 pod weight as the better parent. The dii values ranged from -65.40 to 19.69 percent. The highest heterotic value was showed by Dh(E) 20 x TMV 2 (L3 x T2) and the lowest value by chico x JL 24 (L1 x T3).

Standard heterosis (dii) ranged from -61.24 to 4.96 per cent. The highest value was registered by the hybrid Dh(E) 20 x TMV 2 (L3 x T2) and the lowest value by hico x JL 24 (L1 x T3).

4.2.1.9. Shelling percentage

The mean performance of lines, testers and their hybrids are presented in table 50. The mean values ranged from 58.08 to 74.67 among lines. Among testers, the range was from 65.93 to 74.59. Among hybrids, the mean values ranged from 51.01 to 79.00.

The combining ability effects of lines, testers, and their hybrids are presented in table 51. chico (L1) and ISKN 8827 (L2) showed significant positive gca effects while Dh(E) 20 (L3) and IES 883 (L6) showed significant negative gca effects. Among testers TMV 2 (T2) registered

Table 50. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - SHELLING PERCENTAGE

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	67.85	65.93	74.59
Lines	Mean of Lines	Mean of hybrids		
Chico (L1)	60.38	79.00	73.70	70.14
ISKN 8827 (L2)	71.57	72.74	70.26	73.12
Dh(E) 20 (L3)	58.08	51.01	64.55	68.79
Dh(E) 32 (L4)	64.54	62.60	75.84	73.03
ICGS 35-1 (L5)	74.67	67.37	67.22	62.19
IES 883 (L6)	65.65	61.92	67.79	61.35

Table 51. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - SHELLING PERCENTAGE

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of Testers	-2.15*	1.97*	0.18
Lines	gca of Lines	sca of Combinations		
Chico (L1)	6.36*	6.87*	-2.55	-4.32
ISKN 8827 (L2)	4.11*	2.85	-3.75	0.90
Dh(E) 20 (L3)	-6.47*	-8.29*	1.13	7.16*
Dh(E) 32 (L4)	2.57	-5.74*	3.38	2.36
ICGS 35-1 (L5)	-2.33	3.93	-0.34	-3.59
IES 883 (L6)	-4.24*	0.38	2.13	-2.51

C.D. LINE (5%) = 2.61

C.D. TESTER (5%) = 1.84

C.D. LINE X TESTER (5%) = 4.52

* Significant at 5% level

significant and positive gca effects while TG 3 (T1) registered significant and negative gca effect. Among the eighteen cross combinations, only two showed significant positive sca effects and two, signficant negative sca effects.

The heterosis estimates for the trait are presented in table 52 and figure 20. Heterosis over the mid-parental value (di) ranged from - 18.99 to 23.22 per cent. The highest heterotic value was registered by chico x TG 3 (L1 x T1) while the lowest value was recorded by Dh (E) 20 x TG3 (L3 x T1).

Heterobeltiosis was estimated by considering the parent with the higher shelling percentage as the better parent. Heterosis over the better parental value (dii) ranged from -24.82 to 16.43 per cent.The hybrid chico x TG 3 3 (L1 x T1) recorded the maximum value and the minimum value was registered by Dh(E) 20 x TG 3 (L3 x T1).

Heterosis over the standard type (diii) ranged from - 24.82 to 16.43 per cent. The hybrid chico x TG 3 (L1 x T1) registered the highest value while the lowest heterotic effect was showed by Dh (E) 20 x TG 3 (L3 x T1).

Table 52. HETEROSIS % - SHELLING PERCENTAGE

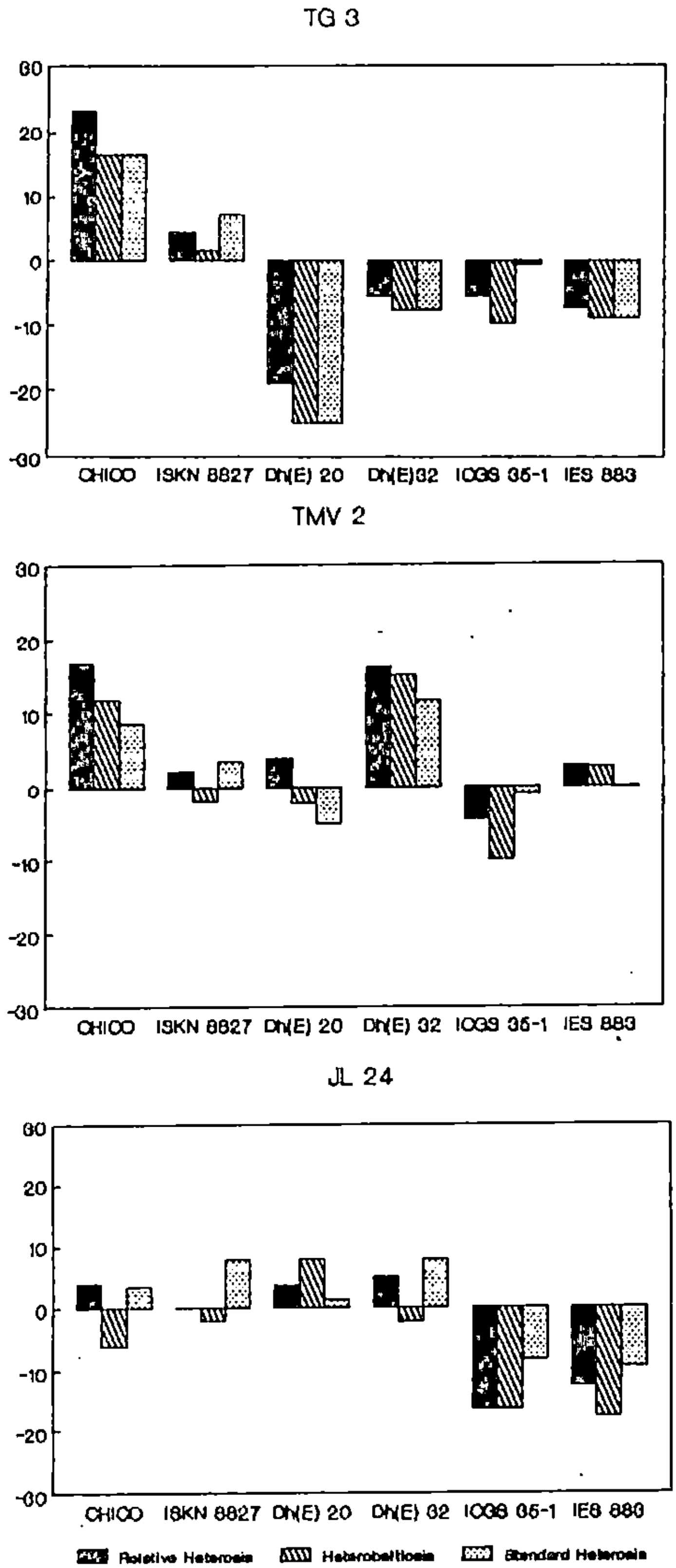
Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)
Chico (L1)	23.22**	16.43**	16.43**	16.70**	11.79**	8.62**	3.93	-5.97**	3.38
ISKN 8827 (L2)	4.35	1.63	7.21**	2.20	-1.83	3.55	0.05	-1.97	7.77**
Dh(E) 20 (L3)	-18.99**	-24.82**	-24.82**	4.10	-2.09	-4.86*	3.70	7.78**	1.39
Dh(E) 32 (L4)	-5.43*	-7.74**	-7.74**	16.26**	15.03**	11.76**	4.98*	-2.09	7.63**
ICGS 35-1 (L5)	-5.46*	-9.78**	-0.71	-4.38	-9.98**	-0.93	-16.67**	-16.71**	-8.34**
IES 883 (L6)	-7.24**	-8.74**	-8.74**	3.04	2.82	-0.09	-12.51**	-17.75**	-9.59**

* Significant at 5% level

** Significant at 1% level

C.D. di (5%) 4.52
C.D. dii (5%) 3.92
C.D. diii (5%) 3.92

Figure 20. HETEROSIS % - SHELLING PERCENTAGE



4.2.1.10. 100 Kernel weight

In table 53 the mean performance of lines, testers and their hybrids for the trait are presented. The mean values ranaged from 21. 96 to 46.13 g. among lines, from 38.52 to 55.51 g. among testers and from 23.00 to 51.04 g. among hybrids.

In table 54, the combining ability effects of lines, testers and their combinations are presented. Dh(E)20 (L3), Dh(E) 32 (L4) and IES 883 (L6) recorded significant positive gca effects while chico (L1) and ISKN 8827 (L2) showed significant negative gca effects.Among testers,TMV 2 (T2) and JL 24 (T3) registered significant and positive gca effects while, TG 3 (T1) registered significant negative effect. Among the eighteen cross combinations, six registered significant and positive sca effects while six others combinations recorded significant and negative sca effects.

The three type of heterosis estimates are presented in table 55 and figure 21. Relative heterosis (di) for the trait ranged from -54.56 to 33.18 percent. The highest heterotic value was showed by IES 883 x TMV 2 (L6 x

Table 53. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - 100 KERNEL WEIGHT (g.)

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	48.54	38.52	55.51
Lines	Mean of Lines	Mean of hybrids		
Chico (L1)	21.96	25.79	23.00	17.60
ISKN 8827 (L2)	38.77	24.30	39.38	41.73
Dh(E) 20 (L3)	38.31	47.43	45.36	41.92
Dh(E) 32 (L4)	46.13	39.27	41.75	49.29
ICGS 35-1 (L5)	39.44	43.11	38.98	33.43
IES 883 (L6)	38.13	46.51	51.04	50.21

Table 54. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - 100 KERNEL WEIGHT

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of testers	-1.16*	1.02*	0.16*
Lines	**gca of lines**	**sca of combinations**		
Chico (L1)	-16.77*	4.82*	-0.15	-4.67*
I4427 (L2)	-3.76*	-9.70*	3.22*	6.46*
Dh(E) 20 (L3)	6.00*	3.68*	-0.57	-3.11*
Dh(E) 32 (L4)	4.57*	-3.00*	-2.71*	5.72*
ICGS 35-1 (L5)	-0.39	5.76*	-0.55	-5.21*
IES 883 (L6)	10.36*	-1.58	0.76	0.82

C.D. LINE (5%) = 0.99

C.D. TESTER (5%) = 0.70

C.D. LINE X TESTER (5%) = 1.72

* Significant at 5% level

Table 55. HETEROSIS % - 100 KERNEL WEIGHT

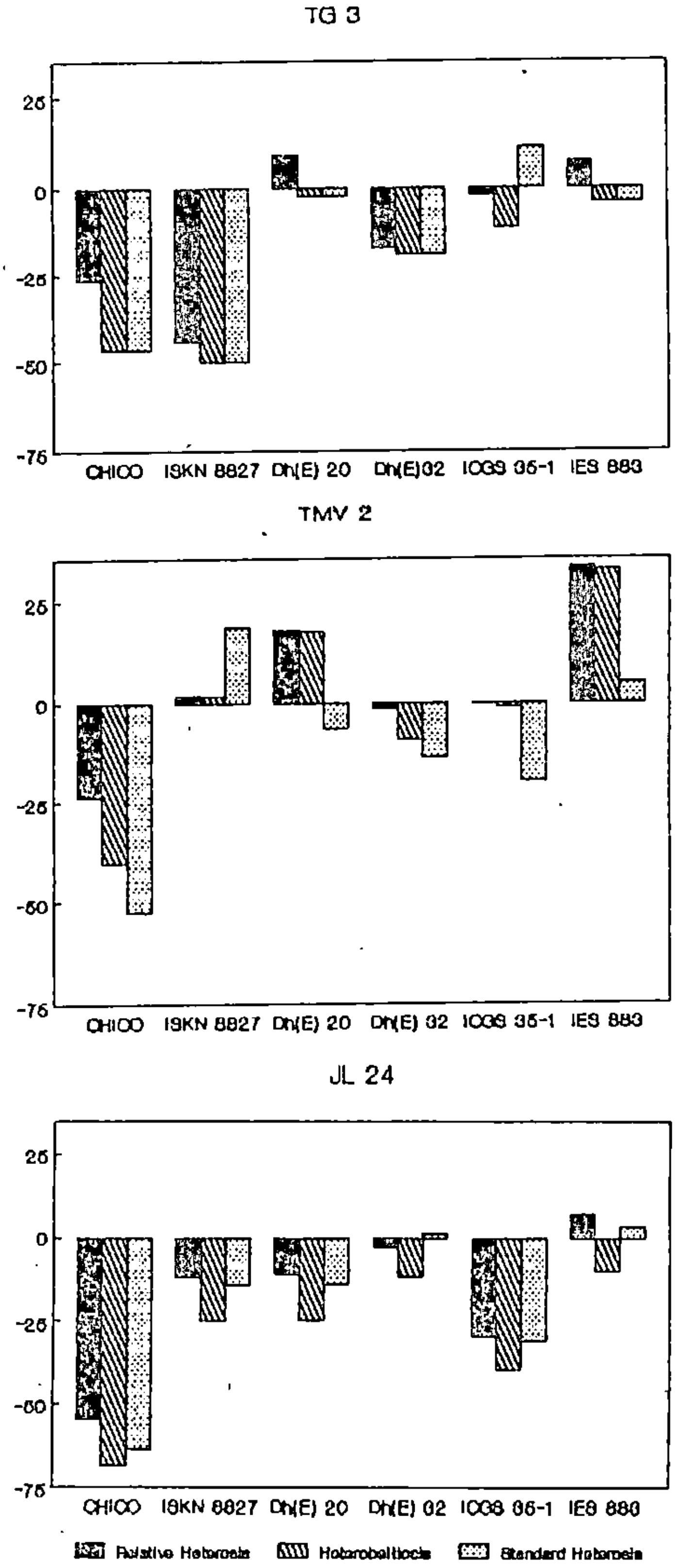
Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis diii)
Chico (L1)	-26.84	-46.87**	-46.87**	-23.94**	-40.29**	-52.62**	-54.56**	-68.29**	-63.74**
ISKN 8827 (L2)	-44.34**	-49.94**	-49.394**	1.90**	1.57*	-18.87**	-11.48**	-24.82**	-14.03**
Dh(E) 20 (L3)	9.22**	-2.29**	-2.29**	18.08**	17.76**	-6.55**	-10.64**	-24.48**	-13.64**
Dh(E) 32 (L4)	-17.04**	-19.10**	-19.10**	-1.36	-9.49**	-13.99**	-3.01**	-11.21**	1.55*
ICGS 35-1 (L5)	-2.00*	-11.19**	-11.19**	0.00	-1.17	-19.70	-29.58**	-39.78**	-31.13**
IES 883 (L6)	7.34**	-4.18**	-4.18**	33.18**	32.50**	5.15**	7.24**	-9.55**	3.44**

* Significant at 5% level

** Significant at 1% level

C.D. di (5%) 1.73
C.D. dii (5%) 1.49
C.D. diii (5%) 1.49

Figure 21. HETEROSIS % - 100 KERNEL WEIGHT



T2) and the lowest value by chico x JL 24 (L1 x T3).

Heterobeltiosis for the trait was estimated by considering the parent with higher 100 kernel weight as the better parent. The dii value ranged from -68.29 to 32.50 percent. The maximum heterotic value was registered by IES 883 x TMV 2(L6 x T2) and the lowest value by chico x JL 24 (L1 x T3).

Standard heterosis (diii) for the trait ranged from - 63.74 to 5.15 percent. The hybrid, IES 883 x TMV 2(L6 x T2) registered the highest value while, the lowest heterotic value was recorded by chico x JL 24 (L1 x T3).

4.2.1.11. Oil content.

The mean perfomance of lines, testers and their hybrids for the trait are presented in table 56. The mean values among lines ranged from 47.44 to 49.33 percent. Among testers, the range was from 47.43 to 49.13 percent. The range of mean among hybrids was from 45.33 to 50.77 percent.

The combining ability effects of lines, testers and their combinations are presented in table 57. Among lines, chico(L1) and ICGS 35-1 (L5) recorded significant and

Table 56. MEAN PERFORMANCE OF LINES, TESTERS AND HYBRIDS - OIL CONTENT (%)

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	Mean of Testers	47.43	49.13	48.35
Lines	Mean of lines	Mean of hybrids		
Chico (L1)	47.44	49.59	49.51	49.50
ISKN 8827 (L2)	48.97	50.07	47.79	48.51
Dh(E) 20 (L3)	48.07	48.12	49.04	49.93
Dh(E) 32 (L4)	48.24	45.33	48.62	48.73
ICGS 35-1 (L5)	48.21	49.91	49.96	49.08
IES 883 (L6)	49.33	50.77	48.01	48.23

Table 57. COMBINING ABILITY EFFECTS OF LINES, TESTERS AND COMBINATIONS - OIL CONTENT

	Testers	TG 3 (T1)	TMV 2 (T2)	JL 24 (T3)
	gca of Testers	0.04	-0.10	0.07
Lines	gca of lines	sca of combinations		
Chico (L1)	0.61**	0.02	0.08	-0.10
I4427 (L2)	-0.14	1.24*	-0.89*	-0.34
Dh(E) 20 (L3)	0.09	-0.95*	0.11	0.83*
Dh(E) 32 (L4)	-1.37**	-2.27*	1.17*	1.10*
ICGS 35-1 (L5)	0.72**	0.22	0.42	-0.64
IES 883 (L6)	0.08	1.73*	-0.89*	-0.84*

C.D. LINE (5%) = 0.47

C.D. TESTER (5%) = 0.33

C.D. LINE X TESTER (5%) = 0.81

* Significant at 5% level

positive gca effects while Dh(E) 32 (L4) recorded significant negative gca effect. None of the testers showed significant gca effects. Five cross combinations recorded significant and positive sca effects while, five other combinations registered significant negative sca effects.

The estimates of the three types of heterosis are presented in table 58 and figure 22. Relative heterosis for oil content ranged from -5.24 to 4.94 percent. The hybrid, IES 883 x TG 3 (L6 x T1) recorded the highest hetrotic value while the lowest value was recorded by Dh(E) 32 x TG 3 (L4 x T1).

Heterobeltiosis was estimated by keeping the parent with higher oil content as the better parent. The (dii) values ranged from -6.03 to 4.53 per cent. The hybrid chico x TG 3 (L1 x T1) registered the highest value while the lowest heterotic value was recorded by Dh(E) 32 x TG 3 (L4 x T1)

Standard heterosis ranged for the trait from -4.43 to 7.04 per cent. The hybrid IES 883 x TG 3 (L6 x T1) recorded the maximum heterotic value while the minimum value was recorded by Dh(E) 32 x TG 3 (L4 x T1).

Table 58. HETEROSIS % - OIL CONTENT

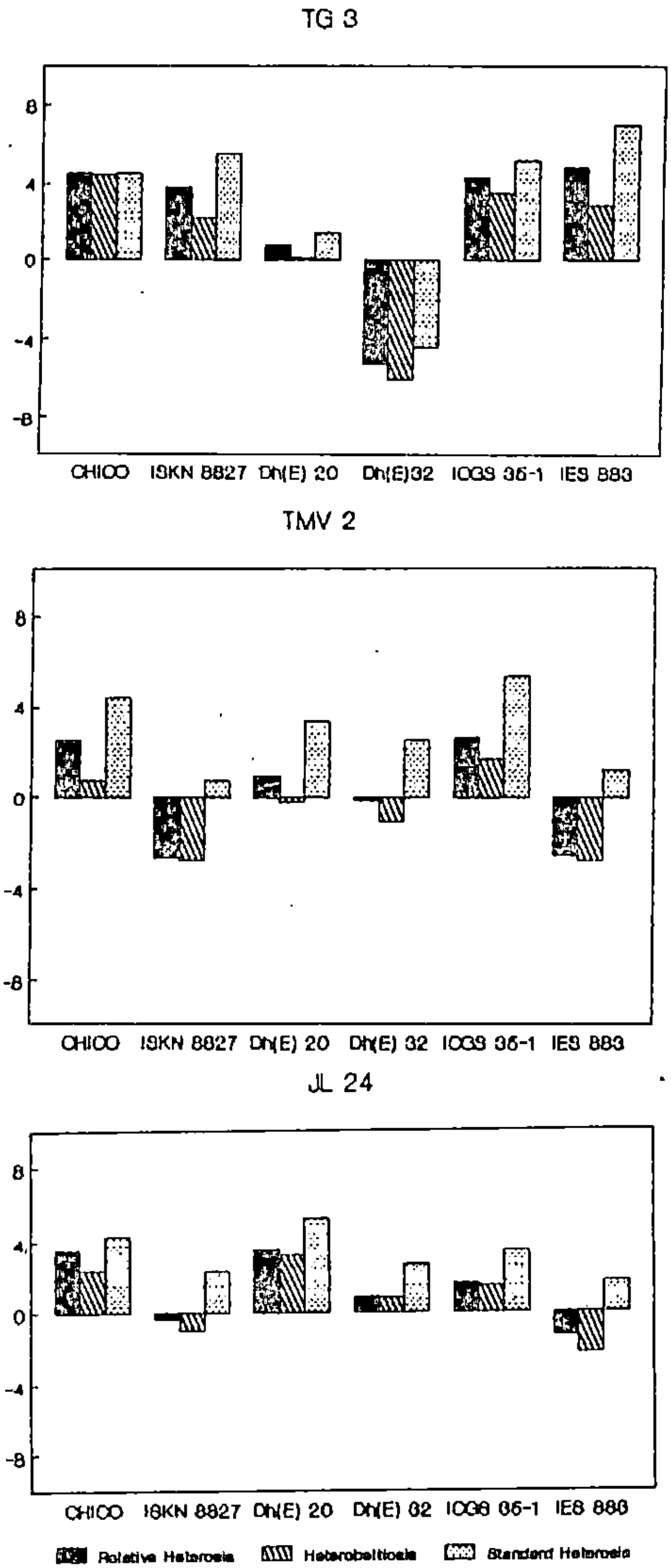
Testers	TG 3 (T1)			TMV 2 (T2)			JL 24 (T3)		
	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)	Relative heterosis (di)	Heterob-eltiosis (dii)	Standard heterosis (diii)
Chico (L1)	4.54**	4.53**	4.55**	2.54**	0.77*	4.39**	3.35**	2.38**	4.36**
ISKN 8827 (L2)	3.88**	2.25**	5.57**	-2.57**	-2.73**	0.76*	-0.31	-0.94**	2.28**
Dh(E) 20 (L3)	0.77	0.10	1.45**	0.91*	-0.18	3.39**	3.57**	3.27**	5.27**
Dh(E) 32 (L4)	-5.24	-6.03**	-4.43**	-0.13**	-1.04**	2.51**	0.90*	0.79**	2.74**
ICGS 35-1 (L5)	4.37**	3.53**	5.23**	2.65**	1.69**	5.33**	1.66**	1.51**	3.48**
IES 883 (L6)	4.94**	2.92**	7.04**	-2.48**	-2.68**	1.22**	-1.25**	-2.23**	1.69**

* Significant at 5% level

** Significant at 1% level

C.D. di (5%) 0.80
C.D. dii (5%) 0.70
C.D. diii (5%) 0.70

Figure 22. HETEROSIS % - OIL CONTENT



4.2.2. Variance Ratio and Genetic component of Variance

The magnitudes of gca and sca variances and the variance ratios (gca/sca) for all the 11 characters were computed and the data are presented in table 59. The genetic components of variances were also estimated and are presented in table 60.

The variance ratio for days to first flowering was 0.11. When inbreeding coefficient (F) was zero, dominance genetic variance for the trait (0.09) was greater than additive genetic variance (0.07), when F=1, additive component (0.03) was greater than the dominance component (0.02).

The variance ratio for spread of flowering was 1.00. Dominance genetic variance (F.0=0.26; F.1= 0.07) was greater than the additive components (F.0=0.01; F.1=0.01).

The variance ratio for days to maturity was 0.05. Dominance genetic component (F.0 = 57.03; F.1=14.26) was greater than additive component (F.0=5.26; F.1=2.63).

Table 59. MAGNITUDE OF GCA VARIANCE AND SCA VARIANCE

Sl.No.	Character	gca Variance	sca Variance	Ratio (gca variance/ sca variance)
1.	Days to first flowering	0.02	0.16	0.11
2.	Spread of flowering	0.01	0.01	1.000
3.	Days to maturity	1.32	29.28	0.05
4.	No. of immature pods per plant	0.02	0.82	0.03
5.	No.of mature pods per plant	0.05	4.41	0.01
6.	Haulms yield per plant	7.56	90.79	0.08
7.	Pod yield per plant	0.49	14.24	0.03
8.	100 pod weight	21.88	370.07	0.06
9.	Shelling percentage	1.19	39.66	0.03
10.	100 kernel weight	6.15	92.56	0.07
11.	Oil content	0.02	1.02	0.02

Table 60. GENETIC COMPONENTS OF VARIANCE

Sl.No.	Character	A		D	
		F.0	F.1	F.0	F.1
1.	Days to first flowering	0.07	0.03	0.09	0.02
2.	Spread of flowering	0.01	0.01	0.26	0.07
3.	Days to maturity	5.26	2.63	57.03	14.26
4.	No. of immature pods per plant	0.09	0.04	1.79	0.45
5.	No.of mature pods per plant	0.20	0.10	12.83	3.21
6.	Haulms yield per plant	30.23	15.12	48.30	12.07
7.	Pod yield per plant	1.95	0.97	43.67	10.92
8.	100 pod weight	87.53	43.76	669.73	167.43
9.	Shelling percentage	4.75	2.37	112.33	28.08
10.	100 kernel weight	24.62	12.31	129.71	32.43
11.	Oil content	0.07	0.04	6.44	1.61

A - Additive component

D - Dominance component

F - Inbreeding coefficient

Number of immature pods per plant showed variance ratio equal to 0.03. Dominance genetic variance (F.0=1.79; F.1= 0.45) was greater than additive genetic variance (F.0=0.09; F.1= 0.04).

The variance ratio for number of mature pods per plant was 0.01. Dominance genetic component(F.0=12.83; F.1=3.21) was greater than the additive component (F.0= 0.20; F.1=0.10).

Haulms yield per plant recorded a variance ratio of 0.08. Dominance component (F.0 = 48.30; F.1=12.07) was greater than the additive component (F.0=30.23; F.1= 15.12).

The variance ratio for pod yield per plant was 0.03. Dominance genetic variance (F.0=43.67; F.1=10.92) was greater than additive genetic variance (F.0=1.95; F.1= 0.97).

100 pod weight recorded variance ratio of 0.06. Dominance genetic component (F.0=669.73; F.1=167.43) was greater than the additive component (F.0=87.53; F.1=43.76)

The variance ratio for shelling percentage was 0.03. Dominance component of variance (F.0=112.33;

F.1=28.08) was greater than the additive counterpart (F.0=4.75; F.1= 2.37).

The variance ratio for 100 kernel weight was 0.07. Dominance genetic component F.0=129.71; F.1=32.43) was greater than the additive component (F.0=24.62; F.1= 12.31).

Oil content recorded variance ratio of 0.02. Dominance genetic variance (F.0=6.44; F.1=1.61) was greater than the additive component (F.0=0.07; F.1=0.04).

4.2.3. Propotional contribution of lines, testers and line x tester to total variance.

The contribution of lines, testers and line x tester to the total variance are presented in table 61 and figure 23. Of the total variance for days to first flowering, the contribution of lines was 78.85 percent, of testers, 3.55 percent and of line x tester, 17.60 percent.

In the case of spread of flowering, of the total variance, the contribution of lines was 33.00 percent, of testers, 4.26 percent and of line x tester, 62.74 percent.

Table 61. PROPORTIONAL CONTRIBUTION OF LINES, TESTERS AND LINE X TESTER TO TOTAL VARIANCE

Sl.No.	Character	Lines (percent)	Testers (percent)	Line x Tester (percent)
1.	Days to first flowering	78.85	3.55	17.60
2.	Spread of flowering	33.00	4.26	62.74
3.	Days to maturity	62.79	8.01	29.20
4.	No. of immature pods per plant	41.60	19.75	38.65
5.	No.of mature pods per plant	29.79	20.00	50.22
6.	Haulms yield per plant	83.86	2.07	14.10
7.	Pod yield per plant	59.08	1.37	39.55
8.	100 pod weight	74.72	0.77	24.51
9.	Shelling percentage	52.03	6.87	41.10
10.	100 kernel weight	80.10	0.84	19.10
11.	Oil content	33.03	0.42	66.55

Figure 23.

X1 - days to first flowering

X2 - spread of flowering

X3 - days to maturity

X4 - number of immature pods per plant

X5 - number of mature pods per plant

X6 - haulms yield per plant

X7 - pod yield per plant

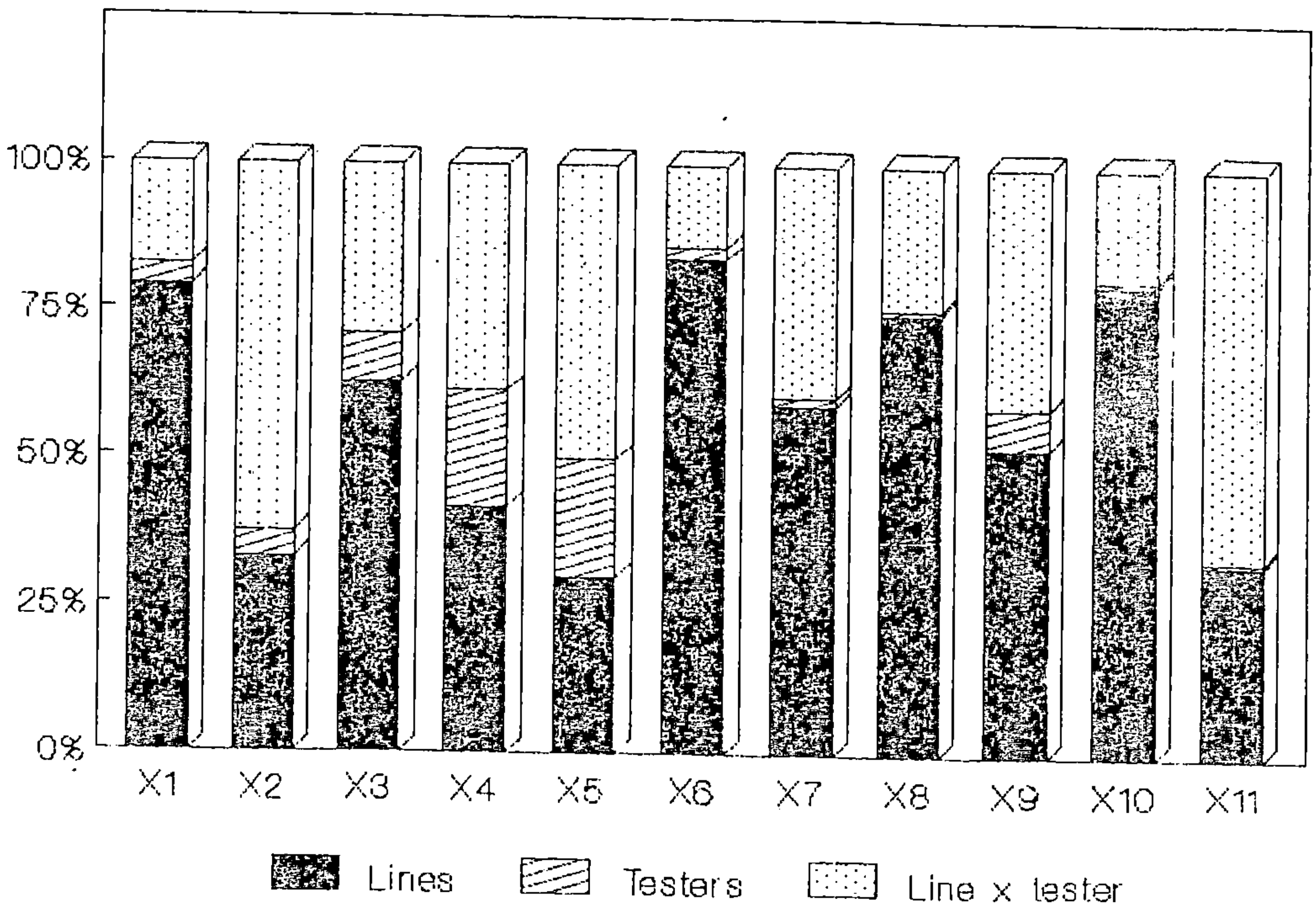
X8 - 100 pod weight.

X9 - shelling percentage

X10 - 100 kernel weight

X11 - Oil content

Figure 23. PROPORTONAL CONTRIBUTION OF LINES, TESTERS AND LINE X TESTER TO TOTAL VARIANCE



With regard to days to maturity, lines contributed 62.79 per cent, testers, 8.01 percent and line x tester, 29.20 per cent to the total variance.

Of the total variance for number of immature pods per plant, the contribution of lines was 41.60 per cent, of tester, 19.75 per cent and of line x tester, 38.65 per cent.

In the case of number of mature Pods per plant, the lines contributed 29.79 percent, testers, 20.00 percent and line x tester 50.22 per cent to the total variance.

Of the total variance for haulms yield per plant, the contribution of lines was 83.86 per cent, of testers, 2.07 per cent and of line x tester, 14.10 per cent.

With regard to pod yield per plant, the lines contributed 59.08 percent, testers, 1.37 percent and line x tester, 39.55 percent to the total variance.

Out of the total variance for 100 pod weight, the proportional contribution of lines was 74.72 per cent, of testers was 0.77 percent and of line x tester was 24.51

percent.

In the case of shelling percentage, of the total variance, the lines contributed 52.03 percent, testers, 6.87 percent, and line x tester, 41.10 percent.

Of the total variance for 100 kernel weight, the proportional contribution of lines was 80.10 percent, of testers, 0.84 per cent and of line x tester, 19.10 percent.

With respect to the oil content, lines contributed 33.03 percent, testers, 0.42 percent and line x tester, 66.55 per cent to the total variance.

4.3. Selection in F_2 population

The range and mean values for the different traits such as number of immature pods per plant, number of mature pods per plant, pod yield per plant, kernel yield per plant and shelling percentage of the F_2 selections in the 18 F_2 families are presented in table 62. In the case of number of immature pods per plant, the lowest range (0 - 6) was recorded by the family, L4 x T1 and the highest range (0-19) by L3 x T1. The lowest mean value for the above trait (2.70) was registered by the family L2 x T2 and

Table 62. RANGE AND MEAN VALUES OF F_2 SELECTIONS

F_2 Families	No of immature pods/plant		No of mature pods / plant		Pod yield/plant (g.)		Kernel yield / plant (g.)		Shelling percentage	
	Range	Mean ± S.E.	Range	Mean ± S.E	Range	Mean ± S.E.	Range	Mean ± S.E.	Range	Mean ± S.E.
L1 X T1	3-12	6.02 ± 0.64	13-32	25.12 ± 1.22	7.88-24.65	12.34 ± 1.10	6.33-14.02	9.86 ± 1.02	56.79-69.70	62.95 ± 1.56
L1 X T2	0-15	5.17 ± 0.58	10.30	26.40 ± 1.80	8.80-26.94	15.26 ± 1.20	4.02-17.99	9.45 ± 1.04	46.65-67.79	61.93 ± 1.55
L1 X T3	1-14	5.30 ± 0.58	11-28	22.70 ± 1.20	8.26-25.05	14.42 ± 1.00	5.05-14.14	9.32 ± 1.07	56.48-67.28	64.63 ± 1.47
L2 X T1	0-11	5.80 ± 0.67	10-29	23.50 ± 1.62	11.39-26.36	16.78 ± 1.12	7.13-14.32	12.10 ± 1.14	58.50-73.40	72.11 ± 1.38
L2 X T2	0-12	2.70 ± 0.53	10-23	19.37 ± 1.29	10.67-25.77	17.21 ± 1.48	7.86-16.56	10.10 ± 1.17	56.60-61.91	58.69 ± 0.98
L2 X T3	0- 9	3.57 ± 0.40	12-30	22.53 ± 1.41	12.70-23.35	19.40 ± 1.22	7.28-17.18	12.66 ± 0.99	61.93-72.17	65.26 ± 1.67
L3 X T1	0-19	4.13 ± 0.65	10-28	23.33 ± 1.12	11.28-29.39	19.69 ± 1.00	8.59-19.74	12.87 ± 1.22	57.08-66.02	65.36 ± 1.50
L3 X T2	0-10	3.86 ± 0.43	10-30	23.27 ± 1.30	9.80-24.69	17.84 ± 1.04	6.36-15.89	12.15 ± 1.03	60.60-73.83	68.11 ± 1.56
L3 X T3	0-12	4.43 ± 0.54	10-29	22.83 ± 1.48	9.14-29.19	20.17 ± 1.12	6.83-18.06	12.65 ± 1.13	55.49-65.09	62.72 ± 1.43
L4 X T1	0- 6	2.90 ± 0.30	10-29	17.93 ± 1.42	9.94-28.03	13.67 ± 1.51	6.32-17.71	10.04 ± 1.05	68.58-76.66	73.45 ± 1.41
L4 X T2	0-11	4.23 ± 0.50	10-24	16.80 ± 1.08	10.31-23.22	11.18 ± 1.02	8.08-15.46	8.75 ± 1.03	60.88-80.00	78.26 ± 1.66
L4 X T3	0-13	3.70 ± 0.55	11-27	22.53 ± 1.38	10.55-25.21	19.27 ± 1.57	7.41-19.83	14.82 ± 1.14	63.37-79.93	76.91 ± 1.58
L5 X T1	0.10	3.03 ± 0.45	14-29	23.50 ± 1.33	12.55-27.79	16.11 ± 1.28	9.36-20.84	10.78 ± 1.47	61.10-72.51	66.91 ± 1.47
L5 X T2	0- 9	3.60 ± 0.45	11-29	18.93 ± 0.84	10.25-26.14	15.55 ± 1.18	7.00-20.03	9.97 ± 1.02	58.82-71.05	64.12 ± 1.57
L5 X T3	0- 8	3.23 ± 0.46	10-27	14.22 ± 1.12	10.09-26.54	13.03 ± 1.24	6.82-19.53	9.96 ± 1.03	68.40-78.76	76.44 ± 0.98
L6 X T1	0- 9	3.00 ± 0.34	10-30	18.51 ± 1.20	9.97-27.72	17.01 ± 1.13	7.47-18.88	11.16 ± 0.99	64.80-69.01	65.61 ± 1.61
L6 X T2	0- 7	3.33 ± 0.32	12-28	17.45 ± 1.32	11.63-25.68	16.94 ± 1.28	8.10-18.78	10.43 ± 1.53	58.90-64.51	61.57 ± 1.48
L6 X T3	0- 8	3.27 ± 0.42	10-33	20.42 ± .37	10.14-30.03	18.96 ± 1.25	7.50-20.32	12.90 ± 1.19	61.88-75.60	68.04 ± 1.52

the highest by L1 x T1 (6.02). For number of mature pods per plant, the highest range was recorded by the family L6 x T3 (10-33) and the lowest by L5 x T1 (14-29). With regard to mean values for the trait, the highest value was registered by L1 x T2 (26.40) and the lowest by L5 x T3 (14.22). The highest range in the case of pod yield per plant was recorded by the family L3 x T3 (9.14 - 29.19 g.) and the lowest by L2 x T3 (12.70 - 23.35 g.). The highest mean pod yield per plant was also registered by the family, L3 x T3 (20.17g.) and the lowest was by L1 x T1 (12.34 g.). In the case of kernel yield per plant the highest range was showed by the family L1 x T2 (4.02 - 17.99 g.) and the lowest by L2 x T1 (7.13 - 14.32 g.). The highest mean kernel yield per plant was recorded by the family L4 x T3 (14.82 g.) and the lowest by L4 x T2 (8.75g.). The highest range for shelling percentage was registered by the family L1 x T2 (46.65 - 67.79) and lowest by L6 x T1 (64.80 - 69.01). The highest mean shelling percentage was recorded by the family L4 x T1 (78.26 percent) while,the lowest was by L1 x T2 (61.93 percent).

4.4. Genotype x Environment interaction

The pooled analysis of variance for the different traits such as number of immature pods per plant, number of mature pods per plant, pod yield per plant, 100 pod weight, shelling percentage and 100 kernel weight under three different environments are presented in table 63. In the case of oil content, the location wise analysis revealed that error variance was heterogeneous and interaction was absent and hence pooling of data was not possible. The study revealed that differences among the types were highly significant for number of immature pods per plant, number of mature pods per plant, pod yield per plant,100 pod weight, shelling percentage and 100 kernel weight. The G x E interaction components were significant for all the traits. The error variances were heterogeneous for all the traits except, 100 kernel weight. Hence, the G X E interaction was analysed only for 100 kernel weight.

The analysis of variance for stability for 100 kernel weight revealed that differences among the types (G) were highly significant (Table 64). The mean squares due to the environment (E), G X E , E + (G X E), E (linear) and G x E (linear) were highly significant. The linear

Table 63. POOLED ANOVA FOR DIFFERENT TRAITS

Source	df	M.S.S.					
		No.of immature pods/plant	No.of mature pods/plant	pod yield/ plant (g.)	100 pod weight(g.)	Shelling (%)	100 kernel weight (g.)
Types (G)	8	4.51**	30.36**	32.30**	1011.48**	52.39*	133.41**
Environments (E)	2	58.43**	87.07**	53.60**	2949.56**	528.56**	408.54**
G X E	16	3.49**	13.54**	9.42**	121.63**	21.59**	37.22**
Pooled Error	48	1.70	2.25	1.38	36.95	2.44	2.45

** Significant at 1% level.

Table 64. ANOVA OF PHENOTYPIC STABILITY FOR 100 KERNEL WEIGHT

Source	df	M.S.S.
Total	26	211.89
Types	8	133.41**
Environment + (Type x Environment)	18	78.48**
Environment (Linear)	1	816.21**
Type x Environment (Linear)	8	58.16**
Pooled Deviation	9	14.56
Pooled Error	48	2.45

** Significant at 1% level.

Table 65. PHENOTYPIC STABILITY PARAMETERS FOR 100 KERNEL WEIGHT

Sl. No.	Types	100 kernel weight (g)		
		Mean ($\bar{X}$)	Regression coefficient (b)	Deviation from regression (S^{-2}_{d1})
1.	Chico	21.70	0.03	-0.79
2.	ISKN 8827	37.88	0.22	-2.63
3.	Dh(E) 20	38.59	1.00	40.64
4.	Dh(E) 32	36.17	1.32	41.17
5.	ICGS 35-1	36.97	0.73	0.23
6.	IES 883	35.43	1.16	9.27*
7.	TG 3	40.24	2.58°	9.16
8.	TMV 2	34.10	0.33	18.72
9.	JL 24	46.95	1.64	6.29

General Mean = 36.45

S.E. (b) = 0.40

* - Significant at 5% level

o - Significantly deviating from 1.00

component of G X E interaction was preponderant. The parameters of phenotypic stability for 100 kernel weight are presented in table 65. With regard to the mean 100 kernel weight, JL 24 recorded the highest value followed by TG 3 , Dh(E) 20, ISKN 8827 and ICGS 35-1. The lowest mean was value shown by chico. With respect to the regression coefficient, Dh(E) 20 recorded unity while, IES 883 and ICGS 35-1 showed values comparatively near to unity. In the case of deviation from regression ($\bar{S}^2_{di}$), the lowest value was showed by ICGS 35-1, followed by chico and ISKN 8827.

DISCUSSION

DISCUSSION

Groundnut is the most important annual oilseed crop in this country. Till the sixties, the crop was grown only during the kharif season. Since then, its cultivation has been extended to the rabi and summer seasons also. This extension of the crop to non-traditional seasons has opened up new possibilities for groundnut production in the southern and central parts of the country. There is considerable scope for increasing production since the productivity of rabi and summer groundnut is double than that of Kharif (Patel,1988). In Kerala, the rice based cropping system with the rice - rice - groundnut sequence in wetlands offer new vistas in the production of groundnut. It is expected that about two lakh hectares of rice fallows can be brought under this crop during the summer season (Anon., 1978a). The major constraint in extending the crop to the summer rice fallows is the lack of an extra early type maturing in 80 to 90 days with synchronized pod maturity and moderate yield potential.

The present study was undertaken with the main objective of providing basic information to overcome the above constraint through development of extra early groundnut types suitable as a summer crop in the rice fallows. The results of studies conducted on variability, heritability, genetic advance, correlations, path analysis, combining ability and stability are discussed.

5.1. Variability, Heritability and Genetic Advance

A preliminary evaluation of 63 bunch types of groundnut was carried out for estimation of variability for maturity and related traits such as number of immature pods per plant, number of mature pods per plant, haulms yield per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 Kernel weight and oil content. Phenotypic coefficient of variation (P.C.V.) as a measure of the total variability was highest for number of immature pods per plant followed by number of mature pods per plant and 100 pod weight and lowest for oil content. Genotypic coefficient of variation (G.C.V.) is useful to assess and compare the range of genetic variability for quantitative traits. The G.C.V. was highest for number of immature pods per plant, followed by haulms yield per plant and 100 Kernel weight. This indicated that number of immature pods per plant had the maximum genetic variability in the types studied. Similar reports were made by Kushwaha and Tawar (1973), Kuriakose (1981) and Pushkaran(1983). The G.C.V. was lowest for oil content which indicated very low genetic variability for the trait. The extent of variability contributed by the environment is measured by the environmental coefficient of variation (E.C.V.). In the present study, the traits such as number of immature pods per plant, pod yield per plant and 100 pod weight showed E.C.V. values which were higher than the respective G.C.V. values indicating the profound influence of environment on these traits.

Burton (1952) had suggested that G.C.V. together with heritability would be a better estimate of heritable variation for exercising selection. The highest heritability estimate was recorded by shelling percentage followed by 100 kernel weight and oil content. Studies of Bernard (1960) and Kuriakose (1981) also indicated high heritability estimate for shelling percentage. The lowest estimate for heritability was for number of mature pods per plant. This is in consensus with the reports of Majumdar et al. (1967), Dixit et al. (1971) and Pushkaran (1983). Johnson et al. (1955) opined that heritability in the broadsense alone is not enough in predicting the resultant effect of selection and that heritability along with genetic advance is more useful for this purpose. Genetic advance was the highest for number of immature pods per plant followed by 100 kernel weight and haulms yield per plant. The lowest value was recorded by oil content. Kuriakose (1981) and Pushkaran (1983) also reported low genetic advance for oil content. High heritability along with moderate genetic advance was recorded by shelling percentage and 100 kernel weight which indicated that these two traits were under the control of additive genes and would respond favourably to selection. High heritability but low genetic advance was recorded for oil content which indicated the non-additive genetic control for this trait. Similar findings were reported by Kuriakose (1981) and Pushkaran(1983). The traits such as number of mature pods per plant, pod yield per plant and 100 pod weight showed low estimates for both heritability and genetic advance indicating the profound influence of environmental factors over these traits. This is further confirmed by the high E.C.V. values for these characters.

5.2. Maturity index.

In order to identify early maturing genotypes it is quite essential to determine their time of optimum maturity. Groundnut is unique compared to other crops, in that it has indeterminate growth habit. Pod maturation, a cumulative and subterranean process, makes determination of time of optimum maturity difficult. Soil and atmospheric factors further complicate the maturity process. For determination of the time of optimum maturity, staggered harvesting was suggested, wherein the types under evaluation are harvested at pre-defined intervals from randomized and replicated field plots (Rào and Gibbons, 1984). Thereafter, the components associated with crop maturity are analysed and time of optimum maturity determined at that point of time when the various maturity related characters attained their peak value. Arunachalam and Bandyopadhyay(1984) opined that decision made jointly on a number of dependent characters was more dependable than that drawn from a direct observation on the final pod yield alone. Rao and Gibbons (1984) suggested that the traits such as pod yield, sound mature kernel yield, 100 pod weight, 100 kernel weight, shelling percentage and sound mature kernel percentage are important traits for determination of the physiological maturity in groundnut. Thus, realizing the difficulty in determining the time of optimum maturity, an index based on maturity related characters such as ratio of number of mature to immature pods per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 Kernel weight and oil content was envisaged to give a more reliable estimate of maturity. Moreover, such an index would help in grouping of types on the basis of maturity. In the formulation of the index, the mean values for the above mentioned traits in each type at the three different stages of harvest namely 80, 95 and 110 days after sowing were taken into consideration. The types included in the extra early group obtained values for maturity related traits which did not show significant difference at the three harvest stages. These types therefore can be harvested at 80 days after sowing without any economic loss. The types in the early group obtained values for maturity related traits which attained peak stage at 95 days after sowing and thereafter did not show significant change. Thus these types can be harvested at 95 days after sowing without any economic loss. The types included in the medium group obtained values for maturity related traits which showed a linear trend from the harvest at 80 days after sowing to the harvest at 110 days after sowing. These types can thus be harvested at 110 days after sowing. An earlier harvest would result in economic loss in these types.

5.3. Correlations and path analysis.

In order to understand the nature of association of characters in the different maturity groups, correlation coefficients, both at phenotypic and genotypic levels were estimated in each of the three maturity groups. This was followed by path analysis on pod yield in order to estimate the direct and indirect effects of traits such as number of immature pods per plant, number of mature pods per plant, haulms yield per plant, , pod yield per plant, shelling percentage and 100 kernel weight, Path analysis was done for oil yield also including oil content in addition to the pod yield components.

5.3.1. The extra early group

Both at the phenotypic and genotypic levels, pod yield per plant showed significant and positive correlation with traits such as 100 pod weight, oil content and oil yield per plant. The significant and positive association of pod yield with 100 pod weight were reported by Nair (1978), Radhika (1984) and Deshmukh et al.(1986). Layrisse et al. (1980) and Kuriakose(1981) also recorded the significant positive correlation of pod yield with oil content. At the genotypic level, 100 pod weight showed significant and positive association with 100 kernel weight but, with haulms yield per plant the relationship was significant and negative. Pushkaran(1983) reported similar association between 100 pod weight and 100 kernel weight. Number of immature pods per plant showed significant and positive correlation with haulms yield per plant but with traits such as shelling percentage, oil content and oil yield per plant, the relationship was significant and negative. Number of mature pods per plant showed significant and positive relationships with haulms yield per plant and oil content. But with pod yield per plant and 100 kernel weight the correlation was significant and negative. Shelling percentage recorded highly significant and positive correlation with 100 kernel weight, oil content and oil yield per plant. Kushwaha and Tawar(1973) however, reported significant negative correlation between shelling percentage and 100 kernel weight. 100 kernel weight showed significant and positive association with oil yield per plant. The relationship of oil content with oil yield per plant was significant and positive.

Among the six different components of pod yield, 100 pod weight exhibited the highest direct effect. Its indirect effect via. number of immature pods per plant and 100 kernel weight were low, but positive. Its indirect effects via. number of mature pods per plant, haulms yield per plant and shelling percentage were negative. Deshmukh et al. (1986) also reported high positive direct effect of

100 pod weight on pod yield. In the case of oil yield per plant, the maximum positive direct effect was recorded by shelling percentage. Its indirect effects via. number of immature pods per plant, number of mature pods per plant, haulms yield per plant, 100 kernel weight and oil content were positive but, via. pod yield per plant and 100 pod weight were negative.

5.3.2. The Early Group

Pod yield per plant showed significant and positive correlation with number of immature pods per plant, number of mature pods per plant, haulms yield per plant, oil content and oil yield per plant. Significant positive correlation of number of mature pods per plant to pod yield was reported by Dorairaj (1962) in both spreading and bunch varieties and by Nair(1978). Chandra mohan *et al*.(1967) reported significant and positive correlation of pod yield with haulms yield. Layrisse *et al*.(1980) and Pushkaran(1983) recorded significant and positive association between pod yield and oil content.

Number of immature pods per plant showed significant and positive correlation with oil content and oil yield per plant but with 100 kernel weight, the relationship was significant and negative. Number of mature pods per plant showed significant and positive relationship with haulms yield per plant, oil content and oil yield per plant. Haulms yield per plant showed significant and negative association with oil yield per plant, but with shelling percentage, the correlation was significant and negative. Shelling percentge recorded significant and positive correlation with oil content and oil yield per plant. Oil content showed significant and positive association with oil yield per plant.

The maximum positive direct effect on pod yield was showed by haulms yield per plant. Its indirect effects via. number of immature and mature pods per plant were positive while via. shelling percentage and 100 kernel weight the indirect effects were negative. With regard to oil yield, the highest positive direct effect was recorded by pod yield per plant. Its indirect effects via. number of immature pods per plant, number of mature pods per plant, haulms yield per plant and oil content were positive but via. shelling percentage and 100 kernel weight the indirect effects were negative.

5.3.3. The medium group

Pod yield per plant showed significant and positive association with haulms yield per plant, shelling percentage and oil yield per plant. Chandra mohan et al.(1967) and Nair (1978) recorded significant and positive correlation of pod yield with haulms yield. Raman et al.(1970), Dholaria et al.(1972), Khangura and Sandhu(1972) and Kumar and Yadav (1981) also reported significant and positive relationship of pod yield with shelling percentage. Number of immature pods per plant showed significant and positive correlation with haulms yield per plant and number of mature pods per plant. Kushwaha and Tawar(1973) also reported significant and positive association of number of mature pods with number of immature pods per plant. The relationship of number of immature pods per plant with 100 pod weight and 100 kernel weight was significant and negative. Number of mature pods per plant recorded significant positive correlation with haulms yield per plant, shelling percentge and oil yield per plant but with 100 pod weight, the relationship was significant and negative. Significant and positive association between number of mature pods per plant and shelling percentage was also reported by Kushwaha and Tawar(1973).

Haulms yield per plant recorded significant and negative relationship with 100 kernel weight and oil content. But Pushkaran(1983) reported significant and positive correlation between haulms yield and 100 kernel weight. 100 pod weight showed significant and positive relationship with traits such as shelling percentage, 100 kernel weight, oil content and oil yield per plant. However, Kushwaha and Tawar(1973) observed significant and negative relationship between 100 pod weight and shelling percentage. They also reported negative correlation of 100 pod weight with oil content. Significant positive correlation of 100 pod weight with 100 kernel weight was also reported by Pushkaran(1983). Shelling percentage showed significant and positive association with 100 kernel weight, oil content and oil yield per plant. However, Kushwaha and Tawar (1973) reported significant and negative relationship between shelling percentage and 100 kernel weight. 100 kernel weight recorded significant and positive relationship with oil yield per plant.

The maximum positive direct effect on pod yield was recorded by number of mature pods per plant. Its indirect effects via. number of immature pods per plant, haulms yield per plant and shelling percentage were positive while, via.

100 pod weight and 100 kernel weight were negative. That number of mature pods per plant had high direct effect on pod yield was reported by Badwal and Singh(1973), Sandhu and Khehra (1977a), Raju(1978) and Deshmukh et al.(1986). The maximum direct effect on oil yield per plant was recorded by shelling percentage. Its indirect effects via. number of mature pods per plant, pod yield per plant, 100 pod weight, 100 kernel weight and oil content were postive, while via. number of immature pods per plant and haulms yield per plant were negative.

5.3.4. Maturity groups - A comparitive assessment

A critical assessment of the more important components of pod yield and oil yield in the three maturity groups is attempted as follows:

In the extra early group, number of mature pods per plant showed significant but, negative association with pod yield. The trait however, showed low but positive direct effect. In the early group, the association of number of mature pods with pod yield was highly significant and positive. This was further strengthened by the high positive direct effect of the trait. In the medium group, the association betwen the traits was positive but not significant. However, the direct effect of the trait on pod yield was positive and high. Hence, number of mature pods per plant could be used as an important selection criteria for pod yield in the early and medium groups.

100 pod weight, another major component of pod yield showed significant positive correlation with pod yield in the extra early group. This was further supported by the high positive direct effect of the trait. In the early group, correlation between 100 pod weight and pod yield was not estimable presumably due to the lack of variation for the trait among the types included in this group. In the medium group, the association between these characters though not significant, was negative. But the direct effect of the trait on pod yield was high and positive. Thus, 100 pod weight could be used as a selection criteria for pod yield in the extra early and medium groups.

Another component of pod yield, shelling percentage showed negative but non significant relationship with pod yield. The direct effect of the trait on pod yield was also negative. In the early group, the correlation between the traits was negative but not significant . But, the direct effect of shelling percentage on pod yield was high and positive. This could be attributed to the positive indirect effect via. 100 kernel weight. In the medium group, the trait showed significant and positive association with pod yield. But its direct effect though low was negative. This might be due to the low but negative indirect effects via. traits such as number of mature pods per plant, 100 pod weight and 100 kernel weight. Thus shelling percentage could be used as an important selection criteria for pod yield only in the early group.

100 kernel weight, yet another important component of pod yield showed positive but non significant correlation with pod yield in the extra early group. The direct effect of the trait was also positive but low. On the contrary in the early group, the relationship between the traits was negative but not significant. However, the direct effect of the trait on pod yield was moderate and positive. In the medium group the trait showed positive but non significant correlation with pod yield. Moreover, the direct effect of the trait though low was positive. Thus 100 kernel weight could be reckoned as a selection criteria for pod yield irrespective of the maturity groups.

With regard to the different components of oil yield in the extra early group, number of mature pods per plant showed negative but non significant correlation with oil yield. Moreover the direct effect of the trait on oil yield was negative and very low. In the early group, the trait showed significant and positive correlation with oil yield. The direct effect of the trait on oil yield was also positive but low. In the medium group the trait showed significant positive correlation with oil yield but its direct effect was low and negative. Thus while exercising selection for oil yield in the early group the importance of number of mature pods per plant might be stressed.

Pod yield per plant showed significant positive correlation with oil yield in all the three maturity groups. The direct effect of the trait on oil yield was also high in all the three groups. Thus irrespective of the maturity groups, pod yield could be considered as a dependable component for improving oil yield.

100 pod weight showed significant positive correlation with oil yield in the extra early group. But its direct effect though positive was low. In the early group, the correlation between 100 pod weight and oil yield could not be worked out because the co-variance was not estimable. In the medium group, the trait showed

significant and positive association with oil yield. But its direct effect on oil yield was negative and low . Thus In the extra early group, the importance of 100 pod weight assumes significance in selection for oil yield.

Shelling percentage recorded significant positive relationship with oil yield in all the three groups. Its direct effect on oil yield was also positive and high in the three groups. Thus irrespective of the maturity groups, shelling percentage could be considered as an important component for exercising selection for oil yield.

100 kernel weight showed significant and positive correlation with oil yield in the extra early group. Its direct effect on oil yield was however low and negative. In the early group, the association of the trait with oil yield was positive but not significant. However, its direct effect on oil yield was low but, negative. In the medium group, the relationship between the traits was significant and positive. The direct effect of 100 kernel weight on oil yield however was negative but, low. Thus 100 kernel weight might not be a reliable component for improving oil yield in any of the three groups.

Oil content recorded significant positive correlation with oil yield in all the three maturity groups. The direct effect of the trait on oil yield however was low, but positive in all the three groups. Hence oil content assumes importance in exercising selection for oil yield in all the three groups.

In the extra early group, selection based on 100 pod weight and 100 kernel weight would help in improving pod yield. However, the negative association of number of mature pods per plant with pod yield and its low but positive direct effect on pod yield indicate that while selecting for pod yield care should be exercised in striking a balance between number of mature pods per plant and the other traits such as 100 pod weight and 100 kernel weight. The negative association of number of mature pods per plant with pod yield is contrary to the results reported by several workers including, Dorairaj (1962); Kushwaha and Tawar (1973); Lakshmaiah (1983) and Deshmukh et al. (1986). The change in the nature of association might be due to the fact that in the extra early types larger number of mature pods per plant was compensated by a higher pod weight. With regard to oil yield in the above group, pod yield per plant and shelling percentage could be reckoned as reliable traits. In addition to, the importance of traits such as

100 pod weight and oil content might be stressed.

In the early group, emphasis must be given to traits such as number of mature pods per plant, shelling percentage and 100 kernel weight for improving pod yield. Pod yield and shelling percentage would be the reliable traits for effecting improvement in oil yield through selection. Besides, the role of number of mature pods per plant and oil content might not be ignored.

In the medium group improvement in pod yield could be made more effective by relying on traits such as number of mature pods per plant, 100 pod weight and 100 kernel weight during selection. With regard to oil yield, stress on traits such as pod yield and shelling percentage could be effective in bringing about improvement through selection. In addition to, the role of oil content might not be minimized.

5.4. Combining ability.

The breeding method to be adopted for improvement of a crop depends primarily on the nature of gene action involved in the expression of quantitative traits of economic importance. Combining ability studies reveal nature of gene action and lead to identification of types with high general combining ability effects, and cross combinations with high specific combining ability effects. This in turn helps in choosing the types to be included in recombination or population breeding programmes. The concept of combining ability was first proposed by Sprague and Tatum (1942) and they attributed general combining ability to additive effect of genes and specific combining ability to dominance deviation and epistatic interaction.

Among the different methods developed to estimate the general and specific combining abilities, diallel analysis and line x tester analysis are in common usage. A diallel cross involves a set of crosses produced by involving `n' lines or inbreds in all possible combinations and the analysis of such crosses is known as diallel analysis. The concept of diallel cross was first described by Yates (1947). The theory and analysis of diallel cross was developed by Jinks and Hayman (1953). The line x tester analysis was proposed by Kempthorne (1957). Here, `l' inbreds are crossed to each of `t' testers and thus `lxt' full-sib progenies are produced. The appropriate method to be chosen is based on whether the breeder is interested about knowing the interaction between the male and female parents and/or the interaction among males and among females also. In the present study, the advantage of using the line x tester method is that it helps in understanding the interaction between the lines (extra early types) and testers (high productive types) excluding the interaction among lines and among testers which is not required. Moreover, the method helps in reducing the number of crosses to be attempted when compared to the n^2 combinations in a complete diallel without affecting the reliability of the information required. This assumes more importance in a crop like groundnut where artificial hybridization is difficult.

With the objective of combining earliness and high yield, six types showing high maturity scores in the extra early group (chico, ISKN 8827, Dh(E) 20, Dh (E) 32, ICGS 35-1 and IES 883) were selected and used as ovule parents. Three types with high productivity in the three groups (TG 3, TMV 2 and JL 24) were used as male parents. Combining ability was estimated for traits such as days to first flowering, spread of flowering, days to maturity, number of immature pods per plant, number of mature pods per plant, haulms yield per plant, pod yield per plant 100 pod weight, shelling percentage, 100 kernel weight and oil content. The general combining ability of the parents and their specific combining ability in cross combinations were estimated and the nature of gene action involved for each trait was assessed. The variance due to the types studied were significant for all traits and hence the data were further analysed for combining ability. In the line x tester analysis, the variance due to lines was significant for traits such as days to first flowering, days to maturity, haulms yield per plant, pod yield per plant, 100 pod weight and 100 kernel weight. But the variance due to testers was not significant for any of the traits. However, the variance due to line x tester interaction were significant for number of immature pods per plant, number of mature pods per plant, haulms yield per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content which indicated that both additive and non-additive gene actions might be involved in their inheritance. The predominanace of sca variance over gca variance for all the traits indicated the preponderance of non-additive genes over additive genes in the control of the traits. This is in tune with the findings of Raju _et al_. (1979). However, Manoharan _et al_. (1985) reported preponderance of additive gene action for pod yield and shelling percentage. The preponderance of additive gene action for days to maturity, no. of mature pods, pod yield, shelling percentage and 100 kernel weight was reported by Basu et al. (1987).

5.5. Evaluation of Parents

In a recombination breeding programme for crop improvement, choice of parents assumes great importance. In the evaluation of parents, their general combining ability effects for the different traits were considered first. In the case of days to maturity, lines chico, ISKN 8827 and Dh(E)32 recorded significant gca effects indicating their good combining ability for earliness. Moreover the line chico exhibited significant negative gca effect for days to first flowering revealing its good combining ability for early flowering. Basu et al. (1986b) in a line x tester study also found chico to be the best combiner for days to 50 percent flowering and for days to maturity, the most important attributes governing earliness. With respect to the spread of flowering, none of the lines showed significant gca effects. In the case of number of immature pods per plant, chico, ISKN 8827 and Dh(E) 32 showed significant negative gca effects expressing their ability as good combiners for lesser number of immature pods per plant. With regard to number of mature pods per plant, Dh (E)20, Dh(E)32 and ICGS 35-1 recorded significant positive gca effects indicating their good combining ability for the trait. For haulms yield per plant, ICGS 35-1 and IES 883 showed significant positive gca effects indicative of their good combining ability for the character. In the case of pod yield per plant, ISKN 8827, Dh(E)20, Dh(E)32 and IES 883 registered significant positive gca effects revealing their better combining ability for the trait. Dh(E) 20 and IES 883 recorded significant positive gca effects for 100 pod weight indicating their high combining ability value for the character. In the case of shelling percentage, chico and ISKN 8827 revealed to be good combiners due to their significant positive gca effects. With respect to 100 kernel weight, Dh(E)20, Dh(E)32 and IES 883 registered significant positive gca effects indicating their good combining ability for the character. In the case of oil content, chico and ICGS 35-1 were found to be good combiners due to their significant positive gca for the character.

Among testers, TMV 2 recorded significant positive gca effects for pod yield per plant indicating the high combining ability of the parent for high yield. This tester also showed significant positive gca effect for days to maturity revealing its good combining ability for early maturity. With regard to traits such as days to first flowering , spread of flowering, number of immature pods per plant, number of mature pods per plant, haulms yield per plant, 100 pod weight and oil content none of the testers showed significant gca effects . But in the case of shelling percentage and 100 kernal weight the tester, TMV 2 recorded significant positive gca effects revealing its high combining ability for both the traits.

The mean performance of the parents used in a recombination breeding programme also assumes importance. Among the lines, chico showed the highest mean performance with regard to traits such as days to first flowering , days to maturity and number of immature pods per plant. The line Dh(E) 32 recorded the best performance with respect to traits such as spread of flowering , number of mature pods per plant, 100 pod weight and 100 kernel weight. Dh(E)20 showed the highest mean performance for pod yield per plant and ICGS 35-1 was the best for shelling percentage. The line IES 883 recorded highest performance with regard to haulms yield per plant and oil content.

Among testers, TG 3 recorded the highest mean performance for days to first flowering, haulms yield per plant, pod yield per plant and shelling percentage. The tester TMV 2 registered the best performances for traits

24. Thus with regard to mean performance, among lines, chico was the best for earliness and among testers, TG 3 proved to be the best for productivity.

In order to identify the stable ones from among the parents used, genotype x environment interaction was estimated. As the error variances were heterogenous for all traits except 100 kernel weight, the G x E interaction was analysed following the Eberhart and Russell (1966) model for 100 kernel weight. Though both the linear and non-linear components of the genotype x environment interaction were significant, the linear portion was preponderant. This is in accordance with the findings of Yadava and Kumar (1978a). The line, ICGS 35-1 was found to possess stability for the trait as it registered the regression coefficient close to unity and the variance due to deviation from regression not significantly different from zero. This line also recorded a low score in the reaction to the incidence of rust disease.

5.6. Evaluation of Cross Combination

The nature of the specific combining ability (sca) effects in the different cross combinations and their mean performance were used for evaluation. In the case of days to first flowering, none of the cross combinations produced significant sca effects. However , the cross combinations, chico x TG 3, chico x TMV 2 and chico x JL 24 recorded early flowering. For spread of flowering, as in the above case none of the cross combination showed significant sca effects. But, the cross combinations, chico x TG 3 and IES 883 x JL 24 registered the least spread of flowering. In the case of days to maturity, IES 883 x TMV 2 recorded the highest significant negative sca effect. However, the cross combination ISKN 8827 x TG 3 registered the least number of days to mature. With regard to number of immature pods per plant, IES 883 x TG 3 recorded the highest significant negative sca effect while the cross combination Dh(E) 32 x TMV 2 showed the least number of immature pods per plant. In the case of number of mature pods per plant, the cross combination ICGS 35-1 x TMV 2 showed the highest significant positive gca effects. However, Dh(E) 20 x JL 24 recorded the highest number of mature pods per plant. With regard to haulms yield per plant, none of the cross combinations recorded significant sca effects. While ,ICGS 35-1 x TMV 2 parents, Dh(E) 32 with highly significant positive gca effect and a comparatively higher positive significant sca effects. Such superior cross combinations involving high performing and low performing parents and exhibiting high sca effects are expected to segregate for desirable transgressive segregants, as the desirable additive gene effect of the high performing parent and the complementary epistatic effects of the cross are coupled in the direction to maximise the expression of the character under consideration (Singh et al., 1990). This supports the importance of both additive and non-additive gene effects in controlling earliness and productivity. However, Basu et al.(1987) reported preponderance of additive gene action for days to maturity and pod yield. In the case of traits such as number of immature pods per plant, number of mature pods per plant, 100 pod weight and shelling percentage, the best cross combinations were resulted by a high x low combiner combination with a high sca effect. This indicated the importance of both additive and non-additive genic systems in the control of these traits as in the case of days to maturity and pod yield per plant. The predominance of sca variance over gca for these traits indicated the predominance of non-additive over additive genes in the control of the traits. Reddy (1982) in his study also indicated the preponderance of non-additive gene action for showed the highest mean value for the trait. For pod yield per plant, ISKN 8827 x TG 3 registered the highest significant positive sca effects. However, the highest yield was showed by Dh(E) 32 x JL 24 . In the case of 100 pod weight, Dh(E) 20 x TMV 2 showed the highest significant positive sca effect. The highest mean performance for shelling percentage was recorded by the cross combination, chico x TG 3 . This combination also registered the highest significant positive sca offect. The cross combination IES 883 x TMV 2 registered the highest mean 100 kernel weight. However, the combination ISKN 8827 x JL 24 recorded the highest significant positive sca effect. With regard to oil content, IES 883 x TG 3 showed the highest mean perfomance and the highest sca effect.

With regard to days to maturity, the most important attribute governing earliness, the best perfomance was showed by the cross combination, ISKN 8827 x TG 3. This could be attributed to the high significant negative gca effect of one of the parents involved namely ISKN 8827 for the trait and comparatively desirable negative significant sca effect produced in the combination. In the case of pod yield per plant also, the combination Dh(E) 32 x JL 24 which gave the highest mean pod yield per plant had one of the parents, Dh(E) 32 with highly significant positive gca effect and a comparatively higher positive significant sca effects. Such superior cross combinations involving high performing and low performing parents and exhibiting high sca effects are expected to segregate for desirable transgressive segregants, as the desirable additive gene effect of the high performing parent and the complementary epistatic effects of the cross are coupled in the direction to maximise the expression of the character under consideration (Singh et al., 1990). This supports the importance of both additive and non-additive gene effects in controlling earliness and productivity. However, Basu et al.(1987) reported preponderance of additive gene action for days to maturity and pod yield. In the case of traits such as number of immature pods per plant, number of mature pods per plant, 100 pod weight and shelling percentage, the best cross combinations were resulted by a high x low combiner combination with a high sca effect. This indicated the importance of both additive and non-additive genic systems in the control of these traits as in the case of days to maturity and pod yield per plant. The predominance of sca variance over gca for these traits indicated the predominance of non-additive over additive genes in the control of the traits. Reddy (1982) in his study also indicated the preponderance of non-additive gene actior for the above characters except 100 pod weight. With regard to haulms yield per plant and 100 kernel weight the best cross combination did not reveal desirable significant sca effects but one of the parents involved was a good general combiner for the trait indicating the role of additive genes in the control of both the traits. The preponderance of additive genetic variance for 100 kernel weight was reported by Reddy (1982) and Basu et al. (1987). But the predominance of sca variance over gca variance for the traits revealed the importance of non-additive genes over additive genes in the control of the traits. For oil content, the cross combination with highest sca effect and mean performance was a product of low x low combiner combination indicating the role of non-additive genes. However, the gca/sca variance ratio which is less than unity for all the traits except spread of flowering indicated the predominance of non-additive gene action in the inheritance of these characters. This may be due to the fact that the parental materials included in the study were highly selected for yield and maturity related traits (Nanda et al., 1983).

SUMMARY

SUMMARY

Groundnut is the most important annual oilseed crop in this country. Till the sixties, the crop was grown only during the kharif season. Since then, its cultivation has been extended to the rabi and summer seasons also. This extension of the crop to non-traditional areas has opened up new possibilities for groundnut production in the southern and central parts of the country. In Kerala, the rice based cropping system with the rice-rice-groundnut sequence in wet lands offer new vistas in the production of groundnut. The major constraint in extending the crop to the summer rice fallows is the lack of an extra early variety maturing in 80 to 90 days with synchronized pod maturity and moderate yield potential. The present study was undertaken with the main objective of providing basic information to overcome the above constraint through development of . extra early groundnut types suitable as a summer crop in the rice fallows. The salient features of the study are summarised here under :

A preliminary evaluation of 63 bunch types of groundnut was carried out in rice fallows during summer 1989 at R.R.S. Kayamkulam for estimation of variability for maturity and related traits such as number of mature pods

per plant, haulms yield per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content. Phenotypic coefficient of variation (P.C.V.) was highest for number of immature pods per plant followed by number of mature pods per plant and 100 pod weight and lowest for oil content. Genotypic Coefficient of variation(G.C.V.) was highest for number of immature pods per plant followed by haulms yield per plant and 100 kernel weight. This indicated that number of immature pods per plant has the maximum genetic variability in the types studied. The G.C.V. was lowest for oil content which indicated very low genetic variability for the trait. Number of immature pods per plant, pod yield per plant and 100 pod weight showed environmental coefficient of variation (E.C.V.) values which were higher than the respective G.C.V. values indicating the profound influence of environment on these traits.

The highest heritability estimate was recorded by shelling percentage followed by 100 kernel weight and oil content. The lowest estimate for heritability was for number of immature pods per plant. Genetic advance was the highest for number of immature pods per plant followed by 100 kernel weight and haulms yield per plant. The lowest value was recorded by oil content. High heritability along with moderate genetic advance was recorded by shelling percentage and 100 kernel weight which indicated that these two traits are under the control of additive genes and would respond favourably to selection. High heritability but low genetic advance was recorded for oil content which indicated non-additive genetic control for this trait. Number of mature pods per plant, pod yield per plant and 100 pod weight showed low estimates for both heritability and genetic advance indicating the profound influence of environmental factors over these traits.

Groundnut is unique compared to other crops in that it has indeterminate growth habit. Pod maturation, a cumulative and subterranean process makes determination of time of optimum maturity difficult. A maturity index based on maturity related characters such as ratio of number of mature to immature pods per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content was envisaged to give a more reliable estimate of maturity. Based on the scores obtained, the 63 types were classified into three groups viz., extra early, early and medium comprising 17, 16 and 30 types respectively. In order to understand the nature of association of characters in the differnt maturity groups, correlation coefficients, both at phenotypic and genotypic levels were estimated in each of the three maturity groups. This was followed by path analysis on pod and oil yields in the three groups. In the extra early group, selection based on 100 pod weight and 100 kernel weight would help in improving pod yield. However, the negative association of number of mature pods per plant with pod yield and its low but positive direct effect on pod yield indicate that while selecting for pod yield care should be exercised in striking a balance between number of mature pods per plant and the other traits such as 100 pod weight and 100 kernel weight. This negative association might be due to the fact that in the extra early types more number of mature pods per plant was compensated by a higher pod weight. With regard to oil yield in the above group, pod yield per plant and shelling percentage could be reckoned as reliable traits. In addition to, the importance of traits such as 100 pod weight and oil content might be stressed.

In the early group, emphasis must be given to traits such as number of mature pods per plant, shelling percentage and 100 kernel weight for improving pod yield. Pod yield and shelling percentage would be the reliable traits for effecting improvement in oil yield through selection.

Besides, the role of number of mature pods per plant and oil content might not be ignored.

In the medium group, improvement in pod yield could be made more effective by relying on traits such as number of mature pods per plant, 100 pod weight and 100 kernel weight during selection. With regard to oil yield, stress on traits such as pod yield and shelling percentage could be effective in bringing about improvement through selection. In addition to, the role of oil content might not be minimized.

With the objective of combining earliness and high yield, six types showing high maturity scores in the extra early group were selected and used as ovule parents. Three types with high productivity were used as male parents. The six lines, three testers and their eighteen hybrids were raised in rice fallows during summer 1990. Combining ability was estimated following the line x tester method. The variance due to the types was significant for days to first flowering, spread of flowering, days to maturity, number of immature pods per plant, number of mature pods per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content. The data were further analysed for combining ability . The variances due to lines were significant for days to first flowering, days to maturity, haulms yield per plant, pod yield per plant, 100 pod weight and 100 kernel weight. But, the variance due to testers was not significant for any of the traits. However, the variances due to line x tester interaction were significant for number of immature pods per plant, number of mature pods per plant, haulms yield per plant, pod yield per plant, 100 pod weight, shelling percentage, 100 kernel weight and oil content which indicated that both additive and non-additive gene actions might be involved in their inheritance. The predominance of sca variance over gca variance for all the traits indicated the preponderance of non-additive genes over additive genes in the control of the traits. Chico was found to be the best combiner for earliness among lines. Among testers, TG 3 proved to be the best for productivity.

In order to identify the stable ones from among the parents used, genotype x environment interaction was estimated under three environments. As the error variances were heterogenous for all traits except 100 kernel weight, the analysis was done only for 100 kernel weight. The line ICGS 35-1 was found to possess stability for the trait.

The cross combination, ISKN 8827 x TG 3 showed the best performance with regard to days to maturity, the most important attribute governing earliness. In the case of pod yield, the cross combination Dh(E) 32 x JL 24 was the best. The best cross combinations were from a high x low combiner combination and a high sca effect. This was true in case of other traits such as number of immature pods per plant, number of mature pods per plant, 100 pod weight and shelling percentage. Such superior cross combinations involving high and low performing parents and exhibiting high sca effects are expected to segregate for desirable transgressive segregants, as the desirable additive gene action of the high performing parent and the complementary epistatic effects of the cross are coupled in the direction to maximize the expression of the character under consideration. This indicated the importance of both additive and non-additive genic systems in the control of these traits. With regard to haulms yield per plant and 100 kernel weight, the best cross combinations did not reveal significant sca effect but, one of the parents involved was a good general combiner for the trait indicating the role of additive genes in their control. For oil content, the cross combination with the highest sca effect and mean performance was a product of low x low combiner combination indicating the role of non-additive genes. The gca/sca variance ratio which was less than unity for all traits except spread of flowering indicated predominance of non-additive gene action in the inheritance of these traits.

Ten high yielding extra early recombinants were selected at 80 days after sowing from the 18 F_2 populations for further testing and selection.

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GENETIC ANALYSIS OF PRODUCTIVITY IN RELATION TO MATURITY IN BUNCH GROUNDNUT

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ABSTRACT OF THE THESIS
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ABSTRACT

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A preliminary evaluation of 63 bunch type of groundnut revealed that the genotypic coefficient of variation was highest for number of immature pods per plant which indicated the maximum genetic variability for the trait and lowest for oil content which indicated low variability for the trait. High heritability along with moderate genetic advance was obtained for shelling percentage and 100 kernel weight which showed the importance of additive genes in their control.

A maturity index was formulated and on its basis the 63 types were classified in to three groups namely, extra early, early and medium. In the extra early group, 100 pod weight and 100 kernel weight were important components for pod yield. In the early group, number of mature pods per plant, shelling percentage and 100 kernel weight were important components for pod yield. In the medium group, number of mature pods per plant, shelling percentage and 100 kernel weight were important components for pod yield. For oil yield in all the three groups, pod yield and shelling percentage were the important components.

Line x Tester analysis with six extra early types as lines and three high productive types as testers indicated predominance of sca variance over gca variance indicating preponderance of non-additive gene action over additive for the traits studied. Chico was the best general combiner for earliness and TMV 2 was the best general combiner for pod yield. High yielding extra early recombinants were selected at 80 days after sowing from the 18 F_2 populations for further testing and selection.