

GENETIC STUDIES IN SESAME (Sesamum indicum L.)

Thesis submitted in part fulfilment of the requirements
for the award of the degree of Doctor of Philosophy in
Plant Breeding and Genetics to the
Tamil Nadu Agricultural University,
Coimbatore

By

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1995

CERTIFICATE

This is to certify that the thesis entitled "Genetic Studies in Sesame (Sesamum indicum L.) submitted in part fulfilment of the requirements for the degree of Doctor of Philosophy in Plant Breeding and Genetics to the Tamil Nadu Agricultural University, Coimbatore is a record of bona fide research work carried by **Mr.N.SUNDARAM** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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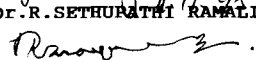

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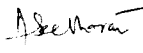

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**Dedicated to my
my beloved Father**

A.NANJAPPA

ACKNOWLEDGMENT

ACKNOWLEDGMENT

I have great pleasure in extending my heartfelt thanks to the Chairman of the Advisory Committee **Dr.S.R.SREE RANGASWAMY**, Ph.D., Professor of Biotechnology, for suggesting the problem and for his inestimable guidance, constant supervision, keen interest and warm encouragement during the entire period of this investigation.

I wish to place on record my sense of gratitude to my former Advisory Committee Chairman, **Dr.M.RATHINAM**, Professor (Forestry) (Retired) Tamil Nadu Agricultural University, Coimbatore and former members **Dr.S.KRISHNASWAMY**, Scientist, SII, CICR, Coimbatore (Retired) and **Dr.N.SHANMUGAM**, Director of Extension Education, Tamil Nadu Agricultural University, Coimbatore (Retired) for their encouragement during the course of the study.

My profound thanks are due to **Dr.R.SETHUPATHI RAMALINGAM**, Director, Students Welfare, **Dr.M.RANGASWAMY**, Director, School of Genetics and **Dr.P.NARAYANA SWAMY**, Professor of Plant Pathology for their valuable guidance during the course of the investigation.

Words are boundless to express the deep sense of gratitude and warm feelings to **Dr.R.RATHNASWAMY**, Professor and Head, Department of Pulses for his constant help,

guidance encouragement and support in bringing out this thesis.

I wish to thank the staff of Department of Pulses especially **Mr.P.NAGARAJAN**, Asst. Professor and **Mr.R.RAVIKESAVAN**, Senior Research Fellow for their help in the course of this study.

I am grateful to the Tamil Nadu Agricultural University, Coimbatore for permitting me to study the Ph.D. course under internal deputation.

A handwritten signature in black ink, appearing to read 'N. Sundaram', written over a horizontal line.

(N.SUNDARAM)

ABSTRACT

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GENETIC STUDIES IN SESAME (*Sesamum indicum*, L.)

By

N.SUNDARAM

DEGREE : DOCTOR OF PHILOSOPHY IN PLANT BREEDING
AND GENETICS

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1995

With the object of identifying superior cross combinations and evolving breeding strategies for enhancement of seed yield in sesame (*Sesamum indicum* L.), a set of 15 x 15 diallel crosses was attempted. A comparative study of performance of hybrids and their parents was made in two seasons viz., kharif, 1980 and summer, 1981. Six characters namely plant height, days to first flower, number of capsules on the main stem, number of capsules on the branches, number of capsules per plant and seed yield per plant were studied. Studies on combining ability, genetical and graphical analyses were done to bring out the information needed.

The genotype x season interaction was significant for all the characters except days to first flower, thereby necessitating that the test has to be carried out in multi-environments for obtaining reliable and precise estimates of seed yield and its components.

The GCA variance was in greater magnitude for all the characters studied in both the kharif and summer seasons.

The proportion of GCA : SCA variance ratio varied among the characters studied. Seed yield per plant had the narrowest ratio. Thus, the yield components were found to be governed comparatively with more of additive genes than seed yield per plant.

Among the seasons, the phenotypic expression of the characters was in higher magnitude during summer season than in the kharif season. The parents KRR 2, TMV 6 and S.i. 2277 were found to perform better than the remaining parents.

The higher magnitude of additive components variation (D), the less than unity ratio of $(H_1/D)^{1/2}$, the intercept of regression line above the origin in W_r-V_r graph for all the characters indicated the preponderance influence of additive gene action for seed yield and yield components in the parents investigated.

The genetical and graphical analyses in the present investigation revealed the genetic architecture of the parents. The ratio of $H_2/4H_1$ was less than 0.25 for most of the characters in both situations pointing to the asymmetry of positive and negative alleles. The gene distribution among the parents was observed to be unequal with greater frequencies of dominant alleles.

Based on *per se* performance and *gca* effects score values, six cross combinations involving two cross combinations each for High x High, High x Low and Low x Low viz., KRR 2 x TMV 6, KRR 2 x S.i.2277 (H x H), KRR 2 x S.i.2631, TMV 6 x S.i.2631 (H x L), S.i.2141 x S.i.2631 and S.i.2340 x S.i.2631 (L x L) were selected and advanced for F_2 generation.

Among the six cross combinations studied, four involving High x High and High x Low *per se* and *gca* effects score values exhibited high mean, high GCV, high heritability (BS) coupled with high genetic advance.

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INTRODUCTION

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the ancient oilseed crops known to man. The crop is grown both under rainfed and irrigated conditions. It ranks third in acreage next only to groundnut and rape-mustard in India. The area under the crop is fluctuating depending on monsoon rains. The productivity also varies widely.

India ranks first in area as well as production of sesame among the sesame producing countries (Sharma, 1985). The crop is predominantly grown in the states of Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu, West Bengal and Gujarat. In Tamil Nadu, it is raised in 1.20 lakh hectares. The productivity is very low in Tamil Nadu (289 kg/ha) compared to other countries like USA, China, Sudan and Yugoslavia. The low productivity in India could be improved by evolving better varieties with high yield through genetic improvement. Therefore, a thorough knowledge of the genetic base of the varieties as well as the nature of gene action for yield and yield contributing factors becomes essential for achieving the goal.

Sesame is generally considered to be a self pollinated crop in spite of varying amounts of natural cross pollination reported by many investigators. The prevalence

of considerable amount of heterosis has also been reported by few scientists. Riccelli and Mazzani (1964) stated that heterosis in sesame is more conspicuous in the hybrids of cultivars from different localities. But, the information gathered so far is very limited and the few estimates of heterosis available have not been related to any specific type of gene action. Therefore, various tools of crop improvement which have been instrumental for the genetic improvement of several self and cross pollinated crops does not seem to have found application in sesame breeding. The major constraint in sesame breeding is its photosensitiveness. Hence, there is need to study the crop under varied environments/seasons.

Different techniques have been employed to estimate the genetic potential of the genotypes to be used in the hybridization programme to enhance the yield potential of crop plants. Combining ability analysis is one such tool widely used by plant breeders. Of the different techniques, the diallel method (Griffing, 1956 and Hayman, 1954) is an appropriate biometrical method which provides a precise estimate of the combining ability of the parents and enables the breeder to eliminate the undersirable hybrid combinations at the early stage itself, besides assessing heterosis, specific combining ability of the hybrids, nature of gene action governing the yield and yield related

characteristics. Further, the study of diallel analysis over different seasons/environments allows the breeder for prediction of the genetic components and their interaction across the seasons.

The gene action of a given trait (Daljit Singh 1973 and 1979) and Arunachalam (1976) is another important factor which decides the breeding methodology and selection procedure of the breeder. A quantitative assessment of the proportion of additive and non-additive genetic components also assumes importance. The extension of the analysis of selected cross combinations involving parents with high and low *per se* performance and/or gca effects or their combinations will provide further information for pursuing selection in latter generations (Rathnaswamy, 1984).
and Jagadisan,

The present investigation is, therefore, aimed ~~for~~ understanding the following objectives :

- i. to obtain information on the magnitude of general and specific combining ability variances besides the reciprocal effects in the hybrids.
- ii. to gather the extent of heterosis in the direct and reciprocal crosses for exploitation.
- iii. to understand the nature of gene action governing yield and components of yield,

- iv. to analyse the stability of the parental genotypes and hybrids over the seasons,
- v. to assess the performance of parents with high or low **per se** performance and/or **gca** effects individually or in combination with the respective hybrids and
- vi. to suggest suitable breeding strategy for improving seed yield and its related traits of sesame.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Investigations carried out on heterosis, combining ability and genetic analysis of sesame (*Sesamum indicum* L.) are reviewed hereunder.

2.1. HETEROSIS

Heterosis is the increased or decreased vigour of F_1 over its better parent or the mid parent value. The floral biology of sesame is such that it is not fully amenable for exploitation of heterosis breeding and so far no hybrid has been released for commercial cultivation. Lack of appropriate and viable methodology for large scale production of hybrid seeds with less cost on labour is the major constraint in the exploitation of hybrid vigour. Sesamum is classified as an often-cross pollinated crop and the percentage of cross pollination varied from 3.61 to 15.32 by Martinez and Quilantan (1964), 1.00 to 17.62 by Muhammad et al. (1965), 3.50 to 9.60 by Rheenen (1968), 3.10 to 6.70 by Khidir (1972) and 60.00 to 65.00 by Uzo (1977).

In the present review the investigations on heterosis is presented with a view to find out the percentage of heterosis realised by different workers and the feasibility of commercial exploitation of hybrid vigour.

Pal (1945) made crosses between certain of the Pusa types and studied eight F_1 s along with their parent

cultivars. The hybrid T 26 x T 20 showed a marked increase in number of branches, greatly surpassing the better parent. The cross T 26 x T 28 and its reciprocal were as early as the early parent. In respect of yield, the best cross was T 26 x T 3 which exceeded the better parent by 121.0 per cent. Negative heterosis was observed for plant height.

Riccelli and Mazzani (1964) studied 510 hybrids from diallel crosses between 32 cultivars of wide geographical origin and found that heterosis in sesame was more conspicuous in the hybrids of cultivars from distant localities. Srivastava and Singh (1968) studied heterosis for different morphological traits. The characters such as yield per plant, plant height, number of branches, number of leaves, number of capsules, length and breadth of capsules and 1000 seed weight showed increases ranging from 2.13 to 44.13 per cent over the superior parent and increases ranging from 4.22 to 42.11 per cent over mid parent value, number of leaves and yield per plant recording the maximum heterosis in the cross between Meyhna x local. The other cross, Meyhna x wild, expressed a relative heterosis of 132.79 per cent and heterobeltiosis of 46.8 per cent for yield. The relative heterosis ranged from 2.05 to 66.57 per cent for other characters. In the third cross, local x wild, the heterosis was 27.46 per cent for yield, 14.26 per cent for plant height, 33.26 per cent for number of branches, 57.02 per cent for number of leaves, 53.30 per cent to

number of capsules, 44.20 per cent for breadth of capsules and 34.22 per cent for 1000 seed weight.

Murthy (1975) in a diallel cross of 10 varieties of sesame of diverse eco-geographical origin involving 90 hybrids along with 10 parents reported on six agronomic and two chemical characters. Seed yield recorded the highest heterosis of 33.00 per cent, followed by number of capsules per plant with 16.00 per cent. The mean percentage of heterosis was significant and positive in earliness, plant height and number of primary branches while it was insignificant for number of secondary branches and oil content. Protein content recorded significantly negative heterosis. Indian x Exotic crosses in general, recorded higher heterosis than the Indian x Indian and Exotic x Exotic crosses. The exotic lines were useful in improving the earliness, number of secondary branches, seed yield and protein content.

Dixit (1976) studied six parents, six F_1 s and six F_2 s of sesame. The cross C 35 x TC 62 recorded 118.75 and 83.81 per cent of heterosis and heterobeltiosis respectively for number of primary branches. For number of capsules on the main fruiting branch, T 4 x C 35 and KL x C 1036 showed 19.59 and 25.51 per cent of heterosis respectively. The cross C 35 x TC 62 expressed 9.84 per cent heterosis for plant height. For capsules per plant, in the cross T4 x C35

115.18 and 114.73 per cent heterosis and heterobeltiosis respectively and in C 1036 x JL 55.01 per cent heterobeltiosis were observed. Heterosis to the extent of 33.99 per cent was recorded for seed yield by TC 62 x KL. Hybrids T4 x C 35 and KL x C 136 registered 78.33 and 115.68 per cent of heterosis and 29.11 and 77.39 per cent heterobeltiosis for seed yield respectively.

Srivastava and Prakash (1977) effected six possible direct crosses using four white seed varieties of indigenous origin. Among them, one hybrid involving the best parent recorded 6.20 per cent increased seed yield and 25.75 per cent increased capsule number over the best parent. None other hybrids exhibited significant deviations over the best and better parents.

Uzo (1977) studied 75 F_1 hybrids involving 21 parents of diverse origin and detected a high degree of hybrid vigour in nine plant characters. All of them were shown to be significantly correlated with seed yield. It was found that the interrelationships of these characters were different among parental lines as contrasted with F_1 population. The yield components carried separately in different parents combined in F_1 to give rise to a geometrical rather than additive effect accounting for the high magnitude of hybrid vigour as measured on yield.

Shrivastava and Singh (1978) in a study of hybrids of 10 x 10 diallel crosses (45 direct crosses without reciprocals) observed maximum heterosis (7.25 per cent) for seed yield and 6.75 per cent for plant height over the better parents. Alternatively, branches and capsule per plant exhibited 36.34 and 18.52 per cent maximum heterosis towards the positive direction. In general, the magnitude of negative heterosis was higher than positive heterosis for all characters. Similarly, the number of crosses below the lower parent were more than the number of crosses above the better parents.

Ashok Kotecha and Yermanos (1978) in an 8 x 8 diallel cross estimated the heterosis percentage over its better parent to range from -28.0 to 237.8, -23.2 to 12.5, -28.8 to 122.6 and -25.7 to 10.6 per cent respectively for seed yield, plant height, capsule number and capsule length.

In crosses between 13 varieties and D 7-11-1, Chaudhari et al. (1979) reported significant heterosis in ten hybrids and significant heterobeltiosis in eight hybrids for seed yield per plant. The cross D 7-11-1 x Dhamera-1 recorded 116.78 per cent heterosis for seed yield and 25.61 per cent for number of nodes. For number of branches, five hybrids expressed significant heterosis and two showed heterobeltiosis. Eleven and two hybrids respectively

exhibited heterosis and heterobeltiosis for number of capsules.

In a 9 x 9 diallel cross in Sesame, Rathnaswamy (1980) studied heterosis for five characters. A maximum heterosis of 24.91 per cent for plant height, 63.64 per cent for branches per plant, 45.57 per cent for capsules per plant, 19.72 per cent for capsule length and 67.94 per cent for seed yield per plant was reported.

Nafie (1980) reported significant heterosis for number of capsules, seed weight per capsule and seed yield per plant in a diallel cross involving six non-dehiscent parents.

In a diallel cross involving ten sesame varieties, Shrivastava and Singh (1981) observed the magnitude of negative heterosis to be higher than positive heterosis for all the characters. Heterosis over mid parent was found to range from -13.76 to 9.26 per cent for plant height, -10.74 to 17.98 per cent for height for first capsule, -24.18 to 47.68 per cent for number of branches per plant, -26.10 to 19.34 per cent for number of capsule per plant and -25.21 to 15.22 per cent for seed yield per plant. Heterosis over better parent was found to range from -19.07 to 6.57 per cent for plant height, -14.82 to 18.89 per cent for height to first capsule, -47.07 to 36.34 per cent for number of branches per

plant. -31.92 to 18.52 per cent for number of capsules per plant and -27.93 to 7.52 per cent for seed yield per plant.

Tyagi and Singh (1981) studied 60 F_1 hybrids along with their parents. Heterobeltiosis of -4.90 to 20.79 per cent for days to first flowering and -11.50 to 22.89 per cent for days to maturity was recorded. Heterosis over the better parent was 166.66 per cent for number of branches, 151.36 per cent for seed yield, 81.70 per cent for test weight, 39.13 per cent for capsules per plant and 32.76 per cent for plant height.

Chavan et al. (1982) studied heterosis for plant height, capsules per plant, number of days to maturity and yield per plant in F_1 and F_2 of six intervarietal crosses derived from eight varieties. Significant positive heterosis was observed in several crosses for capsules per plant, number of days to maturity and yield per plant.

In a study involving 12 varieties and their hybrids. Paramasivan et al. (1982) had recorded a minimum of 5.85 per cent and a maximum of 16.42 per cent of heterobeltiosis for plant height in the crosses Si 2181 x IC 14120 and Si 1845 x IC 14178 respectively. Heterobeltiosis of 41.23 per cent was recorded by the hybrid Si 245 x IC 14120 for number of capsules. Heterobeltiosis of 36.42 per cent and 45.77 per cent was recorded in Si 850 x IC 14178

and Si 1845 x IC 14178 respectively for number of seeds per capsule. For seed yield per plant and 1000 seed weight, 19.91 and 50.66 per cent respectively were recorded by the hybrid YMW x KRR 2.

In a study of nine crosses involving eight parents at three localities by Godawat and Gupta (1983) revealed that heterosis and inbreeding depression were observed in all the crosses for most of the characters in different environments. They concluded that highest heterosis for yield over the mid parent (87.20 per cent) and better parent (65.46 per cent) recorded by the cross RSE 1 x JT 7 was due to simultaneous heterosis for a number of yield component traits.

Sharma and Chauhan (1983) in a study of heterosis and inbreeding depression involving ten varieties of Sesame, observed heterosis for seed yield and eight other component characters. The mid parent and better parent heterosis for seed yield ranged from -16.76 to 105.70 per cent, -36.99 to 60.27 per cent respectively. The heterosis for seed yield appeared to be due to high manifestation of heterosis for number of capsules per plant which in turn was due to additive action of number of primary and secondary branches. Since, majority of the hybrids showed inbreeding depression in F_2 , it was recommended to exploit heterosis in F_1 itself.

Desai et al. (1984) in a study of hybrids involving 15 varieties reported that the cross B 45 x MT 67-52 recorded the highest yield and was most heterotic for yield and oil content. They also reported that heterosis was attributable mainly to increases in number of branches, plant height and 100 seed weight.

Chaudhari et al. (1984a) reported from a 8 x 8 incomplete diallel analysis, heterosis for seed yield per plant and eight yield related quality traits.

Krishnaswami and Appadurai (1984) studied heterosis in thirty six hybrids derived from crossing 12 female and three male parents and reported that the extent of heterosis was high for number of capsules and seed yield.

In another study, Krishnaswami et al. (1985) involving 84 hybrids derived from two sets of crosses, one set using CO 1 and another TMV 3 as ovule parent, the hybrid Si 2327 x CO 1 and Si 2241 x TMV 3 were considered worth exploiting as they showed significant heterosis both for capsule number and seed yield. Heterosis in both combinations ranged from -59.00 to 58.00 per cent for capsule number and -50.00 to 263.00 per cent for seed yield.

Godawat and Gupta (1985) observed from a study of the parents, F_1 , F_2 , BC_1 and BC_2 of five crosses grown in four localities, that heterosis for seed yield was

attributable to heterosis for height and number of capsules per plant. Heterosis was followed by inbreeding depression in all the crosses indicating the involvement of non-additive gene action in the control of seed yield per plant, number of capsules per plant and plant height.

Dora and Kamala (1986) studied a 4 x 4 complete diallel cross and stated that heterosis over the mid parent value was most pronounced for branches per plant, capsules per plant, number of seeds per capsule and seed yield per plant and positive and significant for primary branches per plant and seed length. The magnitude of positive and negative heterosis for different characters in F_1 over the parental means indicated overall dominance of positively acting genes. The higher magnitude of negative heterosis than that of the positive heterosis for secondary branches, capsules length and width, seed thickness, days to first flowering, days to maturity, seed yield per plant and seed yield per plot over the better parents indicated partial dominance. Heterobeltiosis for oil content in the cross B 67 x IS 103 was the maximum (27.20 per cent) with a *per se* oil content of 55.80 per cent. This hybrid along with Madhavi x B 67 with 58.00 per cent oil content were recommended for commercial exploitation.

Singh et al. (1986) studied heterosis in respect of 13 traits in 30 hybrids of white seeded sesame. High

heterotic values were observed for primary branches, secondary branches, capsules, harvest index, yield, protein and oil content. Til 1 x Pb 1 showed the highest heterosis for seed yield (327.74 per cent) over the better parent. It also recorded the highest yield superiority 108.36 per cent over the standard variety T 12.

Four crosses of Sesame were studied for heterosis in respect of seed yield, oil yield and oil content per plant by Reddy et al. (1986). The relative heterosis ranged from 23.40 to 113.00 per cent and heterobeltiosis from nil to 71.40 per cent for seed yield. In respect of oil content, the heterosis was 13.00 to 65.50 per cent and heterobeltiosis from nil to 41.20 per cent.

Krishnadoss et al. (1987) studied heterosis in (20 x 5, line x tester) 100 hybrids along with their parents. Relative heterosis, heterobeltiosis and standard heterosis were estimated. Relative heterosis alone was significant, that too, in four hybrids. Among them, the hybrid L 15 x T 3 recorded a maximum of 174.47 per cent relative heterosis but recorded negative standard heterosis. They concluded that the possibility of exploiting hybrid vigour for commercial purpose for boosting the seed yield in sesame was not bright in the materials studied.

Padmavathi (1987) in a study of 15 x 5 line x tester analysis in sesame for 15 characters, reported that

maximum heterosis of 48.86 per cent was recorded for number of primaries, 36.36 per cent for number of seeds per capsule, 10.49 per cent for capsule length and 49.25 per cent for seed yield per plant. Maximum heterobeltiosis of 18.41 per cent was registered for number of primaries, 15.29 per cent for number of seeds per capsule, 5.29 per cent for capsule length and 14.61 per cent for seed yield. Negative heterosis was observed in many hybrids for characters like plant height, height to first capsule, internodal length, number of secondaries, capsules on branches, first capsule bearing node, capsule breadth and days to maturity.

Anitha (1988) studied 56 hybrids along with their parents (8 x 8 diallel) for 20 morphological and economic traits. Three hybrids viz., Si 1484 x Si. 1003, Si 1225 x Si. 1484 and CO 1 x Si 1003 exhibited significant positive heterobeltiosis for seed yield while positive standard heterosis was seen in four hybrids, namely CO 1 x Si 1003, TSS 5 x TSS 4, TSS 4 x TSS 5 and Si 1225 x TSS 4. The maximum heterosis of 44.02 per cent for seed yield was registered by the cross Si 1484 x Si 1003 and the maximum standard heterosis of 26.84 per cent by the cross CO 1 x Si 1003.

Subbalakshmi (1989) after a study of 6 x 6 diallel crosses for two seasons on six characters observed that heterosis for number of branches, capsule length and seed

yield was higher in summer compared to the expression in kharif. The hybrids CO 1 x TMV 3, Si 964 x Si 1653 and CO 1 x Si 964 were identified as suitable for heterosis breeding since they possessed significantly positive heterosis in both summer and kharif seasons.

Dharmalingam (1990) in a study of 6 x 6 diallel analysis reported significant and positive heterosis in the crosses TMV 6 x S 0549, S 0549 x AT 11, TMV 6 x ACV 2 and S 0549 x ACV 2 for seed yield, plant height, number of branches, number of capsules on main stem, number of capsules on branches, number of capsules per plant and number of seeds per capsule.

Tu et al. (1991) in their study of 6 x 6 diallel cross, observed heterosis for seed yield, plant height, first capsule position, length of main fruit axis, number of branches, number of capsules per plant, seeds per capsule, 1000 seed weight but not for flowering period duration.

2.2. COMBINING ABILITY

The ability of an inbred to transmit its desirable performance to its hybrid progenies is called combining ability. The concept of combining ability in terms of genetic variations was put forward by Sprague and Tatum (1942) using single crosses in maize. They defined the general combining ability (GCA) as the average performance

of a line in several hybrid combinations. The specific combining ability (SCA) was designated to the effects in certain combinations which significantly deviated from what would be expected on the basis of average performance of the lines involved. Sprague and Federer (1951) and Rojas and Sprague (1952) found that GCA involved additive effect of genes as well as additive x additive interactions, which was later confirmed by Carnahan et al. (1960). They attributed SCA not only involved dominance and epistasis but also considerable amount of genotype x environment interactions. Griffing (1956) expressed that GCA involved both additive effects as well as additive x additive interactions. Kempthorne (1957) precisely defined SCA and GCA in terms of covariances of half sibs and full sibs in random mating population. The inheritance of combining ability is governed primarily by many genes with small individual effects. Lines high in combining ability are high in heritability presumably because of large proportion of favourable genes which they carry (Lonnquist, 1951).

Studies on combining ability carried out so far on sesame are discussed hereunder.

Murthy (1975) studied combining ability and reciprocal effects in 10 x 10 diallel analysis. The GCA variances were larger than SCA variances for all the traits except for oil content indicating the predominance of

additive gene action. The SCA variances were considerable for seed yield and protein content. The variances due to reciprocal effects were also significant for all characters except seed yield, percentage of oil and protein content. The variety TMV 2 and Si 770 were good general combiners for plant height, number of primary and secondary branches, number of capsules per plant and seed yield. For oil content, Sel-R was a better general combiner while TMV 2 for protein content and Si 1783 for earliness.

Dixit (1978) studied combining ability analysis in a 5 x 5 diallel excluding reciprocals and concluded that both additive and non additive gene action were responsible for the inheritance of protein content while additive gene action, was predominant for test weight. Jhansi local, TC 62 and Kanpur local were the good general combiners for protein content and T4 and Kanpur local for test weight. The hybrids Kanpur local x T4 and TC 62 x Kanpur local were the best combiners for protein content, while Jhansi local x Kanpur local was for test weight.

Shrivastava and Singh (1978) reported from a study of 10 x 10 diallel cross that GCA and SCA variances were significant for plant height, height from base to first capsule, number of branches per plant, number of capsules per plant and seed yield. The GCA variances was higher than

the SCA variances for all the characters indicating additive gene action for all the characters except plant height.

Ashok Kotecha and Yermanos (1978) after a study of 8 × 8 diallel mating found that the GCA variance for seed yield, plant height, capsule number and capsule length was highly significant and much larger than the SCA variance indicating additive gene action for these characters. Reciprocal differences were also seen for seed yield, plant height, capsule number and capsule length. The same authors (1979) also reported that the average and mean degree of dominance indicated over dominance which was in the direction of seed yield. Reciprocal effects of hybrids was significant indicating also the maternal effects.

Rathnaswamy (1980) in a study of diallel analysis involving nine parents and their 36 hybrid combinations (excluding reciprocals) reported that the GCA variance was greater than the SCA variance for all the characters. The analysis revealed that the varieties Si 2511 and TMV 4 were good general combiners for branches per plant, capsule length and yield per plant. KRR 2 was a good general combiner for plant height, capsules per plant and yield per plant. The types Si 2316 and Si 2300 were good combiners for capsule length. The hybrid Si 1761 × Si 2316, TMV 4 × Si 1782, KRR 2 × Si 2511, Si 1761 × Si 1277 and KRR 2 × Si 2511 were identified to be the best hybrids for plant height.

branches per plant, capsules per plant, capsule length and yield per plant respectively.

Nafie (1980) reported that gca effects were higher than SCA effects for yield components. The sca effects were significant for all characters except plant height.

Gupta (1981) studied four characters in a 6 x 6 diallel analysis. The GCA, SCA and reciprocal variances were highly significant for all the four characters. The GCA had higher magnitude than the SCA variance for yield and yield components. The SCA estimates were high for number of branches, capsules per plant and seed yield. Bahadurpur II was the best general combiner for all the traits studied. Bahadurpur II x TS 15-72, Kalang x Til black, Shahabad x Til black and Shahabad x TS 15-72 showed significant sca effects for plant height, Pb Til No.1 x Kalang, Shahabad x Til black and Shahabad x TS 15-72, for number of branches, Til black x TS 15-72, Shahabad x Til black, Kalang x Bahadurpur II, Kalang x TS 15-72, Shahabad x TS 15-72 and Bahadurpur II x TS 15-72 for capsules per plant and Til black x TS 15-72, Pb Til No 1 x Kalang, Bahadurpur II x TS-15-72, Kalang x TS 15-72, Pb Til No 1. x Bahadurpur II, Pb Til No 1 x Til black and Bahadurpur II x Til black for seed yield.

Both gca and sca effects were highly significant for all the characters in a 6 x 6 diallel mating study by Fatteh **et al.** (1982). The variances due to GCA were high for

all the characters compared to those of SCA suggesting additive type of gene action to govern the traits such as days to flowering, plant height, number of capsules per plant, capsule length to breadth ratio, days to maturity, yield per plant and 1000 seed weight. The non-additive type of gene action appeared to have been involved for oil content and number of effective branches. The types Mrug-1 and MT 67-52 were the best general combiners for all the characters. The type T-85-N was a good general combiner for oil content only. Among the hybrids, Mrug-1 x MT 67-52, Mrug 1 x 1-17-2 and Purva x T-85-N were found to be high yielding combinations. Reciprocal effects were observed for all the characters. Highest reciprocal effect was observed for number of capsules per plant followed by plant height and seed yield.

Reddy et al. (1982) in their combining ability analysis in sesame by line x tester (10 x 5) analysis reported that the proportion of GCA to SCA estimates of variances was more than unity for plant height and oil content indicating the predominance of additive gene action. In respect of other characters viz., days to flowering, effective stem length, number of branches, capsules on the main stem, capsules per plant and seed yield per plant, the influence of non-additive gene action was high since the ratio of GCA/SCA was less than one. The variety Si 851 was

found to be a good general combiner for days to flower, plant height, effective stem length, capsules per plant, seed and oil yield per plant. The hybrids Til 1 x Si 851 and Suwan x Si 851 gave high seed and oil yield. The hybrids ES 22 x x Si 851 and MT 67-38 x C 50 were the next best for seed yield and oil yield per plant.

Singh *et al.* (1983) in a study of 12 x 12 partial diallel mating of white seeded sesame reported that the GCA variance was significant for all the characters in F_1 but was not significant in F_2 for days to reproductive phase, days to maturity, harvest index, 1000 seed weight and protein content. SCA variance was significant for days to reproductive phase and oil content in F_2 . This was confirmed by over dominance observed in F_1 and partial dominance in F_2 . Yield and its important components have shown preponderance of both non-additive and additive genetic variance.

Chaudhari *et al.* (1984a) in a study of 8 x 8 incomplete diallel analysis for combining ability of yield per plant and eight yield related characters reported that biparental mating followed by recurrent selection in segregating generation will be useful for improving sesame.

Chaudhari *et al.* (1984b) studied combining ability for yield per plant and six yield related traits from a 6 x 6 diallel mating excluding reciprocals. The results

indicated that the variances due to GCA were significant for all the characters except length of the capsules and the variances due to SCA were significant for yield per plant, number of branches, length of the capsule, number of nodes per plant and number of grains per capsule. The significant GCA and SCA variances indicated that both additive and non-additive components are influencing the expression of yield per plant and its contributing traits, viz., number of branches per plant, number of nodes per plant and number of seeds per capsule whereas the number of capsules per plant, height of plant and length of capsule have non-additive components.

Djigma (1984) after analysing the hybrids of five varieties from different countries crossed in a diallel model reported that additive effects predominated capsule length and 1000 seed weight and interactions pre dominated for seed yield, length of main stem and number of capsules. The varieties Yendev 55 (Nigeria) and Jaisalmer 128 (India) were identified as the best combiners for 1000 seed weight.

Krishnaswami and Appadurai (1984) after a study of 36 hybrids obtained by crossing 12 lines with three testers, reported that the gca values were high in N 62-34/3 and Jt 62-34/1 among females and in CO 1 among males for the four characters studied. Hybrids involving CO 1 and N 62-

34/3 as parents besides showing high sca. expressed increased values over the best parent CO 1.

Rathnaswamy and Jagathesan (1984) in their combining ability studies involving nine parents and their 36 hybrids, indicated that the GCA variance was greater than SCA variance for all the characters viz., seed yield per plant and four yield related traits. GCA x environment variance was greater than SCA x environment variance.

Reddy et al. (1984) studied combining ability in a 10 x 10 diallel cross. They reported that the parents Anand 747, N 62-38 and C 50 exhibited negative gca effects for days to flower, plant height, effective stem length and number of branches. Si 851 and Si 1551 had positive gca effects for days to flower, plant height and number of branches. T 85 was a desirable combiner for many of the characters studied viz., days to flower, total capsules, seed yield, oil yield and oil content. Si 1854/1 was good general combiner for seed yield. Si 1854/1 x Anand 74 x 91-9-9-9 x Anand 74, N 86 x Si 1854/1 and N 62-38 x T 85 crosses recorded significant sca effects with high mean yield of oil per plant in that order.

Sharma and Chauhan (1985) studied the nature of combining ability in a 10 x 10 diallel and found that the variance for GCA, SCA and reciprocal effects were significant. The magnitude of GCA variances was higher than

that of the SCA variances. Good general combiners for seed yield, oil per cent, days to first flower, days to maturity and number of capsules per plant were JT 7, T 13, B local, T 12, SH 50 and SH 62. The crosses T 12 x N 32, Patan 64 x SH 62 and Patan 64 x T 13 had the highest sca effects for seed yield. JT 66-173 x SH 62 and SH 62 x T 12 were the crosses with high sca effects for capsules per plant and N 32 x SH 62 for 1000 seed weight. For days to flower B local x T 12 had the highest positive effect, while T 12 x SH 50 had the maximum negative effect.

Dora and Kamala (1987) studied combining ability in Sesame from a 4 x 4 diallel mating for 16 characters. Gowri was observed to be a good general combiner for many characters as it had high gca effect. Madhavi was ranked the next best general combiner. Gowri x Madhavi was the best combination for seed yield per plant while Madhavi x Gowri for oil content. The estimates of SCA variances were generally much higher than that of the GCA variances suggesting the influence of both additive and non-additive gene action. The high GCA/SCA ratio, however confirmed the predominance of non-additive gene influence.

Anand kumar and Sree Rangaswamy (1987) studied combining ability of sesame in a line x tester analysis. SCA variances were higher than GCA indicating influence of non-additive alleles for seed yield.

Krishna (doss et al. (1987) in a (20 x 5) line x tester study reported predominance of non-additive over additive gene action for yield per plant and six yield related and other developmental traits. Si 244/2 was a good general combiner for height and number of capsules per plant whereas 68/20 for height and yield per plant.

Padmavathi (1987) evaluated 15 lines and five testers in a line x tester analysis for estimating combining ability and found that GCA variances were greater than SCA variances in respect of yield, plant height, height to first capsule, capsule length, days to maturity indicating the predominance of additive gene action for these traits. For 1000 seed weight and oil content, high SCA variances were recorded revealing that nonadditivity control these traits.

Combining ability was studied in 8 x 3 line tester analysis by Khorgade et al. (1988) for yield and ten other yield related traits. The analysis of variance indicated significant variation for all the characters except oil content and hence excluded from further study. Both GCA and SCA variances were significant for days to maturity, capsule length, number of branches per plant, number of capsules per plant and 1000 seed weight, indicating the preponderance of both additive and non-additive types of gene action in controlling these traits. IC 252 was identified to be the best general combiner for plant height, number of branches

per plant and seed yield per plant and IS 620 for earliness, capsule length, capsule width and number of seeds per capsule. The best cross combination was IC 252 x N 128.

Anitha (1988) studied combining ability in Sesame from 8 x 8 full diallel and reported that reciprocal differences were significant for plant height, number of primaries, 1000 seed weight and oil content. TSS 5, TSS 4, CO 1 and Si 1484 are identified as better general combiners whereas CO 1 x Si 1003 was adjusted to be the best hybrid combination. Based on the *per se* performance, heterobeltiosis and *sca* effects for yield and other economic traits the crosses CO 1 x Si 1003, TSS 4 x TSS 5 and Si 1125 x TSS 4 were reported to be worthy of exploitation for yield improvement.

Subbalakshmi (1989) from a study of 6 x 6 diallel analysis for two seasons reported that mean performance of parents was the indicator of their *gca* effects for all the traits. Predominance of *GCA* over *SCA* variances for all traits were observed. The relationship between *gca* effects of parents and the *sca* effects of hybrids were discussed and brought out.

Dharmalingam (1990) studied a 6 x 6 diallel analysis and observed that the variances due to *GCA* were highly significant for all the traits while the variances due to *SCA* were significant for all characters except length

of capsules. The reciprocal variances were also significant for all the traits except length of capsule which was less significant.

Narkhede and Sudir kumar (1991a) reported from 8 x 8 diallel studies, that the performance of the parents were generally more stable than those of the hybrids over environments. The type RSE 1 was the best combiner for oil and protein content and other characters.

Kandaswami (1992) from a study of 27 x 5 line tester analysis, reported that the magnitude of SCA variances was higher than GCA variances for all the trials in individual season.

2.3. GENETIC ANALYSIS

In a 10 x 10 diallel analysis study in Sesame, Murthy and Hashim (1974) observed significant a and b components for plant height, branches per plant, capsules per plant and plot yield indicating the presence of both additive and dominance genetic effects. The additive variance (D) and dominance components H_1 and H_2 were significant for both the above characters. The H_1 was larger in magnitude than the D component for branches per plant, capsules per plant and plot yield while H_2 was larger for plant height. Partial dominance was observed for plant height while over dominance for branches per plant capsules

per plant and plot yield. The heritability in narrow sense was in the order of 77.50, 40.15, 11.81 and 13.08 per cent respectively for plant height, branches per plant, capsules per plant and plot yield.

Rathnaswamy (1980) from his study of 9 x 9 diallel reported a higher magnitude of additive component variation than dominance component for plant height, number of branches and number of capsules per plant and thereby indicated the predominance of additive gene effects for yield components. However, the degree of dominance ranged from partial dominance in one environment to overdominance in five other environments. This indicated that seed yield per plant though showed some degree of additivity was strongly influenced by dominance and non allelic interactions in most environments. Heritability ranged from 40.3 to 70.65 per cent for plant height, 55.83 to 84.9 per cent for branches per plant, 54.07 to 77.91 per cent for capsules per plant and 52.22 to 62.12 per cent for yield per plant.

Narkhede and Sudir kumar (1991b) in a study of 8 x 8 diallel analysis for seven traits, reported that number of primary branches per plant, capsules per plant, length of capsules, seeds per capsule and yield per plant were generally controlled by dominant gene action. Length of main

reproductive stem was under additive and test weight under both additive and dominant gene action.

2.4. GRAPHICAL ANALYSIS

Murthy and Hashim (1974) in their study indicated that the regression coefficient of W_r , V_r was practically equal to unity for plant height, number of branches per plant but deviated significantly from unity for capsule number and plot yield. Thus, epistasis was either a minor or major feature of genetic system for different characters and probably plays a role in inflating the dominance ratio.

Rathnaswamy (1980) after a study of 9 x 9 diallel mating, reported through graphical analysis that the regression line of W_r on V_r intercepted the 'Y' ordinate above the point of origin in most environments. The parent S.i.1761 clustered mostly near the origin for branches per plant and capsules length while the position of others were inconsistent indicating the presence of dominant alleles for the above two characters.

Subbalakshmi (1989) after study of 6 x 6 diallel analysis reported through graphical analysis significant values of W_r , V_r for number of branches and two of the parents possessed more of dominant alleles since they were nearer the origin on the regression line.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1. MATERIALS

The experimental material consisted of fifteen genotypes of Sesame, *Sesamum indicum* (L.) maintained at School of Genetics, Tamil Nadu Agricultural University, Coimbatore. The origin/source and other particulars of the genotypes are presented in the Table 3.1.

3.2. METHODS

A total of 147 genotypes was collected from oilseeds unit, School of Genetics, Tamil Nadu Agricultural University, Coimbatore. All these genotypes were raised at the Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore during rabi, 1978. Fifteen genotypes were selected at random from these 147 genotypes and selfed seeds of these 15 types were again sown during summer, 1979. These types were again selfed by following the method of holding the petals by tying threads in the afternoon before the flower opening. The selfed capsules were collected and dried seeds obtained from the selfed capsules utilised as parental seeds. The parental seeds of 15 genotypes were sown during kharif, 1979 and crosses were made in all possible ways in a diallel of 15 x 15 including reciprocals. The parental genotypes were continued to be maintained by selfing.

Table 3.1. Origin of parents and their morphological characteristics

Parents	Origin/ source	Code	Duration in days	Capsules per leaf axil	Locules per capsu- le	Seed colour	other characters
KRR 2	Tamil Nadu(TN)	P ₁	85-90	1	4	Dull white	Bushy type, hairy
TMV 6	Tamil Nadu(TN)	P ₂	85-90	1	4	Brown	Medium
S.i.1503	Sudan, Africa	P ₃	80-85	1	4	Dull white	Medium
S.i.1783	Texas, USA	P ₄	80-85	1-3	6-8	Light brown	Medium
S.i.2141	Canada	P ₅	80-85	1-3	4	White	Erect
S.i.2277	Australia	P ₆	85-90	1	4	Brown	Bushy
S.i.2325	Mexico	P ₇	90-95	1	4	Dull white	Bushy, Late
S.i.2332	Mexico	P ₈	85-90	1	4	Brown	Medium
S.i.2340	Morocco	P ₉	85-90	1-3	4	White	Erect, Hairy
S.i.2631	Rajasthan	P ₁₀	80-85	1-3	4	Light brown	Open
S.i.3321	U.A.R.	P ₁₁	80-85	1	6-8	Light brown	Medium
Patan.64	Gujarat	P ₁₂	75-80	1-3	4	White	Open
X 91-9-9	Andhra (AP) Pradesh	P ₁₃	80-85	1-3	4	Light brown	Open
K.79-307	Andhra (AP) Pradesh	P ₁₄	80-85	1	4	Light brown	Medium
SEL.R	IARI, New Delhi	P ₁₅	85-90	1	4	White	Medium

Seeds collected from each of these 210 hybrid combinations (105 direct crosses and 105 reciprocal crosses) were divided into three parts for use in further study, one part for study during kharif 1980, another part for study during summer, 1981 and remaining for study along with the selected F_2 generations. The 210 hybrid combinations along with their parents (15) were raised and studied during kharif, 1980. Randomised block design with three replications was the lay out adopted. The study was repeated during summer, 1981 adopting the same design of layout and number of replications.

The normal cultural, agronomic, plant protection and management practices were adopted as per the recommended schedule. Each entry was raised on the sides of ridges formed 45 cm apart. A spacing of 20 cm was adopted between plants in the row. Irrigation was provided whenever necessary during the crop growth. The list of parents and their code numbers are presented in Table 3.1.

3.3. CHARACTERS STUDIED

Five plants were selected at random in each of the replications (excluding the border plants) in both the parents and hybrid combinations (Panse and Sukatme (1961). The mean values of each replication were utilized for statistical analysis. The characters studied are given

hereunder. The characters selected are directly related to seed yield.

- (1) Plant height - Plant height measured from ground level to the tip of the main stem of the plants in centimetres at the time of harvest.
- (2) Days for first flower - Number of days taken from sowing to the appearance of the first flower on the selected plant.
- (3) Capsules on the main stem - The number of fully developed capsules at the time of harvest on the main axis or main stem of the plant.
- (4) Capsules on the branches - The number of fully developed capsules at the time of harvest on the branches of the plant.
- (5) Capsules per plant - The total number of fully developed capsules at the time of harvest on the plant.
- (6) Seed yield - All the capsules collected from each of the plant were dried, threshed, cleaned, weighed and expressed in grams.

3.4. STATISTICAL ANALYSIS

3.4.1. Analysis of variance

The analysis of variance in individual seasons was carried out and presented as follows

Source	D.F.	Expectations of mean squares
Blocks (b)	(b-1)	$\sigma_e^2 + g \sigma_b^2$
Genotypes (g)	(g-1)	$\sigma_e^2 + b \sigma_g^2$
Error	(b-1) (g-1)	σ_e^2

3.4.2. Pooled analysis of variance

The anova was performed as detailed below.

Source	D.F.	M.S.	Expectations of mean square
Replications (r)	(r-1)	-	-
Seasons (s)	(s-1)	Ms	$\sigma_e^2 + b \sigma_{gs}^2 + b g \sigma_s^2$
Genotype (g)	(g-1)	Mg	$\sigma_e^2 + b \sigma_{gs}^2 + b s \sigma_g^2$
Genotype x seasons (g x s)	(g-1) (s-1)	Mgs	$\sigma_e^2 + b \sigma_{gs}^2$
Error	s(g-1) (r-1)	Me	σ_e^2

The genotypic component σ_g^2 and genotype x season interaction (σ_{gs}^2) estimates were obtained as follows

$$\sigma_g^2 = \frac{Mg - Mgs}{rs}$$

$$\sigma_{gs}^2 = \frac{Mgs - Me}{r}$$

Where, r = number of blocks
 s = number of seasons

3.5. ESTIMATION OF HETEROISIS

Heterosis over mid parent and better parent

Heterosis over mid parent value (d_i) and better parent value (d_{ii}) were calculated and expressed as percentage of increase as detailed below

$$d_i = \frac{\bar{F}_1 - MP}{MP} \times 100$$

$$d_{ii} = \frac{\bar{F}_1 - BP}{BP} \times 100$$

where,

\bar{F}_1 = mean value of the hybrid

MP = mid parent value $\frac{\bar{P}_1 + \bar{P}_2}{2}$

(\bar{P}_1 and \bar{P}_2 are the mean values of the first and second parent respectively)

BP = better parent value

3.6. COMBINING ABILITY ANALYSIS

3.6.1. Analysis of variance for combining ability in individual seasons

The procedure outlined by Griffing (1956) for method I and model I was followed

Source	D.F.	M.S.	Expectations of mean squares
GCA	(p-1)	Mg	$\sigma^2 + \frac{2p}{p-1} \sum_i g_i^2$
SCA	p(p-1)/2	Ms	$\sigma^2 + \frac{2}{p(p-1)} \sum_i < \sum_j s_{ij}^2$
Reciprocal	p(p-1)/2	Mr	$\sigma^2 + \frac{2}{p(p-1)} \sum_i < \sum_j r_{ij}^2$
Error	m	Me	σ^2

Where

p = number of parents

$Me = \frac{Me}{b}$ where Me is the error mean square for the randomised block design and 'b' is the number of blocks

Estimation of general combining ability (g_i), specific combining ability (S_{ij}) and reciprocal (r_{ij}) effects and their standard errors in individual seasons.

These were estimated as follows

$$g_i = \frac{1}{2p} (x_{i.} + x_{.i}) - \frac{1}{p^2} x \dots$$

$$S_{ij} = \frac{1}{2} (x_{ij} + x_{ji}) - \frac{1}{2p} (x_{i.} + x_{.i} + x_{j.} + x_{.j}) + \frac{1}{p^2} x \dots$$

$$r_{ij} = \frac{1}{2} (x_{ij} - x_{ji})$$

The variance of effects were estimated as follows

$$\text{Variance } (g_i) = \left(\frac{p-1}{2p^2} \right) \sigma^2$$

$$\text{Variance } (s_{ij}) = \frac{1}{2p^2} (p^2 - 2p + 2) \sigma^2$$

$$\text{Variance } (r_{ij}) = \frac{1}{2} \sigma^2 \quad (i \neq j)$$

By taking square root of the variances, the corresponding standard errors required for testing were obtained.

3.6.2. Pooled analysis over seasons

Since the experiment was repeated under two seasons, the combining ability analysis of the diallel data over different seasons was performed following the procedures developed by Daljit Singh (1973, 1979) for Method I - Model I of Griffing (1956). The model used for this analysis was :

$$X_{ijklm} = \mu + v_i + l_j + (vl)_{ij} + (lb)_{jk} + (vlb)_{ijk} + e_{ijklm}$$

where,

μ = population mean

v_i = the effect of the i^{th} variety

- l_j = the effect of the j^{th} season
 $(vl)_{ij}$ = the interaction of the i^{th} variety with j^{th} season
 $(lb)_{jk}$ = the effect of k^{th} block within j^{th} season
 $(vlb)_{ijk}$ = the interaction of the i^{th} variety in the k^{th} block of the j^{th} season
 e_{ijkm} = the effect of the i^{th} variety in k^{th} block in j^{th} season associated with m^{th} individual.

3.6.3. Combining ability analysis pooled over seasons

The form of analysis of variance for combining ability and expectations of mean square are given below

Source	D.F.	M.S.	Expectations of mean squares
GCA (G)	$(p-1)$	A_g	$\sigma^2 + \frac{2pl}{p-1} \sum_i y_i^2$
SCA (S)	$p(p-1)/2$	A_s	$\sigma^2 + \frac{2l}{p(p-1)} \sum_i \sum_j s_{ij}^2$
Reciprocal (R)	$p(p-1)/2$	A_r	$\sigma^2 + \frac{4l}{p(p-1)} \sum_{i < j} r_{ij}^2$
Seasons (L)	$(l-1)$	A_l	$\sigma^2 + \frac{p^2}{(l-1)} \sum_k l_k^2$
Interaction (G x L)	$(p-1)(l-1)$	A_{gl}	$\sigma^2 + \frac{2p}{p(p-1)(l-1)} \sum_k \sum_i gl_{ik}^2$
Interaction (S x L)	$\frac{p(p-1)(l-1)}{2}$	A_{sl}	$\sigma^2 + \frac{2}{p(p-1)(l-1)} \sum_k \sum_i \sum_j (sl)_{ijk}^2$
Interaction (R x L)	$\frac{p(p-1)(l-1)}{2}$	A_{rl}	$\sigma^2 + \frac{4}{p(p-1)(l-1)} \sum_k \sum_i \sum_j (rl)_{ijk}^2$
Error		A_e	σ^2

Where

$M_e = M_e/b$ where M_e is the error variance for the pooled analysis of variance and b is the number of blocks

3.6.4. Effects

The models for the calculation of combining ability over different seasons are as follows :

$$\hat{g}_i = (x_{i..} + x_{.i.})/2p - (x_{...}/p^2)$$

$$\hat{s}_{ij} = (x_{ij} + x_{ji})/2l - (x_{i..} + x_{.l.} + x_{j..} + x_{.j.})/2p + \frac{x_{...}}{p^2}$$

$$\hat{r}_{ij} = (x_{ij} - x_{ji})/2l$$

The variance of effects and their interactions with seasons were worked out as detailed below :

$$\text{Var. } \hat{g}_i = ((p-1)/2p^2) \sigma^2$$

$$\text{Var. } \hat{s}_{ij} = ((p^2 - 2p + 2)/2p^2) \sigma^2$$

$$\text{Var. } \hat{r}_{ij} = (1/2l) \sigma^2$$

The effects were tested for their significance with the standard errors obtained by taking square root of the corresponding variances

3.7. GENETIC ANALYSIS

3.7.1. Test of hypothesis

The validity of the assumptions for graphic and genetic analysis as postulated by Hayman (1954) was tested by

$$t^2 = \frac{(n-2)}{4} \times \frac{(\text{Var. Vr.} - \text{Var. Wr})^2}{\text{Var.Vr} - \text{Var.Wr} - \text{Cov}^2(\text{Vr, Wr})}$$

Which is F with 4 and (n-2) degrees of freedom. Significant t^2 indicated failure of at least one of the assumptions postulated.

Deviations of regression coefficient (b) from zero and unity- The regression of covariance on variance and its SE were calculated as

$$b = \text{Cov.} \frac{(W_r, V_r)}{\text{Var. } (V_r)}$$

$$\text{Standard error (b)} = \frac{(\text{Var.} W_r - b \text{ Cov.} W_r, V_r)^2}{\text{Var. } V_r (n-2)}$$

The significance of 'b' from zero and unity were tested as follows

$$\frac{b - 0}{\text{SE}(b)} \quad \text{and} \quad \frac{(1-b)}{\text{SE}(b)}$$

These were tested against table value of 't' for n-2 degrees of freedom.

3.7.2. Estimation of variance components

Partitioning of the total variance was carried out by genetic analysis proposed by Hayman (1954) to estimate the genetic parameters \hat{D} , \hat{H}_1 , \hat{H}_2 , \hat{F} , and \hat{h}^2 .

\hat{D} = Component of variation due to additive effects of the genes

\hat{H}_1 = Component of variation due to dominance effects of the genes

\hat{H}_2 = $H_1(1-(u-v)^2)$, where u = proportion of positive alleles

v = Proportion of negative alleles

$$u+v = 1$$

\hat{h}^2 = dominance effects (as the algebraic sum over all loci in heterozygous phase in all crosses) and

\hat{F} = mean value of F_r over arrays, F_r being covariance of additive and non-additive effects in the r^{th} array

\hat{E} = expected seasonal variation obtained from error variance divided by number of replications

$$(\hat{D}) = V_0 L_0 - \hat{E}$$

$$(\hat{F}) = 2V_0 L_0 - 4 W_0 L_0 - 2(n-2) \hat{E}/n$$

$$(\hat{H}_1) = V_0 L_0 - 4 W_0 L_0 + V_1 L_1 - 3(n-2) \hat{E}/n$$

$$(\hat{H}_2) = 4V_1 L_1 - 4V_0 L_1 - 2 \hat{E}$$

$$(\hat{h}^2) = 4 (ML_1 - ML_0)^2 - 4(n-1) \hat{E}/n^2$$

The significance of the genetic components was tested by using the standard errors of respective genetic parameters. The stand errors were calculated by using the equation $S^2_1 = 1/2 \text{ Var. } (W_r - V_r)$ as the common multiplier and terms of main diagonal of the covariance matrix given by Hayman (1954) as corresponding multipliers.

3.7.3. Ratios of genetic components

The genetic parameters were used for the computation of the following genetic ratios

$$(\hat{H}_1/\hat{D})^{1/2} = \text{Mean degree of dominance over all loci}$$

$$(\hat{H}_2/4\hat{H}_1) = \text{proportion of genes with positive and negative effects in the parents}$$

$$\frac{\hat{h}_D/\hat{h}_R}{\hat{h}_2/\hat{H}_2} = \frac{4(\hat{D}\hat{H}_1)^{1/2} + F}{4(\hat{D}\hat{H}_1)^{1/2} - F} \quad \begin{array}{l} \text{proportion of dominant and} \\ \text{recessive genes in the parents} \end{array}$$

\hat{h}_2/\hat{H}_2 = number of groups of factors controlling the characters and exhibit dominance

$$\frac{1/2\hat{D} + 1/2\hat{H}_1 - 1/2\hat{H}_2 - 1/2\hat{F}}{1/2\hat{D} + 1/2\hat{H}_1 - 1/4\hat{H}_2 - 1/2\hat{F} + \hat{E}} = \text{heritability estimates in the narrow sense}$$

3.8. GRAPHIC ANALYSIS

The graphic analysis was done by the method of Jinks and Hayman (1953) and Hayman (1954) and drawn as per regular procedure (Singh and Chaudhary, 1979). *§ ref*

The following variances were calculated

- V_r = Variance of r^{th} array
- W_r' = Covariance between the non-recurring parent and the off-spring of the r^{th} array
- W_r = Covariance between the array mean and the off-spring of the r^{th} array
- V_0L_0 = Variance of the parent
- V_0l_0 = Variance of the means of the arrays
- V_1l_1 = mean variance of the arrays
- $W_0L_0l_1$ = mean covariance between the parent and the arrays
- $ML_1 - ML_0$ = differences between the mean of the parents and the mean of their n^2 progeny
- E = expected seasonal component of variation

The W_r , V_r and W_r, W_r' were calculated and used in constructing of W_r, V_r graph for each character. The limiting parabola for the W_r, V_r graph was drawn with the formula,

$$W_r^2 = (V_r V_p)^{1/2}$$

3.9. STUDY OF F_2 GENERATION ALONG WITH PARENTS AND HYBRIDS

Based on *per se* performance score of the parents and *gca* effects estimated during summer, 1981, the following six hybrids representing High x High, High x Low and Low x Low combinations were selected for study in F_2 generation.

High x high	-	KRR 2 x TMV 6
		KRR 2 x S.i. 2277
High x low	-	KRR 2 x S.i. 2631
		TMV 6 x S.i. 2631
Low x low	-	S.i. 2141 x S.i. 2631
		S.i. 2340 x S.i. 2631

The above said combinations were forwarded to F_2 generation in order to study and estimate the extent of variability generated through recombination.

The six F_2 cross combinations along with parents and hybrids were raised in randomised block design replicated three times during summer, 1982 season. The plant populations studied are given hereunder.

Generation		Number of plants selected at random and studied
P ₁	-	30
P ₂	-	30
F ₁	-	30
F ₂	-	240

Spacing, agronomic practices and plant protection measures adopted etc., were same as in the study of F₁ generation. The characters studied were also the same, except the character "days to first flower".

3.9.1. Statistical analysis

The mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), GCV/PVC, Heritability (h) (broad sense), genetic advance (GA) and genetic advance expressed as percentage of mean were calculated as detailed below. The above genetical parameters were estimated for F₂ generation only.

3.9.2. Variability analysis

The following formulae were utilized for the calculations as suggested by Panse and Sukatme (1961).

$$\text{General mean} = \frac{\text{Total of all values}}{n}$$

where n = number of observations

$$\text{Variance} = \frac{\text{SS} - \text{CF}}{\text{d.f.}} \quad \text{where}$$

SS = sum of squares of all the observations
the characters

$$\text{CF} = \frac{(\text{grand total})^2}{n}$$

d.f = degrees of freedom

$$\text{Standard deviation (SD)} = \sqrt{\text{Variance}}$$

$$\text{Standard error} = \frac{\text{SD}}{\sqrt{n}}$$

$$\text{Coefficient of variation} = \frac{\text{SD}}{\text{Mean}} \times 100$$

3.9.3. Phenotypic and genotypic variance

The phenotypic and genotypic variances were computed as suggested by Johnson et al., (1955).

$$\text{Genotypic variance, } \sigma^2_g = \frac{M_1 - M_2}{r}$$

Where,

M_1 = Mean sum of squares for genotypes

M_2 = Mean sum of squares for error or error variance

r = number of replications

$$\text{Phenotypic variance, } \sigma^2_p = \sigma^2_g + \sigma^2_e$$

Where σ^2_e = error variance

3.9.4. Heritability and genetic advance as percentage of mean

Heritability in the broad sense (h^2) was derived based on the formulae by Lush (1940) and expressed as percentage

$$h^2 = \frac{\text{genotypic variance}}{\text{phenotypic variance}} \times 100$$

Genetic advance for each individual character was obtained by following the formula of Johnson et al., (1955).

$$\text{Genetic advance (GA)} = \sqrt{p^2 \times h^2 \times k} \quad \text{where}$$

p^2 = phenotypic variance

h^2 = heritability

k = selection differential, the value of which is 2.06 at 5 per cent selection intensity

(Falconer, 1967).

Genetic advance expressed as percentage of mean

$$= \frac{\text{GA}}{\text{General mean}} \times 100$$

3.9.5. Phenotypic and genotypic coefficient of variation

The method suggested by Burton (1952) was used to calculate these parameters

$$\text{PCV} = \frac{\text{Phenotypic standard deviation}}{\text{General mean}} \times 100$$

$$\text{GCV} = \frac{\text{Genotypic standard deviation}}{\text{General mean}} \times 100$$

EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

The fifteen parents and 210 hybrids were evaluated during kharif, 1980 and summer, 1981 seasons. Six characters viz., height of the plant, days to first flower, capsules on the main stem, capsules on the branches, capsules per plant and seed yield were recorded from five randomly selected plants in each parent/hybrid, in each replication and the mean values were utilized for statistical analysis.

4.1.1. Analysis of variance in individual seasons

The analysis of variance for all the six characters were carried out for both the seasons and presented in Table 4.1. The differences among the genotypes were statistically significant at one per cent level for plant height, days to first flower, capsules on the main stem, capsules on the branches and seed yield and at 5 per cent level only for total capsules during kharif, 1980 season. In summer, 1981 season, the differences between the genotypes were statistically significant at one per cent level for all the characters.

4.1.2. Analysis of variance for pooled data over seasons

The analysis of variance for pooled data over the seasons are presented in Table 4.2. The differences between the genotypes were statistically significant at one per cent level for days to first flower, number of capsules on main

stem, number of capsules on the branches and seed yield per plant. The differences between the parents and hybrids were statistically significant at five per cent level for number of capsules per plant. In respect of height of the plants, the differences were not statistically significant.

To obtain further information, estimates of σ^2_g (estimate of genotypic component) and σ^2_{g1} (estimate of genotype x environment interaction component) were computed utilizing the expectations mean squares. The σ^2_{g1} estimate was larger than σ^2_g component for all the characters except for days to first flower. The ratio of $\sigma^2_g : \sigma^2_{g1}$ ranged from 0.14:1 for seed yield to 11.9 for days to first flower (Table 4.2 and Fig.A).

4.2. Performance of the parents and hybrids

The performance of the parents and hybrids in both the seasons and over all mean values for the six characters is presented in the Tables 4.3 to 4.8. The results are presented characterwise.

4.2.1. Performance of the parents

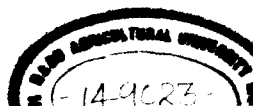
Height of the plant : The variety S.i. 2325 (Mexico) expressed maximum height during kharif, 1980 while the variety KRR 2 showed the maximum height during summer, 1981. However, the variety S.i. 2325 (Mexico) was found to be tallest in the mean value for both the seasons.

Days to first flower : The parent S.i. 2325 (Mexico) was found to be late in both the seasons as well as in the mean value for over the seasons. The parent S.i. 2141 (Canada) was the earliest to flower in both the seasons as well as in the mean value for the two seasons.

Capsules on the main stem : Maximum number of capsules on the main stem was observed in the parent K.79-307 (AP) during kharif, 1980 while the parent S.i. 2325 (Mexico) was found to record the maximum number of capsules in summer, 1981. The parent S.i. 2325 (Mexico) recorded the maximum number of capsules on the main stem in the mean value for both the seasons.

Capsules on the branches : The parent S.i. 1783 (USA) recorded the maximum number of capsules on the branches in kharif, 1980 whereas KRR 2 (TN) was found to possess the highest number in summer, 1981. In the mean value also, the variety KRR 2 was found to record the highest number of capsules.

Capsules per plant : The parent K.79-307 (AP) was found to possess the maximum number of capsules per plant during kharif, 1980 while the variety KRR 2 (TN) was found to have the highest number in summer, 1981. In the mean value for both the seasons, the variety KRR 2 (TN) recorded the maximum number of capsules per plant.



Seed yield : In kharif, 1980, the seed yield was found to be highest in the variety S.i. 1783 (Texas) but in summer, 1981 the variety KRR 2 (TN) was found to record the highest seed yield. In the mean for both the seasons, highest seed yield was recorded by the parent X 91-9-9 (AP) followed by the variety KRR 2 (TN).

4.2.2. Performance of hybrids - The results are presented below character wise (vide Tables 3.4 to 4.8).

Plant height - Hybrid $P_{7.15}^*$ had the highest value (116.54 cm) during kharif, 1980 season followed by $P_{2.7}$ (111.04 cm). In summer, 1981 the highest value was observed in $P_{1.8}$ (125.16 cm) followed by $P_{1.11}$. In the mean value for the both the seasons, the hybrid $P_{1.7}$ (106.18 cm) was found to be the tallest, followed by $P_{2.7}$.

Days to first flower - None of the hybrid combinations was earlier than the earliest parent in both the seasons as well as based on the pooled performance (34.8, 33.23 and 34.01 days). Hybrid $P_{9.10}$ was found to be earliest in both the seasons as well as in the mean performance (35.09, 33.51 and 34.30 days). The hybrid $P_{6.7}$ was found to be late for first flower in both the seasons as well as based on the pooled values (48.36, 45.60 and 46.40 days).

* ($P_{X.Y}$ indicates henceforth parent [X]crossed with parent [

Capsules in the main stem - In kharif, 1980, the hybrid P_{5.9} recorded the maximum number of capsules on the main stem (54.56) followed by P_{7.12} (49.03). However, in summer, 1981, the latter hybrid viz., P_{7.12} recorded the maximum number (48.5) followed by P_{2.14} (35.3). In the mean value for both the seasons, the hybrid P_{7.12} was found to register the highest values (48.76) followed by P_{5.9} (43.34).

Capsules on the branches - In 1980 kharif season, the hybrid P_{6.11} was found to record the maximum number of capsules in the branches (49.23) followed by hybrid P_{2.4} (46.68). In summer, 1981, the hybrid P_{1.9} registered the maximum number of capsules (80.33) followed by the hybrid P_{1.11} (79.29). In the mean performance for the two seasons, the hybrid P_{2.11} was found to possess the highest capsules number of 57.97 followed by the hybrid P_{1.11} with 57.04.

Capsules per plant - The hybrid P_{7.15} was found to register the highest number of capsules per plant (81.86) followed by the hybrid P_{4.10} (73.93) during kharif, 1980 season. In summer, 1981, the hybrid P_{1.11} was found to record the maximum number of capsules per plant (112.56) followed by the hybrid P_{1.9} (110.56). In the mean value for the two seasons, the hybrid P_{1.4} had the maximum number of 82.87 capsules per plant followed by the hybrid P_{1.11} (82.64).

Seed yield - The maximum seed yield during the kharif, 1980 season was seen in the hybrid P_{7.15} (11.76) followed by P_{7.11} (11.69). In summer, 1981, the highest seed yield was observed in the hybrid P_{1.6} (13.41) followed by P_{2.8} (12.31). In the mean for the two seasons, the highest value was seen in the hybrid P_{10.11} (10.27) followed by the hybrid P_{10.13} (10.13).

4.3. Heterotic expression over mid parent and better parent values

The estimates of heterosis are presented in Tables 4.9 to 4.14 and graphically presented in Fig.B and Fig.C.

4.3.1. Heterosis over mid parent value

Plant height :

Kharif, 1980 - Eighteen hybrids exhibited significant and positive heterosis over mid parent value. Hybrids P_{2.11}, P_{5.8} and P_{5.11} recorded 23.87, 25.58 and 39.14 per cent respectively over the mid parent value. The hybrids P_{4.9}, P_{6.13} and P_{10.14} showed negative heterosis of -16.86, -30.95 and -12.51 per cent respectively over the mid parent value. The range of heterosis observed varied from -30.95 to 39.14 per cent.

Summer, 1981 - The heterosis ranged from -26.55 to 69.07 per cent over the mid parent value. A total of 16 hybrids registered positive and significant heterosis, particularly P_{11.12}, P_{11.15} and P_{12.15} which recorded 38.49, 69.07 and

30.69 per cent respectively. The hybrid P_{5.9} alone showed negative and significant heterosis viz., -26.55 per cent over the mid parent value.

Pooled - The range of heterosis over the mid parent value was -9.02 to 30.02 per cent. Positive and significant heterosis was observed in 16 hybrids. Maximum heterosis of 30.02 per cent was observed in P_{5.11} followed by P_{5.11} (29.47), P_{11.12} (27.24), P_{2.5} (24.04) and P_{5.6} (20.98). Hybrids P_{1.11}, P_{2.5}, P_{5.6}, P_{5.11} and P_{11.12} showed positive heterosis in both kharif, 1980 and summer, 1981 seasons with a range of 15.91 to 38.49 per cent.

Days to first flower :

Kharif, 1980 : Eleven hybrids exhibited significant and positive heterosis over the mid parent value. The hybrids P_{1.9}, P_{5.14} and P_{5.15} exhibited 12.80, 8.30 and 8.15 per cent heterosis over the mid parent value. Fourteen hybrids showed significant negative heterosis ranging from -5.16 to -8.07 per cent. The hybrids P_{3.14}, P_{4.5} and P_{4.10} registered -8.07, -7.77 and -8.00 per cent respectively. The range of heterosis was seen to vary from -8.07 to 12.80 per cent. The high negative heterosis was an indication of earliness in days to first flowering.

Summer, 1981 : The range of heterosis during the season varied from -8.30 to 13.26 per cent. While twelve hybrids

showed positive and significant heterosis over the mid parent value, another 10 showed significant and negative heterosis. The hybrids which showed positive heterosis were $P_{1.9}$, $P_{5.6}$ and $P_{5.14}$ with 11.48, 8.42 and 13.26 per cent respectively over their respective mid parent values. Among the hybrids which recorded negative heterosis were $P_{1.2}$ (-8.07) $P_{1.4}$ (-8.07) and $P_{4.10}$ (-8.30).

Pooled : The range of heterosis varied from -8.15 to 12.14 per cent in the mean value for the two seasons. While twelve hybrids exhibited significant and positive heterosis over their mid parent value, fourteen showed significant and negative heterosis. The promising hybrids with negative heterosis showing earliness in flowering were $P_{4.10}$ (-6.15), $P_{1.4}$ (-7.79) and $P_{1.2}$ (-7.62). The hybrids which showed lateness in flowering were $P_{5.6}$ (8.12), $P_{5.14}$ (10.78) and $P_{8.1.9}$ (12.14).

The behaviour of the hybrids $P_{1.2}$, $P_{1.4}$, $P_{2.15}$, $P_{3.14}$, $P_{4.10}$ etc. was found to be almost similar in both the seasons, showing a little earliness while the hybrids $P_{1.9}$, $P_{5.14}$, $P_{5.15}$ etc. exhibited delay in the first flowering.

Capsules - Main stem

Kharif, 1980 : Fourteen hybrids registered significant and positive heterosis while 26 showed negative and significant heterosis over the mid parent value. The range of heterosis observed was -56.71 to 72.18 per cent. The prominent hybrids

which showed positive heterosis were $P_{1.3}$, $P_{3.11}$, $P_{5.9}$ and $P_{7.12}$ with 35.68, 33.52, 72.18 and 39.85 per cent respectively. The hybrids which showed negative heterosis were $P_{2.14}$, $P_{6.14}$ and $P_{9.14}$ with -48.40, -56.71 and -53.35 per cent respectively over the mid parent value.

Summer, 1981 - Significant and positive heterosis was observed in 26 hybrids while significant and negative heterosis was observed in 14 hybrids. The range observed varied from -65.11 to 48.76 per cent over the mid parent value. The hybrids $P_{1.11}$, $P_{2.14}$ and $P_{3.6}$ showed heterosis of 39.57, 48.76 and 41.73 per cent respectively. Among the hybrids which showed negative heterosis, $P_{2.9}$, $P_{4.9}$, $P_{5.9}$, $P_{6.9}$, $P_{7.9}$, $P_{8.9}$, $P_{9.10}$ and $P_{9.15}$ were conspicuous with -50.50, -50.89, -45.46, -40.55, -41.49, -43.53, -57.81 and -65.11 per cent respectively over the mid parent value. The combinations involving the parent (P_9) S.i. 2340 (Morocco) were conspicuous in having less number of capsules on the main stem.

Pooled : Thirteen hybrid combinations showed positive and significant heterosis over the mid parent value while twenty exhibited significant, negative heterosis. The range of variation in heterosis observed was from -46.69 to 33.24 per cent. Among the hybrids, $P_{1.11}$, $P_{6.11}$ and $P_{7.12}$ exhibited 29.12, 32.37 and 33.24 per cent heterosis on the positive side while the hybrids $P_{1.9}$, $P_{9.14}$ and $P_{9.15}$ on the negative

side. In both the seasons, the hybrids P_{3.10}, P_{4.9}, P_{9.14}, P_{9.15} and P_{10.14} showed negative heterosis consistently while the hybrids P_{1.11}, P_{2.11}, P_{6.11} and P_{7.12} registered positive heterosis.

Capsules - branches

Kharif, 1980 : Positive and significant heterosis was seen in 41 hybrid combinations, especially in the hybrids P_{5.11}, P_{9.11}, P_{9.12} and P_{9.14} with 207.45, 174.17, 171.21 and 168.75 per cent respectively over the mid parent value. Negative and significant heterosis was observed in five hybrid combinations, particularly in P_{3.14}, P_{7.12} and P_{14.15} with -29.0, -30.89 and -61.19 per cent respectively over the mid parent value. The range of heterosis varied from -61.19 to 207.45 per cent over the mid parent value.

Summer, 1981 : The range of heterosis varied from -23.01 to 244.66 per cent over the mid parent value. Positive and significant heterosis was seen in 53 combinations, prominent among them being P_{4.5}, P_{4.9} and P_{5.10} with 192.71, 182.75 and 244.66 per cent respectively over the mid parent value. The hybrids P_{1.3}, P_{3.12}, P_{8.13} and P_{8.15} though exhibited negative heterosis of -23.01, -16.02, -13.50 and -12.96 per cent respectively were not significant over the mid parent value.

Pooled : Forty two hybrid combinations exhibited positive and significant heterosis over the mid parent value.

particularly the combinations P_{5.11}, P_{9.10} and P_{9.11} with 175.19, 144.03 and 171.94 per cent over the mid parent value. Negative but non significant heterosis was observed in hybrids P_{1.7}, P_{1.8}, P_{7.12}, P_{8.15} and P_{13.14} with -18.50, -13.25, -11.47, -13.18 and -16.18 parent respectively over the mid parent value. The range of heterosis varied from -18.50 to 175.19 per cent.

Capsules - plant

Kharif, 1980 - The heterosis for this character ranged from -38.28 to 72.18 per cent over the mid parent value. Thirty seven hybrids exhibited positive and significant heterosis over the mid parent value, particularly P_{5.9}, P_{10.11}, P_{10.12} and P_{3.9} with 72.18, 68.79, 69.17 and 65.01 per cent respectively. The hybrids viz., P_{2.14} and P_{6.14} recorded significantly negative heterosis of -30.57 and -38.28 per cent respectively.

Summer, 1981 - Thirty two hybrids registered significant and positive heterosis over the mid parent value while two recorded significant and negative heterosis. The hybrids which recorded positive heterosis were P_{4.5}, P_{4.14}, P_{5.6}, P_{5.11} and P_{5.15} with 59.88, 52.81, 56.10, 64.19 and 54.17 per cent respectively while the hybrids seen with negative heterosis were P_{5.9} and P_{9.15} with -45.46 and -27.98 per cent respectively over the mid parent value. Six hybrids which showed positive heterosis during kharif, 1980

exhibited the same during summer, 1981 season. But, three hybrids were found to be at variance between the seasons viz., P_{2.14}, P_{8.14} and P_{14.5}. The range in heterosis was found to vary from -45.46 to 64.19 per cent.

Pooled - A total of 19 hybrids was found to register significant and positive heterosis, particularly P_{2.11}, P_{5.11} and P_{11.12} with 51.59, 53.34 and 57.20 per cent respectively over the mid parent value. None of the hybrids exhibited significant negative heterosis. The range of heterosis varied from -16.31 to 57.20 per cent.

Seed yield

Kharif, 1980 : The range of heterosis observed was from -45.98 to 91.83 per cent over the mid parent value. Twenty four hybrids exhibited significant positive heterosis over the mid parent value, particularly the hybrids P_{1.5} (67.50), P_{3.10} (49.88), P_{8.10} (50.00) and P_{10.11} (91.83) while ten hybrids showed significant negative heterosis. The hybrids with negative heterosis were P_{1.7}, P_{4.6} and P_{6.14} with -37.04, -38.10 and -45.98 per cent respectively.

Summer, 1981 : Nineteen hybrids exhibited significant and positive heterosis over the mid parent value, the prominent hybrids among them being P_{3.4}, P_{5.11}, P_{5.12} and P_{10.11} with 48.58, 52.85, 49.42 and 51.70 per cent respectively. Eleven hybrids registered significant negative heterosis viz., P_{5.0}, P_{5.12} and P_{7.12} with -54.44, -38.91 and -45.40 per

cent respectively over the mid parent value. Two hybrids viz., P_{5.15} and P_{10.11} was found to be consistently positive in seed yield heterosis in both the seasons, while one hybrid P_{13.14} was negative in both kharif, 1980 and summer, 1981. The range of variation in heterosis observed was from -54.44 to 52.85 per cent.

Pooled - The range in heterosis varied from -29.67 to 71.76 per cent over the mid parent value. Two hybrids exhibited negative but significant heterosis over the mid parent value viz., P_{1.7} and P_{13.14} with -28.75 and -29.67 respectively. A total of 19 hybrids was found to record significant and positive heterosis, particularly the hybrids P_{5.11}, P_{5.15} and P_{10.11} with 37.53, 42.07 and 71.76 per cent respectively. The latter two hybrids were also found to be consistent in both the seasons.

4.3.2. Heterotic expression over better parent

Plant height

Kharif, 1980 : The heterosis range varied from -30.54 to 25.85 per cent over the better parent value. Six hybrids registered positive and significant heterosis particularly P_{2.8} and P_{5.11} with 17.42 and 25.85 per cent over the better parent. A total of 14 hybrids recorded significant and negative heterosis, particularly the hybrids P_{4.9}, P_{5.7}, P_{10.14} and P_{11.15} with -30.54, -24.60, -25.71 and -21.09 per cent respectively.

Summer, 1981 : Eight hybrids exhibited significant and positive heterosis particularly $P_{1.12}$, $P_{5.12}$, $P_{11.12}$ and $P_{12.14}$ with 15.14, 15.13, 31.02 and 29.92 per cent respectively over the better parent. Thirteen hybrids showed significant but negative heterosis, prominent among them being $P_{3.8}$, $P_{5.9}$, $P_{5.13}$ and $P_{6.10}$ with -22.23, -36.35, -20.77 and -20.44 per cent respectively over the better parent value. The range in heterosis varied from -36.35 to 31.02 per cent.

Pooled : Four hybrids with positive and significant heterosis and eight hybrids with negative and significant heterosis were seen over the better parent. The hybrids $P_{3.11}$, $P_{5.11}$, $P_{10.11}$ and $P_{11.12}$ were found to record 10.37, 16.59, 10.87 and 21.27 per cent positive heterosis while the hybrids $P_{5.7}$, $P_{7.8}$ and $P_{9.15}$ registered -16.80, -15.79 and -17.39 per cent respectively. The range in heterosis observed varied from -17.39 to 21.27 per cent.

Days to first flower :

Kharif, 1980 : The range of heterosis varied from -16.96 to 4.27 per cent over the better parent value. Ten hybrids showed significant and negative heterosis particularly $P_{3.5}$, $P_{3.9}$, $P_{4.5}$ and $P_{4.10}$ with -14.20, -14.16, -16.96 and -16.11 per cent respectively.

Summer, 1981 : The range of heterosis observed was from 16.73 to 5.76 per cent over better parent value. Two hybrids with significant and positive heterosis, especially $P_{5.9}$ and $P_{5.10}$ with 5.76 and 5.73 per cent respectively and twelve hybrids with negative and significant heterosis, particularly $P_{3.9}$ (-14.70), $P_{4.5}$ (-15.49) $P_{4.10}$ (-16.73) and $P_{12.15}$ (15.16) were observed during the season.

Pooled : The heterosis ranged from -16.42 to 8.23 per cent over better parent value. Two hybrids exhibited positive significant heterosis viz., $P_{1.4}$ and $P_{5.10}$ with 8.23 and 5.00 per cent respectively over the better parent value. Sixteen hybrids showed negative and significant heterosis over the better parent, prominent among them being $P_{3.5}$, $P_{3.9}$, $P_{4.5}$ and $P_{4.10}$ with -14.42, -14.43, -16.23 and -16.42 per cent respectively.

Four hybrids were found to be consistent in both the season for hybrid vigour towards the negative side.

Capsule - main stem

Kharif, 1980 : The range of heterosis was found to vary between -70.62 to 49.08 per cent over the better parent. Eight hybrids showed positive and significant heterosis particularly $P_{5.9}$ and $P_{1.3}$ with 49.08 and 28.39 per cent respectively. A total of 41 hybrids exhibited significant and negative heterosis, especially the hybrids $P_{2.14}$, $P_{6.14}$

P_{8.14} and P_{9.14} with -65.74, -70.62, 57.16 and -64.51 per cent respectively.

Summer, 1981 : Two hybrids viz., P_{2.14} and P_{10.15} were found to record significant positive heterosis of 40.64 and 33.12 per cent over the better parent value. A total of 31 hybrids showed significant and negative heterosis, especially the hybrids P_{2.9}, P_{3.9}, P_{4.9}, P_{9.10}, P_{9.11} and P_{9.15} with -67.87, -67.00, -67.00, -65.55, -65.89 and -78.63 per cent respectively. The range of heterosis varied between -78.63 to 40.64 per cent.

Pooled : Five hybrids expressed significant and positive heterosis while 29 showed negative and significant heterosis. The range of heterosis observed was from -63.28 to 18.14 per cent. The hybrids which exhibited negative heterosis were P_{1.9}, P_{9.11}, P_{9.14} and P_{9.15} with -54.18, -51.69, -63.28 and -52.17 per cent respectively. Eleven hybrids showed significant and negative heterosis in both kharif, 1980 and summer, 1981 seasons viz., P_{1.9}, P_{1.10}, P_{2.9}, P_{3.10}, P_{4.9}, P_{5.14}, P_{6.9}, P_{8.10}, P_{9.11}, P_{9.14} and P_{10.14}.

Capsule - branches

Kharif, 1980 : Sixteen hybrids showed heterosis in positive direction with significance of which P_{7.11}, P_{10.11} and P_{11.12} are outstanding with 91.60, 138.51 and 115.42 per cent respectively. A total of 16 hybrids showed negative but

significant heterosis over better parent especially $P_{1.7}$, $P_{4.5}$, $P_{4.9}$ and $P_{7.12}$ with -39.21, -47.73, -42.81 and -43.38 per cent respectively. The range in heterosis observed was from -47.73 to 138.51 per cent.

Summer, 1981 : The range of heterosis varied from -46.28 to 81.52 per cent. Twenty hybrids showed positive and significant heterosis, prominent among them being $P_{4.14}$, $P_{5.10}$, $P_{7.14}$ and $P_{10.14}$ with 81.52, 72.33, 67.30 and 73.21 per cent respectively. A total of 14 hybrids were found to express negative and significant heterosis, particularly the hybrids $P_{1.7}$, $P_{1.12}$, $P_{5.13}$ and $P_{6.10}$ with -39.96, -39.13, -46.28 and -39.73 per cent respectively over the better parent.

Pooled : A total of 15 hybrids showed positive and significant heterosis while 14 expressed significant and negative heterosis over the better parent. Those hybrids with positive heterosis were $P_{7.11}$, $P_{10.11}$ and $P_{11.12}$ with 58.76, 87.86 and 81.24 per cent respectively and the hybrids which were with negative heterosis being $P_{1.7}$, $P_{1.12}$ and $P_{6.10}$ with -39.59, -37.55 and -37.33 per cent respectively. The range in heterosis was found to vary from -39.59 to 87.76 per cent. Six hybrids viz., $P_{5.10}$, $P_{5.11}$, $P_{7.11}$, $P_{9.11}$, $P_{11.12}$ and $P_{11.13}$ expressed positive heterosis in both the seasons while three viz., $P_{1.7}$, $P_{1.12}$ and $P_{6.10}$ exhibited negative heterosis both in kharif, 1980 and

Capsules - plant

Kharif, 1980 - The range observed was found to vary between -49.61 to 72.18 per cent. Prominent hybrids among the 12 which expressed positive significant heterosis were $P_{3.11}$, $P_{5.9}$ and $P_{11.12}$ with 36.51, 49.08 and 50.14 per cent respectively over the better parent. Likewise, prominent among the hybrids which showed negative heterosis were $P_{2.14}$, $P_{4.9}$ and $P_{6.14}$ with -45.14, -39.12 and -49.61 per cent respectively.

Summer, 1981 - The range of heterosis observed varied between -61.69 and 45.07 per cent. While 18 hybrids expressed positive and significant heterosis over the better parent, 26 exhibited negative and significant heterosis. Prominent hybrids with positive expressions were $P_{4.14}$, $P_{11.14}$, $P_{11.15}$ and $P_{14.15}$ with 45.07, 39.89, 38.89 and 38.81 per cent and those with negative were $P_{5.9}$, $P_{9.14}$ and $P_{9.15}$ with -61.69, -36.61 and -42.48 per cent respectively.

Pooled - Positive and significant heterosis was observed in twelve hybrids particularly in the hybrids $P_{2.11}$, $P_{5.11}$, $P_{6.11}$, $P_{10.11}$ and $P_{11.12}$ with 23.66, 36.75, 20.37, 30.12 and 39.59 per cent respectively over the better parent. Eleven hybrids exhibited significant negative heterosis particularly $P_{1.7}$, $P_{4.9}$ and $P_{9.14}$ with -31.13, -29.95 and -32.45 per cent respectively. Four hybrids expressed

positive heterosis consistently in both the seasons viz., P_{2.11}, P_{5.11}, P_{10.11} and P_{11.12}.

Seed yield

Kharif, 1980 - The range of heterosis varied from -53.42 to 42.28 per cent. Twelve hybrids exhibited significant positive heterosis particularly the hybrids P_{1.5}, P_{2.12} and P_{10.11} with 37.05, 40.00 and 42.28 per cent respectively. A total of 33 hybrids exhibited significant negative heterosis, especially P_{1.7}, P_{4.6}, P_{4.9}, P_{6.14} and P_{13.14} with -53.30, -49.17, -48.53, -53.42 and -43.06 per cent respectively over the better parent.

Summer, 1981 - The range of heterosis observed was from -63.99 to 43.73 per cent. Nine hybrids expressed positive and significant heterosis over the better parent, prominent among them being P_{3.4}, P_{10.11} and P_{12.15} with 43.73, 39.37 and 40.29 per cent respectively. Among the 33 hybrids which exhibited significant negative heterosis, three viz., P_{5.9}, P_{5.13} and P_{7.13} were conspicuous with -63.99, -57.87 and -54.84 per cent respectively.

Pooled - The range in heterosis observed varied from -44.59 to 41.12 per cent. The hybrids viz., P_{3.12} and P_{10.11} were found to register positive and significant heterosis of 20.81 and 41.12 per cent respectively. Twenty eight hybrids recorded significant negative heterosis, prominent among them being P_{1.7}, P_{4.13}, P_{5.9} and P_{13.14} with -38.68, 38.29,

-39.98 and -44.59 per cent respectively over the better parent. The hybrid P_{10.11} alone exhibited consistency in both the seasons.

4.4. Combining ability analysis

4.4.1. Analysis of variance for combining ability (GCA and SCA) in individual seasons and pooled analysis

The characterwise analysis of variance for combining ability in individual seasons as well as the pooled analysis are presented in Tables 4.15 to 4.21.

Plant height : The variance due to GCA alone was significant at one per cent level in both the seasons as well as in the pooled data. The magnitude of GCA variance was higher than that of the SCA variance and the GCA:SCA ratio was greater in kharif 25.75 : 1 than in summer 11.05 : 1. The SCA and reciprocal variances were significant at one and five per cent levels respectively in the pooled analysis only.

Days to first flower : The GCA variance alone was significant in both the seasons. The proportion of GCA:SCA was almost similar in both the seasons namely 24.51 : 1.00 (kharif) and 24.98 : 1 (summer). Both SCA and reciprocal variances were significant at one per cent level in pooled analysis.

Capsules - main stem : The GCA variances in both kharif, 1980, summer, 1981 and in the pooled analysis were

significant at one per cent level. The GCA variance was higher in kharif, 1980 than in summer, 1981. The GCA:SCA ratio was higher in kharif (15.76 : 1) than in summer, 1981 (2.55 : 1). The SCA and reciprocal variances were significant in the pooled analysis only.

Capsules - branches : The GCA variance was greater in summer and is highly significant in both the seasons. The GCA:SCA ratio was higher in summer, 1981 (11.43 : 1) than in kharif, 1980 (6.62 : 1). The SCA and reciprocal variances were highly significant in the pooled analysis.

Capsules - Plant : The GCA variances were significant at one per cent level in kharif, 1980, summer, 1981 and in the pooled data. The GCA variance was greater in summer, 1981 than in kharif, 1980. The GCA:SCA ratio was found to be similar in both kharif, 1980 and summer, 1981 seasons. In the pooled analysis, both the sca and the reciprocal variances were significant at five per cent level.

Seed yield : The GCA variance in both kharif, 1980 and summer, 1981 seasons were found to be almost similar. The proportion of GCA to SCA ratio was found to be slightly higher in kharif (9.39 : 1) than in summer (7.18 : 1). The SCA variance and the reciprocal variance in the pooled analysis were found to be significant at five per cent level only. The GCA variances were highly significant at one per

cent level in both kharif, 1980, summer, 1981 and in the pooled analysis.

4.4.2. Combining ability effects

The season wise combining ability effects (gca) specific combining effects (sca) and the reciprocal effects (rca) for all the six characters are presented in Tables 4.22 to 4.27.

Plant height

General combining ability effects : Parents P_2 P_7 P_8 and P_{14} exhibited significant and positive gca effects during kharif, 1980 while P_2 P_6 and P_8 in summer, 1981. Only P_2 was consistent in both the seasons in its gca effect. The parents P_3 P_5 and P_{10} expressed significant negative gca effects in both the seasons. The gca effects of the parents P_1 P_7 and P_{14} were found to vary in magnitude. In the pooled analysis, 11 parents (P_1 P_2 P_3 P_5 P_6 P_7 P_8 P_9 P_{10} P_{12} and P_{13}) were found to show significant positive (5) or negative (6) effects.

Specific combining ability effects : The hybrids $P_{5.15}$, $P_{9.12}$ and $P_{13.14}$ exhibited positive sca effects while $P_{4.9}$, $P_{7.5}$ and $P_{11.15}$ expressed negative effects in kharif, 1980. In the pooled analysis significant positive effects were seen in $P_{1.9}$ (8.70), $P_{5.6}$ (7.75) and $P_{8.9}$ (7.74) and significant and negative effects in $P_{5.9}$ (-12.20), $P_{6.10}$ (-7.51) and $P_{9.15}$ (-8.45). In 1981, summer, the hybrids $P_{1.9}$,

P_{2.5} and P_{3.9} were found to show positive effects while P_{4.11}, P_{5.9} and P_{9.5} were seen with negative effects. The sca effects were found to be consistent in both the seasons in the hybrids P_{1.9}, P_{2.5}, P_{5.6}, P_{8.9} and P_{11.12} with positive magnitude while in P_{1.2}, P_{6.10} and P_{9.15} it was negative.

Reciprocal effects : The hybrids P_{7.9}, P_{7.10} and P_{7.12} were found to show positive effects and the hybrids P_{3.12}, P_{3.14} and P_{5.7} negative effects in kharif, 1980. In the pooled value, hybrids P_{6.10}, P_{7.10} and P_{7.15} showed significant positive effects while P_{5.7} alone expressed significant negative effect. The sca and reciprocal effects were positive in P_{7.9} and negative in P_{5.7} in both the seasons. In the pooled analysis, the sca effect of the hybrid P_{6.10} varied with that of the reciprocal effect in magnitude.

Days to first flower

General combining ability effects : The parents P₂, P₆, P₇ and P₁₄ expressed significant positive gca effects towards lateness in both the seasons while the parents P₅ and P₉ expressed negative gca effects towards earliness. The gca effects were found to vary between -2.65 (P₁₀) to 2.63 (P₇) over the seasons.

Specific combining ability effects : None of the hybrids expressed significant sca effects during kharif, 1980. In

summer, 1981 the hybrids $P_{1.9}$, $P_{2.9}$ and $P_{5.14}$ expressed positive and significant effects. In the mean over the seasons, the hybrids $P_{1.9}$, $P_{5.14}$ and $P_{5.15}$ exhibited significant positive effects while the hybrids $P_{1.2}$, $P_{4.7}$ and $P_{5.12}$ expressed significant negative effects.

Reciprocal effects : Significant and positive effects were observed in 12 hybrids during kharif, 1980 and significant and negative effects in four hybrids. In summer, 1981, significant positive effects were seen in eight hybrids and negative effects in nine hybrids. In both the seasons, hybrids $P_{6.9}$, $P_{6.10}$, $P_{7.9}$, $P_{7.10}$, $P_{7.12}$ and $P_{8.9}$ exhibited positive effects while $P_{1.9}$, $P_{5.6}$ and $P_{5.7}$ showed negative effects. In the mean over the seasons, 23 hybrids were found to show positive effects and 10 negative effects. The hybrid $P_{1.9}$ was found to express positive sca effects and negative reciprocal effects in summer, 1981 as well as in the mean over the seasons. Similarly the hybrids $P_{1.9}$ and $P_{5.14}$ were found to show positive sca effects in summer, 1981 whereas negative reciprocal effects in the mean over the seasons.

Capsules - main stem

General combining ability effects : Parents P_1 P_2 P_4 P_8 and P_{11} showed significant and negative gca effects indicating less number of capsules in the main stem during kharif, 1980. Only two parents, P_3 and P_{12} showed significant gca effects in summer, 1981, the former negative

and the latter positive side. The mean over the seasons indicated significant **gca** effects expressed by all the parents except P_{13} . Of the 14 parents, six expressed positive and significant effects while the remaining eight negative effects.

Specific combining ability effects : The hybrid $P_{5.9}$ showed significant positive effect during kharif, 1980 and the hybrid $P_{7.12}$ during summer, 1981. The hybrid $P_{9.14}$ and $P_{9.15}$ expressed significant negative **sca** effects in kharif, 1980 and summer, 1981 season respectively. In the mean over the seasons, four hybrids expressed positive and six hybrids negative **sca** effects.

Reciprocal effects : Three hybrids during kharif, 1980 were found to show significant and positive reciprocal effects while four others registered negative effects. During summer, 1981, only one hybrid, $P_{9.13}$ was observed to have significant and positive reciprocal effect. None of the 105 hybrids exhibited any negative effects during the summer, 1981 season. In the mean value over the seasons, five hybrids with significant and positive reciprocal effects and nine with significant and negative effects were observed. Of these 14 hybrids, the hybrid $P_{7.12}$ was found to exhibit both positive and significant **sca** and reciprocal effects.

Capsules - branches

General combining ability effects : Positive and significant *gca* effects were observed in P₂ P₄ P₁₁ and P₁₅ and negative and significant effects in P₅ P₉ P₁₂ and P₁₃ during kharif, 1980. In summer, 1981, significant positive *gca* effects were seen in P₁ P₂ P₆ and P₁₁ and negative effects in P₅ P₇ P₉ and P₁₅. The magnitude of the *gca* effects were at variance between the seasons in the parent P₁₅. Consistency over the seasons was observed in the parents P₂ P₅ P₉ P₁₁ and P₁₂.

Specific combining ability effects

None of the hybrids expressed significant and positive *sca* effects during kharif, 1980, but the hybrid P_{8.9} exhibited the *sca* effect in summer, 1981. The hybrid P_{5.9} was found to register significant, negative heterosis during kharif, 1980. In the mean over the seasons, eight hybrids were seen with positive, significant *sca* effects and seven with negative effects.

Reciprocal effects : Only significant and negative reciprocal effects were seen in two hybrids in kharif, 1980 as well as in summer, 1981. Positive and significant reciprocal effects were not observed during kharif, 1980, while two hybrids expressed the effects in summer, 1981. In the pooled data, six hybrids exhibited positive and significant reciprocal effects and six with negative

effects. None of the hybrids which exhibited significant **sca** effects expressed reciprocal effect of any magnitude.

Capsules - plant

General combining ability effects : The parents P_1 P_4 P_5 P_7 P_9 P_{13} and P_{15} expressed significant effects during summer, 1980 while P_1 P_2 P_5 P_6 P_{10} P_{12} and P_{14} in summer, 1981. Consistency was observed in the parent P_5 only. The effects were at variance in the parents P_1 P_6 and P_{15} . In the pooled data, the parents P_1 P_2 P_4 P_6 and P_7 were seen with positive and significant effects while P_5 P_9 P_{12} and P_{13} were observed to have negative and significant gca effects.

Specific combining ability effects : None of the hybrids expressed **sca** effects of any magnitude during the kharif, 1980 season while during summer, 1981, the hybrid $P_{5.9}$ exhibited significant negative **sca** effect. In the mean values, five hybrids were seen with positive and significant **sca** effect and four with negative effects.

Reciprocal effects : The reciprocal effects of the hybrids were not positive and significant during the kharif, 1980 season. However, significant and negative reciprocal effects were seen in three hybrids i.e., $P_{1.4}$, $P_{1.3}$ and $P_{6.12}$. Two hybrids $P_{1.9}$ and $P_{2.9}$ were found to show positive and significant reciprocal effects and three hybrids viz., $P_{5.15}$, $P_{6.7}$ and $P_{11.15}$ negative effects during summer, 1981.

In the mean value over the seasons, three and seven hybrids expressed significant positive and negative effects respectively. Of the 105 hybrids, the hybrid $P_{1.9}$ alone was found to exhibit significant and positive *sca* and reciprocal effect in the mean value for the two seasons.

Seed yield

General combining ability effects : The parents P_4 and P_7 were found to express positive and significant *gca* effects while P_1 and P_5 negative effects in kharif, 1980. In summer, the parents P_1 , P_2 and P_6 exhibited significant and positive *gca* effects while the parents P_5 and P_9 negative effects. Consistency over the seasons, was observed only in the parent P_5 . In the mean value for the two seasons, significant positive effects were seen in P_2 , P_4 , P_6 , P_7 and P_{11} and negative effects in P_3 , P_5 , P_9 and P_{10} .

Specific combining ability effects : None of the hybrids expressed significant *sca* effect during kharif, 1980 season. In summer, 1981, the hybrid $P_{7.12}$ expressed significant positive effect while $P_{3.1}$ negative effect. In the mean value over the seasons, five hybrids i.e., $P_{1.6}$, $P_{2.4}$, $P_{3.4}$, $P_{7.15}$ and $P_{10.11}$ was found to show significant positive effects while $P_{2.6}$, $P_{4.6}$ and $P_{5.9}$ negative effects.

Reciprocal effects : Positive and significant reciprocal effect was not seen in any hybrids studied but negative

effect was observed in two hybrids viz., P_{2.4} and P_{7.15} during kharif, 1980. The hybrid P_{6.9} was found to exhibit positive and significant effect while the hybrids P_{1.2} and P_{2.4} negative effects during summer, 1981. In the pooled value for the two seasons, two hybrids viz., P_{2.9} and P_{4.8} were seen with positive and significant reciprocal effects while seven others showed negative effects. None of these hybrids was found to behave similarly in both sca and reciprocal effects.

4.5.1. Per se performance score

Assuming 'm' to be the mean value of 15 parents in a season for a character and 's' the standard error of the mean based on the analysis of variance, three classes viz., (i) mean falling above $m + s$ (ii) mean falling between $m + s$ and $m - s$ and (iii) mean falling below $m - s$ were formed and respective per se score of +1, 0 and -1 was allotted. The above procedure was followed for each character, thus providing a score for each character of a variety. The scores totalled over for all the characters separately for each season and presented in Tables 4.28 and 4.29. The parents with a final score greater than or equal to the general mean were allotted to high (H) and the rest were assigned to low (L) phenotypic status.

Parents P₁ P₄ P₆ P₇ P₁₄ and P₁₅ attained high phenotypic status during kharif, 1980. In summer, 1981,

season the parents which attained high status were P_1 P_2 P_6 P_7 P_8 and P_{12} while others were low. While the parents P_1 P_6 and P_7 attained high phenotypic status in both the seasons, the parents P_2 P_8 and P_{13} attained low status in kharif, 1980 but high status in summer, 1981. Parents P_3 P_5 P_9 P_{10} P_{11} and P_{12} attained low status in both the seasons. The parents P_4 P_{14} and P_{15} were found to attain high status in kharif, 1980 and low status in summer, 1981.

4.5.2. **gca effects score** : Three classes viz., (i) varieties having positive and significant gca effects (ii) varieties having non-significant (positive or negative) effects and (iii) varieties with significant but negative gca effects were grouped and scores equal to +1, 0 and -1 were assigned for individual character. The same procedure was followed for each character, thus providing a score for each character and the parent. The score is totalled over for all the characters and presented for individual season in Table 4.30 and 4.31. Those parents getting a final score greater than or equal to general mean were allotted to a high status and others to low status for the gca effects. The total score for the six characters revealed that the parent P_2 was found to be high in both the seasons. The parents P_1 P_6 and P_8 expressed low status in kharif, 1980 but high status in summer, 1981. Those parents which attained high status in kharif, 1980 and low status in summer, 1981 were P_4 P_7 P_{14}

and P₁₅. The rest viz., P₃ P₅ P₉ P₁₀ P₁₁ P₁₂ and P₁₃ attained low status in both the seasons.

4.5.3. Ranking of the parents on per se performance and gca effects

Ranks were given to individual parents based on the per se performance and gca effects. The parent which had the highest per se performance was given the rank one and the parent which expressed the lowest phenotypic value was given the rank fifteen. Similarly, scores were given for gca effects also. These scores for individual character were totalled over for all the characters of a variety. The character wise ranks and the rank total for each parent are given in Tables 4.32 and 4.33. The parent P₇ P₄ P₁₄ P₁₅ and P₂ attained ranks 1, 2, 3, 4 and 5 respectively during kharif, 1980 and P₁₀ P₁₃ P₁₂ P₈ and P₅ attained the ranks 11 to 15. In summer, 1981, the parents P₁ P₆ P₂ P₈ and P₇ attained ranks from 1 to 5 while P₁₄ P₁₂ P₁₀ and P₅ ranked from 11 to 15. The performance of other parents were at variance between the two seasons.

4.6. Genetical analysis

4.6.1. Validity of the hypothesis

The estimate of t^2 values for individual seasons are presented in Table 4.34. The t^2 estimates were not significant for all the characters in both the seasons,

except for plant height in summer, 1981 and capsules on main stem in kharif, 1980.

The estimates of regression coefficient for W_r and V_r (b), t values of deviation of 'b' from zero and unity are presented in Table 4.35. Excepting plant height and capsule per plant in summer, 1981 and capsules on main stem and seed yield in kharif, 1980 all the 'b' values did not deviate significantly from unity.

4.6.2. Estimates of genetic parameters and genetic ratios

The estimates of genetic parameters and the genetic ratio are presented in Tables 4.36 to 4.41.

Plant height : The additive component of variation (D) was significant in both the seasons when tested against their respective S.E. The additive variance in kharif, 1980 was higher than in summer, 1981. Both H_1 and H_2 components were significant in both the seasons as well as in the pooled analysis. The h^2 component was also significant in both the seasons as well as in the pooled data.

The ratio of $(H_1/D)^{1/2}$ was less than one (0.986) in kharif, 1980 and (0.744) in summer, 1981 (Fig.D). The estimates of $H_2/4H_1$ was found to be around 0.25 in summer, 1981 (0.244) and less in kharif, 1980 (0.123) and in the pooled analysis (0.180). The ratio of KD/KR varied from 1.244 (summer, 1981) to 2.407 (kharif, 1980). The genetic

ratio h^2/H_2 ranged from 0.653 to 2.407. The percentage of narrow sense heritability estimates were 69.6 in kharif, 1980, 56.1 in summer, 1981 and 66.7 in the pooled analysis (Table 4.36 and Fig.E).

Days to first flower : The variance of the additive component (D) was significant at one per cent level in kharif, 1980, summer, 1981 and in the pooled analysis. The F values were also significant in both the seasons and in the pooled data. The H_1 and H_2 components of variance were significant in kharif, 1980, summer, 1981 and in the pooled analysis as well. The h^2 component was not significant in both the seasons.

The $(H_1/D)^{1/2}$ ratio was below unity in both the seasons as well as in the pooled analysis (Fig.D). The $H_2/4H_1$ was below 0.25 in the two seasons and in the pooled data. The KD/KR ratio was above unity in kharif, 1980, summer, 1981 and in the pooled data. The h^2/H_2 ratio was higher in summer, 1981 than in kharif, 1980. The narrow sense heritability estimates (Fig.E) were 73.7, 73.9 and 74.5 per cent respectively during kharif, 1980, summer, 1981 and pooled analysis (Table 4.37).

Capsule-main stem : The additive component of variance (D) was highly significant in kharif, 1980, summer, 1981 and in the pooled analysis. However, the F, H_1 , H_2 and h^2 and error variance components were not significant in kharif, 1980 but

highly significant in summer, 1981 and in the pooled analysis.

The ratio of $(H_1/D)^{1/2}$ ratio was near unity in the summer, 1981 and less than unity in kharif, 1980 and in the pooled data (Fig.D). The $H_2/4H_1$ ratio was almost equal to 0.25 in kharif, 1980 but deviated highly in summer, 1981 and in the pooled analysis. The KD/KR ratio ranged from 0.80 (kharif, 1980) to 11.10 (summer, 1981). The range observed for h^2/H_2 varied from 0.11 (kharif, 1980) to 0.94 (summer, 1981). The narrow sense heritability estimate (Fig.E) was moderate in kharif, 1980 (62.3 per cent), low in summer, 1981 (31.1 per cent) and moderate in the pooled analysis (60.5 per cent) (Table 4.38).

Capsules-branches : The components D, H_1 , H_2 , h^2 and E were significant at one per cent level in kharif, 1980, summer, 1981 and in the pooled analysis. The F component was significant in both kharif, 1980 and in the pooled data but not significant during summer, 1981 when tested against the respective SE values.

The $(H_1/D)^{1/2}$ ratio was less than unity in both the seasons (Fig.D). The $H_2/4H_1$ ratio was less than 0.25 in both the seasons. The KD/KR ratio was higher than unity in both kharif, 1980 and in summer, 1981 seasons. The range observed for h^2/H_2 was 2.26 (kharif, 1980) 2.81 (summer,

1981) and 3.03 (pooled). The heritability in narrow sense (Fig.E) was low in kharif, 1980 (39.8 per cent) and medium in summer, 1981 (61.0 per cent) and in pooled analysis (65.6 per cent) (Table 4.39).

Capsules-plant : The additive component of variance was significant in both kharif, 1980, summer, 1981 and in the pooled analysis. The component F was not significant in both the seasons. The error (E) component was significant at one per cent level in both the seasons as well as in the pooled data. The H_1 , H_2 and h^2 components were not significant in kharif, 1980. The H_1 and h^2 components were found to be significant at one per cent level while H_2 component of variance was significant at five per cent level in the pooled analysis.

The $(H_1/D)^{1/2}$ ratio was near unity in summer, 1981 and in the pooled analysis but very less than unity in kharif, 1980 (Fig.D). The ratio of $H_2/4H_1$ was lower than 0.25 in kharif, 1980, summer, 1981 and in the pooled analysis. The KD/KR ratio was almost at unity in summer, 1981 but deviated highly during kharif, 1980 and in the pooled analysis. The h^2/H_2 component ranged from 0.96 (summer, 1981) to 4.14 (kharif, 1980). The narrow sense heritability estimates (Fig.E) were found to be low viz., 34.6 (kharif, 1980) 49.8 (summer, 1981) and 33.5 per cent (pooled) (Table 4.40).

Seed yield : The additive component of variance (D) was found to be significant in both kharif, 1980, summer, 1981 and in the pooled analysis. The F component was significant at five per cent level in summer, 1981 only. The H_1 component was significant at one per cent level in summer, 1981 and at five per cent level in the pooled analysis, while H_2 component was significant at one per cent level in summer, 1981 only. The h^2 component did not attain the level of significance in both the seasons as well as in the pooled analysis whereas the error (E) component showed significance at one per cent level in both summer, 1981 and in the pooled analysis.

The $(H_1/D)^{1/2}$ was very lower than unity in kharif, 1980 but near the unity in summer, 1981 and lower than unity in the pooled analysis (Fig.D). The $H_2/4H_1$ ratio was found to be very high in kharif, 1980 and less than 0.25 in summer, 1981 and in the pooled analysis. The KD/KR ratio was higher than unity in both the seasons and in the pooled analysis. The h^2/H_2 ratio ranged from 0.19 in summer, 1981 to 2.32 in kharif, 1980. The heritability estimate in narrow sense (Fig.E) was found to be very low viz., 37.7 (kharif, 1980), 41.9 (summer, 1981) and 33.6 per cent (pooled) (Table 4.41).

4.7. Graphical analysis

The assumptions of the diallel design and the nature of gene action were verified by the W_r , V_r and W_r-W_r' graphs. The estimated value of array variances (V_r) and the covariances between the parents and their progenies in each array (W_r) and the covariances between the array means and off spring in each array (W_r') were computed from the diallel tables with the reciprocals averaged.

The deviations of the regression slope of W_r on V_r from unity as well as from zero were tested. The results are presented in Table 4.35.

On examination of the results, it could be observed that the two characters namely days to first flower and capsules in main stem were only found to satisfy both the tests namely (i) significant deviation from zero and (ii) no deviation from unity. In plant height and capsules per plant there were significant deviations from zero as well as from unity during summer, 1981 season whereas, in capsules on main stem and seed yield there were significant deviations from zero and unity during kharif, 1980.

Graphic analysis (W_r-V_r , W_r-W_r' and the standardised deviation graph) of the data was carried out for all the six characters in both kharif, 1980, summer, 1981 and the pooled data over the seasons and discussed.

Plant height : The regression line of W_r and V_r intercepted the Y ordinate above the point of origin in kharif, 1980, summer, 1981 seasons and in the pooled analysis (Fig. 1, 2 and 3).

In kharif, 1980 the parents P_2 , P_6 , P_7 , P_8 and P_{14} were located near the points of origin whereas the parents P_4 , P_5 , P_9 , P_{11} and P_{12} were away from the origin. In summer, 1981 the parents P_2 , P_4 , P_6 and P_8 were located near the origin.

In the pooled analysis the parents P_2 , P_6 , P_8 and P_{10} are located towards the origin and P_5 and P_9 away from the origin. The array points of parents P_2 , P_6 , P_8 and P_{10} during kharif, 1980, P_2 , P_4 , P_6 and P_{12} during summer, 1981 and P_1 , P_2 , P_6 and P_8 in the pooled analysis were below the regression line in W_r , V_r graph. Interchange of positions of parental arrays was observed in W_r , W_r' graph (Fig.4, 5 and 6). In the standardised deviation graph, the parents P_1 , P_2 , P_6 , P_7 and P_8 were found to be consistently confined to dominant high quadrant and P_5 and P_{11} to the recessive low quadrant (Fig.7, 8 and 9).

Days to first flower : The regression line of W_r on V_r intercept the Y axis above the point of origin in both the seasons as well as in the pooled analysis.

In both the seasons as well as in the pooled analysis, the parents P_1 P_2 P_{14} and P_{15} were located near the origin and P_4 P_5 and P_9 were located away from the origin consistently (Fig.9, 10 and 11). The position of these parents were located below the regression line and there were interchange in the position of the parents in relation to the regression line in Wr-Wr' graphs (Fig.13, 14 and 15). The parents P_1 P_2 P_3 P_6 and P_8 occupied the dominant high quadrant while the parents P_5 P_9 and P_{10} occupied the recessive low quadrant consistently in the standardised deviation graph (Fig.16, 17 and 18).

Capsules-main stem : While the Wr-Vr regression line crossed the Y ordinate above the point of origin in kharif, 1980 and in the pooled analysis it crossed at the point of origin during summer, 1981 season. The parents P_1 and P_2 were found to occupy positions near the point of origin and P_5 away from the point of origin in both the seasons as well as in the pooled analysis (Fig.19, 20 and 21). The positions of these parents were below the regression line in Wr-Vr graph and there were interchanges in the position of parents in relation to the regression line in Wr-Wr' graphs (Fig.22, 23 and 24).

In the standardised deviation graph, the parents P_1 P_2 P_3 P_6 and P_8 occupied dominant low quadrant and P_7 and P_{10} occupied recessive high quadrant consistently in

kharif, 1980, summer, 1981 and in the pooled analysis (Fig.25, 26 and 27).

Capsules-branches : The regression line of W_r on V_r intercepted the Y ordinate above the point of origin in both kharif, 1980 and summer, 1981 seasons, as well as in the pooled analysis. The parents P_2 and P_8 were found to occupy positions near the origin and P_5 away from the origin consistently through the seasons and in the pooled analysis (Fig.28, 29 and 30). The location of these parents were below the regression line in W_r - V_r graphs and there were exchanges in the position of parents in relation to the regression line in W_r - W_r' graphs (Fig.31, 32 and 33).

The parents P_1 P_2 P_3 P_6 and P_8 occupied dominant high quadrant while the parents P_9 P_{10} P_{11} and P_{12} positioned in the recessive low quadrant consistently in the standardised deviation graphs of kharif, 1980, summer, 1981 and in the pooled analysis (Fig.34,35 and 36).

Capsules-plant : The W_r - V_r regression line intercepted the Y axis above the point of origin in both the seasons as well as in the pooled analysis. The parents P_2 and P_7 were found to be located near the point of origin and P_9 and P_{11} away from it consistently in both seasons and in the pooled analysis (Fig.37, 38 and 39). The positions of the parents P_2 and P_7 were located below the regression line in W_r - V_r graph and there were interchanges in the position in

relation to the regression line in $Wr-Wr'$ graph in both seasons as well as in the pooled analysis (Fig.40, 41 and 42). While parent P_9 and P_{11} exchanged positions in relation to the regression in $Wr-Wr'$ graph in 1980, they didn't during the summer, 1981 season. In the pooled analysis, only the parent P_{11} exchanged position in relation to the regression line while the parent P_9 did not.

In the standardised deviation graph, the parents P_1 and P_8 occupied the dominant high quadrant while P_5 , P_9 and P_{11} the recessive low quadrant consistently during the kharif, 1980, summer, 1981 and in the pooled analysis (Fig.43, 44 and 45).

Seed yield : The regression line of Wr on Vr intercepted the Y ordinate above the origin in kharif, 1980 and in the pooled analysis and at the point of origin in summer, 1981. The parents P_3 , P_6 and P_{14} were near the origin while P_4 and P_{15} were located away from the origin in kharif, 1980. However, in summer, 1981, the parents P_4 , P_6 and P_7 were near and P_9 away from the origin. In contrast, the parents P_1 , P_6 , P_7 , P_{14} and P_{15} were located near and P_9 away from the origin in the pooled analysis (Fig.46, 47 and 48).

The parents listed above in both the seasons and in the pooled analysis which were located below the regression line in $Wr-Vr$ graph were found to have changed

their positions in relation to the regression line in Wr-Wr' graphs (Fig.49, 50 and 51).

The parent P_8 was found to occupy consistently the dominant high quadrant in the standardised deviation graph while the parents P_9 and P_{10} the recessive low quadrant in both the seasons and in the pooled data (Fig.52, 53 and 54).

4.8. Study of F_2 generation

Based on the *per se* performance score of the parents and gca effects score observed during summer, 1981 the following six hybrid combinations were selected for study of the F_2 generation during the summer, 1982 season.

- | | | | | | |
|----|-------------|----|----|------------------------------|--|
| 1. | High x High | .. | 1. | KRR ₂ x TMV 6 | |
| | | | 2. | KRR ₂ x S.i. 2277 | |
| 2. | High x low | .. | 1. | KRR ₂ x S.i. 2631 | |
| | | | 2. | TMV 6 x S.i. 2631 | |
| 3. | Low x low | .. | 1. | S.i. 2141 x S.i. 2631 | |
| | | | 2. | S.i. 2340 x S.i. 2631 | |

From each hybrid, 5 plants were selected at random in each of the replications totalling 15 plants for each combination. For study of F_2 each hybrids combination formed a unit consisting of P_1 P_2 F_1 and F_2 . The parents and hybrids were raised in a single row while the F_2 in four rows. Ridges were formed at 45 cm apart and the seeds dibbled on one side at a distance of 20 cm. The length of the ridge was 6 meters. Randomised blocks design of layout

with three replications was the design adopted. Ten plants per replication for the parents and hybrids and 20 plants for F_2 were selected at random per row forming 30 plants for parents and F_1 and 240 plants for F_2 for recording the observations. The crop was raised in summer, 1982 adopting the recommended agronomic practices. Five characters were studied when the plants attained maturity.

The data collected were tabulated and the following parameters estimated for each character for each combination.

i) Mean and (ii) Range

For the F_2 data, the phenotypic coefficient of variation, genotypic coefficient of variation, heritability (broad sense) genetic advance and genetic advance expressed as percentage of mean were computed and presented in Tables 4.42 to 4.46.

Plant height : The mean value of the hybrid was found to be higher than the parents as well as the F_2 progeny. However, the range of the F_2 population was found to be wider than that of the F_1 or hybrids (Fig.55-60). The genetic advance in the high x high combinations were found to be in general higher in high x high combinations than in low x low combinations.

Capsule-main stem : The hybrids were found to express higher mean value than the parents and F_2 . The range was observed to be widened in F_2 compared to the hybrids and parents (Fig.61-66). The genetic advance involving the parent TMV 6 as female was higher than the other parent KRR_2 .

Capsule-branches : The hybrid exhibited higher mean value than that of the segregating population. Besides, the range was found to wider in F_2 than in the F_1 and parents (Fig.67 to 72). The heritability in broad sense was higher in high x high combinations. Similar trend was also noticed in genetic advance with higher values for high x high than low x low combinations.

Capsules-plant : The hybrids expressed higher mean values than the parents and the hybrids. However, the range was wider in the segregating generation than the hybrid and parents (Fig. 73-78). Genetic advance was found to be on higher side in high x high than in high x low and low x low combinations. The GCV/PCV ratio was found to be higher in KRR_2 x S.i. 2277 (high x high) and S.i. 2340 x S.i. 2631 (low x low) combinations.

Seed yield : The hybrids expressed better than the parents and F_2 in mean seed yield. However, wide range was observed in the segregating populations compared to the parents and the hybrids (Fig. 79-84). Heritability in broad sense was found to be highest in KRR_2 x S.i. 2277, a high x high combination.

DISCUSSION

5. DISCUSSION

Sesame is one of the oldest, ancient and traditional oilseed crops of India. Productivity in terms seed as well as oil is low compared to groundnut and soybean. Therefore, crop improvement for increasing the productivity of seed of sesame was found to be a necessity under the present situation. A thorough understanding of the genetics of yield and components of yield forms the basis for crop improvement. The present investigation was oriented towards elucidating the basic and applied information which can throw light on the breeding methodology to be adopted by a breeder for improving the yield potential of sesame. The information obtained in this study is discussed in detail in this chapter to obtain a comprehensive structure of the genetic make up of the parents and suggest suitable breeding technique for adoption with particular reference to the materials handled in the present study.

5.1. Selection of Biometrical Techniques

In sesame, numerous genotypes from different agro-climatic or eco-geographical regions have been collected and maintained for use in hybridization programme with a view to generate new variability for effecting selection of suitable types. In the hybridization programme, a breeder often encounters problem in the choice of suitable parents. A thorough knowledge of the genetic architecture of the parents

for yield and the contributing characters would be of help in identifying superior cross combinations, avoiding the undesirable ones in the early generations.

Recent developments in the biometrical genetics have led to the formulation of a number of statistical procedures for genetic analysis of quantitative traits. The diallel analysis is one such procedure which provides all the necessary information in the early generation itself (Hayman, 1954, Jinks, 1954, Griffing, 1956, ~~1988~~, Mather and Jinks, 1977) was adopted for the present study.

5.2. Selection of Environment

Sesame is cultivated in Tamil Nadu in different seasons under different agricultural situations. They are (i) rainfed south west monsoon (June-July), (ii) rainfed north east monsoon or cold weather (Nov.-January), (iii) irrigated summer (Dec - May) and (iv) rainfed summer (April-June). Predicting the gain in selection is the ultimate aim of estimating all the genetic parameters. The accuracy of the prediction depends on the consistency over the environments. The degree to which the estimate represents the relevance of the genetic parameters and depends largely in the genotype x environment/season interaction bias in the estimates. Therefore, in the present investigation, two distinct major sesame growing seasons viz, Kharif/monsoon

(June-September) and summer (February-May) were selected for effective evaluation of the breeding materials.

5.3. Test for Differences Among the Genotypes and Their Interaction with Environments

Fifteen parents belonging to six countries namely India, Australia, Sudan, Mexico, USA and Canada having wide morphological and yield dissimilarities were selected randomly from the gene pool and 210 hybrids (direct and reciprocal) obtained from 15 x 15 diallel cross formed the testing material for this study under two environmental/seasonal conditions.

A perusal of the analysis of variance for individual seasons and the pooled analysis indicated that hybrids and parents differed among themselves for all the characters. This led the way for further analysis and interpretations so as to arrive at meaningful conclusions.

5.4. Combining Ability Analysis

5.4.1. Combining ability variance

The combining ability analysis in Method I, Model I, as suggested by Griffing (1956) for individual seasons and by Daljit Singh (1973, 1979) for pooled data was carried out and discussed hereunder.

The GCA variances were significant for plant height in both the seasons while the SCA variances were not

significant. However, the GCA variances were greater in magnitude than the SCA variances in both seasons as seen by the GCA:SCA ratios (25.75:1 and 11.05:1). This indicated the significant and predominant role of additive gene action in determining the expression of plant height in the present study. The findings of Murthy (1975), Shrivastava and Singh (1978), Ashok Kotecha and Yermanos (1978), Gupta (1981), Fatteh et al. (1982) Rathnaswamy and Jagathesan (1984), Padmavathi (1987), Anitha (1988), Subbalakshmi (1989) and Dharmalingam (1990) are in agreement with the present results. However, it is pertinent to mention that the findings of the above authors were from a study at a single location compared to the present study at two seasons.

In respect of days to first flower, the GCA variances were significant in both the seasons and in the pooled analysis. The SCA variances were not significant in both the seasons but significant in the pooled analysis. The GCA variances in both the seasons as well as in the pooled analysis were greater than the SCA variances as indicated by high GCA:SCA ratio of 24.51:1, 24.98:1 and 30.23:1. This indicates the high and preponderance of additive genes in controlling the expression of the days to first flower.

The GCA variances for the capsules on the main stem were significant in both the seasons as well as in the pooled analysis. The SCA variances were not significant in

either of the seasons but significant in the pooled analysis. The magnitude of GCA variances was higher than that of SCA variances as observed by GCA:SCA ratio of 15.76:1 in kharif, 1980 and 2.55:1 in summer, 1981. This indicates the predominant role of additive genes in determining the character. Murthy (1975), Ashok Kotecha and Yermanos (1978), Gupta (1981), Anitha (1988) and Dharmalingam (1990) reported similar observations for this character. However, non-additivity was observed to be predominant for the trait by Shrivastava and Singh (1981), Reddy et al. (1982), Djigma (1984), Dora and Kamala (1987) and Krishnadoss et al. (1987).

The GCA variances for capsules on branches were significant in both the seasons as well as in the pooled analysis. The variance for SCA is significant only in the pooled analysis. The GCA:SCA ratio was found to be 6.62:1 in kharif, 1980 compared to 11.43:1 in summer, 1981. The higher magnitude of GCA variance than the SCA variance indicated the presence of additive gene action in determining the character. This was in agreement with that expressed by Anitha (1988).

The significant GCA variances for capsules per plant in both the kharif, 1980 and summer, 1981 seasons and in the pooled analysis and the higher magnitude of GCA variance over the SCA variance revealed the significant role

of additive gene action in determining the character. Similar results were reported by other workers in their study at single environment (Murthy, 1975; Shrivasa and Singh, 1978; Ashok Kotecha and Yermanos, 1978) and in multi environments (Rathnaswamy, 1980, Subbalakshmi, 1989 and Dharmalingam, 1990).

The GCA variances for seed yield, the most important trait were significant in both the seasons as well as in the pooled analysis. The magnitude of GCA:SCA variances were higher as seen by GCA:SCA ratio 9.39:1 in kharif and 7.18:1 in summer. This indicated the role of additive gene action in governing the expression of the character. The results were in agreement with those reported by Murthy (1975), Shrivasa and Singh (1978), Ashok Kotecha and Yermanos (1978), Rathnaswamy (1980), Chaudhari et al. (1984), Padmavathi (1987), Anitha (1988), Subbalakshmi (1989) and Dharmalingam (1990).

An overall ranking of the characters possessing relatively more fixable additive variations was possible by using different criteria viz., (i) comparison of GCA:SCA variances ratio and (ii) least deviation of the ratios and estimates across the environments. Thus ranking of the characters based on these criteria enables the breeder for applying selection in succeeding generation based on one or more characters. In the present study, all the six

characters had high magnitude of GCA variance (fixable genetic portion) compared to SCA variance (non fixable genetic portion) and thus respond to selection conferring rapid improvement of these traits.

The genotype x environment interaction is a major source of bias that affects the general and specific combining ability testing. In the present study, the combined analysis of combining ability over the seasons revealed that the interaction variance GCA x season was significant for all the characters except for days to first flower. The sca x season variances were significant for plant height and capsules on the main stem. Both the interaction variances were not significant for days to first flower indicating the consistency of the average level of dominance/epistatic or additive effects for each parent in this character. The magnitude of GCA x seasons variance was more for all the characters except for days to first flower in which the SCA x seasons variance was high.

Thus, the present study indicated the unstable and sensitive nature of the GCA variance (additive) compared to the SCA variance (non additive and epistatic) over the seasons for five out of six characters. Matzinger *et al.* (1959) in corn, Liang (1967) and Palaniswamy (1981) in sorghum, Paroda and Joshi (1970), Kumar *et al.* (1983) and

Nanda et al. (1983a) in wheat, Paroda and Hayes (1971) and Hayes and Paroda (1974) in barley, Singh and Singh (1976) in chilli and Ayyamperumal (1981) in soybean also observed similar viz., higher interaction of GCA with environment. However, Malhotra et al. (1980) in green gram, Rathnaswamy (1980) in Sesame, Sukanya Subramanian (1981) in rice, Gupta and Lodi (1985), Venkateswarlu and Singh (1981) in Pea and Narkhede and Sudir Kumar, (1991a) in Sesame obtained greater SCA x season interaction variance than GCA x season interaction variance for the characters studied and concluded that SCA or dominance and epistatic effects were more unstable than GCA or additive effects.

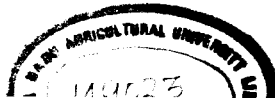
Reciprocal variances were not significant in both the seasons for all the six characters under study but significant in the pooled analysis. The reciprocal x season interaction variance was significant for all the characters except days to first flower. Reciprocal differences for plant height, capsules on branches, capsule per plant and seed yield were well pronounced in summer than days to first flower and capsules on main stem. This may be due to the fact that in this crop, temperature and long day conditions of summer might have influenced these characters in summer. Pal (1945) and Murthy (1975) observed several instances of reciprocal differences in Sesame.

5.5 Genetical and Graphical Analyses

Mather and Jinks (1977) discussed the implications of genetical and graphical analysis of W_r and V_r statistics. The essential points to be gained from the graphical analysis are (a) average degree of dominance from the distance from the origin and W_r intercept of the regression line, (b) the relative proportion of dominant and recessive genes in the parents from the distribution of their respective array points along the regression line and (c) a measure of genetic diversity among the parents from the distance between array points.

The genetical analysis provides certain additional information such as (a) the mean degree of dominance, (b) the proportion of genes with positive and negative effects in the parents, (c) the proportion of dominant and recessive genes in the parents and (d) heritability estimates in the narrow sense.

According to Arunachalam (1976) and Baker (1978) the diallel approach of Hayman is restricted to one gene-model and based on several assumptions like (i) the inheritance is wholly diploid, (ii) the parents are homozygous, (iii) there are no maternal effects (iv) each locus is represented by not more than two alleles, (v) non-correlated gene distribution and (vi) absence of genic interactions (no epistasis).



In the present study, the sesame varieties selected are secondarily derived balanced polyploids behaving like diploids ($2n=26$) and the inheritance is disomic. The parents involved are homozygous as they are self pollinated. There are no reports of multiple allelism in this crop. Hence, most of the requirements are satisfied in the materials selected for an effective genetical analysis.

The t^2 values and the regression coefficients of W_r on V_r values were used for testing the validity of the assumptions. The t^2 estimates were nonsignificant for all the characters during kharif, 1980 except capsules on main axis and significant for plant height alone in summer, 1981. In the pooled analysis, the t^2 estimate was not significant for any of the characters studied. Similarly, the estimates of regression coefficient 'b' did not deviate significantly from unity excepting for plant height in summer, 1981 and capsules on main stem in kharif, 1980, thus indicating the adequacy of the simple additive-dominance model and fulfilment of the assumptions. However, significant t^2 values and significant deviations of 'b' from unity for one or more characters indicated the non-fulfilment of certain assumptions. In such cases, estimates are not as reliable as they will be, had all the assumptions being fulfilled. The results of the present investigations must be considered in the light of the limitations pointed out earlier.

The position of array points in W_r , V_r graph was highly sensitive to environmental alterations for all the characters. When tests are conducted at different environments, such changes in position of array points do occur commonly (Jana, 1975; Suresh Kumar et al., 1980; Rathnaswamy, 1980; Ayyamperumal, 1981 and Mohamed Sheriff, 1985) indicating the influence of seasons/environments. Though reversal in the position of array points may be interpreted as different loci being active in different environments, a more likely explanation would be reversal of dominance effects at that loci which control the character in different environment (Jana, 1975).

The results of graphical and genetical analysis of the present investigation are discussed below.

5.5.1. Plant height

Khariif, 1980 - The genetic parameter D was significant and numerically high compared to H_1 and H_2 indicating the preponderance of additive gene action in governing the character, plant height. Similarly, the combining ability studies in the present investigation also confirms the above finding.

The degree of dominance was partial as indicated by $(H_1/D)^{1/2}$ ratio. The $H_2/4 H_1$ ratio was less than 0.25 and may be attributed to asymmetry of positive and negative

alleles. The ratio of KD/KR was observed to be greater than unity indicating the preponderance of dominant alleles than the recessive ones in the parents. The narrow sense heritability of 69.6 per cent indicates the preponderance of high amount of fixable additive gene action in the parents utilized in the study. This was in agreement with Murthy and Hasim (1974) and Rathnaswamy (1980).

The regression line intercepts the Y-ordinate above the origin in Wr-Vr graph indicating the dominance as partial. The parents P 8,6,14,2,7,1 and 3 are near the origin indicating the presence of more of dominant alleles while the parents P 13,15,4,5,11 and 9 are away from the origin indicating the presence of more of recessive alleles. This was also confirmed by the standardised deviation graph. Non allelic interaction was inferred by the interchange of array points from Wr-Vr graph to Wr-Wr' graph.

Summer 1991 - The preponderance of additive gene action in governing this character could be deduced from the significant and numerically high genetic parameter D compared to H_1 and H_2 .

The degree of dominance was also partial, similar to Kharif, 1980 as indicated by the $(H_1/D)^{1/2}$ ratio. The $H_2/4H_1$ ratio is nearer to the expected 0.25 and indicates symmetry in gene distribution in respect of positive and negative genes in the parents. Preponderance of dominant

alleles in the parents was evident from the KD/KR ratio which was greater than unity. The narrow sense heritability of 56.1 per cent indicates the preponderance of additive gene action utilized in the present study. This result is concurrent with those of Murthy and Hasim (1974) and Rathnaswamy (1980).

The regression line intercepts the Y-ordinate above the origin in the W_r-V_r graph indicating the dominance to be partial. The parents P 2,6,7,8,1 and 12 are nearer the origin indicating the presence of more of dominant alleles while the parents P 3,5,9,11,13 and 15 are away from the origin pointing to the presence of more of recessive alleles. This was confirmed by the standardised deviation graph. Inter change of positions from W_r-V_r to W_r-W_r' graph indicates the presence of non-allelic interaction.

Pooled - The significant and numerically higher magnitude of the parameter D compared to H_1 and H_2 indicates the presence of additive gene action in governing this character in the parents under study. The $(H_1/D)^{1/2}$ ratio was less than unity confirming the partial dominance observed in both the seasons. The $H_2/4H_1$ ratio was less than 0.25 and indicates the presence of asymmetry in the distribution of positive and negative genes in the parents. The preponderance of dominant alleles in the parents was evident

from the KD/KR ratio which was greater than unity. The narrow sense heritability (66.7 per cent) indicates the preponderance of high amount of fixable additive genes in the parents.

The Y-ordinate was intercepted by the regression line above the origin in W_r-V_r graph indicating the partial dominance of this trait. The parents P 2,8,6,1,14 and 7 are positioned near the origin, a feature for presence of dominant alleles, while the parents P 10,11,12,9 and 5 were seen away from the origin indicating the presence of recessive alleles. This distribution is confirmed by these parents occupying dominant high and recessive low quadrants respectively in the standardised deviation graph. Interchange of the position of the array points by the parents above and below the regression line from W_r-V_r to W_r-W_r' graph indicated the presence of non allelic interaction.

5.5.2. Days to first flower

Kharif, 1980 - The genetic parameter D was observed to be significant and numerically higher than the parameters H_1 and H_2 indicating the preponderance of additive gene action governing this character in the parents under study. The degree of dominance was partial as observed by the $(H_1/D)^{1/2}$ ratio which was less than unity. The asymmetry of gene distribution with regard to positive and negative alleles in the parents could be seen by the lower values of $H_2/4H_1$

compared to the expected 0.25. Preponderance of dominant alleles in the parents was evident from the KD/KR ratio which was greater than unity. The high narrow sense heritability value of 73.7 per cent indicates the presence of high amount of fixable additive genes in the parents used in the study.

The regression line intercepts the Y-ordinate above the origin in W_r-V_r graph indicating partial dominance. The parents P 14,11,2,6,15,1,8,7 and 3 are located near the origin indicating the presence of more of dominant alleles while the parents P 10,12,4,5 and 9 are away from the origin indicating the presence of more of recessive alleles. This distribution was confirmed by the parents occupying the dominant high and recessive low quadrants in the standardised deviation graph. Non allelic interaction could be inferred by the interchange of array points of the parents positioned above and below the regression line from W_r-V_r graph to W_r-W_r' graph.

Summer, 1981 - The parameter D was significant and numerically high compared to H_1 and H_2 indicating the preponderance of additive gene action in governing the character, days to first flower. The combining ability studies in the present investigation also confirms the above point. The degree of dominance was observed to be partial as seen from the $(H_1/D)^{1/2}$ ratio. The $H_2/4H_1$ ratio was less

than 0.25 which could be attributed to the asymmetry in the distribution of positive and negative alleles. The higher magnitude of the KD/KR ratio above the unity indicates to the preponderance of dominant alleles than the recessive alleles in the parents. The narrow sense heritability of 73.9 per cent indicates to the preponderance of high amount of fixable additive gene action in the parents.

The Y ordinate was intercepted by the regression line above the origin in the W_r-V_r graph indicating the partial dominance. The parents P 14,15,2,1,11,6 and 8 are located near the origin and indicates presence of more of dominant alleles while the parents P 10,12,9,4 and 5 are positioned away from the origin pointing to the presence of more of recessive alleles. This was also confirmed by the parents occupying dominant high and recessive low quadrants respectively in the standardised deviation graph. The interchange of positions above and below the regression line by these parents from W_r-V_r to W_r-W_r' graph indicated the non-allelic interaction.

Pooled - The preponderance of additive gene action in governing the character could be inferred by the significant and numerically high genetic parameter D compared to the H_1 and H_2 . This was confirmed by the results of the combining ability studies in the present investigation. The degree of dominance was partial as seen from the $(H_1/D)^{1/2}$ ratio,

which is less than unity. The $H_2/4H_1$ ratio estimate was lower than 0.25 and indicated asymmetry in the distribution of genes in respect of positive and negative alleles. Preponderance of dominant alleles in the parents was evident from the KD/KR ratio which was high and greater than unity. The high heritability (NS) estimate of 74.5 per cent indicates to the preponderance of additive gene action in the parents.

The regression line intercepts the Y-ordinate above the origin in the W_r-V_r graph indicating the dominance as partial. The parents P 14,2,15,1,6,8,11,7 and 3 are found to be located near the origin while P 5,9 and 4 away from the origin. The former indicates the presence of more of dominant alleles while the latter more of recessive alleles. This was also confirmed by the standardised deviation graph. The inter change of positions by the parents below and above the regression line in the W_r-V_r graph to W_r-W_r' graph indicates to presence of non-allele interaction.

5.5.3. Capsules-main stem

Kharif, 1980 - The significant and numerically higher value of the parameter D compared to H_1 and H_2 indicates the presence of additive gene action in governing this character in the parents studied. This was in confirmity with the present combining ability studies.

The degree of dominance was partial as indicated by the $(H_1/D)^{1/2}$ ratio. The $H_2/4H_1$ ratio was found to be 0.25 indicating symmetry in gene distribution with respect to positive and negative alleles in the parents. The KD-KR ratio was found to be less than unity indicating preponderance of recessive alleles than dominant alleles in the parents. The high narrow sense heritability of 62.3 per cent indicates the preponderance of high amount fixable additive genes in the parents studied.

The regression line intercepts the Y ordinate above the origin in Wr-Vr graph indicating the partial dominance for the character under study. The parents P 2,1,6,8,11,3 and 15 are near the origin indicating the presence of more of dominant alleles while the parents P 5,9,14,12 and 13 are away from the origin suggesting the presence of recessive alleles. This was also confirmed by the standardised deviation graph. The exchange of positions of the array points above and below the regression line from Wr-Vr to Wr-Wr' graph indicates the presence of non-allelic interaction.

Summer, 1981 - The genetic parameter D was observed to be significant and numerically higher than H_1 and H_2 suggesting the presence of additive genes in governing this character. This result was found to be in confirmity with the combining ability analysis.

The degree of dominance was complete as indicated by the $(H_1/D)^{1/2}$ ratio. The $H_2/4H_1$ ratio was found to be far less than 0.25 indicating asymmetrical distribution of positive and negative alleles in the parents. The KD/KR ratio was observed to be numerically very high than unity indicating more of dominant alleles than recessive alleles in the parents. The medium narrow sense heritability (31.1 per cent) observed indicates the presence of medium amount of additive genes in the parents studied.

The regression line intercepts the Y-ordinate almost at the point of origin indicating complete dominance for the character. All the parents except P 9 are located near the origin indicating the presence of more of dominant alleles in these parents. The parent P 9 alone was found to be located far away from the origin suggesting the presence of more of recessive alleles. The standardised deviation graph also confirms this by locating these parents in dominant low and recessive high quadrants. The interchange of positions of the parents below and above the regression line from W_r-V_r to W_r-W_r' graph indicates to the presence of non-allelic interaction.

Pooled - The D parameter was significant and numerically greater than H_1 and H_2 indicating the presence of additive genes in governing this character in the parents. The combining ability studies also confirmed this conclusion.

The $(H_1/D)^{1/2}$ ratio was found to be less than unity and indicates partial dominance. The $H_2/4H_1$ ratio was found to be less than 0.25 suggesting asymmetry in the distribution of positive and negative alleles in the parents. The preponderance of dominant alleles than recessive alleles in the parents could be seen from the KD/KR value which was more than unity. The high narrow sense heritability (60.5 per cent) indicates the preponderance of high amount of fixable additive genes in the parents.

The regression line intercepts the Y-ordinate above the origin in the W_r-V_r graph indicating partial dominance for the character. The parents P 1,2,14,15,6, 8, 3 and 11 are located towards the origin of regression line suggesting the presence of more of dominant alleles, while the parents P 10,7,12,5 and 9 are located away from the origin indicating the presence of more of recessive alleles. This was confirmed in the standardised deviation graph wherein they are located in dominant low and recessive high quadrants respectively. The position of the array points of the parents located above and below the regression line in W_r-V_r graph got changed in W_r-W_r' graph indicating the presence of non-allelic interaction.

5.5.4. Capsules-branches

Kharif 1980 - The genetic parameter D is significant and higher than the H_1 and H_2 indicating preponderance of the

additive genes in governing the character. This result is in conformity with the combining ability analysis.

The degree of dominance was partial as indicated by the $(H_1/D)^{1/2}$ ratio which was less than unity. The $H_2/4H_1$ ratio was found to be less than 0.25 which indicates the asymmetrical distribution of genes with respect to positive and negative alleles in the parents. The KD/RR ratio was more than unity indicating the preponderance of dominant alleles than recessive alleles in the parents. The narrow sense heritability was found to be medium (39.8 per cent) indicating the presence of moderate amount fixable additive genes in the parents.

The regression line intercepts the Y-ordinate above the origin in W_r-V_r graph indicating the presence of partial dominance. The parents P 15,14,6,8,3,2 and 1 are situated near the origin suggesting the presence of more of dominant alleles while the parents P 5,9,10 and 12 are located away from the origin implying the occurrence of recessive alleles. This was confirmed by the standardised deviation graph wherein the former parents are located in dominant high and the latter parents in recessive low quadrants. The existence of non-allelic interaction is indicated by the exchange of position of the parents above and below the regression line from W_r-V_r to W_r-W_r' graph.

Summer, 1981 - The significant and numerically high value of the genetic parameter D , compared to H_1 and H_2 indicates the presence of additive gene action in governing this trait. This confirms the combining ability studies carried out in the present investigation.

The $(H_1/D)^{1/2}$ value was observed to be less than unity indicating the partial dominance. The $H_2/4H_1$ ratio was found to be less than 0.25 suggesting asymmetrical distribution of genes in respect of positive and negative alleles in the parents. The KD/KR ratio was more than unity indicating the presence of more of dominant alleles than recessive ones. The narrow sense heritability was found to be high (61.0 per cent) suggesting the presence of more fixable additive genes in the parents.

The regression line intercepts the Y ordinate above the origin suggesting the presence of partial dominance. The parents $P 1,2,8,6,3$ are located near the origin indicating the presence of more of dominant alleles while the parents $P 13,11,10,5$ and 9 are positioned away from origin suggesting the presence of more of recessive alleles. This finding is confirmed by the standardised deviation graph. The change in position of parents, located above and below the regression of line from $Wr-Vr$ graph to $Wr-Wr'$ graph leads to the inference that non-allelic interaction exists in the parents.

Pooled - The genetic parameters D is significant and numerically higher compared to H_1 and H_2 indicating the presence of partial dominance. The combining ability analysis of this investigation also confirms the above result.

The $(H_1/D)^{1/2}$ ratio was observed to be less than unity and indicates that dominance was partial. The $H_2/4H_1$ ratio was found to be less than 0.25 and hence it could be stated that distribution of genes was asymmetrical in respect of the positive and negative alleles in the parents. The KD/KR was more than unity indicating preponderance of dominant alleles than recessive ones. The high narrow sense heritability of 65.6 per cent indicates the presence of more of fixable additive genes in the parents.

The regression line intercepts the Y ordinate above the origin in W_r-V_r graph suggesting the presence of partial dominance. The parents P 2,15,8,6,1,3 and 14 are located near the origin indicating the presence of more of dominant alleles while the parents P 10,12,5 and 9 are located away from the origin suggesting the occurrence of more number of recessive alleles in the parents. This was confirmed by the standardised deviation graph wherein these parents are located in dominant high and recessive low quadrants respectively. The presence of non-allelic interaction is indicated by the exchange of position of the

array points of the parents above and below the regression line from W_r-V_r to W_r-W_r' graph.

5.5.5. Capsules/plant

Kharif, 1980 - The genetic parameter D was significant and numerically higher compared to the H_1 and H_2 suggesting partial dominance. This finding agrees with that observed in the combining ability analysis.

The $(H_1/D)^{1/2}$ ratio was less than unity suggesting the presence of partial dominance. The $H_2/4H_1$ ratio was observed to be less than 0.25 indicating the asymmetrical distribution of the genes in respect of positive and negative alleles in the parents. The KD/KR ratio was higher than unity indicating preponderance of dominant alleles than recessive ones. The medium narrow sense heritability (34.6 per cent) indicated the presence of moderate amount of fixable additive genes in the parents.

The regression line intercepts the Y-ordinate above the origin which suggests the presence of partial dominance. The parents P 2,6,3,8,13 and 7 are located near the origin suggesting the presence of more of dominant alleles while the parents P 9,4,5,14,15,10,12 and 11 are positioned away from the origin indicating the presence of more of recessive alleles in the parents. This was confirmed by the standardised deviation graph. The existence of non-

allelic interaction is inferred from the exchange of position of the array points of the parents above and below the regression line from $Wr-Vr$ to $Wr-Wr'$ graph.

Summer, 1981 - The D (genetic) parameter is significant and numerically higher than the H_1 and H_2 indicating partial dominance. This result is in conformity with that observed in combining ability analysis.

The $(H_1/D)^{1/2}$ ratio is nearer the unity indicating the dominance for the character under study. The $H_2/4H_1$ ratio is less than 0.25 suggesting asymmetrical distribution of genes in respect of positive and negative alleles in the parents. The KD/KR ratio was nearer to unity indicating equal distribution of dominant and recessive alleles. The narrow sense heritability was observed to be medium (49.8 per cent) indicating the presence of moderate amount of fixable additive genes in the parents.

The Y -ordinate is intercepted by the regression line above origin suggesting the presence of partial dominance. The parents P 2,6,3,8,7 and 12 are located near the origin indicating the presence of more number of dominant alleles while the parents P 9 and 11 are located away from the origin suggesting the occurrence of more number of recessive alleles in the parents. This is confirmed by the standardised deviation graph. Non-allelic interaction is

indicated by the exchange of position of array points of the parents above and below the regression line from W_r-V_r graph to W_r-W_r' graph.

Pooled - The genetic parameter D is significant. Also higher in magnitude compared to H_1 and H_2 indicating additive gene action. This is in confirmity with the result of combining ability analysis.

The $(H_1/D)^{1/2}$ ratio is around unity and suggests the presence of dominance. The $H_2/4H_1$ ratio is less than 0.25. This indicates that the distribution of genes is asymmetrical in respect of positive and negative allele in the parents. The KD/KR ratio is more than unity which indicates the preponderance of dominant alleles than recessives. The narrow sense heritability is medium (33.5 per cent) suggesting the presence of medium amount of fixable additive genes in the parents.

The regression line intercepts the Y-ordinate above the origin which indicates the presence of partial dominance. The parents P 2,7,13,8,6,14 and 15 are positioned near the origin indicating the presence of more of number of dominant alleles while the parents P 5,9 & 11 are located away from the origin suggesting the occurrence of more number of recessive alleles. This is confirmed by the standardised deviation graph. The existence of non-allelic interaction is inferred by the exchange of position of the array points of

the parents below and above the regression line from Wr-Vr to Wr-Wr' graph.

5.5.6. Seed yield

Kharif, 1980 - The parameter (Genetic) D is significant and numerically greater compared to H_1 and H_2 which indicates the presence of additive gene action. This agrees with the result obtained in the combining ability analysis of this investigation.

The $(H_1/D)^{1/2}$ ratio was less than the unity and indicates the presence of partial dominance. The $H_2/4H_1$ ratio was less than 0.25 which suggests the unequal distribution of genes in respect of positive and negative alleles in the parents. The KD/KR ratio was more than unity and indicates the preponderance of dominant alleles than recessive ones. The narrow sense heritability was observed to be medium (37.7 per cent) and suggests the presence of moderate amount of fixable additive genes in the parents.

The interception of Y ordinate by the regression line above the point of origin indicates partial dominance. The parents P 3,6,14,13 and 8 are located nearer the origin indicating the presence of more number of dominant alleles while the positioning of parents P 15,4,7 and 10 away from the origin suggests the occurrence of more of recessive alleles in the parents. This fact is confirmed by the

standardised deviation graph. The exchange of positions of the array points by the parents below and above the regression line from $Wr-Vr$ to $Wr-Wr'$ graph indicates the existence of non-allelic interaction.

Summer, 1981 - The D (genetic) statistic was found to be significant and also numerically higher than H_1 and H_2 . This indicates the preponderance of additive gene action for the trait. The fact was confirmed by the combining ability analysis under the present study.

The $(H_1/D)^{1/2}$ ratio is less than unity and suggests the presence of partial dominance. The $H_2/4H_1$ ratio observed is less than 0.25 which indicates the asymmetrical distribution of genes in respect of positive and negative alleles in the parents. The KD/KR ratio is more than unity which leads to the inference that the dominant alleles are more than the recessive ones. The narrow sense heritability of 41.9 per cent suggests the existence of moderate number of fixable additive genes in the parents.

The regression line intercepts the Y ordinate above the origin indicating the preponderance of partial dominance. The parents P 2,12,4,6 and 7 are located nearer the origin and hence suggests the presence of more number of dominant alleles while the parents P 9 and 13 are positioned away from the origin indicating the occurrence of more number of recessive alleles. This is confirmed by the standardised

deviation graph. The non-allelic interaction was inferred by the exchange of positions of the array points of the parents from W_r/V_r to W_r/W_r' graph.

Pooled - The genetic parameter D is significant and numerically higher than H_1 and H_2 indicating the additive gene action which is confirmed by the combining ability analysis in the present study.

The $(H_1/D)^{1/2}$ ratio is less than unity and suggests the presence of partial dominance. The $H_2/4H_1$ ratio observed is less than 0.25. This might be due to unequal distribution of the genes with respect to positive and negative alleles. The KD/KR ratio is more than unity indicating the preponderance of dominant alleles than recessive ones. The narrow sense heritability of 33.6 per cent suggests the presence of moderate number of fixable additive genes in the parents.

The regression line of W_r on V_r intercepted the Y ordinate above the origin in kharif, 1980 and in the pooled data while it cuts it at the point of origin during summer, 1981 which indicated the preponderance of partial dominance for the character, seed yield. The parents P 1,3,6,7 and P 14 are located near the origin while P 9 and P 10 away from the origin indicating the presence of more number of dominant alleles in the former and recessive alleles in the

latter. This is confirmed by the standardised deviation graph. The non-allelic interaction was inferred by the exchange of position of the array points of the parents below and above the regression line from W_r - V_r graph to W_r - W_r' graph.

5.6. Combining Ability Effects

5.6.1. Breeding value of parents

The estimates of general combining ability effects and the mean performance of parents helps the plant breeder to gain an in depth knowledge of the genetic architecture of the selected parent over a wide range of environment. These information may help the breeder in choosing the appropriate parent for exploitation of heterosis and in recombination breeding programmes. The objective is feasible only when these parameters are evaluated for their potentialities viz., stability over environments and combining ability attributes.

Among the parents P 2,6 and 8 were found to exhibit significant and positive *gca* effects for plant height while the parents P 3,4,5,9,10,11,12,13 and 15 significant and negative *gca* effects both in kharif, 1980, summer, 1981 and in the pooled analysis. The expression was at variance in the different seasons by the parents P 1,7 and 14 while the parent P 1 showed significant and high positive *gca* effects in the summer, 1981 and pooled

analysis, the parent P 7 showed the same trend in kharif, 1980 and in the pooled analysis. The parent P 14 expressed contradictory effects in season viz., significant and highly positive gca effects in kharif, 1980 and less significant and negative effects in summer, 1981, with non significant very low positive effects in the pooled analysis.

The present day concept of breeding for earliness, short duration and high yield needs no emphasis. Parents with positive gca effects for long duration viz., long days to flower coupled with tall stature may not be proper choice for such circumstances. The desired parent should exert gca effects towards earliness and dwarfness i.e. should show negative gca effects. As observed for plant height, six out of nine parents viz., P 5,9,10,12,13 and 15 exhibited significant and negative effects for days to first flower (an indication to earliness). Therefore, these six parents serve as good combiners for breeding for earliness and dwarfness.

With reference to the character, number of capsules on the main stem, the long and medium duration plants with more number of primary and secondary branches in general possessed less number of capsules in contrast to the early types with less duration and short stature with nil or 1 or 2 branches. The parents P 2,3,4,8,11,13 and 15 had negative gca effects (either significant or non-significant)

while the parents P 5,7,9,10 and 12 registered positive effects in both the seasons as well as in the pooled data. The expression of the character was at variance in other parents in the different seasons and in pooled analysis.

As discussed in the preceeding paragraphs, the long and medium duration types exhibited higher number of capsules on the branches while short duration ones with lesser number. The parents P 2 and 11 registered significant and positive gca effects while the parents P 5,7,9,10,12,13 and 14 exhibited significant and negative gca effects in both the seasons and in the pooled analysis. Other parents i.e., P 3,4 and 15 were found to express positive and negative effects in different seasons. The parents P 1,6 and 8 were found to exhibit positive gca effects in both the seasons and in the pooled analysis, but the significance could be seen only in summer, 1981 and in the pooled analysis.

The expression of the character capsules per plant was found to be at variance in the two seasons. While the parent P 5 expressed significant and negative gca effects in both the seasons and in the pooled analysis, all others exhibited either positive or negative effects in kharif, 1980 and vice versa in summer, 1981. In the pooled analysis, the parents P 1,2,6 and 7 exhibited significant and positive gca effects while the parents P 5,9,12 and 13 expressed significant negative effects.

In respect of seed yield, the parent P 5 alone exhibited significant and negative *gca* effects in both the seasons as well as in the pooled analysis. The parents which expressed positive and significant *gca* effect in summer, 1981 and pooled analysis were P 2 and 6 and those which were negative and significant being P 9 and 10.

Since there were inconsistencies in the expression of the *gca* effects, during kharif, 1980 and summer, 1981, reliable selection couldn't be made based on *gca* effects. However, the parents which exhibited high *gca* effects during summer, 1981 could be considered appropriate since maximum expression was seen in summer than kharif (Rathnaswamy 1980; Shanmugasundaram, 1989; Subbalakshmi, 1989 and Dharmalingam, 1990).

Per se performance

There were also good correspondence between per se performance of the parents and their *gca* effects in the present study. Studies made by Rathnaswamy, (1980) in sesame, Ayyamperumal (1981) in soybean, Mohamed Sherif (1985) in sorghum, Shanmugasundaram (1989) in blackgram in recent past also exhibited such positive relationship between per se performance and *gca* effects.

Ranks were given to individual parents based on per se performance and *gca* effects for each character and ranks totalled over the six characters revealed that the

parents, P 1,2 and 6 attained high ranks of I, II & III in the pooled data.

Based in *gca* effects score over the six characters, parents P 1,2 and 6 attained high (H) status in the pooled data and P 5,9 and 10 low (L) status.

Breeding value of hybrids

Heterosis - Number of hybrids which exhibited heterosis over mid parent (*di*) and better parent (*dii*) and their range in percentage are presented below in a tabular form.

Range of heterosis (*di* and *dii*) in Sesame (Summer, 1981)

Characters	Number of hybrids	
	<i>di</i> (Mid parent)	<i>dii</i> (Better parent)
Plant height	16 -26.55-69.07	8 -36.35-31.02
Days to first flower	12 -8.30-13.26	2 -16.73-5.76
Capsules/main stem	26 -65.11-48.76	2 -78.63-40.64
Capsules/branches	53 -23.01-244.66	20 -46.28-81.52
Capsules/plant	32 -45.46-64.19	18 -61.69-45.07
Seed yield	19 -54.44-52.85	9 -63.99-43.73

Rathnaswamy (1980) reported heterosis for seed yield and number of capsules in the crop. Subbalakshmi (1989), Dharmalingam (1990) also reported heterosis for seed yield in this crop and Shanmugasundaram (1989) in black gram.

The scope for exploitation of hybrid vigour in any crop will depend on (i) the high mean performance of the hybrids over a wide range of environments (ii) magnitude of heterosis and (iii) the biological feasibility of large scale production of hybrid seeds. Although many hybrids exhibited a high mean performance over the better parent in the present investigation, the immediate utility for commercial exploitation as hybrids is not feasible due to biological hindrances such as the lack of high natural cross pollination, but feasible if genic or cytoplasmic or cytoplasmic-genic male sterility could be identified. In grain legumes and other crops like redgram, the exploitation of heterosis is successful owing to the cross pollination and availability of genic male sterility (Reddy and Rao, 1981, Rathnaswamy, 1980 and Shanmugasundaram, 1989). Any how, non availability of male sterile lines and feasibility of realising hybrids for commercial exploitation in this crop is rather remote at present. Alternatively, recombination breeding in order to obtain superior

segregants with desirable attributes is suggested based on the results obtained in the present investigation.

It seems that ranking on the basis of heterotic response and *sca* effects is not reflected by the ranking based on performance. Heterosis being $F_1 - \bar{P}$ can more or less depend on the mean of the concerned parents. Similarly, the *sca* effects are merely a deviation of the F_1 performance. There is every possibility of getting a cross with high *per se* performance but with low heterosis, if parental performance is also high. Certainly, there can also be a cross with poor *per se* performance but high heterotic response if parental performance is poor.

The choice of the best cross combinations on the basis of *sca* effects need not necessarily be one which could give highest *per se* performance. Moreover, the *sca* effects was much influenced by the seasons in the present study ~~for~~ most of the characters. Similar results were also reported by Bhullar et al. (1979) in wheat, Rathnaswamy (1980) in Sesame, Ayyamperumal (1981) in soybean and Shanmugasundaram (1989) in black gram. For breeding a hybrid of High x High (HH) or High x Low (HL), single cross which is highly heterotic on the strength of *sca* effects can be tested over time for stability of performance (Arunachalam, ^{et al} 1980).

The *per se* performance being the realised value, but heterotic response and *sca* effects being an estimate, the *per se* performance should be given preference while making selection among cross combinations. Similar views were expressed by others in recent past (Khangura et al. (1980), Rathnaswamy (1980), Ayyamperumal (1981) and Shanmugasundaram (1989).

Based on *per se* performance of the hybrids in summer, 1981, viz., P 1.2, P 1.6, P1.10, P2.4, P2.10, P2.11, P2.12, P2.13, P2.14, P2.15, P3.4, P3.13 and P6.15 were found superior for seed yield. These hybrids also ranked high for capsules per plant. The *per se* performance of the hybrids involving good general combiners (parents P 1, 2 and 6) was generally high indicating that the combining ability of the parents was related to the performance of hybrids than the *sca* effects. This view confirms with that expressed by Lodhi et al. (1978), Khangura et al. (1980), Rathnaswamy (1980), Tiwari and Pandey (1986) and Shanmugasundaram (1989) in different crops.

The hybrids, P_{1.6}, P_{2.4}, P_{2.6}, P_{4.6} and P_{5.9} were superior in *sca* effects. The parents involved particularly P 1, 2 and 6 were H x H and P.9 L x L group. The high *sca*

effects of the $P_{1.6}$ involving parents with H x H **gca** indicated the presence of additive and additive x additive type of fixable gene effects. The increase in yield in such crosses may also be due to the combined effects of other important traits. Such crosses were desirable and expected to produce outstanding segregants, Singh et al. (1987) and Shanmugasundaram (1989).

The crosses which involved high combining parents and exhibited high mean performance and **sca** effects can be exploited by following conventional breeding procedures which aims at increasing the frequency of desirable alleles in the population (Mohinder Singh et al., 1987).

5.6.4. Study of F_2 progenies

Based on **per se** performance for seed yield during summer, 1981 and the **gca** effects, six crosses were selected two each for High x High, (H x H), High x Low (H x L) and Low x Low (L x L) combinations. The parents selected were 1,2,5,6,9 and 10 and combinations being $P_{1.2}$, $P_{1.6}$ (H x H) $P_{1.10}$, $P_{2.10}$ (H x L) $P_{5.10}$ and $P_{9.10}$ (L x L).

These combinations were studied in F_2 along with their parents and F_1 s in randomised block design with three replications. The results realised are given hereunder.

Study of F_2 progenies : Summer, 1982 (seed yield)

Details of cross combinations	Mean	Range	GCA	G.A.as % of mean
High x High				
KRR 2 x TMV 6 ($P_{1.2}$)	9.74	1.15-14.00	15.64	19.29
KRR 2 x Si.2277 ($P_{1.6}$)	9.13	1.50-13.15	18.93	30.26
High x Low				
KRR 2 x Si.2631 ($P_{1.10}$)	6.78	1.35-9.50	6.09	13.97
TMV 6 x Si.2631 ($P_{2.10}$)	7.54	0.55-10.20	14.25	18.98
Low x Low				
Si.2141 x Si.2631 ($P_{5.10}$)	4.86	0.30-9.10	11.68	11.02
Si.2340 x Si.2631 ($P_{9.10}$)	5.06	0.80-9.30	16.16	22.50

The six F_2 populations studied exhibited high mean, wide variability, high GCV coupled with high genetic advance in respect of High x High combinations, compared to High x Low and Low x Low combinations. Thus, consideration of the parental and F_1 per se values and the gca effects of the parents for further selection is a progressive and viable method of advancing the materials for a given set of cross combinations to effectively maintain the superior crosses in the recombination breeding, is emerged from the present investigation, if the characters are under the control of additive gene action. Therefore, the present

study indicated that *per se* performance of the parents and *gca* effects could be used as tool for maintaining the superior crosses in the recombination breeding (Nass, 1979), Rathnaswamy and Jagathesan (1984) and Shanmugasundaram (1989).

5.6.5. Suggestions for genetic improvement of yield

From the foregoing discussion, it would appear that yield improvement in sesame is possible by selecting appropriate parents based on heterotic vigour, combining ability and *per se* performance through suitable breeding strategies.

In the present study most of the yield contributing traits are governed by both additive and non-additive gene effects with moderate to high heritability values. Hence, to harness the above gene actions, it would be more appropriate to exploit and realise high yielding superior recombinants in latter generations. Intermating of desirable segregants by adopting the diallel selective mating system is suggested as proposed by Jensen (1970). This will be a useful and viable approach for rapid genetic improvement in this ancient oilseed crop of India.

SUMMARY

6. SUMMARY

The present investigation was designed to identify potential parents and superior cross combinations, and to conceptualise breeding strategies for yield improvement in sesame. The required information of genetic components governing inheritance was obtained by adopting well established biometrical approaches such as combining ability, genetical and graphical analyses.

Fifteen genotypes of sesame, (*Sesamum indicum* L.) belonging to diverse eco-geographical centres were chosen from the germplasm and crosses in all possible ways with reciprocals were made. The 15 parents and 210 hybrids were studied in two seasons namely kharif and summer. Six characters viz., height of the plant, days to first flower, number of capsules on the main stem, number of capsules on the branches, number of capsules per plant and seed yield were taken into consideration. Among the 210 cross combinations studied, six cross combinations were selected based on *per se* performance and the *gca* effects of the parents and studied in F_2 generation.

The results obtained in the present investigation are summarised below :

The genotype x season interaction was significant for all the characters except for days to first flower.

Among the characters, $\sigma^2_g : \sigma^2_{gl}$ ratio was widest for capsules on branches followed by capsules per plant. Days to first flower had the narrowest ratio followed by seed yield per plant thereby necessitating that the test be carried out in multi-environments for obtaining reliable and precise estimates of seed yield.

The GCA variance was greater in magnitude than the SCA variance for all the characters studied in both the kharif and summer seasons.

The proportion of GCA : SCA variance (ratio) varied among the characters studied. Days to first flower had the widest ratio followed by plant height. Seed yield per plant had the narrowest GCA : SCA ratio. Thus, the yield components were found to be governed comparatively with more additive genes than seed yield per plant.

The pooled analysis of variance over seasons for combining ability indicated that GCA x seasons were highly significant for all the characters, except for days to first flower indicating the sensitiveness of GCA variance for seasonal fluctuations. The SCA x seasons variance was significant for plant height and capsules on main stem. Other characters did not exhibit significant differences.

The range of heterosis over the mid parent varied between -30.95 to 39.14 for plant height, -8.07 to 12.80 for

KRR 2, TMV 6 and S.i. 2277 were found to perform better than other parents during summer and hence suggested for further investigation.

The gca effects score values were also found to be in the order of the *per se* performance. There seems to exist a fair correspondence between the *per se* performance and gca effects.

The higher magnitude of additive component (D) of variation than the dominance component (H_1), the less than unity ratio $(H_1/D)^{1/2}$, the intercept of regression line above the origin in Wr-Vr graph for all the characters indicated the predominant influence of additive gene action on yield and yield components.

The yield components exhibited higher heritability estimates than seed yield in both kharif and summer seasons confirming the conclusions drawn through combining ability analysis.

The ratio of $H_2/4H_1$ was less than the theoretical expectation of 0.25 for all the characters in most situations and pointed to the asymmetry of positive and negative alleles expressed by the parents.

The gene distribution among the parents was observed to be unequal with greater frequencies of dominant alleles for all the characters both in kharif and summer

days to first flower, -56.71 to 72.18 for capsules on main stem, -61.19 to 207.45 for capsules on branches, -38.28 to 72.18 for capsules per plant and -45.98 to 91.83 per cent for seed yield during kharif, 1980.

The range of heterosis over the better parent was from -30.54 to 25.85 for plant height, -16.96 to 4.27 for days to first flower, -70.62 to 49.08 for capsules on main stem, -47.73 to 138.51 for capsules on branches, -49.61 to 50.14 for capsules per plant and -55.30 to 42.28 per cent for seed yield during kharif, 1980.

In summer 1981, the heterosis ranged from -26.55 to 69.07 for plant height, -8.30 to 13.26 for days to first flower, -65.11 to 48.76 for capsules on main stem, -23.01 to 244.66 for capsules on branches, -45.46 to 64.19 for capsules per plant and -54.44 to 52.85 per cent for seed yield over the mid parent value.

The range of heterosis over the better parent was found to vary from -36.35 to 31.02 for plant height, -16.73 to 5.76 for days to first flower, -78.63 to 40.64 for capsules on main stem, -46.28 to 81.52 for capsules on branches, -61.69 to 45.07 for capsules per plant and -63.99 to 43.73 per cent for seed yield during summer, 1981.

Among the two seasons, the phenotypic expression of the characters was high during summer season. The parents

KRR 2, TMV 6 and S.i. 2277 were found to perform better than other parents during summer and hence suggested for further investigation.

The **gca** effects score values were also found to be in the order of the **per se** performance. There seems to exist a fair correspondence between the **per se** performance and **gca** effects.

The higher magnitude of additive component (D) of variation than the dominance component (H_1), the less than unity ratio $(H_1/D)^{1/2}$, the intercept of regression line above the origin in W_r-V_r graph for all the characters indicated the predominant influence of additive gene action on yield and yield components.

The yield components exhibited higher heritability estimates than seed yield in both kharif and summer seasons confirming the conclusions drawn through combining ability analysis.

The ratio of $H_2/4H_1$ were less than the theoretical expectation of 0.25 for all the characters in most situations and pointed to the asymmetry of positive and negative alleles expressed by the parents.

The gene distribution among the parents was observed to be unequal with greater frequencies of dominant alleles for all the characters both in kharif and summer

seasons except for the character capsules on main stem in kharif season.

Based on the *per se* performance, score of the parents and the *gca* effects, six cross combinations were advanced for study under F_2 generation. They are :

- | | | |
|---------------------|---|---------------|
| 1. KRR ₂ | x | TMV 6 |
| 2. KRR ₂ | x | S.i. 2277 |
| 3. KRR ₂ | x | S.i. 2631 |
| 4. TMV ₆ | x | S.i. 2631 |
| 5. S.i. 2141 | x | S.i. 2631 and |
| 6. S.i. 2340 | x | S.i. 2631 |

The six selected F_2 populations studied exhibited high mean, wide variability and high GCV coupled with high genetic advance as percentage of mean in respect of high x high combinations followed by high x low compared to and low x low combinations. Thus, consideration of the parental and F_1 *per se* values and the *gca* effects of the parents for further selection as a progressive and viable method of advancing the materials for recombination breeding has emerged from the present investigation.

Yield components were largely governed by additive gene action thereby providing high heritability estimates in narrow sense. Therefore, selection based on yield components is preferable in early generations of hybrids instead of yield *per se*.

The F_2 studies indicated that selection of high x high followed by high x low combinations instead of low x low combinations may be adopted for discrimination of F_1 cross combinations.

The above investigation has advanced the knowledge on breeding improved varieties of sesame, and provided further refinements therein.

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* Originals not seen

TABLES

Table 4.1 Analysis of variance for individual season

Characters	Seasons	Variance due to		
		Genotypes	Error	SE
Plant height	kharif 1980	481.924 ^{**}	117.540	6.259
	summer 1981	569.405 ^{**}	180.064	7.743
Day to first flower	kharif 1980	28.527 ^{**}	5.200	1.316
	summer 1981	25.865 ^{**}	4.493	1.224
Capsules - main stem	kharif 1980	309.216 ^{**}	88.902	5.444
	summer 1981	128.364 ^{**}	47.516	3.980
Capsules - branches	kharif 1980	363.595 ^{**}	149.066	7.049
	summer 1981	837.414 ^{**}	238.9576	8.925
Capsules/plant	kharif 1980	488.363 ^{**}	254.263	9.206
	summer 1981	952.686 ^{**}	347.604	10.764
Seed yield	kharif 1980	14.929 ^{**}	6.245	1.443
	summer 1981	17.052 ^{**}	6.967	1.524

*Significant at 5% level

**Significant at 1% level

Table 4.2. Analysis of variance for pooled data

Source	D.F.	Plant height	Days to first flower	Capsules main stem	Capsules branches	Capsules plant	Seed yield
Replications	2	1438.96**	22.70**	82.64**	820.72**	522.89**	6.29**
Locations	1	9041.45**	783.57**	5863.72**	62123.82**	99969.53**	2114.15**
Locations x Replications	2	537.23*	43.11**	453.92**	3012.02**	4964.90**	8.93*
Genotypes	224	583.14**	49.46**	222.32**	685.83**	802.28**	13.16**
Genotypes x Locations	224	460.96**	6.46	181.76**	422.76**	623.10**	11.62**
Error	896	155.33	4.66	82.70	215.85	335.39	6.20
σ^2_{2y}		20.36	7.16	6.85	43.85	29.86	0.26
σ^2_{2yl}		101.87	0.60	32.84	68.97	95.90	1.80
$\sigma^2_{y : \sigma^2_{yl}}$		0.20:1	11.9:1	0.20:1	0.64:1	0.31:1	0.14:1

* Significant at five per cent level

** Significant at one per cent level

Table 4.3. Mean performance of parents and hybrids in the two seasons

Parents/ Hybrids	Plant height		
	1980 kharif	1981 summer	Pooled
P ₁	83.80	115.30	99.55
2	88.66	102.40	95.53
3	78.13	72.66	75.39
4	94.86	83.73	89.29
5	54.83	63.13	58.98
6	88.73	103.83	96.28
7	122.20	93.46	107.83
8	86.06	113.16	99.61
9	63.13	89.43	76.28
10	75.46	85.36	80.41
11	67.76	79.73	73.74
12	73.43	71.13	72.28
13	78.16	97.43	87.79
14	108.06	70.30	89.18
15	92.20	87.13	89.66
P ₁ x P ₂	90.01	103.43	96.72
3	80.41	97.40	88.90
4	93.64	112.46	103.05
5	85.56	99.18	92.37
6	84.94	115.76	100.35
7	103.28	109.09	106.18
8	88.83	110.73	99.78
9	78.41	125.16	101.78
10	84.34	111.33	97.83
11	87.84	117.93	102.88
12	79.76	97.84	88.80
13	86.58	119.04	102.81
14	97.51	92.74	95.12
15	84.43	120.01	102.22
P ₂ x P ₃	98.44	94.85	96.64
4	96.99	100.39	98.69
5	88.36	103.39	95.87
6	101.09	102.73	101.91
7	111.04	96.46	103.75
8	104.11	93.25	98.68
9	87.01	95.38	91.19
10	95.98	95.85	95.91
11	96.88	93.65	95.26
12	89.59	96.06	92.82
13	89.96	100.40	95.18
14	97.70	97.03	97.36
15	88.65	97.54	93.09

Contd.,

Table 4.3 Contd.,

Parents/ Hybrids	Plant height				
	1980 kharif	1981 summer	Pooled		
P ₃ x P ₄	5	79.48	94.96	87.22	
	6	73.98	72.00	72.99	
	7	87.88	98.91	93.39	
	8	99.14	82.91	91.02	
	9	90.86	87.66	89.26	
	10	75.56	101.46	88.51	
	11	82.93	81.93	82.43	
	12	87.56	86.01	86.78	
	13	81.83	80.79	81.31	
	14	77.78	89.36	83.57	
	15	92.83	77.83	85.33	
		79.43	82.41	80.92	
	P ₄ x P ₅	6	71.96	91.78	81.87
		7	92.91	92.68	92.79
		8	103.23	86.81	95.02
9		95.26	95.93	95.59	
10		65.89	97.53	81.71	
11		82.21	79.64	80.92	
12		88.26	80.38	84.32	
13		85.81	94.15	89.98	
14		86.53	89.08	87.80	
15		91.66	92.96	92.31	
		88.01	90.38	89.19	
P ₅ x P ₆		7	87.09	100.71	93.90
		8	92.14	85.05	88.59
		9	88.46	98.83	93.64
		10	72.89	56.03	64.46
	11	77.01	86.16	81.58	
	12	85.28	85.58	85.43	
	13	69.44	81.89	75.66	
	14	81.01	77.19	79.10	
	15	91.41	67.94	79.67	
		88.26	83.96	86.71	
	P ₆ x P ₇	8	106.43	99.81	103.12
		9	91.75	100.24	95.99
		10	83.39	100.21	91.80
		11	82.63	52.61	82.62
		12	90.18	103.81	96.99
13		87.21	95.96	91.58	
14		90.99	96.66	93.82	
15		86.58	99.63	93.10	
		84.76	94.68	89.72	

Table 4.3 Contd.,

Parents/ Hybrids	Plant height		
	1980 kharif	1981 summer	Pooled
P ₇ x P ₈	105.41	92.98	99.19
	103.66	92.93	98.29
	105.06	87.81	96.43
	108.03	87.61	97.82
	105.58	97.09	101.33
	107.08	81.74	94.41
	103.46	86.15	94.80
116.64	82.81	99.72	
P ₈ x P ₉	86.45	106.16	96.30
	91.66	102.66	97.16
	88.44	109.03	98.93
	89.90	90.49	90.14
	88.50	102.98	95.44
	92.81	96.16	94.48
	89.98	96.31	93.14
P ₉ x P ₁₀	78.81	79.31	79.06
	80.68	93.11	82.39
	80.93	77.96	79.44
	68.34	89.26	78.80
	86.73	89.49	88.11
	77.23	72.85	75.04
P ₁₀ x P ₁₁	86.36	91.60	88.98
	73.45	85.83	79.64
	69.56	88.58	79.07
	80.28	94.11	87.19
	85.16	81.98	83.57
P ₁₁ x P ₁₂	81.89	104.46	93.17
	78.84	94.09	86.46
	93.29	82.99	88.14
	72.76	99.34	86.05
P ₁₂ x P ₁₃	75.44	90.08	82.76
	89.63	92.41	91.02
	76.94	92.08	84.51
P ₁₃ x P ₁₄	96.96	81.53	89.24
	85.81	92.26	89.03
P ₁₄ x P ₁₅	90.64	86.21	93.92
SE	6.25	7.47	5.00

Table 4.4. Mean performance of parents and hybrids in the two seasons

Parents/ Hybrids	Days to first flower		
	1980 kharif	1981 summer	Pooled
P ₁	43.53	42.63	43.08
2 ₁	45.16	43.60	44.38
3	46.26	44.70	45.48
4	43.46	41.90	42.68
5	34.80	33.23	34.01
6	45.56	44.00	44.78
7	46.30	45.03	45.66
8	42.06	40.50	41.28
9	35.83	34.23	35.03
10	35.80	34.20	35.00
11	42.20	40.60	41.40
12	38.10	37.03	37.56
13	42.00	40.40	41.20
14	45.46	42.20	43.83
15	41.56	39.96	40.76
P ₁ x P ₂	41.16	39.63	40.39
3	43.76	40.43	42.09
4	40.23	38.85	39.54
5	38.75	37.18	37.96
6	44.46	42.89	43.67
7	45.48	43.81	44.64
8	42.11	40.65	41.38
9	44.76	42.84	43.80
10	39.01	38.19	38.60
11	40.09	38.53	39.31
12	40.83	39.24	40.03
13	42.33	40.66	41.49
14	42.23	40.61	41.42
15	41.04	39.61	40.32
P ₂ x P ₃	43.35	41.79	42.57
4	43.33	41.78	42.55
5	42.13	40.58	41.35
6	44.38	42.81	43.59
7	44.91	43.33	44.12
8	44.16	42.59	43.37
9	41.66	39.93	40.79
10	38.93	39.75	39.34
11	44.15	42.56	43.35
12	42.64	41.06	41.85
13	43.93	42.26	43.09
14	43.69	42.09	42.89
15	40.66	39.08	39.87

Table 4.4 Contd.,

Parents/ Hybrids	Days to first flower				
	1980 kharif	1981 summer	Pooled		
P ₃ x P ₄	4	42.24	40.70	41.47	
	5	39.69	38.16	38.92	
	6	43.53	41.96	42.74	
	7	44.86	42.53	43.69	
	8	42.58	41.01	41.79	
	9	39.71	38.13	38.92	
	10	41.74	39.79	40.76	
	11	43.19	41.58	42.38	
	12	41.53	39.94	40.73	
	13	41.51	39.73	40.62	
	14	42.16	40.58	41.37	
	15	41.30	39.71	40.50	
	P ₄ x P ₅	5	36.09	35.41	35.75
		6	43.03	41.96	42.49
		7	46.38	44.75	45.56
8		41.88	40.31	41.09	
9		39.96	38.23	39.09	
10		36.46	34.89	35.67	
11		41.73	40.14	40.93	
12		40.29	38.64	39.46	
13		40.93	39.34	40.13	
14		41.69	40.49	41.09	
15		40.40	38.81	39.60	
P ₅ x P ₆		6	43.40	41.86	42.63
		7	41.28	39.66	40.47
		8	39.04	38.31	38.67
		9	36.80	36.20	36.50
	10	37.33	36.16	36.74	
	11	40.65	39.06	39.85	
	12	35.09	33.51	34.30	
	13	40.01	38.43	39.22	
	14	43.46	42.71	43.08	
	15	41.29	39.54	40.41	
	P ₆ x P ₇	7	47.36	45.60	46.48
		8	44.39	42.84	43.61
		9	42.71	41.20	41.95
		10	41.04	39.46	40.25
		11	43.83	42.21	43.02
12		41.31	39.73	40.52	
13		45.33	43.64	44.48	
14		45.09	43.49	44.29	
15		46.89	41.84	44.36	

Table 4.4 Contd.,

Parents/ Hybrids	Days to first flower			
	1980 kharif	1981 summer	Pooled	
P ₇ x P ₈	9	45.05	42.08	43.56
	10	42.96	41.46	42.21
	11	42.59	40.99	41.79
	12	44.73	43.16	43.94
	13	42.13	40.54	41.33
	14	44.26	42.68	43.47
	15	44.76	43.19	43.97
P ₈ x P ₉	10	43.56	41.98	42.77
	11	40.06	38.49	39.27
	12	41.20	39.60	40.40
	13	41.83	40.20	40.51
	14	41.76	40.14	40.95
	15	42.68	41.10	41.79
	15	42.53	40.94	41.73
P ₉ x P ₁₀	11	42.69	41.06	41.87
	12	34.78	34.03	34.40
	13	41.96	40.36	41.16
	14	38.04	36.44	37.24
	15	39.24	37.68	38.46
	15	40.93	39.33	40.13
	15	40.83	39.21	40.02
P ₁₀ x P ₁₁	12	38.48	37.04	37.76
	13	37.06	35.48	36.27
	14	37.79	36.04	36.91
	15	40.96	39.53	40.24
	15	38.69	37.09	37.89
P ₁₁ x P ₁₂	13	41.86	40.01	40.93
	14	41.54	39.94	40.24
	15	42.81	41.33	42.07
	15	40.90	39.31	40.10
P ₁₂ x P ₁₃	14	40.36	39.03	39.69
	15	40.14	38.43	39.28
	15	39.00	37.70	38.35
P ₁₃ x P ₁₄	15	42.06	40.46	41.26
	15	41.09	39.49	40.29
P ₁₄ x P ₁₅		42.06	40.48	41.27
SE		1.31	1.22	1.22

Table 4.5. Mean performance of parents and hybrids in the two seasons

Parents/ Hybrids	Capsules-main stem		
	1980 kharif	1981 summer	Pooled
P ₁	16.60	30.53	23.56
2 ₁	16.80	25.10	20.95
3	18.60	25.93	22.26
4	35.23	28.93	32.08
5	36.53	34.06	35.29
6	18.33	31.06	24.69
7	42.40	36.40	39.40
8	16.53	27.93	22.23
9	26.73	84.13	55.43
10	35.60	53.26	44.43
11	13.80	17.13	15.46
12	27.73	40.20	33.96
13	25.33	27.03	26.18
14	51.26	22.36	36.76
15	29.46	18.96	24.21
P ₁ x P ₂	18.96	31.16	25.06
3	23.88	25.81	24.84
4	21.79	34.36	28.07
5	17.73	26.00	21.86
6	16.36	31.43	23.89
7	20.83	29.39	25.11
8	16.18	23.73	19.95
9	14.89	30.23	22.56
10	17.75	33.25	25.50
11	18.04	33.26	25.65
12	16.51	29.73	23.12
13	16.99	29.98	23.48
14	26.58	29.03	27.80
15	19.06	29.53	24.29
P ₂ x P ₃	22.43	27.69	25.06
4	18.65	28.61	23.63
5	16.93	29.21	23.07
6	16.29	29.05	22.67
7	23.73	30.19	26.96
8	16.83	29.59	23.21
9	18.26	27.03	22.64
10	27.36	26.19	26.77
11	17.26	28.93	23.09
12	20.08	28.01	24.04
13	15.95	29.96	22.95
14	17.56	35.30	26.43
15	17.70	26.93	22.31

Table 4.5 Contd.,

Parents/ Hybrids	Capsules-main stem				
	1980 kharif	1981 summer	Pooled		
P ₃ x P ₄	4	27.51	30.43	28.97	
	5	25.23	25.34	25.28	
	6	19.16	29.04	24.10	
	7	32.83	30.13	31.48	
	8	16.04	26.63	21.33	
	9	29.14	27.76	28.45	
	10	18.46	25.33	21.89	
	11	21.63	20.89	21.24	
	12	23.13	28.68	25.90	
	13	20.89	27.60	24.24	
	14	37.73	26.73	32.23	
	15	25.80	24.43	25.11	
	P ₄ x P ₅	5	35.79	30.48	33.13
		6	17.38	28.13	22.75
		7	42.16	31.36	36.76
8		24.76	28.19	26.47	
9		22.93	27.76	25.34	
10		39.96	32.83	36.39	
11		27.21	22.03	24.62	
12		34.38	32.29	33.33	
13		26.29	26.60	26.44	
14		33.36	30.09	31.72	
15		28.39	23.76	26.07	
P ₅ x P ₆		6	19.03	31.33	25.18
		7	36.99	32.13	34.56
		8	15.69	30.73	23.21
		9	54.46	32.23	43.34
	10	29.20	32.09	30.64	
	11	20.13	27.06	23.59	
	12	34.59	31.86	33.32	
	13	29.04	31.89	30.46	
	14	27.63	23.26	25.44	
	15	22.93	25.53	24.23	
	P ₆ x P ₇	7	29.66	29.08	29.37
		8	13.78	29.69	21.73
		9	18.06	34.24	26.15
		10	25.28	28.53	26.90
		11	20.63	32.83	26.73
12		18.51	32.53	25.52	
13		14.74	27.49	21.11	
14		15.06	30.09	22.57	
15		15.90	29.20	22.55	

Table 4.5 Contd.,

Parents/ Hybrids	Capsules-main stem		
	1980 kharif	1981 summer	Pooled
P ₇ x P ₈	34.29	26.43	30.36
9	42.43	35.26	38.84
10	43.00	28.28	35.64
11	30.26	27.49	28.87
12	49.03	48.50	48.76
13	37.76	28.06	32.91
14	39.73	26.23	32.98
15	37.26	32.26	34.76
P ₈ x P ₉	20.76	31.64	26.20
10	22.83	28.38	25.60
11	16.88	29.80	23.34
12	20.33	26.50	23.41
13	19.04	30.43	24.73
14	21.96	34.49	28.22
15	22.79	24.78	23.78
P ₉ x P ₁₀	39.08	28.98	34.03
11	16.71	28.70	22.70
12	29.68	33.49	31.58
13	26.19	33.21	29.70
14	18.19	31.93	25.06
15	21.89	17.98	19.93
P ₁₀ x P ₁₁	27.21	33.36	30.28
12	31.81	28.10	29.95
13	31.20	32.69	31.94
14	32.53	26.98	29.75
15	32.29	25.24	28.76
P ₁₁ x P ₁₂	22.59	34.66	28.62
13	16.79	29.53	23.16
14	28.59	25.90	27.24
15	17.20	24.01	20.60
P ₁₂ x P ₁₃	28.09	29.76	28.92
14	41.86	29.00	35.43
15	27.53	27.69	27.61
P ₁₃ x P ₁₄	38.60	24.38	31.69
15	24.34	25.35	24.84
P ₁₄ x P ₁₅	29.49	28.13	28.81
SE	5.44	3.97	3.40

Table 4.6. Mean performance of parents and hybrids in the two seasons

Parents/ Hybrids	Capsules-branches		
	1980 kharif	1981 summer	Pooled
P ₁	38.00	75.33	56.66
2	31.70	59.30	45.50
3	29.33	47.00	38.16
4	49.53	29.93	39.73
5	0.00	0.00	0.00
6	34.60	52.73	43.66
7	22.96	28.40	25.68
8	37.73	52.80	45.26
9	0.00	0.00	0.00
10	17.66	9.94	13.80
11	19.06	32.70	25.88
12	14.66	23.93	19.29
13	24.27	46.46	35.36
14	32.33	30.46	31.39
15	41.16	31.30	36.23
P ₁ x P ₂	36.83	64.38	50.60
3	35.44	47.09	41.26
4	44.79	64.79	54.79
5	29.73	48.49	39.11
6	41.66	67.78	54.72
7	23.10	45.23	34.16
8	32.24	56.59	44.41
9	28.29	80.33	54.31
10	31.48	63.39	47.43
11	34.79	79.29	57.04
12	24.33	45.85	35.09
13	26.98	62.11	44.54
14	28.91	65.33	47.12
15	33.60	54.81	44.20
P ₂ x P ₃	41.08	54.19	47.63
4	46.68	56.53	51.60
5	31.45	52.71	42.08
6	33.89	62.73	48.31
7	39.76	53.09	46.42
8	34.23	62.80	48.51
9	31.20	59.76	45.48
10	33.13	58.24	45.68
11	45.81	70.13	57.97
12	41.71	55.23	48.47
13	28.63	60.64	44.63
14	28.40	59.81	44.10
15	40.93	46.26	43.59

Table 4.6 Contd.,

Parents/ Hybrids	Capsules-branches				
	1980 kharif	1981 summer	Pooled		
P ₃ x P ₄	5	44.16	63.06	53.61	
	6	25.75	33.64	29.69	
	7	32.73	53.05	42.89	
	8	33.09	40.64	36.86	
	9	28.33	48.90	38.61	
	10	33.69	48.65	41.17	
	11	39.79	33.86	36.82	
	12	43.79	42.96	43.37	
	13	29.36	29.78	29.57	
	14	29.53	49.96	39.74	
	15	21.89	41.75	31.82	
		34.59	37.09	35.84	
	P ₄ x P ₅	5	25.89	43.79	34.84
		6	34.18	52.09	43.13
		7	35.58	41.10	38.34
8		43.30	43.96	43.63	
9		28.33	42.30	35.31	
10		38.56	35.65	37.10	
11		45.13	33.86	39.49	
12		35.06	34.39	34.72	
13		31.73	36.31	34.02	
14		31.93	55.29	43.61	
15		45.46	38.31	41.88	
P ₅ x P ₆		6	38.59	55.73	47.16
		7	30.95	30.71	30.83
		8	23.13	43.46	33.29
		9	0.00	0.00	0.00
	10	22.81	37.13	29.97	
	11	29.30	41.93	35.61	
	12	13.73	24.00	18.86	
	13	22.11	24.96	23.53	
	14	37.33	30.53	33.93	
	15	39.39	39.46	39.42	
	P ₆ x P ₇	7	29.70	62.83	46.26
		8	34.49	62.09	48.29
		9	31.43	54.74	43.08
		10	22.24	31.78	27.01
		11	49.23	58.26	53.74
12		41.34	50.99	46.16	
13		29.28	62.86	46.07	
14		27.06	53.49	40.27	
15		35.28	55.79	45.53	

Table 4.6 Contd.,

Parents/ Hybrids	Capsules-branches		
	1980 kharif	1981 summer	Pooled
P ₇ x P ₈	26.83	42.71	34.77
	25.03	32.86	28.94
	20.83	28.78	24.80
	43.99	41.18	42.58
	13.00	28.24	20.62
	34.53	36.60	35.56
	30.19	50.96	40.57
15	44.26	41.51	42.88
P ₈ x P ₉	36.33	64.89	50.61
	41.33	50.72	46.04
	40.73	56.69	48.71
	33.68	49.66	41.67
	30.24	42.93	36.58
	31.06	55.59	43.32
	34.16	36.60	35.38
P ₉ x P ₁₀	17.48	33.63	25.55
	26.18	44.20	35.19
	19.88	22.43	21.15
	19.66	31.61	25.63
	43.43	21.40	32.41
	40.59	30.41	35.50
P ₁₀ x P ₁₁	45.46	44.86	45.16
	13.39	24.83	19.11
	19.59	37.26	28.42
	24.76	52.76	38.76
	45.96	27.69	36.82
P ₁₁ x P ₁₂	41.06	48.09	44.57
	34.46	59.46	46.96
	39.23	48.23	43.73
	31.99	45.79	38.89
P ₁₂ x P ₁₃	30.01	32.26	31.13
	29.79	33.23	31.51
	36.93	43.83	40.38
P ₁₃ x P ₁₄	21.63	35.08	28.35
	28.56	39.75	34.15
P ₁₄ x P ₁₅	32.63	45.21	38.92
SE	7.04	8.92	5.70

Table 4.7. Mean performance of parents and hybrids in the two seasons

Parents/ Hybrids	Capsules plant		
	1980 kharif	1981 summer	Pooled
P ₁	44.60	105.86	75.23
2	48.50	84.40	66.45
3	47.93	72.93	60.43
4	84.70	58.86	71.81
5	36.53	34.06	35.29
6	52.93	83.80	68.36
7	65.36	64.80	65.08
8	54.26	80.73	67.49
9	25.73	84.13	55.43
10	53.26	63.20	58.23
11	32.86	49.83	41.34
12	42.40	64.13	53.26
13	49.60	73.50	61.55
14	83.60	52.90	68.25
15	70.63	50.26	60.44
P ₁ × P ₂	55.79	95.54	75.66
3	59.33	72.90	66.11
4	66.60	99.15	82.87
5	47.46	74.49	60.97
6	58.03	99.21	78.62
7	43.95	74.63	59.29
8	48.43	80.33	64.38
9	41.60	110.56	76.08
10	49.23	96.64	72.93
11	52.73	112.56	82.64
12	40.86	78.58	59.72
13	43.93	92.09	68.01
14	55.49	94.36	74.92
15	52.63	84.35	68.49
P ₂ × P ₃	63.01	81.89	72.45
4	65.33	85.14	75.23
5	48.38	81.93	65.15
6	50.20	91.78	70.99
7	63.49	83.29	73.39
8	51.06	92.39	71.72
9	47.99	86.79	67.29
10	60.50	84.52	72.50
11	63.08	99.40	81.24
12	61.80	83.24	72.52
13	44.58	91.61	68.09
14	45.86	95.11	70.48
15	58.63	73.20	65.91

Table 4.7 Contd.,

Parents/ Hybrids	Capsules plant		
	1980 kharif	1981 summer	Pooled
$P_3 \times P_4$	71.51	93.49	82.50
5	50.98	58.99	54.98
6	50.69	82.09	66.39
7	68.36	72.45	70.40
8	45.53	75.53	60.53
9	61.60	76.41	69.00
10	58.26	59.20	58.73
11	65.43	68.86	64.64
12	52.49	58.98	55.73
13	49.59	77.61	63.60
14	59.63	68.53	64.08
15	60.73	61.53	61.13
$P_4 \times P_5$	59.38	74.28	66.83
6	51.90	80.73	66.31
7	77.74	72.46	75.10
8	68.06	72.04	70.05
9	51.60	66.66	59.13
10	78.53	68.48	73.50
11	72.34	55.98	64.16
12	69.63	66.70	68.16
13	58.01	6.91	60.46
14	69.99	85.39	77.69
15	73.93	62.08	68.00
$P_5 \times P_6$	52.63	91.99	72.31
7	68.08	62.84	65.46
8	38.83	74.20	56.51
9	54.46	32.23	43.34
10	52.01	69.23	60.62
11	49.43	68.86	59.14
12	48.33	55.86	52.09
13	45.83	56.86	51.34
14	64.96	53.80	59.38
15	62.33	65.00	63.66
$P_6 \times P_7$	59.26	91.88	75.57
8	48.28	91.93	70.10
9	49.49	90.79	60.14
10	47.83	60.31	54.07
11	69.86	91.13	80.49
12	59.86	83.53	71.69
13	44.03	90.36	67.19
14	42.13	85.43	63.78
15	51.18	84.99	68.08

Table 4.7 Contd.,

Parents/ Hybrids	Capsules plant			
	1980 kharif	1981 summer	Pooled	
P ₇ × P ₈	9	61.13	69.14	65.13
		67.46	68.13	67.79
	10	68.83	56.96	62.89
	11	74.26	68.83	71.54
	12	62.03	76.74	69.28
	13	72.30	58.36	65.33
	14	69.93	78.86	74.39
	15	81.86	73.78	77.82
P ₈ × P ₉		55.43	96.54	75.98
	10	64.16	79.19	71.67
	11	57.63	86.49	72.06
	12	54.03	76.16	65.09
	13	49.20	73.80	61.50
	14	53.03	89.60	71.31
	15	56.96	61.38	59.17
P ₉ × P ₁₀	11	56.53	62.59	59.56
	12	42.90	73.00	57.95
	13	49.56	55.93	52.74
	14	46.49	64.83	55.66
	15	59.96	53.33	56.64
		62.49	48.39	55.44
P ₁₀ × P ₁₁	12	72.68	78.23	75.45
	13	50.56	52.93	51.74
	14	46.39	57.61	52.00
	15	57.26	80.08	68.67
		7.13	48.19	63.16
P ₁₁ × P ₁₂	13	63.66	82.76	73.21
	14	51.29	88.99	70.14
	15	67.83	74.00	70.91
		49.19	69.81	59.50
P ₁₂ × P ₁₃	14	58.11	62.03	60.07
	15	71.66	71.23	71.44
		64.50	71.53	68.01
P ₁₃ × P ₁₄	15	56.19	59.46	57.82
		52.96	65.10	59.03
P ₁₄ × P ₁₅		62.20	73.43	67.81
GR		9.20	10.76	7.31

Table 4.8. Mean performance of parents and hybrids in the two seasons

Parents/ Hybrids	Seed yield		
	1980 kharif	1981 summer	Pooled
P ₁	4.40	9.73	7.06
2	5.50	14.13	9.81
3	5.10	7.16	6.13
4	10.90	7.66	9.28
5	2.80	5.13	3.96
6	7.00	9.96	8.48
7	9.10	8.86	8.98
8	6.33	12.96	9.64
9	5.86	8.83	7.34
10	3.36	7.63	5.49
11	6.93	6.46	6.69
12	5.70	6.90	6.30
13	6.30	13.53	9.91
14	9.66	6.80	8.23
15	8.43	6.86	7.64
P ₁ x P ₂	6.38	11.16	8.77
3	6.68	8.80	7.74
4	7.16	9.64	8.40
5	6.03	7.38	6.70
6	5.56	13.41	9.48
7	4.25	7.39	5.82
8	4.15	9.93	7.04
9	3.50	10.89	7.19
10	4.53	11.59	8.06
11	5.38	11.03	8.20
12	4.88	8.08	6.48
13	4.78	11.04	7.91
14	6.81	9.10	7.95
15	6.39	10.91	8.65
P ₂ x P ₃	6.93	10.19	8.56
4	11.33	11.84	11.58
5	4.50	9.88	7.19
6	6.01	9.38	7.69
7	8.01	10.06	9.03
8	6.54	12.31	9.42
9	7.61	10.64	9.12
10	6.19	11.44	8.81
11	7.48	11.41	9.44
12	7.98	11.79	9.88
13	4.61	11.65	8.13
14	6.04	11.76	8.90
15	5.09	11.73	8.41

Table 4.8 Contd.,

Parents/ Hybrids	Seed yield				
	1980 kharif	1981 summer	Pooled		
P ₃ x P ₄	5	8.08	11.01	9.54	
	6	4.74	6.85	5.79	
	7	5.13	9.74	7.43	
	8	7.36	9.01	8.18	
	9	5.41	8.38	6.89	
	10	5.94	8.33	7.13	
	11	6.34	7.84	7.09	
	12	6.26	8.34	7.30	
	13	7.26	8.18	7.72	
	14	5.06	11.14	8.10	
	15	6.38	5.88	6.13	
		5.19	6.91	6.05	
	P ₄ x P ₅	6	6.11	7.33	6.72
		7	5.54	8.48	7.01
		8	10.11	7.93	9.02
9		7.75	7.36	7.55	
10		5.61	8.24	6.92	
11		8.00	7.13	7.56	
12		8.19	7.88	8.03	
13		8.01	10.48	9.24	
14		7.58	7.29	7.43	
15		7.85	10.06	8.95	
		10.79	6.76	8.77	
P ₅ x P ₆		7	4.84	9.23	7.03
		8	7.81	8.70	8.25
		9	5.64	8.58	7.11
		10	5.51	3.18	4.34
	11	4.23	7.78	6.00	
	12	5.94	8.85	7.39	
	13	4.89	8.98	6.93	
	14	5.33	5.70	5.51	
	15	7.69	6.11	6.90	
		8.13	8.34	8.23	
	P ₆ x P ₇	8	7.91	10.81	9.36
		9	5.53	9.55	7.54
		10	4.68	9.43	7.05
		11	4.76	7.03	5.89
		12	8.48	9.91	9.19
13		4.81	9.74	7.27	
14		5.28	10.89	8.08	
15		4.50	9.66	7.08	
		5.23	11.06	8.14	

Table 4.8 Contd.,

Parents/ Hybrids	Seed yield		
	1980 kharif	1981 summer	Pooled
P ₇ x P ₈	8.78	6.96	7.87
9	9.50	7.29	8.39
10	8.56	6.13	7.34
11	11.69	8.58	10.13
12	8.31	8.80	8.55
13	8.23	6.11	7.17
14	8.03	10.29	9.16
15	11.76	8.10	9.93
P ₈ x P ₉	6.54	10.68	8.61
10	7.26	9.71	8.48
11	7.36	9.70	8.53
12	5.49	8.65	7.07
13	6.96	8.93	7.94
14	6.23	10.39	8.31
15	5.93	7.63	6.78
P ₉ x P ₁₀	4.56	7.18	5.87
11	5.48	7.96	6.72
12	5.81	7.69	6.75
13	6.51	7.93	7.22
14	7.54	6.31	6.92
15	8.28	5.26	6.77
P ₁₀ x P ₁₁	9.86	10.68	10.27
12	5.61	7.41	6.51
13	5.26	6.88	6.07
14	6.71	8.99	7.85
15	7.70	5.69	6.69
P ₁₁ x P ₁₂	9.06	7.64	8.35
13	6.43	9.61	8.02
14	8.24	8.60	8.42
15	7.06	8.03	7.54
P ₁₂ x P ₁₃	5.30	9.08	7.19
14	8.36	7.86	8.11
15	5.53	9.68	7.60
P ₁₃ x P ₁₄	5.50	7.29	6.39
15	6.15	8.91	7.53
P ₁₄ x P ₁₅	6.53	7.76	7.14
SE	1.44	1.52	1.04

Table 4.9. Heterosis over mid parent value and heterobeltiosis over better parent value (Plant height)

Hybrids	MP		BP		MP Pooled	BP Pooled		
	1980	1981	1980	1981				
	kharif	summer	kharif	summer				
P ₁ x P ₂	P ₂	4.38	-4.98	1.52	-10.39	-0.30	-4.39	
	P ₃	-0.68	3.64	-4.05	-15.52	1.48	-9.79	
	P ₄	4.82*	13.01	-1.09	-2.46	8.91*	-1.78	
	P ₅	23.44	11.18	2.10	-13.98	17.31	-5.94	
	P ₆	-1.54	5.66	-4.28	0.40	2.06	-1.94	
	P ₇	0.27	4.51	-15.49	-5.39	2.39	-10.44	
	P ₈	4.59	-3.06*	3.21	-3.94	0.76	-0.38	
	P ₉	6.73	22.27	-6.44	8.55	14.50	1.05	
	P ₁₀	5.91*	10.76*	0.64	-3.62	8.33*	-1.49	
	P ₁₁	15.91	20.94	4.82	2.28*	18.42	3.55	
	P ₁₂	1.46	4.97	4.83	15.14	3.21	-9.99	
	P ₁₃	6.91	11.92	3.21	3.24	9.41	3.27	
	P ₁₄	1.64	0.80	-9.77	-19.57	1.22	-14.67	
	P ₁₅	-4.06	18.58	-8.43	4.08	7.26	-2.18	
	P ₂ x P ₃	P ₃	18.04*	8.36	11.03	-7.37	13.20	1.83
P ₄		5.69**	7.88*	2.24	-1.96	6.78**	0.14	
P ₅		23.16	24.93	-0.34*	0.97	24.04	0.31	
P ₆		13.98	-0.37	13.92	-1.06	6.80	6.43	
P ₇		5.32*	-1.50	-9.14*	-5.80	1.91	-7.47	
P ₈		19.17	-13.48	17.42	-17.59	2.84	-0.09	
P ₉		14.65*	6.65	-1.87	-6.86	10.65	-4.37	
P ₁₀		16.96**	2.10	2.25	-6.40	9.53	-2.08	
P ₁₁		23.87	2.84	9.27	-8.54	13.35	0.36	
P ₁₂		10.55	10.72	1.04	-6.19	10.63	-2.58	
P ₁₃		7.85	0.49	1.46	-1.95	4.17	-0.25	
P ₁₄		-0.68	12.37	-9.59	-5.24	-5.84	-7.42	
P ₁₅		-1.97	2.93	-3.86	-4.75	0.48	-4.31	
P ₃ x P ₄		P ₄	-8.11	21.14*	-16.22	13.41*	6.51	-1.41
		P ₅	11.28	6.05	-5.32	-0.91	8.66	-3.12
	P ₆	5.33	12.09	0.96	-4.74	8.71	-1.89	
	P ₇	-1.02	-0.18	-18.87	-11.29	-0.60	-15.08	
	P ₈	10.68	-5.65*	5.57	-22.53*	2.51	-8.48	
	P ₉	6.98	25.20	-3.29	13.45	16.09	5.08	
	P ₁₀	7.99*	3.70	6.14*	-4.02	5.84*	1.06*	
	P ₁₁	20.04	12.89	12.87	7.88	16.46	10.37	
	P ₁₂	7.98	12.38	4.73	11.19	10.18	7.96	
	P ₁₃	-0.46	5.08	-0.49	-8.28	2.31	-4.39	
	P ₁₄	-0.28	8.89	-14.10	7.12	4.30	-3.49	
	P ₁₅	-6.73	3.15	-13.85	-5.42	-1.79	-9.64	

Contd.,

Table 4.9 Contd.,

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980 kharif	1981 summer	1980 kharif	1981 summer		
$P_4 \times P_5$	-3.85	24.99	-24.15	9.61	10.57	-7.27
P_5	1.22	-1.17	-2.06	-10.74	0.02	-6.40
P_6	-4.88	-2.01	-15.53	-7.12	-3.45	-11.33
P_7	5.30	-2.55	0.42	-15.23	1.37	-7.41
P_8	-16.86	12.65	-30.54	9.06	-2.11	10.74
P_9	-3.47	-5.80	-13.34	-6.70	-4.64	-10.02
P_{10}	8.54	-1.65*	-6.96	-4.00*	3.44	-5.48
P_{11}	1.98	21.59	-9.54	12.44	11.78	1.45
P_{12}	0.02	-1.66*	-8.78	-8.57	-0.82	-8.68
P_{13}	-9.66	20.71	-15.18	11.02	5.52	-2.08
P_{14}	-5.91	5.79	-7.22	3.73	-0.06	-1.75
P_{15}						
$P_5 \times P_6$	21.32*	20.64*	-1.85	-3.01	20.98*	-2.43
P_6	4.10*	8.63	-24.60	-9.00	6.36*	-16.80
P_7	25.58*	12.13*	2.79*	-12.66	18.85	-4.94
P_8	23.58*	-26.55	15.46	-36.35	-1.49*	-10.95
P_9	18.22**	16.06*	2.05*	0.93	17.14**	1.49*
P_{10}	39.14	19.81*	25.85	7.34*	29.47*	16.59
P_{11}	8.28*	21.99	-5.44	15.13	15.13	4.84
P_{12}	21.84*	-3.85	3.64	-20.77	8.99	-8.57
P_{13}	12.24	-1.84	-15.41	-3.36	7.04*	-9.39
P_{14}	20.06	11.75	-4.28	-3.64	15.90	-3.96
P_{15}						
$P_6 \times P_7$	0.92	1.19	-12.91	-3.87	1.05	-8.39
P_7	4.99	-7.60	3.40	-11.42	-1.31	-4.01
P_8	9.82	3.70	-6.02	-3.49	6.76	-4.76
P_9	0.66	-12.67	-6.88	-20.44	-6.01*	-13.66
P_{10}	15.26	13.11	1.63	-0.02	14.18	0.80
P_{11}	7.56	9.69	-1.72	-7.58	8.62	-4.65
P_{12}	-30.95	-3.95	2.55	-6.91	-17.45	-2.18
P_{13}	-12.01	14.44	-19.88	-4.05	1.21	-11.97
P_{14}	-6.30	-0.84	-8.07	-8.81	-3.57	-8.44
P_{15}						
$P_7 \times P_8$	1.23	-10.00	-13.74	-17.83	-4.39	-15.79
P_8	11.87	1.63	-15.17	-0.57	6.75	-7.87
P_9	1.30	-1.79	-14.03	-6.05	0.24	-10.04
P_{10}	13.74	1.18	-11.60	-6.26	7.46	-8.93
P_{11}	7.94	17.98	-13.60	3.88	12.96	-4.86
P_{12}	6.89	-14.35	-12.38	-16.10	-3.73	-14.24
P_{13}	-10.14	5.21	-15.44	-7.82	-2.47	-11.58
P_{14}	8.80	-8.28	-4.55	-11.40	0.26	-7.98
P_{15}						

Contd.,

Table 4.9 Contd..

Hybrids	MP		BP		MP Pooled	BP Pooled	
	1980 kharif	1981 summer	1980 kharif	1981 summer			
P ₈ x P ₉	P ₉	15.90*	4.81	0.45	-6.19	10.35	-2.87
	P ₁₀	13.50	3.43	6.51	-9.28	8.46*	-1.39
	P ₁₁	14.99	13.05	2.76	-3.65	14.02	-0.45
	P ₁₂	12.62	-1.79	4.00	-0.03	5.41	1.98
	P ₁₃	7.78	-2.76	2.35	-9.53	2.51	-3.59
	P ₁₄	-4.38	4.83	-14.11	-15.02	0.22	-14.56
	P ₁₅	0.95	-3.83	-2.41	-14.89	-1.44	-8.65
P ₉ x P ₁₀	P ₁₀	13.74	-9.25	4.44	-11.32	2.24	-3.44
	P ₁₁	9.53*	10.08	5.78	4.11	9.80	4.94
	P ₁₂	18.53	-2.89	10.21	-12.83	7.82	-1.31
	P ₁₃	-3.26	-4.46	-12.57	-8.39	-3.86	-10.48
	P ₁₄	1.33	12.06	-19.74	0.07	6.69	-9.84
	P ₁₄	-0.55	-17.48	-16.24	-18.54	-9.02	-17.39
	P ₁₅						
P ₁₀ x P ₁₁	P ₁₁	20.60*	10.98	14.44*	7.31	15.79*	10.87*
	P ₁₂	-1.33	9.70	-2.66	0.55	4.18	-1.06
	P ₁₃	-9.44	-3.07*	-11.01	-9.08	-6.26	-10.05
	P ₁₄	-12.51	20.92	-25.71	10.25	4.20	-7.73
	P ₁₄	1.58	-4.94	-7.64	-5.91	-1.68	-6.78
	P ₁₅						
P ₁₁ x P ₁₂	P ₁₂	16.00*	38.49*	11.52	31.02**	27.24*	21.27*
	P ₁₃	8.06	6.22	0.87	-3.43	7.14	-1.28
	P ₁₄	6.12	10.64**	-13.67	4.09*	8.38**	-4.79
	P ₁₄	-9.03	69.07	-21.09	14.01	30.02**	-3.54
	P ₁₅						
P ₁₂ x P ₁₃	P ₁₃	-0.46	6.88**	-3.48	-7.56**	3.21*	-5.52
	P ₁₄	-1.23	30.69	-17.06	29.92	14.73	6.43
	P ₁₅	-7.09	16.37	-16.55	5.68	4.64	-5.44
P ₁₃ x P ₁₄	P ₁₄	4.13	-2.78	-10.27	-16.32	0.67	-13.30
	P ₁₅	0.74	-0.02	-6.93	-1.31	0.36	-4.12
P ₁₄ x P ₁₅	-9.48	23.50*	-16.12	11.57	7.01	-2.28	

MP - Mid parent value

BP - Better parent value

* - Significant at 5 per cent level

** - Significant at 1 per cent level

Table 4.10. Heterosis over mid parent value and heterobeltiosis over better parent value (Days to first flower)

Hybrids	MP		BP		MP Pooled	BP Pooled		
	1980	1981	1980	1981				
	kharif	summer	kharif	summer				
P ₁ x P ₂	P ₂	-7.17*	-8.07*	-8.86	-9.11	-7.62*	-8.99	
	P ₃	-2.52	-7.40	-5.41	-9.55	-4.96	-7.48	
	P ₄	-7.50*	-8.07*	-7.58	-8.87*	-7.79*	8.23	
	P ₅	-1.05	-1.98	-10.97*	-12.78	-1.52	-11.88*	
	P ₆	-0.18	-0.97	-2.42	-2.52	-0.58	-2.47	
	P ₇	1.27	-0.05	-1.77	-2.71	0.61	-2.24	
	P ₈	-1.59	-2.19	-3.26	-4.64	-1.89	-3.95	
	P ₉	12.80	11.48	2.82*	0.49	12.14	1.66	
	P ₁₀	-1.64	-0.57	-10.38	-10.42	-1.11	-10.40*	
	P ₁₁	-6.46*	-7.40*	-7.90	-9.62	-6.93*	-8.76	
	P ₁₂	0.05	-1.48	-6.20	-7.95	0.72	-7.08	
	P ₁₃	-1.01	-2.05	-2.76	-4.62	-1.53	-3.69	
	P ₁₄	-5.91*	-4.24	-6.89	-4.74	-5.08*	-5.82	
	P ₁₅	-3.53	-4.07	-5.72	-7.08	-3.80	-6.40	
	P ₂ x P ₃	P ₃	-5.16*	-5.35	-6.29	-6.51	-5.26*	-6.40
P ₄		-2.21	-2.27	-4.05	-4.17	-2.24	-4.11	
P ₅		5.38*	5.65*	-6.71	-6.93	5.51*	-6.82	
P ₆		-2.16	-2.26	-2.59	-2.70	-2.21	-2.65	
P ₇		-1.79	-2.21	-3.00	-3.78	-2.00	-3.39	
P ₈		1.26	1.28	-2.22	-2.32	1.27	-2.27	
P ₉		2.89	2.62	-7.75*	-8.45	2.75	-8.10	
P ₁₀		-3.83	2.18	-13.80	-8.83	-0.83	-11.32	
P ₁₁		1.07	1.09	-2.24	-2.39	1.08	-2.32	
P ₁₂		2.42	1.86	-5.58	-5.83	2.14	-5.71	
P ₁₃		0.80	0.62	-2.72	-3.07	0.71	-2.90	
P ₁₄		-3.58	-1.89	-3.89	-3.46	-2.74	-3.68	
P ₁₅		-6.23*	-6.47*	-9.97	-10.37	-6.35*	-10.17*	
P ₃ x P ₄		P ₄	-5.84*	-6.01*	-8.69	-8.95*	-5.93*	-8.82
		P ₅	-2.07	-2.05	-14.20	14.63	-2.06	-14.42
	P ₆	-5.18*	-5.39	-5.90	-6.13	-5.29*	-6.02	
	P ₇	-3.06	-5.19	-3.11	-4.85	-4.13	-3.98	
	P ₈	-3.58	-3.73	-7.96*	-8.16*	-3.66	-8.11	
	P ₉	-3.24	-3.37	-14.16	-14.70*	-3.31	-14.43	
	P ₁₀	1.73	0.86	-9.77	-10.98	1.29	-10.38	
	P ₁₁	-2.35	-2.51	-6.64	-6.98	-2.43	-6.81	
	P ₁₂	-1.54	-2.25	-10.23	-10.65	-1.90	-10.44	
	P ₁₃	5.94*	-6.63*	-10.27	-11.12	-6.29*	-10.70	
	P ₁₄	-8.07	-6.61*	-8.86*	-9.22*	-7.34*	-9.04	
	P ₁₅	-5.94*	-6.19*	-10.72	-11.16	-6.07*	-10.94	

Contd.,

Table 4.10 Contd.,

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980	1981	1980	1981		
	kharif	summer	kharif	summer		
$P_4 \times P_5$	-7.77*	-5.72*	-16.96	-15.49	-6.75*	-16.23
P_5	-3.33	-2.31	-5.55	-4.64	-2.82	-5.10
P_6	3.34	2.97	1.17	-0.62	3.15	0.90
P_7	-2.06	-2.16	-3.64	-3.79	-2.11	-3.72
P_8	1.81	0.45	-8.06*	-8.76*	1.13	-8.41*
P_9	-8.00*	-8.30*	-16.11	-16.73	-8.15*	-16.42
P_{10}	-2.57	-2.69	-3.98	-4.20	-2.63	-4.09
P_{11}	-1.20	-2.08	-7.29	-7.78	-1.64	-7.54
P_{12}	-4.21	-4.40	-5.82	-6.11	-4.31	-5.97
P_{13}	-6.23*	-3.71	-8.29	-4.05	-4.97	-6.17
P_{14}	-4.96	-5.18	-7.04	-7.37	-5.07*	-7.21
P_{15}						
$P_5 \times P_6$	8.01*	8.42*	-4.74*	-4.86*	8.21*	-4.80*
P_6	1.80	1.35	-10.84*	-11.93	1.57	-11.39
P_7	1.59	3.93	-7.18	-5.41	2.76	-6.30
P_8	4.22	7.32*	2.71	5.76	5.77*	4.23
P_9	5.75*	7.27*	4.27	5.73	6.51*	5.00
P_{10}	5.58*	5.82*	-3.67	-3.79	5.70*	-3.73
P_{11}	-3.73	-4.61	-7.90	-9.51	-4.71	-8.71
P_{12}	4.19*	4.40*	-4.74	-4.88	4.29*	-4.81
P_{13}	8.30*	13.26*	-4.40	1.21	10.78*	-1.60
P_{14}	8.15	8.06*	-0.65	-1.05	8.10	-0.85
P_{15}						
$P_5 \times P_7$	3.11	2.45	2.29	1.27	2.78	1.78
P_7	1.32	1.40	-2.57	-4.64	1.36	-3.61
P_8	4.96	5.34*	-6.26	-6.36*	5.15*	-6.31*
P_9	0.88	0.92	-9.92	-10.32*	0.90	-10.12
P_{10}	-0.12	-0.21	-3.80	-4.07	-0.17	-3.94
P_{11}	-1.24	-1.93	-9.33	-9.70	-1.59	-9.52
P_{12}	3.94	3.01	-0.51	-0.82	3.47	-0.67
P_{13}	-0.92	0.90	-1.03	-1.16	-0.01	-1.10
P_{14}	7.64*	-0.33	2.92	-4.91	3.65	-1.00
P_{15}						
$P_7 \times P_8$	1.97	-1.59	-2.70	-6.55	0.19	-4.63
P_8	4.63	4.62	-7.22	-7.93	4.62	-7.58
P_9	3.75	3.48	-8.01	-8.97	3.61	-8.49
P_{10}	1.08	0.82	-3.39	-4.15	0.95	-3.77
P_{11}	-0.17	-1.19	-9.01	-9.97	-0.68	-9.49
P_{12}	0.25	-0.07	-4.41	-5.22	0.09	-4.82
P_{13}	-2.44	-0.97	-3.33	-4.09	-1.71	-3.71
P_{14}	-0.84	-1.20	-5.92	-6.77	-1.02	-6.35
P_{15}						

Contd.,

Table 4.10 Contd.,

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980 kharif	1981 summer	1980 kharif	1981 summer		
$P_8 \times P_9$	2.85	3.02	-4.75	-4.96	-2.94	-4.86
P_9^{10}	5.83*	6.02*	-2.05	-2.22	5.92*	-2.14
P_9^{11}	-0.71	-0.86	-0.88	-0.98	-0.79	-0.93
P_9^{12}	4.19	3.56	-0.71	-0.89	3.87	-0.80
P_9^{13}	1.55	1.61	1.47	1.48	1.58	1.47
P_9^{14}	-2.81	-0.99	-1.45	-1.99	-1.90	-1.72
P_9^{15}	2.10	2.06	1.50	1.38	2.08	1.44
$P_9 \times P_{10}$	-2.88	-0.53	-2.93	-1.58	-1.71	-2.26
P_{10}^{11}	7.56*	7.89*	-0.57	-0.59	7.72*	-0.58
P_{10}^{12}	2.92	2.27	-0.16	-1.59	2.59	-0.88
P_{10}^{13}	0.85	0.99	-6.57	-6.73	0.92	-6.65
P_{10}^{14}	0.71	2.93	-9.96	-6.80	1.82	-8.38
P_{10}^{15}	5.53*	5.72*	-1.76	-1.88	5.62*	-1.82
$P_{10} \times P_{11}$	-1.34	-0.96	-8.38	-8.77	-1.15	-8.58
P_{11}^{12}	0.30	-0.37	-2.73	-4.19*	-0.04	-3.46*
P_{11}^{13}	-2.85	-3.38	-10.02	-10.79	-3.12	-10.41*
P_{11}^{14}	0.81	3.48	-9.90	-6.33	2.14	-8.12
P_{11}^{15}	0.02	0.03	-6.91	-7.18	0.02	-7.05
$P_{11} \times P_{12}$	4.26	3.09	-0.81	-1.45	3.67	-1.13
P_{12}^{13}	-1.33	-1.38	-1.56	-1.63	-1.36	-1.60
P_{12}^{14}	-2.33	-0.17	-5.83	-2.06	-1.25	-3.95
P_{12}^{15}	-2.34	-2.41	-3.08	-3.18	-2.38	-3.13
$P_{12} \times P_{13}$	0.77	0.83	-3.91*	-3.39	0.80	-3.65*
P_{13}^{14}	-3.93	-2.98	-11.70	-8.93	-3.46	-10.32*
P_{13}^{15}	-2.08	-2.05	-6.16	-15.66*	-2.07	-10.91*
$P_{13} \times P_{14}$	-3.82	-2.03	-7.48	-4.12	-2.93	-5.80
P_{14}^{15}	-1.65	-1.72	-2.17	-2.25	-1.69	-2.21
$P_{14} \times P_{15}$	-3.33	-1.46	-7.48	-4.08	-2.40	-5.78

MP - Mid parent value

BP - Better parent value

* - Significant at 5 per cent level

** - Significant at 1 per cent level

Table 4.11. Heterosis over mid parental value and heterobeltiosis over better parental value (Capsules-main stem)

Hybrids	MP		BP		MP Pooled	BP Pooled		
	1980 kharif	1981 summer	1980 kharif	1981 summer				
P ₁ x P ₂	P ₂	13.53**	12.05	12.86**	2.06	12.79*	7.46	
	P ₃	35.68**	-8.57*	28.39	-15.46*	13.55	6.46	
	P ₄	-15.90	15.57	-38.15	12.55	-0.17	-12.80	
	P ₅	-33.25	-19.48	-51.47	-23.66	-26.37	-37.57	
	P ₆	-6.30	2.08	-10.75	1.09	-2.11	-4.83	
	P ₇	-29.39	-12.16	-50.87	-19.26	-20.78	-35.07	
	P ₈	-2.30	-18.82	-2.53	-22.27	-10.56	-12.40	
	P ₉	-31.26	-47.27	-44.29	-64.07	-39.27	-54.18	
	P ₁₀	-31.99*	-20.63**	-50.14	-37.57	-26.31**	-43.85	
	P ₁₁	18.68	39.57	8.67	8.94	29.12	8.80	
	P ₁₂	-25.50	-14.92	-50.46	-26.04	-20.21	-38.25	
	P ₁₃	-18.94	4.17	-32.93	-1.80	-7.39	-17.37	
	P ₁₄	-21.66	9.80*	-48.15	-4.91	-5.93	-26.53	
	P ₁₅	-17.24	19.36	-35.30	-3.28	1.06	-19.29	
	P ₂ x P ₃	P ₃	26.72**	8.55	20.57*	6.79	17.63*	13.68*
P ₄		-28.30	5.92	-47.06	-1.11	-11.19	-24.09	
P ₅		-36.50	-1.25	-53.65	-14.24	-18.86	-33.95	
P ₆		-7.23	3.45	-11.13	-6.47	-1.89	-8.80	
P ₇		-19.83	-1.82*	-44.03	-17.06	-10.83	-30.55	
P ₈		1.02	11.62	0.18	5.94	6.32	3.06	
P ₉		-16.09	-50.50	-31.69	-67.87	-33.30	-49.78	
P ₁₀		4.43*	-33.15**	-23.15	-50.83*	-14.36*	-36.99*	
P ₁₁		12.81	37.04	2.74	15.26	24.92	9.00	
P ₁₂		-9.79	-14.21*	-27.59	-30.32	-12.00	-28.96	
P ₁₃		-24.26	14.97**	-37.03	10.84**	-4.65	-13.10	
P ₁₄		-48.40	48.76*	-65.74	40.64	0.18	-12.55	
P ₁₅		-23.48	22.24	-39.92	7.29	-0.62	-16.32	
P ₃ x P ₄		P ₄	2.23	10.94*	-21.91	5.18	6.58	-8.37
		P ₅	-8.45	-15.51**	-30.93	-25.61	-11.98**	-28.27
	P ₆	3.79	41.73	3.01	-6.50	22.76	-1.75	
	P ₇	7.64	-3.31	-22.57	-17.23	2.16	-19.90	
	P ₈	-8.66**	-1.11	-13.77	-4.65	-4.89	-9.21	
	P ₉	28.60	-49.80	9.02	-67.00	-10.60	-28.99	
	P ₁₀	-31.88**	-36.02	-48.15*	-52.44	-33.95*	-50.30	
	P ₁₁	33.52	-2.97	16.29	-19.44	15.27	-1.58	
	P ₁₂	-0.13	-13.25	-16.59	-28.66	-6.69	-22.63	
	P ₁₃	-4.87	4.23*	-17.53	2.11	-0.32	-7.71	
	P ₁₄	8.02	10.73	-26.39	3.09	9.37	-11.65	
	P ₁₅	7.37	8.87	-12.43	-5.78	8.12	-9.11	

Contd.,

Table 4.11 Contd.,

Hybrids	MP		BP		MP	BP		
	1980	1981	1980	1981	Pooled	Pooled		
	kharif	summer	kharif	summer				
P ₄ x P ₅	P ₅	-0.25	-3.21	-2.03	-10.51	-1.73	-16.27	
	P ₆	-35.10	-6.20	-50.67	-10.98	-20.65	-30.83	
	P ₇	8.63	-3.98	-0.57	-13.85	2.32	-7.21	
	P ₈	-4.33	-0.84	-29.72	-2.56	-2.59	-6.14	
	P ₉	-25.98*	-50.89	-34.91*	-67.00	-38.44	-50.96	
	P ₁₀	12.85	-21.10	12.25	-38.36	-4.13	-13.06	
	P ₁₁	1.68	-4.34	-22.76	-23.85	-1.33	-23.31	
	P ₁₂	9.21	-6.57	-2.41	-19.68	1.32	-11.05	
	P ₁₃	-13.18	-4.93*	-25.38	-8.05	-9.06	-16.72	
	P ₁₄	-22.85	17.36	-34.92	4.01	-2.75	-15.46	
	P ₁₅	-12.21	-0.75	-19.42	-17.87	-6.48	-18.65	
	P ₅ x P ₆	P ₆	-30.62	-3.78	-47.91	-8.02	-17.20	-27.97
		P ₇	-6.26	-8.80	-12.76	-11.73	-7.53	-12.25
		P ₈	-40.86**	-0.84	-57.05**	-9.78	-20.85*	-33.42
		P ₉	72.18	-45.46	49.08	-61.69	13.36	-6.31
P ₁₀		-19.02	-26.50	-20.07	-39.75	-22.76	-29.91	
P ₁₁		-19.99	5.74	-44.89	-20.55	-7.13	-32.72	
P ₁₂		7.66	-14.19	-5.31	-20.75	-3.27	-13.03	
P ₁₃		-6.11	4.56	-20.50	-6.37	-0.78	-13.44	
P ₁₄		-37.05	-17.55	-46.10	-31.71	-27.30	-38.91	
P ₁₅		-30.49	-3.70	-37.23	-25.04	-17.10	-31.14	
P ₆ x P ₇		P ₇	-2.31	-13.79	-30.05	-20.11	-8.05	-25.08
		P ₈	-20.94	0.68	-24.82	-4.41	-10.13	-14.62
		P ₉	-19.84	-40.55	-32.44	-59.30	-30.20	-45.87
		P ₁₀	-6.23**	-32.33**	-28.99*	-46.43	-19.28**	-37.71*
		P ₁₁	28.46	36.28	12.55	5.70	32.37*	9.12
	P ₁₂	-19.63	-8.70	-33.25	-19.08	-14.16	-26.17	
	P ₁₃	-32.48	-5.34*	-41.81	-11.49	-18.91	-26.65	
	P ₁₄	-56.71	12.65*	-70.62	-3.12	-22.03	-36.87	
	P ₁₅	-33.44	16.75	-46.03	-5.99	-8.35	-26.01	
	P ₇ x P ₈	P ₈	16.40*	-17.82	-19.13	-27.39	-0.71	-23.26
		P ₉	22.77*	-41.49	0.07	-58.03	-9.36	-28.98
		P ₁₀	10.25	-36.92	1.41	-46.90	-13.33	-22.74
		P ₁₁	7.69*	2.73**	-28.63*	-24.48**	5.21*	-26.56**
		P ₁₂	39.85*	26.63**	15.64	20.65**	33.24*	18.14*
		P ₁₃	11.52	-11.51	-10.94	-22.91	0.00	-16.93
P ₁₄		-15.16	-10.72*	-22.49	-27.94	-12.94*	-25.22	
P ₁₅		3.70	16.55	-12.12	-11.37	10.12	-11.75	

Contd.,

Table 4.11 Contd.,

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980 kharif	1981 summer	1980 kharif	1981 summer		
$P_8 \times P_9$	-4.02	-43.53	-22.33	-62.39	-23.78	-42.36
P_9	-12.39	-30.08**	-35.87	-46.71	-21.24**	-41.29
P_{10}	11.35	33.27	2.12	6.70	22.31	4.41
P_{11}	-8.13	-22.20*	-26.68	-34.08	-15.17	-30.38
P_{12}	-9.03	10.74**	-24.83	8.95**	0.85	-7.94
P_{13}	-35.20	37.19	-57.16	23.49	0.99	-16.84
P_{14}	-0.70	5.72	-22.64	-11.28	2.51	-16.96
P_{15}						
$P_9 \times P_{10}$	25.42**	-57.81	9.77*	-65.55	-16.20	-27.89
P_{10}	-17.52	-43.31	-37.49	-65.89	-30.42	-51.69
P_{11}	9.00	-46.12	7.03	-60.19	-18.56	-26.58
P_{12}	0.61	-40.25	-2.02	-60.53	-19.82	-31.28
P_{13}	-53.35	-40.03	-64.51	-62.05	-46.59	-63.28
P_{14}	-22.07	-65.11	-25.70	-78.63	-43.59	-52.17
P_{15}						
$P_{10} \times P_{11}$	10.16	-5.20	-23.58	-37.36	2.48	-30.47
P_{11}	0.47	-39.87	-10.65	-47.24	-19.70	-28.95
P_{12}	2.43	-18.56	-12.36	-38.62	-8.07	-25.49
P_{13}	-25.10	-28.64	-36.54	-49.34**	-26.87	-42.94*
P_{14}	-0.74	-30.10	-9.30	33.12*	-15.42	11.91*
P_{15}						
$P_{11} \times P_{12}$	8.82	20.94**	-18.54	-13.78	14.88*	-16.16
P_{12}	-14.16	33.74**	-33.71	9.25*	9.79*	-12.23
P_{13}	-12.11	31.21**	-44.23	15.83**	9.55	-14.20
P_{14}	-20.48	33.09	-41.62	26.64*	6.30	7.49
P_{15}						
$P_{12} \times P_{13}$	5.88	-11.45	1.30	-25.97	-2.79	-12.34
P_{13}	6.00	-7.29	-18.34	-27.86	-0.65	-23.10
P_{14}	-3.71	-6.39	-6.55	-31.12	-5.05	-18.83
P_{15}						
$P_{13} \times P_{14}$	0.81	-1.26	-24.70	-9.80	-0.23	-17.25
P_{14}	-11.14	10.27	-17.58	-6.22	-0.44	-11.90
P_{15}						
$P_{14} \times P_{15}$	-26.93	36.16**	-42.47	25.81**	4.61	-8.33

MP - Mid parent value

BP - Better parent value

* - Significant at 5 per cent level

** - Significant at 1 per cent level

Table 4.12. Heterosis over mid parental value and heterobeltiosis over better parental value (Capsules-branches)

Hybrids	MP		BP		MP Pooled	BP Pooled		
	1980 kharif	1981 summer	1980 kharif	1981 summer				
P ₁ x P ₂	P ₂	5.68	-4.35	-3.08	-14.54	0.66	-8.81	
	P ₃	5.29	23.01	-6.74	-37.49	-8.86	-22.12	
	P ₄	2.35*	3.45	-9.57	-13.99	2.90*	-11.78	
	P ₅	56.47	28.75	-21.77	-35.71	38.05	-30.98	
	P ₆	14.77	5.86	9.63	-10.02	10.31	-0.20	
	P ₇	-24.21	-12.78	-39.21	-39.96	-18.50	-39.59	
	P ₈	-14.84*	-11.66	-15.16	-24.88	-13.25	-20.02	
	P ₉	48.89	113.30*	-25.56	6.64	81.10*	-4.15	
	P ₁₀	13.12	48.70*	-17.16	-15.85	30.91*	-16.51	
	P ₁₁	21.94	46.81	-8.45	5.26	34.37	-1.60	
	P ₁₂	-7.60	-7.62	-35.97	-39.13	-7.61	-37.55	
	P ₁₃	-13.33	2.00	-29.00	-17.55	-5.67	-23.28	
	P ₁₄	-17.78	23.52	-23.92	-13.27	2.87	-18.60	
	P ₁₅	-15.11	2.81	-18.37	-27.24	-6.15	-22.81	
	P ₂ x P ₃	P ₃	34.64*	1.96	29.59*	-8.62	18.30	10.48
P ₄		14.95*	26.72**	-5.75	-4.67	20.83	-5.21	
P ₅		98.42*	77.77	-0.79	-11.12	84.96	-7.52	
P ₆		2.23	11.99	-2.05	5.78	7.11	1.86	
P ₇		45.48	21.07	25.43	-10.47	33.27	7.48	
P ₈		-1.39*	12.15**	-9.28	6.00	5.38**	-1.64	
P ₉		96.84*	101.55*	-1.58	0.77	99.91*	-0.40	
P ₁₀		34.24**	68.23*	4.51*	-1.79*	51.23**	1.36*	
P ₁₁		86.50**	52.46*	44.51*	18.26	66.48*	31.38	
P ₁₂		79.94	32.73	31.58	-6.86	56.33	12.36	
P ₁₃		2.32	14.67*	-9.68	2.26	8.49	-3.71	
P ₁₄		-11.28	33.27*	-12.16	0.99	10.99*	-5.59	
P ₁₅		12.35	47.80	-0.56	-21.99	30.07*	-11.28	
P ₃ x P ₄		P ₄	11.99**	63.96**	-10.84	34.17*	37.97*	11.66
		P ₅	75.64	43.14	-12.11	-28.43	55.60	-22.20
	P ₆	2.41	6.40	-5.41	0.61	4.40	-2.40	
	P ₇	26.59	7.80	12.82	-13.53	17.19	-0.36	
	P ₈	-15.51**	-2.00**	-24.91	-7.39	-8.76**	-16.15	
	P ₉	129.80**	107.02	14.86*	3.51	115.77*	7.88	
	P ₁₀	69.39**	18.93	35.66*	-27.96	44.16	3.85*	
	P ₁₁	81.03	7.80	49.30*	-8.60	44.41	20.35	
	P ₁₂	33.52	-16.02	0.10	-36.64	8.75	-18.27	
	P ₁₃	10.19	6.91	0.68	6.30	8.55	3.49	
	P ₁₄	-29.00	7.80	-32.29	-11.17	-10.60	-21.73	
	P ₁₅	-1.84	-5.26	-15.96	-21.09	-3.55	-18.53	

Contd.,

Table 4.12 Contd.,

Hybrids	MP		BP		MP	BP		
	1980 kharif	1981 summer	1980 kharif	1981 summer	Pooled	Pooled		
P ₄ x P ₅	P ₅	4.98	192.71**	-47.73	46.35*	75.42*	-12.29	
	P ₆	-18.74	26.03*	-30.99	-1.21**	3.64	-16.10	
	P ₇	-1.82	40.95	-28.16	37.32	19.56	4.58	
	P ₈	-0.76	6.29**	-12.58	-16.74**	2.76**	-14.66	
	P ₉	14.41	182.75	-42.81	41.37	77.99*	-11.11	
	P ₁₀	14.80	78.63	-22.15	18.94	46.71	-1.61	
	P ₁₁	31.61	8.14	-8.88	3.55	19.87	-2.67	
	P ₁₂	9.26	27.70	-29.21	14.90	18.48	-7.16	
	P ₁₃	-14.01	-4.92**	-35.94	-21.85**	-9.47*	-28.90*	
	P ₁₄	-22.00	83.14	-35.53	81.52	30.57	22.99	
	P ₁₅	3.70	25.16	-8.22	22.40	14.43	7.09	
	P ₅ x P ₆	P ₆	123.06**	111.41**	11.53*	5.70	115.34**	8.61*
		P ₇	169.59	116.26	34.79	8.13	139.92*	20.05
		P ₈	22.64	64.24	-38.70	-17.87	47.10	-28.28
		P ₉	0	0	0	0	0	0
P ₁₀		158.32**	244.66**	29.16**	72.33**	90.73**	44.71**	
P ₁₁		207.45**	156.45**	53.72	28.22	175.19	37.59	
P ₁₂		87.31**	100.66	-6.35	0.33	-2.23*	-10.83	
P ₁₃		82.19**	7.44**	-8.91	-46.28	43.18**	-27.19	
P ₁₄		131.00**	100.45**	15.00	0.22*	118.90**	8.09	
P ₁₅		91.39	152.14	-4.31	26.07	118.03	8.80	
P ₆ x P ₇		P ₇	3.20	54.91*	-14.16	19.15	29.05	2.49
		P ₈	-4.62**	17.68**	-8.59	17.59	6.53**	4.50
		P ₉	81.67	107.66**	-9.17	3.83	96.71	-1.33
		P ₁₀	-14.89*	1.37	-35.72*	-39.73	-6.76*	-37.73*
		P ₁₁	83.49*	36.41*	42.28	10.49	59.95*	26.38
	P ₁₂	67.84*	33.03	19.48	-3.30	50.43	8.09	
	P ₁₃	-0.51	26.76	-15.86	-18.72	13.12	-17.29	
	P ₁₄	-19.13	25.61*	-21.79	1.44	3.24	-10.18	
	P ₁₅	-6.86	32.80	-14.29	5.80	12.97	-4.25	
	P ₇ x P ₈	P ₈	-11.57**	5.20**	-28.89	-19.11	-3.19**	-24.00
		P ₉	118.03	131.40*	13.77	15.70	125.21	12.69
		P ₁₀	2.56**	50.13*	-9.28**	1.34*	26.34**	-3.97**
		P ₁₁	108.58	34.80	91.60	25.93	71.69	58.76
		P ₁₂	-30.89*	7.95	-43.38*	-0.56	-11.47	-21.97
		P ₁₃	46.25	-2.22**	42.27	-21.22**	22.01*	10.52
P ₁₄		9.23*	73.16*	-6.62	67.30*	41.19*	30.34*	
P ₁₅		38.05	39.06	7.53	32.62	38.55	20.07	

Contd.,

Table 4.12 Contd.,

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980	1981	1980	1981		
	kharif	summer	kharif	summer		
$P_8 \times P_9$	92.62*	145.79**	-3.69	22.89*	123.64**	11.82
P_{10}	50.45*	61.68*	9.54	-3.94	56.06*	2.80
P_{11}	43.47	32.61	7.95	7.37	38.04	7.66
P_{12}	28.60	29.46	-10.73	-5.95	29.03	-8.34
P_{13}	-2.45	-13.50*	-19.85	-18.69	-7.98	-19.27
P_{14}	-11.33	32.81	-17.68	4.72	10.74	-6.48
P_{15}	-13.39	-12.96	-17.01	-30.68	-13.18	-23.85
$P_9 \times P_{10}$	97.96**	174.24**	-1.02*	37.12**	144.03**	18.05**
P_{11}	174.17**	170.33**	37.08*	35.16*	171.94**	35.97**
P_{12}	171.21**	87.54*	35.60	-6.23	129.64	14.00
P_{13}	62.07*	36.07*	-18.97*	-31.97	49.07	-26.90
P_{14}	167.09**	40.51**	34.17	-29.75	104.10**	3.24
P_{15}	97.23	94.31	-1.39	-2.85	96.66	-2.02
$P_{10} \times P_{11}$	147.60**	110.41**	138.51**	37.02	129.00**	87.76**
P_{12}	-17.14	46.66	-24.18	3.76	14.76	-10.21
P_{13}	-6.54	4.98**	-19.28	-19.80**	-0.78	-19.54*
P_{14}	-0.53*	91.92*	-23.42	73.21	45.70*	24.89
P_{15}	56.27	34.29	11.66	-11.53	45.28	0.06
$P_{11} \times P_{12}$	143.53**	69.87**	115.42**	47.06**	106.70**	81.24**
P_{13}	59.09*	50.23*	41.99	27.98**	54.66	34.98*
P_{14}	52.71	53.72*	21.34	41.49**	53.21	31.41
P_{15}	6.24	43.09	-22.28	40.03	24.66	8.87
$P_{12} \times P_{13}$	54.21*	-8.33	23.65	-30.56	22.94	-3.46
P_{14}	26.82	22.21*	-7.86	9.09**	24.51*	0.61
P_{15}	32.32	58.75	-10.28	40.03	45.53	14.87
$P_{13} \times P_{14}$	-23.57	-8.79	-2.17	-24.49	-16.18	-13.33
P_{15}	-12.69	2.21	-30.61	-14.44	5.23	-22.53
$P_{14} \times P_{15}$	-61.19	46.40*	-20.72	44.44**	7.40	11.86

MP - Mid parent value

BP - Better parent value

* - Significant at 5 per cent level

** - Significant at 1 per cent level

Table 4.13. Heterosis over mid parent value and heterobeltiosis over better parent value (capsules/plant)

Hybrids	MP		BP		MP Pooled	BP Pooled		
	1980 kharif	1981 summer	1980 kharif	1981 summer				
P ₁ x P ₂	P ₂	19.85*	0.43	15.03*	-9.75	10.14	2.64	
	P ₃	28.25	-18.45*	23.78	-31.14	4.90	-3.68	
	P ₄	2.97	20.39	-23.69	-6.34	11.68	-15.02	
	P ₅	17.01*	6.48	6.41	-29.63	11.74	-11.61	
	P ₆	19.01	4.62	9.64	-6.28	11.81	1.68	
	P ₇	-20.07	-12.54	-32.76	-29.50	-16.31	-31.13	
	P ₈	-2.03	-13.89	-10.74	-24.12	-7.96	-17.43	
	P ₉	16.66	16.39	-6.73	4.44	16.52	-1.15	
	P ₁₀	0.61*	14.33	-7.57	-8.71	7.47*	-8.14*	
	P ₁₁	36.15*	44.60	18.23	6.33	40.37	12.28	
	P ₁₂	-6.07	-7.54	-8.39	-25.77	-6.81	-17.08	
	P ₁₃	-6.73	2.69	-11.43	-13.01	-2.02	-12.22	
	P ₁₄	-13.44	18.87	-33.62	-10.86	2.71	-22.24	
	P ₁₅	-8.64	8.06	-25.48	-20.32	-0.29	-22.90	
	P ₂ x P ₃	P ₃	30.70*	4.11	29.92*	-2.97	17.40	13.47*
P ₄		-1.95	18.86*	-22.92	0.88	8.45*	-11.02	
P ₅		13.81	38.33	-0.25	-2.93	26.07	-1.59	
P ₆		-1.01	9.13	-5.16	8.74	4.06	1.79	
P ₇		11.52	11.65	-2.86	-1.32	11.58	-2.09	
P ₈		-0.62*	11.91	-5.90	9.47	5.64	1.78	
P ₉		27.07	3.00	-1.46	2.83	15.03	0.68	
P ₁₀		18.91*	14.51**	13.59**	0.13*	16.71*	6.86*	
P ₁₁		55.06**	48.12	30.06**	17.27	51.59	23.66*	
P ₁₂		35.97	12.09	27.42*	-1.37	24.03	13.02	
P ₁₃		-9.11	16.04*	-10.12	8.94*	3.46	-0.59	
P ₁₄		-30.57	38.54	-45.14	12.69	3.98	-16.23	
P ₁₅		-1.56	8.72	-16.99	-13.27	3.58	-15.13	
P ₃ x P ₄		P ₄	0.79*	41.89**	-15.63	28.19*	21.34	6.28
		P ₅	20.72	10.28	6.36	-10.11	15.50	-1.88
	P ₆	0.52*	4.76	-4.23	-2.04	2.64	-3.14	
	P ₇	20.69	5.21	4.59	-0.66	12.95	1.96	
	P ₈	-10.88**	-1.69	-16.09*	-6.44	-6.29*	-11.27	
	P ₉	65.01	-2.70	28.52	-9.18	31.15	9.67	
	P ₁₀	15.16**	-13.02	9.39*	-18.83	1.07*	-4.78*	
	P ₁₁	62.00	4.04	36.51	-12.44	33.02	12.03	
	P ₁₂	16.23	-13.94	9.51	-19.13	1.14	-4.81	
	P ₁₃	1.70	6.01	-0.02	5.59	3.85	2.78	
	P ₁₄	-9.32	8.93	-28.67	-6.03	-0.20	-17.35	
	P ₁₅	2.45	-0.10	-14.02	-15.63	1.17	-14.83	

Contd..



Table 4.13 Contd.,

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980	1981	1980	1981		
	kharif	summer	kharif	summer		
$P_4 \times P_5$	-2.08	59.88**	-29.94	26.20*	28.90*	-1.87
$P_4 \times P_6$	-24.61	13.18	-38.77	-3.66	-5.72	-21.22
$P_4 \times P_7$	3.57	17.19	-8.28	11.82	10.38	1.77
$P_4 \times P_8$	-2.09	3.22	-19.70	-10.76	0.56	-15.23
$P_4 \times P_9$	-7.43	-6.76	-39.12	-20.77	-7.09	-29.95
$P_4 \times P_{10}$	13.80*	12.21	-7.35	8.35	13.00	0.50
$P_4 \times P_{11}$	23.03*	3.02	-14.65	-4.89	13.02	-9.77
$P_4 \times P_{12}$	9.52	8.47	-17.85	4.01	9.00	-6.92
$P_4 \times P_{13}$	-13.65	-4.94**	-31.56	-14.41**	-9.30	-22.96*
$P_4 \times P_{14}$	-16.86	52.81	-17.3	45.07	17.97	13.82
$P_4 \times P_{15}$	-4.84	-13.78	-12.78	5.47	4.47	-3.66
$P_5 \times P_6$	17.66*	56.10**	-0.57	9.77	36.88*	4.60
$P_5 \times P_7$	33.65*	27.13*	4.16	-3.02	30.39	0.57
$P_5 \times P_8$	-14.45**	29.29	-28.44*	-8.09	7.42	-18.27
$P_5 \times P_9$	72.18	-45.46**	49.08	-61.69	13.36*	-6.31
$P_5 \times P_{10}$	15.86**	42.36**	-2.35*	9.54**	29.11**	3.59**
$P_5 \times P_{11}$	42.49*	64.19	35.31	38.19	53.34**	36.75*
$P_5 \times P_{12}$	22.48	13.79	13.99	-12.90	18.13	0.54
$P_5 \times P_{13}$	6.43	5.73*	-7.60	-22.64	6.08	-15.12
$P_5 \times P_{14}$	8.16	23.74**	-22.30	1.70*	15.95*	-10.30
$P_5 \times P_{15}$	16.33	54.17	-11.75	29.33	35.25	8.79
$P_6 \times P_7$	0.20	23.66*	-9.33	9.64	11.93	0.15
$P_6 \times P_8$	-9.91*	11.76	-11.02	9.70	0.92	-0.66
$P_6 \times P_9$	24.25	8.13	-6.50	7.92	16.19	0.71
$P_6 \times P_{10}$	-9.91**	-17.95*	-10.20*	-28.03	-13.93*	-19.12*
$P_6 \times P_{11}$	62.88**	36.40	31.99	8.75	49.64	20.37
$P_6 \times P_{12}$	25.60	12.94	13.09	-0.32	19.27	6.38
$P_6 \times P_{13}$	-14.10	14.89*	-16.81	7.83	0.39	-4.49
$P_6 \times P_{14}$	-38.28	24.99*	-49.61	1.95	-6.64	-23.83
$P_6 \times P_{15}$	-17.16	26.79	-27.54	1.42	4.81	-13.06
$P_7 \times P_8$	2.21**	-4.98	-6.47	-14.36	-1.39	-10.42
$P_7 \times P_9$	46.52	-8.50	3.21	-19.02	19.01	-7.91
$P_7 \times P_{10}$	16.05**	-11.05*	5.31	-12.10	2.52*	-3.40
$P_7 \times P_{11}$	51.21	20.08	13.62	6.22*	35.64	9.92
$P_7 \times P_{12}$	15.13*	19.05	-5.09	18.43	17.09	6.68
$P_7 \times P_{13}$	25.78	-15.60*	10.62	-20.60*	5.09	-4.99
$P_7 \times P_{14}$	-6.11*	34.00*	-16.35	26.70*	13.94	5.17*
$P_7 \times P_{15}$	20.40	28.25	15.90	13.86	24.32	14.88

Contd.,

Table 4.13 Contd.,

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980 kharif	1981 summer	1980 kharif	1981 summer		
$P_8 \times P_9$	36.90*	17.12	2.16	14.75*	27.01*	8.45
P_9	19.35*	10.05*	18.25	-1.91	14.70*	8.17
P_{10}	32.30	32.49	6.21	7.13	32.39	6.67
P_{11}	11.79	5.15	-0.42	-5.66	8.47	-3.04
P_{12}	-5.26	-4.29*	-9.33	-8.58	-4.78	-8.96
P_{13}	-23.07	34.11	-36.57	10.99	5.52	-12.79
P_{14}	-8.78	-6.28	-19.35	-23.97	-7.53	-21.66
P_{15}						
$P_9 \times P_{10}$	41.36**	-15.03	6.14	-25.60	13.16*	-9.73
P_{10}	44.00**	8.99	30.55	-13.23	26.49	8.66
P_{11}	43.40**	-24.55	16.87	-33.52	9.42	-8.33
P_{12}	21.83	-17.74	-6.27	-22.94	2.04	-14.61
P_{13}	8.70*	-22.16	-28.28	-36.61	-6.73	-32.45
P_{14}	28.37*	-27.98	-11.52	-42.48	0.19	-27.00
P_{15}						
$P_{10} \times P_{11}$	68.79**	38.44*	36.46*	23.78*	53.61**	30.12**
P_{11}	5.71	-16.85	-5.07	-17.46	-5.57	-11.27
P_{12}	-9.80	-15.71*	-12.90	-21.62**	-12.76	-17.26
P_{13}	-16.32*	37.95	-31.51	26.71	10.81	-2.40
P_{14}	26.14	-15.05	10.62	-23.75	5.54	-6.57
P_{15}						
$P_{11} \times P_{12}$	69.17**	45.24**	50.14**	29.05**	57.20**	39.59*
P_{12}	24.40	44.32**	3.41	21.07**	34.36*	12.24
P_{13}	16.49	44.08**	-18.86	39.89**	30.28	10.51
P_{14}	-4.93	39.51	-30.36	38.89	17.29	4.26
P_{15}						
$P_{12} \times P_{13}$	26.33*	-9.85*	17.16	-15.61	8.24	0.77
P_{13}	13.75	21.74*	-14.28	10.07	17.74	-2.11
P_{14}	14.14	25.07	-8.68	11.54	19.60	1.43
P_{15}						
$P_{13} \times P_{14}$	-15.63	-5.92	-32.79	-19.10	-10.78	-25.95
P_{14}	-11.89	5.20	-25.02	-11.43	-3.35	-18.23
P_{15}						
$P_{14} \times P_{15}$	-19.34	42.36**	-25.60	38.81**	11.51	6.60

MP - Mid parent value

BP - Better parent value

* - Significant at 5 per cent level

** - Significant at 1 per cent level

Table 4.14. Heterosis over mid parent value and heterobeltiosis over better parent value (Seed yield)

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980	1981	1980	1981		
	kharif	summer	kharif	summer		
$P_1 \times P_2$	28.89	-6.45	16.00*	-21.02	11.22	-2.51
P_2	40.63	4.27	30.98	-9.56	22.45	10.71
P_3	-6.4	10.93	-34.31*	-0.92	2.26*	-17.62
P_4	67.50**	-0.67	37.05	-24.15*	33.41*	6.45
P_5	-2.46	36.28*	-20.57	34.64	16.91	7.03
P_6	-37.04	-20.45	-53.30	-24.05	-28.75	-38.68
P_7	22.57	-12.43	-34.44	-23.38	-17.50	-28.91
P_8	-31.77	17.35*	-40.07	11.92	-7.21*	-14.08*
P_9	16.75	33.53*	2.95	19.11	25.14	11.03
P_{10}	-4.95	36.34*	-22.37	13.36	15.69	-4.51
P_{11}	-3.37	-2.77	-14.39	-16.96	-3.07	-15.68
P_{12}	-10.65	-5.07	-24.13	-18.40	-7.86	-21.27
P_{13}	-3.13	10.17*	-29.50	-6.47	3.52	-17.99
P_{14}	-0.31	31.60	-24.20	12.13	15.64	-6.04
P_{15}						
$P_2 \times P_3$	30.75*	-4.23	26.00*	-27.88	13.26*	-0.94
P_3	38.17*	8.72	3.94	-16.21	23.44	-6.14
P_4	8.43	2.60	-18.18	-30.08	5.51	-24.13
P_5	-3.84	-22.09	-14.14	-33.62	-12.97	-23.88
P_6	9.93	-12.45	-11.98	-28.80	-1.26	-20.39
P_7	10.66*	-9.08	3.32*	-12.88	0.79	-4.78
P_8	33.98*	-7.32	29.86	-24.70	13.33	2.58
P_9	39.73*	5.15	12.55	-19.04	22.44	-3.25
P_{10}	20.45*	10.88	7.94*	-19.25	15.66*	-5.66*
P_{11}	42.50	12.18	40.00	-16.56	27.34	11.72
P_{12}	-21.86	-15.76	-26.83	-17.55	-18.81	-22.19
P_{13}	-20.32	12.43	-37.47	-16.77	-3.95	-27.12
P_{14}	-26.87	11.82	-39.62	-16.99	-7.53	-28.31
P_{15}						
$P_3 \times P_4$	1.00	48.58**	-25.87	43.73*	24.79*	8.93
P_4	20.00	11.56	-7.06	-4.33	15.78	-5.70
P_5	-15.21	13.79	-26.71	-2.21	-0.71	-14.46
P_6	3.66	12.48	-19.12	1.69	8.07	-8.72
P_7	-5.25	-16.70	-14.53	-35.34	-10.98	-24.94
P_8	8.39**	4.26	1.37*	-5.67	6.32*	-2.15*
P_9	49.88**	6.09*	24.31	2.75	27.98	13.53
P_{10}	4.16*	22.47*	-9.67*	16.48	13.31*	3.40*
P_{11}	34.44	16.36	27.37	14.25	25.40	20.81
P_{12}	-24.48	7.74	-19.68	-17.66	-8.37	-18.67
P_{13}	-13.55	-15.76	-33.95	-17.88	-14.66	-25.92
P_{14}	-23.22	-1.43	-38.43	-3.49	-12.33	-20.96
P_{15}						

Contd.,

Table 4.14 Contd.,

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980	1981	1980	1981		
	kharif	summer	kharif	summer		
$P_4 \times P_5$	-10.80	14.71	-43.94	-4.31	1.95	-24.13
P_5	-38.10	-3.75	-49.17	-14.86	-20.93	-32.02
P_6	1.10	-4.00	-7.25	-10.50	-1.45	-8.88
P_7	-9.99	-28.61	-28.90	-43.21	-19.30	-36.06
P_8	-33.05	0.00	-48.53	-6.68	-16.53	-27.61
P_9	12.20	-6.68	-26.61	-6.92	2.76	-16.77
P_{10}	-8.08	11.61*	-24.86	2.87*	1.76*	-11.00
P_{11}	-3.49	43.96*	-26.51	36.81	20.23	5.15
P_{12}	-11.86	-31.16*	-30.46	-46.12*	-21.51	-38.29
P_{13}	-23.64	39.14	-27.98	31.33	7.75	1.67
P_{14}	11.70	-6.89	-1.01	-11.75	2.40	-6.38
P_{15}						
$P_5 \times P_6$	-1.22*	22.41*	-30.86	-7.33	10.59*	-19.10
P_6	31.26*	24.46	-14.18	-1.81	27.86	-8.00
P_7	23.68*	-5.09	-10.90	-33.80	9.29	-22.35
P_8	27.25*	-54.44	-15.97*	-63.99	-13.60*	-39.98*
P_9	37.34	21.94**	25.89	1.97*	29.64*	13.93*
P_{10}	22.22	52.85**	-14.29	36.99*	37.53*	11.35
P_{11}	15.06	49.42	-14.21	30.14	32.24	7.96
P_{12}	17.14*	-38.91	-15.40	-57.87	-10.89	-36.64
P_{13}	23.43*	2.52*	-20.39	-10.15	12.97*	-15.27
P_{14}	44.92	39.23	-3.56	21.57	42.07	9.00
P_{15}						
$P_6 \times P_7$	-1.74	14.88	-13.08	8.53	6.57	-2.28
P_7	-16.97	-16.67	-21.00	-26.31	-16.82	-23.66
P_8	-27.22	0.43	-33.14	-5.32	-13.40	-19.23
P_9	-8.11	-20.02	-32.00	-29.42	-14.07*	-30.71
P_{10}	21.84	20.71	21.14	-0.50	21.27	10.32
P_{11}	-24.25	15.54	-31.29	-2.21	-4.36	-16.75
P_{12}	-20.60	-7.24	-24.57	-19.51	-13.92	-22.04
P_{13}	-45.98	15.27*	-53.42	-3.01	-15.36	-28.22
P_{14}	-32.17	31.51	-37.96	11.04	-0.33	-13.46
P_{15}						
$P_7 \times P_8$	13.88*	-36.21	-3.52	-46.30	-11.17	-24.91
P_8	27.01*	-17.53	4.40	-17.73	4.74	-6.67
P_9	37.40*	-25.61	-5.93*	-30.81	5.89*	-18.37*
P_{10}	45.94*	12.01	28.46	-3.16	28.97	12.65
P_{11}	13.38	18.68	-7.80	-0.68	16.93	-4.24
P_{12}	6.88	-45.40*	-9.56	-54.84	-19.26	-32.20
P_{13}	-14.39*	31.42	-16.87*	16.14	8.50*	-0.37
P_{14}	34.25	3.05	29.23	-8.58	18.65	10.32
P_{15}						

Contd.,

Table 4.14 Contd.,

Hybrids	MP		BP		MP Pooled	BP Pooled
	1980 kharif	1981 summer	1980 kharif	1981 summer		
$P_8 \times P_9$	7.39**	-1.93	3.32	-17.59	2.73	-7.14
P_9^{10}	50.00	-5.64	14.69	-25.08	22.18	-5.20
P_9^{11}	11.01	-0.10	6.20	-25.15	5.45	-9.48
P_9^{12}	-8.65	-12.89	-13.27	-33.26	-10.77	-23.27
P_9^{13}	10.30	-32.56	9.95	-34.00	-11.13	-12.03
P_9^{14}	-22.03	5.16	-35.51	-19.83	-8.44	-27.67
P_9^{15}	-24.75	-23.01	-29.66	-41.13	-23.88	-35.40
$P_9 \times P_{10}$	-1.08	-12.76	-22.18	-18.69	-6.92	-20.44
P_{10}^{11}	-14.24	4.19	-20.92	-9.85	-5.03	-15.39
P_{10}^{12}	0.52	-2.16	-8.85	-12.91	0.82	-10.88
P_{10}^{13}	7.07	-29.07	3.33	-41.39	-11.00	-19.03
P_{10}^{14}	-2.84	-19.21	-21.95	-28.54	-11.03	-25.25
P_{10}^{15}	15.97	-32.91	-1.78	-40.43	-8.47	-21.11
$P_{10} \times P_{11}$	91.83**	51.70**	42.28*	39.97*	71.76**	41.12*
P_{11}^{12}	23.84	2.07	-1.58	-2.88	12.95	-2.23
P_{11}^{13}	8.90	-34.97*	-16.51	-49.15	-13.04	-32.83
P_{11}^{14}	3.07	24.69	-30.54	17.82	13.88	-6.36
P_{11}^{15}	30.73	-21.41	-8.66	-25.43	4.66	-17.05
$P_{11} \times P_{12}$	43.58*	14.37	30.74*	10.72	28.97*	20.73*
P_{12}^{13}	-2.72	-3.80*	-7.22	-28.97*	-3.26	-18.10
P_{12}^{14}	-0.60	29.71	-14.70	26.47	14.55	5.88
P_{12}^{15}	-8.07	20.57	-16.26	17.06	6.25	0.40
$P_{12} \times P_{13}$	-11.67	-11.07	-15.87	-32.89	-11.37	24.38
P_{13}^{14}	8.85	14.74*	-13.46	13.91*	11.79	0.22
P_{13}^{15}	-21.67	40.70	-34.40	40.29	9.51	2.94
$P_{13} \times P_{14}$	-31.08	-28.25	-43.06	-46.12	-29.67	-44.59
P_{14}^{15}	-16.44	-12.56	-27.05	-34.15	-14.50	-30.60
$P_{14} \times P_{15}$	-27.77	13.38	-32.40	13.20	-7.18	-9.60

MP - Mid parent value

BP - Better parent value

* - Significant at 5 per cent level

** - Significant at 1 per cent level

Table 4.15. Analysis of variance for combining ability in individual seasons (plant height)

Source	D.F.	Mean square	
		1980 kharif	1981 summer
GCA	14	1393.7899 **	1254.7250 **
SCA	105	54.1172	113.5357
Reciprocal	105	102.7301	124.0471
Error	448	117.5403	180.0640
GCA : SCA		25.75:1	11.05:1

* Significant at 5% level

** Significant at 1% level

Table 4.16. Analysis of variance for combining ability in individual seasons (Days to first flower)

Source	D.F.	Mean square	
		1980 kharif	1981 summer
GCA	14	75.4923**	69.4792**
SCA	105	3.0387	2.7807
Reciprocal	105	6.8693	6.3493
Error	448	5.1998	4.4930
GCA : SCA		24.51:1	24.98:1

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

Table 4.17. Analysis of variance for combining ability in individual seasons (Capsules-main stem)

Source	D.F.	Mean square	
		1980 kharif	1981 summer
GCA	14	821.2629**	126.3545**
SCA	105	52.0838	49.5066
Reciprocal	105	62.7819	24.9272
Error	448	88.9021	47.5159
GCA : SCA		15.76:1	2.55:1

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

Table 4.18. Analysis of variance for combining ability in individual seasons (Capsules - branches)

Source	D.F.	Mean square	
		1980 kharif	1981 summer
GCA	14	627.3779**	2034.2137**
SCA	105	94.7479	177.856
Reciprocal	105	80.4552	155.3710
Error	448	149.0662	238.9575
GCA : SCA		6.62:1	11.43:1

* Significant at 5% level

** Significant at 1% level

Table 4.19. Analysis of variance for combining ability in individual seasons (Capsules/plant)

Source	D.F.	Mean square	
		1980 kharif	1981 summer
GCA	14	972.388**	1976.1263**
SCA	105	105.6115	201.6275
Reciprocal	105	134.3837	212.3441
Error	448	254.2631	347.6043
GCA : SCA		9.20:1	9.80:1

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

Table 4.20. Analysis of variance for combining ability in individual seasons (Seed yield)

Source	D.F.	Mean square	
		1980 kharif	1981 summer
GCA	14	25.4875**	27.4625**
SCA	105	2.7137	3.8198
Reciprocal	105	4.4757	4.6458
Error	448	6.2447	6.9671
GCA : SCA		9.39:1	7.18:1

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

Table 4.21. Analysis of variance for combining ability - pooled analysis over seasons

Source	D.F.	Plant height	Days to first flower	Capsules- main stem	Capsules- branches	Capsules/ plant	Seed yield
GCA	14	1476.1935**	139.6370**	379.9481**	1720.4386**	859.4620**	15.0089**
SCA	105	89.5978**	4.6187**	49.1215**	147.0258**	159.7166	3.0659*
Reciprocal	105	128.2676**	11.9472**	58.3163**	111.2986*	168.7740*	3.2013*
Seasons	1	3013.7685**	262.1536**	1955.0092**	20709.047**	33322.9250**	704.7029**
GCA x seasons	14	922.9814**	0.5115	212.3500**	703.4837**	1463.7271**	20.2670**
SCA x seasons	105	85.3273*	1.5932	47.1525*	76.8434	149.6809	2.6830
Reciprocal x seasons	105	119.4094**	1.6485	43.4031**	129.9824**	225.6689**	3.9766**
Error	896	51.7795	2.1534	27.5689	71.9520	111.7962	2.0697
GCA:SCA		16.47:1	30.23:1	7.73:1	11.70:1	5.38:1	4.89:1

* Significant at 5% level

** Significant at 1% level

Table 4.22. gca, sca and reciprocal effects

Parents/ Hybrids	Plant height		
	1980 kharif	1981 summer	Pooled
gca effects of parents			
1	-0.5117**	16.7375**	8.1332**
2	7.1635*	5.1418*	6.1465**
3	-3.3864	-6.3464	-4.8446
4	-0.2004**	-0.8991**	-0.7101**
5	-7.2840	-9.4381**	-8.2301**
6	1.9692**	6.1272	3.9031**
7	18.3565*	-2.2414**	8.0810**
8	3.9095**	6.6418	5.3398**
9	-9.1274*	-2.0041*	-5.5901**
10	-4.4094	-4.1061	-4.2429
11	-2.1317**	0.9555	-0.6390**
12	-5.0830*	-3.2074*	-4.1390*
13	-3.6900**	-0.4787*	-2.0057
14	5.5005**	-5.1901	0.1287
15	-1.0750	-1.6924	-1.3912
SE (gi)	1.616	2.000	0.8820
sca effects of hybrids			
Pl.2	-4.4409	-11.5405	-7.2609*
1.3	-3.4909	-6.0822	-4.9198
1.4	6.5530	3.5354	5.0457
1.5	5.5567	-1.2105	1.9323
1.6	-4.3165	-0.1908	-2.1676
1.7	-2.3689	1.5077	-0.5787
1.8	-2.3719	-5.7405	-4.2376*
1.9	0.2500	17.3354	8.7090
1.10	1.4620	5.6074	3.4112
1.11	2.6844	7.1457	4.8579
1.12	-2.4492	-8.7762	-5.7420
1.13	2.9777	9.6951	6.6245
1.14	4.7220	-11.8935	-3.6598
1.15	-1.7872	11.8737	4.9434
2.3	6.8637	2.9634	4.8601
2.4	2.2277	3.0611	2.7923**
2.5	0.6764	15.2001	7.7957
2.6	4.1580	-1.6302	1.3957
2.7	-2.2792	0.4734	-0.9487
2.8	5.2377	-11.6248	-3.3576

Contd.,

Table 4.22 Contd.,

Parents/ Hybrids	Plant height		
	1980 kharif	1981 summer	Pooled
2.9	1.1747	-0.8488	0.1557
2.10	5.4217	1.7231	3.5745
2.11	4.0440	-5.5385	-1.1120
2.12	-0.2895	1.0344	0.3545
2.13	-1.3125	2.7107	0.5879
2.14	-2.7682	3.9871	0.6034
2.15	-5.2425	1.0044	-2.1431
3.4	-4.7372	9.1144	2.2501
3.5	-3.1535	-5.3065	-2.0298
3.6	1.4930	6.0431	3.8534
3.7	-3.6292	-1.5882	-2.6742
3.8	2.5377	-5.7215	-1.6498
3.9	0.2747	16.7194	6.8801
3.10	2.9217	-0.7085	1.0490
3.11	5.2740	-1.6902	1.7957
3.12	2.4954	-2.7422	-0.1876
3.13	-2.9475	3.0991	-0.0709
3.14	2.9117	-3.7245	-0.4387
3.15	-3.9125	-2.6372	-3.3020
4.5	-8.3545	9.0261	0.3190
4.6	3.3420	-5.6392	-2.6309
4.7	-2.7302	-3.1405	-2.8087
4.8	1.0517	-2.9038	-1.1089
4.9	12.5812	7.3421	-2.4709
4.10	-0.9792	-8.4408	-4.0520
4.11	2.7930	-12.7675	-4.8220
4.12	3.2944	5.1654	4.3612
4.13	2.6164	-2.6332	0.0445
4.14	-1.4392	5.9631	1.9934
4.15	1.4864	-0.1195	0.8301
5.6	4.6057	10.9297	7.7557
5.7	-6.7315	3.6384	-1.7220
5.8	4.0304	8.5351	6.0690
5.9	1.5024	-25.6188	-12.2009
5.10	0.8994	6.6131	3.5845
5.11	6.8917	2.3214	4.4979
5.12	-5.9919	1.4494	-2.4354
5.3	4.2650	-5.9792	-1.0854
5.14	5.3894	-10.5178	-2.7031
5.15	8.8200	2.0044	5.2668
6.7	-1.6999	2.8381	0.6612
6.8	-1.9329	-5.6152	-3.7309
6.9	2.7490	3.0007	3.0323**
6.10	-2.7339	-12.4972	-7.5154
6.11	2.5384	3.6411	3.2645

Contd.,

Table 4.22 Contd.,

Parents/ Hybrids	Plant height		
	1980 kharif	1981 summer	Pooled
6.12	2.5247	-0.0458	1.3145
6.13	4.9117	-2.0745	1.4645
6.14	-8.6939	5.6017	-1.4198
6.15	-3.9332	-2.8458	-3.2665
7.8	-4.6552	-4.5115	-4.6928
7.9	6.6317	4.0844	5.3212
7.10	3.3087	1.0664	2.1068
7.11	4.0010	-4.1902	-0.1131
7.12	4.5024	9.4527	6.9201
7.13	4.6094	-8.6258	-1.3131
7.14	-8.2012	0.4904	-3.8976
7.15	-11.5594	-6.3472	2.5390
8.9	3.8637	8.4361	7.7457
8.10	4.3557	7.0331	5.5812
8.11	-1.1369	8.3414	3.5445
8.12	3.1694	-6.0305	-1.5387
8.13	0.4764	3.1257	1.6445
8.14	-4.4082	1.6221	-1.4565
8.15	-0.6585	-1.7305	-1.2698
9.10	4.5427	-7.6658	-1.5887
9.11	-4.8649	1.0724	-1.8420
9.12	7.3364	-9.9145	-1.2920
9.13	-6.6415	-1.3432	-4.0920
9.14	2.5527	3.5981	3.0901
9.15	-0.3715	-16.5445	-8.4565
10.11	5.1020	1.6594	3.4434
10.12	-4.8615	0.0524	-2.4231
10.13	-10.1395	0.0737	-5.1565
10.14	-8.6152	10.3151	0.8423
10.15	2.8404	-5.3125	-1.2709
11.12	1.3057	13.6207	7.5068
11.13	-3.1372	0.5271	-1.3431
11.14	2.1220	-5.8615	-1.8276
11.15	-11.8372	6.9907	-2.3909
12.13	-3.5359	0.6751	-1.5765
12.14	1.4084	7.7164	5.0723
12.15	-4.7009	3.8887	-0.4409
13.14	7.3454	-5.8922	0.6390
13.15	2.7760	1.3451	2.2923
14.15	-1.5845	11.0064	4.7245
SE(S _{ij})	7.49	9.27	3.5359

Contd.,

Table 4.22 Contd.,

Parents/ Hybrids	Plant height		
	1980 kharif	1981 summer	Pooled
Reciprocal effects of hybrids			
P1.2	2.9850	-1.7000*	1.4500
1.3	1.2850	16.2000	8.7333
1.4	-3.6150	5.0650	0.7000
1.5	4.6350	14.3800	9.5000
1.6	-6.5150	5.6650	-0.4000
1.7	-3.7500	1.1350	-1.3000
1.8	-0.5000	-2.2300	-1.3666
1.9	3.4850	0.8000	2.1500
1.10	-3.4850	10.1000	3.3000
1.11	0.4850	6.6000*	3.5500
1.12	1.6000	15.7850	8.6833
1.13	-3.1800	9.6850	2.8833
1.14	-9.5150	-9.8150	-9.6666
1.15	-3.5000	-5.9500	-4.7166
2.3	5.3150	1.6500	3.4666
2.4	-7.4650	-0.5650	-4.0000
2.5	7.8000	-6.8350	0.4833
2.6	-5.0650	1.9700	-1.5500
2.7	2.3150	10.0350	6.1833
2.8	6.5150*	-13.1500	-3.4000
2.9	14.0850*	8.4200	11.2500
2.10	4.2500	-10.4500	-3.0500
2.11	7.9200	-2.2500	3.2666
2.12	0.1650	-7.9000	-3.8666
2.13	6.6650	1.0350	3.8666
2.14	-0.4000	10.7300	5.1500
2.15	12.0500	4.3850	8.2166
3.4	0.2500	-2.5000	-1.1666
3.5	0.6800	-13.2000	-3.9000
3.6	-9.0200	-3.0850	-6.0500
3.7	-12.7150	-8.1150	-10.4333
3.8	-7.6350	-0.9650	-4.2500
3.9	0.0350	3.1000	3.1500
3.10	3.5700	-11.0700	-3.7333
3.11	2.2000*	10.1500	6.1833
3.12	-12.7700	1.0350	-5.8666
3.13	7.5200*	-11.5650	-2.0166
3.14	-15.2700*	2.2300	-6.5166
3.15	0.3700	4.3850	2.3666
4.5	5.3350	-9.1500	-1.9166
4.6	0.8150	1.8500	-0.4333
4.7	-10.6300	-3.1500	-6.9000

Contd.,

Table 4.22 Contd.,

Parents/ Hybrids	Plant height		
	1980 kharif	1981 summer	Pooled
4.8	2.9350	10.4000	6.9000
4.9	-2.6650	-10.1300	-6.4000
4.10	-4.4850	-0.3850	-2.0000
4.11	-2.3350	0.9800	-0.6666
4.12	-2.8850	-9.5500	-3.3166
4.13	-0.6300	-10.0800	-5.3666
4.14	0.6350	-8.8350	-3.6833
4.15	3.0850	0.8800	2.0000
5.6	0.9650*	-1.4500	-0.2333*
5.7	-16.1850	-11.0500	-13.6000
5.8	-9.0000	1.0000	-4.0166
5.9	-2.8350	-12.8700	-7.8500
5.10	0.6500	-10.5000	-4.9166
5.11	1.3500	-11.6300	-5.1666
5.12	-0.6850	-3.5350	-2.1000
5.13	1.8350	-15.1350	-6.6500
5.14	-6.8500	-0.8150	-3.8333
5.15	4.1350	-14.7650	-5.3166
6.7	-5.2300	-3.3850	-4.3166
6.8	1.5500	-3.9850	-1.2166
6.9	4.3650	0.5850*	2.4833*
6.10	5.3000	19.4850*	12.4166*
6.11	-3.5500	-1.8150	-2.7000
6.12	-3.9150	1.0650	-1.4500
6.13	10.7650	5.5650	8.1666
6.14	-0.5200	4.5300	2.0166
6.15	1.0350	4.8200	2.9166
7.8	11.5850*	0.1200	5.8666
7.9	22.2350**	-0.2000	11.0166**
7.10	25.6000*	9.2500	17.4166
7.11	-4.5700**	5.5150	0.4666
7.12	22.3800*	-1.0350	10.6666
7.13	14.2500	2.3850	9.1666
7.14	-8.6000	-1.1500	-4.8833*
7.15	9.2850	16.2500	12.7666
8.9	9.8500	4.4650	8.8333
8.10	4.1000	5.8000	4.9500
8.11	2.5150	-0.9000	0.8166
8.12	7.4000	4.1650	5.7666
8.13	3.0000	-2.5800	0.2166
8.14	-1.2500	4.0650	1.4166
8.15	-2.0500	4.5500	1.2500
9.10	-4.1500	0.4850	-1.8166
9.11	-2.1500	4.2150	1.0333
9.12	3.8000	-11.2350	-3.7166

Contd.,

Table 4.22 Contd.,

Parents/ Hybrids	Plant height		
	1980 kharif	1981 summer	Pooled
9.13	0.9850	-1.5350	-0.2833
9.14	-5.1000	-5.1350	-5.1000
9.15	-9.3000	-2.0500	-5.6666
10.11	-2.4350	-14.5000	-8.4333
10.12	0.4500	7.0000	3.6666
10.13	-3.5650	3.6500	0.0333
10.14	-5.7800	-3.4500	-4.6333
10.15	3.3000	-4.3500	-0.5333
11.12	-1.6350	-3.7000	-2.6666
11.13	-5.8850	-8.7650	-7.3166
11.14	-7.9650	2.4650*	-2.7666
11.15	-0.9000	-17.9150	-9.4166
12.13	0.8350	1.1200	0.9500
12.14	-2.0000	10.4500	4.7333
12.15	-3.0150	5.0200	1.0000
13.14	-8.1000	13.6000	2.7333
13.15	-8.0150	0.4650	-3.4666
14.15	5.3850	14.4150	9.9000
SE(rij)	6.25	7.74	5.9867

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.23. *gca*, *sca* and reciprocal effects

Parents/ Hybrids	Days to first flower		
	1980 kharif	1981 summer	Pooled
<i>gca</i> effects of parents			
1	0.2407**	0.2686**	0.2772**
2	1.3653**	1.4080**	1.3905**
3	0.7500	0.6146	0.6628**
4	-0.4839	-0.3987	-0.4482**
5	-2.1346**	-2.1084**	-2.1849**
6	2.4123**	2.2190**	2.3094**
7	2.6957	2.6045	2.6339*
8	0.5240**	0.5150**	0.5528**
9	-1.7279**	-1.5977**	-1.6338**
10	-2.7662	-2.6314	-2.6538
11	0.2523	0.2846**	0.2717**
12	-1.7209	-1.6524	-1.6827
13	-0.0732*	-0.0424*	-0.0582**
14	0.9257	0.9433	0.9161
15	-0.2592	-0.4537	-0.3527
SE (gi)	0.3398	0.3159	0.2163
<i>sca</i> effects of hybrids			
P1.2	-2.1870	-2.1633	-2.2294**
1.3	1.0282	-0.5695	0.2149
1.4	-1.2727	-1.1366	-1.2405
1.5	-1.1020	-1.8969	-1.0705
1.6	0.0659	0.2987	0.1516
1.7	0.7976	0.8288	0.7938
1.8	-0.4007	-0.2773*	-0.3417**
1.9	4.5062	4.0573	4.2282
1.10	-0.2103	0.4410	0.4649**
1.11	-2.1440	-2.1399	-2.1772**
1.12	0.5642	0.5120	0.5105
1.13	0.4166	0.3220	0.3527
1.14	-0.6323	-0.7136	-0.7050
1.15	-0.5823	-0.3216	-0.5361
2.3	-0.5113	-0.3422	-0.4317
2.4	0.7036	-0.6540	0.6794
2.5	-1.1532	1.1637	1.1994
2.6	-1.1437	-0.9286	-1.0450
2.7	-0.8970	-0.7992	-0.8361

Contd.,

Table 4.23 Contd.,

Parents/ Hybrids	Days to first flower		
	1980 kharif	1981 summer	Pooled
P2.8	0.5296	0.5283*	0.4949
2.9	0.2816	3.0444	0.1816
2.10	0.9849	0.8567	0.8682
2.11	0.7862	0.7557	0.7594
2.12	1.2546	1.1927	1.2138
2.13	0.8919	0.7777	0.8394
2.14	-0.3420	-0.3729	-0.3350*
2.15	-2.1870	-1.9909	-2.0161
3.4	0.2329	0.3673	0.3071
3.5	-0.6663	-0.4579	-0.5061
3.6	-1.3783	-0.9852	-1.1672
3.7	-0.3317	-0.8059	-0.5417
3.8	-0.4400	-0.2632	-0.3605
3.9	-1.0580	-1.0036	-1.0405*
3.10	2.0152	1.6958	1.6627*
3.11	0.4466	0.5640	0.5205
3.12	0.7549	0.8660	0.8249
3.13	-0.9127	-0.7589	-0.8161
3.14	-1.2567	-1.0946	-1.1405
3.15	-0.9367	-0.5626	-0.7383*
4.5	-2.1323	-2.1146	-2.0617
4.6	-0.6443	-0.4719	-0.5561**
4.7	2.4222	2.4273	-2.4360**
4.8	0.0939	0.0500	0.0338
4.9	0.4309	0.1097	0.2371**
4.10	-2.0307	-2.1916	-2.1594**
4.11	0.2156	0.0923	0.1649
4.12	0.6539	0.5793	0.6360
4.13	-0.2587	-0.3306	-2.2883
4.14	-0.4927	-0.1662	-0.2961
4.15	-0.6027	-0.4492	-0.5272
5.6	1.4062	1.6377	1.5805
5.7	-1.0270	-0.9479	-1.0772
5.8	-1.0903	-0.2402	-0.2128
5.9	-1.0833	-0.2106	-0.6094
5.10	0.8849	0.7880	0.8438
5.11	0.7862	0.7720	0.8349**
5.12	-2.7953	-2.8409	-2.7605
5.13	0.4769	0.4640**	0.5316**
5.14	2.9229	3.7633	3.8405*
5.15	1.9429	1.9903	2.0260
6.7	0.5109	0.6597	0.5949
6.8	-0.2873	-0.0326	-0.1905

Contd.,

Table 4.23 Contd.,

Parents/ Hybrids	Days to first flower		
	1980 kharif	1981 summer	Pooled
P6.9	0.2846	0.4620	0.3468
6.10	-0.3470	-0.2442	-0.3339
6.11	-0.5807	-0.4102	-0.4928
6.12	-1.1273	-0.9532	-1.0383
6.13	1.2449	1.3517	1.3038
6.14	0.0109	0.2610	0.1460
6.15	2.9959	-0.0369	1.4816
7.8	0.0842	-1.1832	-0.5650
7.9	0.2512	0.3413	0.2716
7.10	0.9196	0.9050	0.8916
7.11	0.0359	0.1590	0.0994
7.12	-0.5907	0.5239	-0.5461
7.13	-0.1083	1.0444	-0.0372
7.14	-0.6073	1.4696	0.5117
7.15	-0.6223	-0.2876	-0.4428
8.9	-0.4770	-0.5659	-0.5805
8.10	1.6962	1.5727	1.5727
8.11	-0.6923	-0.7432	-0.7361
8.12	1.2159	1.1387	1.1516
8.13	0.4832	0.4837	0.4271
8.14	-0.6657	-0.6569	-0.6639
8.15	0.6842	0.8900	0.7382*
9.10	-2.4717	-1.8576	-1.8239*
9.11	1.6896	1.5563	1.5671
9.12	-0.2520	-0.4216	-0.3617
9.13	-0.6997	-0.7966	0.7861
9.14	-0.0137	-0.1322	-0.0772
9.15	1.0712	1.1497	1.0749
10.11	-0.7520	-0.7249	-0.7794
10.12	-0.1987	-0.3529	-0.3250
10.13	-1.1113	-1.3979	-1.2994
10.14	1.0596	1.1013	1.0594
10.15	-0.0253	0.0633	-0.0217
11.12	1.5876	1.2660	1.4160
11.13	-0.3800	-0.4139	-0.3917
11.14	-0.1090	-0.0146	0.0338
11.15	-0.8390	-0.6326	-0.7472
12.13	0.4082	0.6080	0.5127
12.14	-0.8057	-0.9776	-0.8450
12.15	-0.4657	-0.3106	-0.3928
13.14	-0.5333	-0.5526	-0.5194
13.15	-0.3183	-0.1256	-0.2172
14.15	-0.3473	-0.1262	-0.2250
SE(sij)	1.57	1.467	0.8116

Contd.,

Table 4.23 Contd.,

Parents/ Hybrids	Days to first flower		
	1980 kharif	1981 summer	Pooled
Reciprocal effects of hybrids			
1.2	0.3650	0.3700	0.3666
1.3	-0.7650	-2.4000	-1.5833*
1.4	1.7700	1.9500	1.8500*
1.5	1.0500	1.0500	1.0500
1.6	-0.7350	-0.7350	-0.7333
1.7	-0.0500	-0.1500	-0.1000
1.8	0.0500*	0.1500*	0.1500*
1.9	-3.4350	-3.1150	-3.2666
1.10	0.1500	0.9650	0.9833
1.11	0.7650	0.7700	0.7666
1.12	0.3700	0.3850*	0.3666**
1.13	2.5300	2.4650	2.5000
1.14	-0.1000	-0.1150	-0.1166
1.15	-0.2850	-0.4500	-0.3833
2.3	1.0500	1.0650	1.0500
2.4	1.2700	1.3200	1.2833**
2.5	2.5300	2.5200	2.5333**
2.6	0.3200	0.3150	0.3166
2.7	-0.2500	-0.2700	-0.2500
2.8	0.4350	0.4350	-0.4333**
2.9	2.4650*	2.3000	2.4666**
2.10	2.6300	2.6500	2.6333
2.11	0.5500	0.5650	0.5500**
2.12	2.3150	2.3350	2.3166**
2.13	0.3300	0.4000	0.3666
2.14	1.0350*	1.0350	1.0333**
2.15	1.6650	2.6800	2.5833**
3.4	2.1150*	2.1000	2.1166**
3.5	2.9650	2.9350	2.9666**
3.6	-2.0700	-2.0650	-2.0666**
3.7	-1.8000	-1.1000	-1.4500
3.8	0.6500	-0.6500	0.6500
3.9	0.6500	0.6700	0.6500
3.10	1.4850	1.8350	1.8333
3.11	-0.0650	-0.0500	-0.0500
3.12	1.4000	1.4150	1.4000
3.13	0.9500	0.9700	0.9500
3.14	-0.1650	-0.1500	-0.1666
3.15	1.1000	1.1150	1.1000
4.5	0.5350	0.4650	0.5000
4.6	-1.4300	-1.4350	-1.4333
4.7	-1.3200	-1.2500	-1.2833

Contd.,

Table 4.23 Contd.,

Parents/ Hybrids	Days to first flower		
	1980 kharif	1981 summer	Pooled
P4.8	-0.5500	-0.5500	-0.5333
4.9	-0.3650	-0.2000	-0.2833
4.10	1.4650	1.4650	1.4666
4.11	-0.6000	-0.5650	-0.5833
4.12	-1.8650	-1.8150	-1.8333
4.13	0.4700	0.4850	0.4666
4.14	-0.8350	-1.2350	-1.0333
4.15	-0.6000*	-0.5850*	-0.6000**
5.6	-2.6300**	-2.6350*	-2.6333**
5.7	-4.7200*	-4.6650	-4.5333**
5.8	-2.6850	-1.8500	-1.8500
5.9	0.0000	1.0000	0.5000*
5.10	1.8700	1.8650	1.8666
5.11	-1.0500	-1.0350	-1.0500
5.12	-0.4350	-0.4150	-0.4333**
5.13	-2.2850	-2.2700*	-2.2833**
5.14	-2.4000	-3.2150	-3.2333**
5.15	0.9650	0.8150	0.8833
6.7	-0.3650	-0.5000	-0.4333
6.8	1.6650**	1.6850*	1.6666**
6.9	4.3150**	4.2000*	4.2500**
6.10	4.5850**	4.6000	4.5833
6.11	-0.2300	-0.2500	-0.2500*
6.12	2.0500*	2.0700*	2.0500**
6.13	3.0700	2.9850	3.0166
6.14	0.6350**	0.6350	0.6333**
6.15	5.7650	2.3150	4.0333**
7.8	1.9500*	0.5500*	1.2500**
7.9	2.6350**	2.5650*	2.6000**
7.10	4.0650	4.0650	4.0666**
7.11	0.5300*	0.5350*	0.5333**
7.12	3.0700	3.0850	3.0666
7.13	1.2000	1.2200	1.2000
7.14	1.5000	1.5350	1.5000
7.15	1.7000*	1.6800*	1.7000**
8.9	3.5350	3.5350	3.5333*
8.10	2.2000	2.2000	2.2000
8.11	0.6300	0.6000	0.6166**
8.12	2.4350	2.4150	2.4166
8.13	-0.1200	-0.1000	-0.1500
8.14	-0.2000	-0.1850	-0.2000
8.15	-0.7650	-0.7650	-0.8000
9.10	1.2800	-0.4300	0.4500

Contd.,

Table 4.23 Contd.,

Parents/ Hybrids	Days to first flower		
	1980 kharif	1981 summer	Pooled
P9.11	0.3000	0.3000	0.3333*
9.12	+1.8150*	1.8150*	1.8166**
9.13	-3.3150	-3.3200	-3.3166
9.14	-1.6700	-1.6700	-1.6666
9.15	-0.3000	-0.3150	-0.3166
10.11	-0.8500	-0.6850*	-0.7666**
10.12	-2.5000	-2.4800*	-2.5000**
10.13	-2.5650	-2.7150	-2.6500
10.14	-0.3650	-0.5300	-0.0450*
10.15	2.2350	2.2350	2.2333
11.12	-0.3350	0.1850	-0.0666
11.13	-0.7150	-0.7150	-0.7166
11.14	0.0150	-0.2000	-0.1833
11.15	0.7000	0.7150	0.7000
12.13	1.5000	1.7700**	1.6333**
12.14	-2.4150	-2.6300	-2.5500
12.15	-0.7000	-0.7000	-0.7000
13.14	-0.7350	-0.7350	-0.7333
13.15	-1.0350	-1.0350	-1.0333
14.15	-0.5350	-0.5200	-0.5333
SE(rij)	1.31	1.223	0.8673

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.24. gca, sca and reciprocal effects

Parents/ Hybrids	Capsules-main stem		
	1980 kharif	1981 summer	Pooled
gca effects of parents			
1	-6.6504**	0.4015	-3.0473**
2	-6.3754**	-0.5621*	-3.4906**
3	-1.1971*	-2.5944*	-1.9195**
4	3.6535*	-0.3691	1.6215*
5	2.7985**	0.1205	1.4582**
6	-6.7827**	0.8218	-2.8440**
7	10.8295**	1.9872	6.4437**
8	-5.4411	-0.8634	-3.0928**
9	1.2995**	4.2122	2.5982**
10	4.8822**	1.4595	3.2371**
11	-4.3321**	-1.7214*	-2.9906**
12	3.0632	2.6402	2.8515
13	-0.5737**	-0.4951	-0.6840**
14	5.3478**	-1.1967	1.9360**
15	-0.5217	-3.8407	-2.0773**
SE (gi)	1.4055	1.0275	0.6013
sca effects of hybrids			
P1.2	6.6611	1.8975	4.2517
1.3	6.3971	-1.4198	2.4806
1.4	-0.5378	4.9047	2.1562
1.5	-3.7478	-3.9498	-3.8971
1.6	4.4684	0.7787	2.8551*
1.7	-8.6788	-2.4215	-5.6326
1.8	2.9417	-5.2358	-1.2460
1.9	-5.0838	-3.8115	-4.3371
1.10	-5.8115	1.9611	-1.8093
1.11	3.6977	5.1521	4.3517
1.12	-5.2275	-2.7395	-4.0237
1.13	-1.1105	0.6457	-0.1048
1.14	2.5527	0.3974	1.5751
1.15	0.9074	3.5414	2.0717
2.3	1.1727	1.4237	2.8740
2.4	-3.9578	0.1134	-1.8337
2.5	-4.8228	0.2287	-2.2371
2.6	4.1234	-0.6375	1.6651
2.7	-6.0538	-0.6578	-3.3226
2.8	3.3167	1.5927	2.4473

Contd.,

Table 4.24 Contd.,

Parents/ Hybrids	Capsules-main stem		
	1980 kharif	1981 summer	Pooled
P2.9	-1.9888	-6.0478	-3.8604
2.10	3.5234	-4.1302	-0.2993
2.11	2.6427	1.7857	2.2284
2.12	-1.9375	-3.4958	-3.4804
2.13	-2.4305	1.5945	0.2115
2.14	-6.7372	7.6311	0.6351
2.15	-0.7325	1.9051	0.5484
3.4	-0.2712	3.9657	1.9284
3.5	-1.7012	-1.6088	-1.5915
3.6	1.8151	1.3897	1.5273
3.7	-2.1322	1.3094	-1.2437
3.8	-2.6465	0.6601	-0.9904
3.9	3.7127	-3.2805	0.4351**
3.10	-10.5498	-2.9628	-6.7704**
3.11	1.8294	-4.2168	-1.1760
3.12	-4.0658	-0.7935	-2.3682
3.13	-2.6638	1.2617	0.4993*
3.14	8.2494	1.1434	4.8806*
3.15	2.1891	1.4374	1.7606
4.5	4.0331	1.3007	2.7340
4.6	-4.8205	-1.7505	-3.3637
4.7	2.3521	0.3191	1.3651
4.8	1.2227	-2.2222	0.6017**
4.9	-7.3528	-5.5108	-6.2226**
4.10	6.0994	2.3117	4.1884
4.11	2.5587	-5.3072	-1.3504
4.12	2.3484	0.5961	1.5240
4.13	-2.1145	-1.9635	-1.8404
4.14	-0.9662	2.2331	-0.0104
4.15	-0.0665	-1.4528	-0.8137
5.6	-2.3155	0.9597	-0.7671
5.7	-1.9628	0.5944	-0.6215
5.8	-6.9922**	2.0451	-2.5015**
5.9	25.0321**	-1.5305	11.9406**
5.10	-3.8105	1.0871	-1.3815
5.11	-3.6662	-0.7668	-2.2204
5.12	3.4034	-0.3235	1.6206
5.13	1.4904	2.8417	2.3562*
5.14	-5.8462	-5.0915	-5.9637
5.15	-4.6765	-0.1775	-2.5004
6.7	0.2884	-3.1568	-1.5693
6.8	0.6741	0.3007	0.3340
6.9	-1.7815	-0.2168	-0.9404

Contd.,

Table 4.24 Contd.,

Parents/ Hybrids	Capsules-main stem		
	1980 kharif	1981 summer	Pooled
P6.10	1.8507	-3.1792	-0.8293*
6.11	6.4151	4.3017	5.2151
6.12	-3.0952	-0.3598	-1.5771
6.13	-3.2282	-2.2595	-2.6915
6.14	-8.8348	1.0421	-3.8615
6.15	-2.1252	2.7911	0.9684
7.8	3.5767	-4.1215	-0.3371
7.9	4.9711	-0.3622	2.4551
7.10	1.9584	-4.5915	-1.4504
7.11	-1.5622	-2.1985**	-1.9060
7.12	9.8074	14.4447*	12.1184**
7.13	2.1744	-2.8588	-0.1960
7.14	-1.7772	-3.9882	-1.8993
7.15	1.6274	4.6907	3.0473
8.9	-0.4232	-1.1315	-0.6415
8.10	-2.3408	-1.6438	-1.8471
8.11	1.3234	2.9571	2.0806
8.12	-2.6218	-4.7045	-3.6948
8.13	-0.2698	2.3607	1.2240
8.14	-3.2715	6.6274	1.7873
8.15	-3.4281	0.0564	1.6173
9.10	7.5684	-6.1195	0.8284
9.11	-5.5872	-3.2185	-4.2437
9.12	-0.0125	-2.7852	-1.2026
9.13	0.1394**	0.0701	-0.3837**
9.14	-13.7822**	0.5132*	-6.8204**
9.15	-4.2125	-11.8192	-7.9237
10.11	1.3351	4.1941	2.7006
10.12	-1.4652	-5.4275	-3.4748
10.13	1.5617	2.3027	2.0440
10.14	-3.0298	-2.7105	-2.7593
10.15	2.6047	-1.8015	0.3539
11.12	-1.4658	4.3134	1.4362
11.13	-3.6288	2.3187	-0.5115
11.14	2.2494	-0.6095	0.9517
11.15	-3.2758	0.1494	-1.6515
12.13	0.2757	-1.8128	-0.5871
12.14	0.1241	-1.8712	3.2928
12.15	-0.3412	-0.5322	-0.4937
13.14	8.4961	-3.3558	0.8951
13.15	0.1607	0.2581	0.2917
14.15	-0.6608	3.7397	1.6884
SE(sij)	6.5173	4.7646	2.2557

Contd.,

Table 4.24 Contd.,

Parents/ Hybrids	Capsules-main stem		
	1980 kharif	1981 summer	Pooled
Reciprocal effects of hybrids			
P1.2	1.1650	-6.8350	-2.8333
1.3	6.0200	1.2850	3.6666
1.4	-7.9350	-0.2350	-4.0833
1.5	-1.2000	5.6000	2.2000
1.6	-0.1650	3.1700	1.0833
1.7	-5.3700	-1.9350	-3.6500
1.8	1.3500	-1.4000	-0.0333
1.9	-1.7650	1.7700	0.0000
1.10	-1.5500	3.7500	0.9000
1.11	-3.0150	-5.0000	-4.0000
1.12	-1.8850	2.2000	0.1666
1.13	-4.5350	0.0200	-2.2833
1.14	-12.7200	-6.3700	-9.5500
1.15	-0.6650	0.8700	0.1000
2.3	-0.3670	-0.6350	-2.1500
2.4	-2.8500	-0.0500	-1.4500
2.5	-1.2000	-2.7150	-1.9833
2.6	-0.3350	-1.1500	-0.7500
2.7	-2.6000	0.9350	-0.8500
2.8	1.3000	-6.4650	-2.5833
2.9	-0.0650*	1.3000	0.6666*
2.10	-11.3000*	0.0650	-5.6000*
2.11	0.9350	-2.4000	-0.7333
2.12	-2.1800	2.1500	-0.8333
2.13	-0.9500	-4.7350	-2.8333
2.14	-3.0350	0.7000	-1.1666
2.15	-3.7000	5.2300	0.7666*
3.4	-7.6850	-2.2300	-4.9500*
3.5	-2.9000	-6.3850	-4.6333
3.6	-4.4350	-0.5850	1.9166
3.7	0.9700	-2.7300	-1.7000
3.8	-0.6150	-1.3700	-0.9833
3.9	-2.5150	-1.3650	-1.9333
3.10	4.4650	-1.0700	1.7000
3.11	4.1000	0.6350	2.3666
3.12	-5.0000	2.4500	-1.2833
3.13	-0.7650*	-2.2000	-1.4833**
3.14	-15.6700*	0.7800	-7.4500**
3.15	-1.8000	0.1700	-0.8166
4.5	-3.5350	-1.4800	-2.5000
4.6	4.0200	0.4700	2.2333
4:7	-0.5350	-1.9650	-1.2500

Contd.,

Table 4.24 Contd.,

Parents/ Hybrids	Capsules-main stem		
	1980	1981	Pooled
	kharif	summer	
P4.8	2.7650	4.5350	3.6500
4.9	-6.6700	-0.9000	-3.7833
4.10	-4.4350	-0.1700	-2.3000
4.11	3.9500	3.7000	3.8333
4.12	-0.0650	-2.4350	-1.2500
4.13	-3.1650	-1.8000	-2.4833
4.14	-5.1650	-4.5650	-4.0333
4.15	2.2650	1.7650	2.0166
5.6	2.7000	-0.0300	1.3333**
5.7	-9.8650	-4.6000	-7.3000**
5.8	3.2350	-1.2000	1.0166
5.9	-5.8000	4.7000	-0.5500
5.10	-0.7000	-4.5650	-2.6333
5.11	3.5300	-3.8000	-0.1333*
5.12	-4.6650	-5.1350	-4.8500
5.13	-2.1850	1.4350	-0.3833*
5.14	8.3700	0.8000	5.2500
5.15	4.6000	-2.4000	1.1000*
6.7	-7.6650	-5.5800	-6.6166
6.8	-2.2500	-6.1650	-4.2166
6.9	-4.8650*	3.1850	-0.8333*
6.10	-12.5200*	2.0000	-5.2500
6.11	0.9700	2.1000	1.5333
6.12	-5.0850	-4.4700	-4.5166
6.13	-2.2000	0.6350	1.5333
6.14	-1.4000**	-0.2000	-0.7833
6.15	17.4350**	2.4300	-1.6333**
7.8	17.4350**	2.4300	9.9333**
7.9	15.3700*	1.4650	8.4166*
7.10	-3.8000	0.2800	-1.8166
7.11	-3.0650*	-0.0350	-1.5666**
7.12	11.8300*	7.1000	9.4666**
7.13	4.7000	0.9350	2.8166
7.14	-1.5300	-0.9000	-2.0333
7.15	-1.0650	6.6650	2.8000
8.9	-3.8350	1.8850	-0.9833
8.10	-4.4300	1.5500	-1.2166
8.11	2.7800	0.6000	1.6833
8.12	-4.9300	-2.1000	-3.5166
8.13	-2.2850	-3.8300	-3.1000
8.14	1.8350	5.9350	3.8833
8.15	-3.3350	1.4500	-0.9333
9.10	7.7200	-4.0500	1.8500
9.11	-5.5500	4.9000	-0.3166

Contd.,

Table 4.24 Contd.,

Parents/ Hybrids	Capsules-main stem		
	1980 kharif	1981 summer	Pooled
P9.12	-7.4200	-7.3650*	-7.4000**
9.13	3.6650	8.1850	6.7500**
9.14	-0.7350	3.2000	1.2333
9.15	0.5650	0.1800	0.3833
10.11	0.2850	-3.5000	-1.6000
10.12	5.2500	3.7000	4.4666
10.13	-7.6000	6.7650	-0.4166
10.14	4.6700	-4.3800	0.1333
10.15	-8.5650	3.3150	-2.7000
11.12	-0.9350	-6.6000	-3.7833
11.13	-1.9350	-3.2700	-2.6000
11.14	-6.5350	1.7000	-2.4166*
11.15	-3.0000	-8.3150	-5.6666*
12.13	0.6350	-0.9000	-0.1333
12.14	-6.5350	4.2000	-1.1666
12.15	2.1300**	4.3650	3.2666**
13.14	-19.4000**	2.3500	-6.5333**
13.15	2.0650	0.7500	1.4166
14.15	3.3650	5.1300	4.3333
SE(rij)	5.4437	3.9797	2.4106

* Significant at 5 per cent level

* Significant at 1 per cent level

Table 4.25. *gca*, *sca* and reciprocal effects

Parents/ Hybrids	Capsules-branches		
	1980 kharif	1981 summer	Pooled
<i>gca</i> effects of parents			
1	0.6443*	15.7592**	8.0570**
2	4.3276	12.7665	8.7281
3	1.4706	-0.8461	0.5437
4	6.6513**	-0.8301	3.1392**
5	-7.3570	-10.6758**	-9.2874**
6	2.3466	9.8042*	6.3970**
7	-1.7806	-4.6954*	-3.7429**
8	1.8199**	5.4425**	3.2292**
9	-6.5996**	-8.5118**	-7.5129**
10	-3.0893**	-7.9773**	-5.2951**
11	5.9803*	5.7488**	5.3659**
12	-4.1713*	-8.6941	-6.4185**
13	-4.5800	-2.1531	-3.1162
14	-1.3290**	-0.0951*	-0.8085
15	5.6663	-5.0424	0.7214
SE (<i>gi</i>)	1.8200	2.3043	1.0065
<i>sca</i> effects of hybrids			
Pl.2	-0.1776	-9.7685	-4.8381
1.3	1.2943	-13.4408	-5.9870
1.4	5.4636	4.2431	4.9340
1.5	4.4070	-2.2112	1.6774
1.6	6.6383	-3.5062	1.5596*
1.7	-7.7993	-11.4565	-8.8170
1.8	-2.2549	-10.2295	-5.5225**
1.9	2.2146	27.4598	14.3862**
1.10	1.8893	9.9901	6.0351
1.11	-3.8653	12.1641	4.9574
1.12	-4.1786	-6.8378	-5.2081
1.13	-1.1199	2.8861	0.9562
1.14	-2.4409	4.0431	1.2151
1.15	-4.7463	-1.5245	-3.2314
2.3	3.2460	-3.3482	-0.2914
2.4	3.6653	-1.0292	1.0796
2.5	2.4436	5.0014	3.9896
2.6	-4.8149	-5.4635	-5.4781
2.7	5.1823	-0.5988	2.7785

Contd.,

Table 4.25 Contd.,

Parents/ Hybrids	Capsules-branches		
	1980 kharif	1981 summer	Pooled
P2.8	-3.9533	-1.0318	-2.1103
2.9	1.4363	9.8874	5.7318
2.10	-0.1439	7.8328	3.6474
2.11	3.4713	5.9918	5.2196*
2.12	9.5230	5.5348	7.5040
2.13	-3.1553	4.4088	0.3685
2.14	-6.6343	1.5208	-2.4892
2.15	-1.0996	-7.0818	-4.5192**
3.4	4.0073	19.1134	11.2640**
3.5	-0.3993	-0.4558	-0.2092
3.6	-3.1229	-1.5308	-3.1270
3.7	1.3693	0.5638	1.4129
3.8	-6.9963	-1.3192	-3.8092**
3.9	6.7883	12.3851	11.0162**
3.10	9.3780	-2.9345	2.9151
3.11	4.3083	-7.5655	-1.1959
3.12	0.0300	-6.3025	-3.2281
3.13	0.6036	7.3364	3.6529
3.14	-10.2823	-2.9315	-6.7381
3.15	-4.5776	-2.6392	-4.0848
4.5	-5.4349	9.6781	2.3451
4.6	-6.8536	-2.0018	-4.8059
4.7	-1.3263	1.0028	0.2840
4.8	2.7930	-6.2752	-1.4048
4.9	-3.7573	6.0192	1.5040
4.10	2.9623	-1.1655	0.6029*
4.11	0.4626	-16.6765	-7.6748*
4.12	0.5493	-1.7035	-0.2403
4.13	-2.3769	-6.3295	-4.6592
4.14	-5.4279	10.5974	2.6162
4.15	1.1116	-1.4482	-0.6303**
5.6	11.5696	15.9778	11.4040
5.7	0.0520	0.4634	5.2107
5.8	-3.3686*	3.0704*	0.5218*
5.9	-18.0789*	-26.4352*	-19.5025**
5.10	1.2206	10.1601	5.8962
5.11	-1.3589	18.8691	0.8685
5.12	-6.7773	-2.2528	-4.0970
5.13	2.0163	-7.8288	-2.7159
5.14	13.9803	-9.3218	5.3596*
5.15	9.0500	9.5554	9.3462*
6.7	-2.9016	12.0984	4.9262
6.8	-1.7073	1.2254	0.0707
6.9	3.6473	7.8298	5.2296

Table 4.25 Contd.,

Parents/ Hybrids	Capsules-branches		
	1980 kharif	1981 summer	Pooled
P6.10	-9.0479	-15.6698	-12.7381**
6.11	8.8673	-13.8808	3.3174*
6.12	11.1348	4.2621	7.5018*
6.13	-0.5223	9.5861	4.1329
6.14	-5.9883	-1.8368	-3.9748
6.15	-4.7686	5.4104	-0.2214
7.8	-5.2449	-3.6598	-3.4059
7.9	1.3746	0.4494	-0.7470
7.10	-6.3356	-4.1702	-4.8148
7.11	7.7596	3.5388	2.2407*
7.12	-13.0836	-3.9882	-7.8748*
7.13	8.8550	-2.1742	0.5729
7.14	1.2690	10.1328	6.4651
7.15	8.3436	5.6301*	7.2518
8.9	9.0740	22.3414*	7.1307*
8.10	10.5636	7.6568	9.4462
8.11	0.8940	-4.5842	1.4518
8.12	3.9956	7.2938	6.2029
8.13	0.9693	-5.9822	-2.1325
8.14	-1.4616	4.6248	0.6596
8.15	-5.3569	-9.4228	-7.2370
9.10	-4.8666	4.4961	0.1051
9.11	5.2363	-9.2298	0.2607
9.12	-1.3846	-5.9868	-5.9548
9.13	-1.1909*	-3.3428	-1.1570
9.14	19.3230*	-15.6158	1.7851
9.15	9.4926	1.6585	3.8551
10.11	10.5333	0.5854	6.4262*
10.12	-11.3799	-4.1215	-7.8392
10.13	-4.7713	1.7724	-1.8248
10.14	-2.8523	15.2144	6.2007
10.15	11.3473	-9.9082	0.2540
11.12	7.2153	12.5824	6.9329
11.13	1.0290	4.0114	6.0474
11.14	2.5430	5.7184	0.5062
11.15	-11.6873	-0.5342	-5.8570
12.13	6.7306	-2.5155	2.0151
12.14	3.2596	-3.6035	0.0740**
12.15	3.9993	11.9438	10.7440
13.14	-4.4966	-8.2945	-6.3781
13.15	-4.5569	1.3228	-2.1081
14.15	-3.7429	4.7248	0.3507
SE(Sij)	8.4392	10.6849	3.7756

Contd.,

Table 4.25 Contd.,

Parents/ Hybrids	Capsules-branches		
	1980 kharif	1981 summer	Pooled
Reciprocal effects of hybrids			
Pl.2	11.1700	-14.6500	-1.7500
1.3	1.5150*	3.9650	2.7500
1.4	-15.0650	1.1350	-6.9666
1.5	1.8000	11.8350	6.8166
1.6	-0.4650	3.0500	1.2833
1.7	0.9000	-0.5000	0.2000
1.8	3.2150	10.2650**	6.7333**
1.9	-1.0350	29.4700	14.9333**
1.10	-3.2200	-5.1350	-4.1666
1.11	0.0650	-13.5650	-6.7500
1.12	1.3300	7.1500	2.9000
1.13	-4.4800	9.6150	2.5666
1.14	1.4500	12.0700	5.3000
1.15	-0.2000	2.6850	1.2500
2.3	7.6500	-1.9350	2.8500
2.4	1.1200	-5.4700	-2.1833
2.5	2.7500	-6.4150	-1.8333
2.6	-3.3650	-0.6000	-1.9833
2.7	1.9650	10.0350	6.0000
2.8	3.9700	-3.8000	0.0833**
2.9	7.4000	20.635	13.3833
2.10	6.3000	-9.0150	-1.3833
2.11	11.4850	-4.8700	3.3166
2.12	1.9850	7.7700	4.8853*
2.13	-3.6300	-12.4150	-8.0166*
2.14	1.0000	-12.7850	-5.9000
2.15	-10.8700	5.9650	-2.4333
3.4	-2.8350	-1.4000	-2.1166
3.5	-0.7500	-8.0850	-4.4166
3.6	7.7300	-2.6500	2.1166
3.7	6.6350	-12.6850	-3.0166
3.8	0.0700	-7.1000	-3.5333
3.9	6.9650	4.4500	4.1833
3.10	-6.4650	1.8650	-2.3000
3.11	3.8650	-3.9000	-0.0166
3.12	-3.9650	2.1500	-0.9000
3.13	-5.5300	-5.1000	-5.3166
3.14	3.4350	0.9500	2.3666
3.15	0.0650	4.9650	2.5166
4.5	6.2350	1.1650	3.7000
4.6	3.8200	2.6650	3.2333
4.7	-0.8500	15.0000	7.3166

Table 4.25 Contd.,

Parents/ Hybrids	Capsules-branches		
	1980 kharif	1981 summer	Pooled
P4.8	9.1000	7.9000	8.5000*
4.9	-5.8700	-5.3000	-6.0666
4.10	4.9000	-2.5500	1.1833
4.11	-0.1300	2.4650	1.1666**
4.12	8.2650	12.5350	10.8166
4.13	-2.3300	1.7500	-0.3000
4.14	8.3300	1.6350	4.9833
4.15	1.5350	0.0500	0.8000
5.6	12.8650	-0.9700	3.4500
5.7	-3.6500	-1.3150	-2.4833
5.8	-0.2000	-6.0000	-2.9333
5.9	0.0000	0.0000	-2.3666
5.10	-3.5500	-15.3300	-9.4500
5.11	0.9000	8.8350	-3.9500
5.12	1.4700	0.0000	0.7333
5.13	2.0850	-15.5650	-6.7500**
5.14	-8.3300	-19.6000*	-11.4666**
5.15	9.5350	-22.0000*	-6.2166
6.7	9.5000	-16.6300	-3.5500
6.8	-8.6350	-1.2350	-4.8666
6.9	-5.7000	12.0150	3.6166*
6.10	1.9850	14.9500	8.4666
6.11	-4.5700*	-0.8350	2.7833
6.12	-15.7850*	7.065	-4.3166
6.13	5.6200	4.2000	4.9166
6.14	-2.8650	8.4350	2.7833
6.15	-2.8800	1.7350	-0.5666
7.8	-10.1700	6.5500	-1.8500**
7.9	-16.1000	-13.6550	-12.6000**
7.10	3.1000	14.3800	8.7500
7.11	-10.1350	14.3150	-2.5000
7.12	-9.4000	-3.7150	-6.5666
7.13	6.0000	-0.6000	5.8833*
7.14	-8.9350	-7.3650	-8.1500
7.15	-12.6650	2.3850	-5.1333
8.9	1.2700	0.2350	-3.9833
8.10	-5.8700	5.3150	-0.2833
8.11	3.2000	3.3700	5.5166
8.12	2.2500	1.2650	1.7500
8.13	4.3850	8.2700	6.2833
8.14	10.4650	1.6650	4.3166
8.15	-10.6350	1.2000	-4.7166
9.10	-2.4200	5.9000	2.1333
9.11	-5.9500	0.8300	4.3166

Contd.,

Table 4.25 Contd.,

Parents/ Hybrids	Capsules-branches		
	1980 kharif	1981 summer	Pooled
P9.12	12.3200	-4.4300	1.5500
9.13	-2.4650	5.1150	2.5166**
9.14	-12.3000	-9.0000	-10.9333**
9.15	0.0650	-2.6500	-1.0666**
10.11	-13.0000	-11.2800	-11.7000**
10.12	-3.7350	-6.1700	-4.9500
10.13	-7.2650	6.8650	-0.2000
10.14	-2.2350	-2.7650	-2.5000
10.15	5.3000	-0.7350	2.2833
11.12	2.6000	-5.2000	2.2500
11.13	-1.9350	5.2300	-1.4666
11.14	-0.8300	-8.5350*	-0.3000**
11.15	-1.4650	-19.7350	-10.6000**
12.13	2.9150	-2.8000	0.0500
12.14	5.1350	-9.4300	-2.1500
12.15	-0.8700	6.2300	-0.6500
13.14	-0.1000	-5.6800	-2.9000
13.15	-7.2350	-0.6500	-3.9333
14.15	-3.2300	6.5500	1.6666
SE(rij)	7.0490	8.9248	4.0350

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.26. gca, sca and reciprocal effects

Parents/ Hybrids	Capsules/plant		
	1980 kharif	1981 o summer	Pooled
gca effects of parents			
1	-7.5017**	16.2638**	4.3894**
2	-1.9777	12.3944**	5.2105
3	0.3598**	-3.1645	-1.3172**
4	10.7768*	-1.3005	4.8305**
5	-4.8714	-11.2828**	-8.0883*
6	-4.1684**	11.7388	3.5860*
7	9.7645	-3.3805	3.1405
8	-3.5727*	5.0391	0.7327
9	-4.9584*	-3.5698*	-4.1928**
10	2.4295	-7.0975	-2.3594
11	1.8318	2.6574*	2.2571*
12	-0.5464*	-5.7695	-3.1072**
13	-6.6307	-3.2462	-4.4494
14	4.1368*	-0.5578**	1.1194
15	5.3782	-8.7242	1.7517
SE (gi)	2.3770	2.7792	1.2905
sca effects of hybrids			
Pl.2	8.0947	-8.4898	-0.2660
1.3	9.2921	-15.1158	-2.2549
1.4	6.1451	9.2702	7.8472
1.5	2.6534	-5.4124	-1.4338
1.6	12.9704	-3.7141	4.5417*
1.7	-15.4925	-13.1798	-14.3460**
1.8	2.3247	-15.8994	-6.8549*
1.9	-3.1195	22.9445	9.7705
1.10	-2.8775	12.5522	4.8539*
1.11	1.2201	18.7172	9.8872
1.12	-8.2715	-9.8408	-7.4982
1.13	-14.6172	4.1508	1.9605
1.14	1.6801	3.7275	-6.2916
1.15	-2.4262	1.8838	-0.2538
2.3	7.4531	-2.2614	2.4572
2.4	-0.6488	-0.8754	-0.9071
2.5	-1.9505	5.8918	1.9283
2.6	-0.3835	-7.2798	-3.9127
2.7	-1.4715	-0.6454	-1.0505
2.8	-0.5642	0.0348	-0.3260

Contd.,

Table 4.26 Contd.,

Parents/ Hybrids	Capsules/plant		
	1980 kharif	1981 summer	Pooled
P2.9	-2.4485	3.0438	0.1661
2.10	2.8684	4.2915	3.5661
2.11	6.0461	9.4215	8.4828
2.12	7.1444	1.6935	4.3139
2.13	-3.9912	7.5352	1.2228
2.14	-13.4738	8.3518	-1.9460
2.15	-1.9502	-5.3968	-3.6582**
3.4	3.1934	23.0335	12.8872**
3.5	-1.6882	-1.4841	-1.7105
3.6	-2.2262	-1.4058	-1.9849
3.7	1.0607	4.0685	2.4772
3.8	-10.4368	-1.2711	-5.9482
3.9	9.0187	8.2228	8.4105
3.10	-1.7092	-5.4644	-3.7060
3.11	6.0584	-10.5544	-2.4060
3.12	-4.4982	-7.0124	-5.9416
3.13	1.3138	9.0942	3.6839
3.14	-2.0465	-2.6741	-1.0016
3.15	-2.1878	-1.5878	-1.9138
4.5	-3.7052	11.9368	3.9750
4.6	-11.4382	-4.6348	-7.6160
4.7	0.0237	2.2195	1.0294
4.8	3.6811	-6.6281	-1.5627
4.9	-11.3982	-3.3911	-6.7538
4.10	8.1437	1.9515	5.3794
4.11	2.5564	-20.3034	-9.0205
4.12	2.2197	-1.1564	0.2439
4.13	-3.2958	-7.4698	-6.0138
4.14	-2.0985	12.3268	5.6339
4.15	0.5951	-2.8218	-1.1782*
5.6	4.9401	16.6125	11.3528
5.7	6.0071	2.5818	4.3150
5.8	-9.9055	5.5172*	-2.2438*
5.9	7.1101	-27.8438	-10.4849*
5.10	-2.7278	12.6838	4.9817
5.11	-4.7102	2.5638	-0.9849
5.12	-3.4318	-2.0091	-2.8205
5.13	5.1524	-3.5324	0.2717
5.14	8.5197	-9.2858	0.0861
5.15	4.6434	10.0805	7.4072
6.7	-2.9608	8.5952	2.7905
6.8	-0.7085	0.2255	-0.3182
6.9	1.8921	7.6995	4.6405**
6.10	-7.1608	-19.2578	-13.2594

Contd.,

Table 4.26 Contd.,

Parents/ Hybrids	Capsules/plant		
	1980 kharif	1981 summer	Pooled
P6.11	15.4667	1.8872	8.5239
6.12	7.8501	2.6342	5.1050
6.13	-1.9005	6.9458	1.9472
6.14	-14.5682	-0.6774	-7.0382
6.15	-6.7595	7.0538	0.1494
7.8	-2.2415	-7.4481	-4.8394
7.9	5.4791	0.1538	2.7361
7.10	-0.5438	-7.4834	-3.9971
7.11	5.4837	-5.3734	0.0528
7.12	-4.3678	10.9685	3.2505
7.13	11.9864	-9.9348	0.5261
7.14	-1.1512	7.8768	4.0239*
7.15	9.5374	10.9582	10.3283*
8.9	6.7814	20.1492	14.1772
8.10	8.1234	6.3268	7.1105
8.11	2.1911	3.8718	2.9605
8.12	0.9694	1.9688	1.3583
8.13	2.4237	-2.9194	-0.7994
8.14	-4.7138	10.1922	3.3483
8.15	-2.0202	-9.8614	-5.9138
9.10	1.8791	-1.6641	-0.0305
9.11	-11.1532	-1.0141	-6.2805
9.12	-2.1148	-9.6571	-6.0660
9.13	0.9044	-3.2804	-1.8071
9.14	3.6067	-17.4688	-6.3927
9.15	4.8954	-14.2374	-4.7216
10.11	11.2387	7.7436	9.4528
10.12	-8.4978	-9.1294	-8.8827
10.13	-6.5835	-6.9178	-7.2738
10.14	-6.4862	12.8088	3.8072
10.15	13.1424	-10.9098	1.1617
11.12	5.1997	10.9505	7.9672
11.13	-1.1008	14.6572	6.2261
11.14	4.6814	-3.0261	1.4905
11.15	-15.1948	0.9582	-7.0882
12.13	8.1074	-3.8808	1.5239
12.14	10.8897	2.6308	7.3217
12.15	2.4884	11.0972	6.7594
13.14	1.5091	-11.6574	-4.9527
13.15	-2.9622	7.7855	1.9994
14.15	-4.4948	2.1438	-0.8649
SE(sij)	11.0218	12.8871	4.8409

Contd.,

Table 4.26 Contd.,

Parents/ Hybrids	Capsules/plant		
	1980 kharif	1981 summer	Pooled
Reciprocal effects of hybrids			
Pl.2	12.3350	-21.0350	-4.3500
1.3	7.5300*	5.2500	6.6000*
1.4	-23.0000*	0.9000	-11.3500
1.5	0.6000	17.4350	9.0166
1.6	-0.6300	6.1150	2.7333
1.7	-4.4500	-2.4300	-3.4333
1.8	4.5700	8.8700*	6.7166**
1.9	-4.4000	31.2350	13.4166**
1.10	-4.7700	-1.3850	-3.1000
1.11	-3.0700	-18.5650	-10.8166
1.12	-3.2000*	9.3500	1.4000
1.13	-24.5700*	9.6350	0.2833**
1.14	-14.1650	5.7000	-13.8333**
1.15	-0.9000	3.5500	1.3333
2.3	3.9850	-2.5650	0.7000
2.4	-1.7300	-5.5150	-3.6166
2.5	1.5500	-9.1300	-3.8000
2.6	-3.7000	-1.7500	-2.7333
2.7	-0.6350	10.9650	5.1500
2.8	5.2650	-10.2650*	-2.5000**
2.9	5.6650	21.9350*	13.8000**
2.10	-5.0000	-9.0150	-7.0000
2.11	12.4200	-7.6000	3.2666
2.12	-0.2000	9.9150	4.8666
2.13	-4.5800	-16.1500	-10.3666
2.14	-2.1350	-12.0850	-7.1000
2.15	-14.5700	11.2000	-1.6833
3.4	-10.3500	-3.6350	-6.9833
3.5	-3.6500	-14.4650	-9.0666
3.6	11.6350	-3.2350	4.2000
3.7	10.0350	-13.7500	-1.8500
3.8	-1.4000	-8.4700	-4.9833
3.9	3.2000	3.0850	3.1500
3.10	-2.0000	0.8000	-0.6000
3.11	7.9700	-3.2650	2.3500
3.12	-8.9650	5.1200	-1.9166
3.13	-7.4650	-7.3500	-7.8333
3.14	-12.2300	1.7300	-6.0833
3.15	-2.0700	5.1300	1.5333
4.5	5.0200	-0.3200	2.3333
4.6	7.5000	3.1300	4.7166
4.7	-1.3850	13.5350	6.0833

Contd.,

Table 4.26 Contd.,

Parents/ Hybrids	Capsules/plant		
	1980 kharif	1981 summer	Pooled
P4.8	11.8650	12.5550	12.1500*
4.9	-12.2000	-2.9350	-6.7000
4.10	0.4700	-2.7200	-1.5666
4.11	3.8150	6.0800	4.9500
4.12	8.3700	10.1000	9.1500
4.13	-5.5000	-0.0500	-2.7833
4.14	-1.5350	-2.9350	-2.2333
4.15	3.8700	1.8200	2.8500
5.6	10.5700	-1.0650	5.4000
5.7	-13.6500	-5.9150	-9.7833
5.8	3.0300	-7.2000	-2.0833
5.9	-5.8000	4.7000	-0.5500*
5.10	-4.2500	-19.9000	-12.0833*
5.11	4.4300	-12.7350	-4.0000
5.12	-3.2000	-5.1350	-4.1666
5.13	-0.4300	-14.1350	-7.2833
5.14	0.0350	-13.8000*	-6.7333
5.15	14.1300	-24.4000*	-5.1166*
6.7	1.8350	-22.1800	-10.1666*
6.8	-10.8800	-7.2700	-9.0833
6.9	-10.8650	13.6650	1.5500
6.10	-10.8300	16.9500	3.0500
6.11	-3.6000*	12.2000	4.3166
6.12	-20.8650	2.6000	-9.1333
6.13	6.3000	6.5650	6.4333
6.14	-5.0700	7.2300	1.0833
6.15	-4.2800	1.5350	-1.3666
7.8	7.2700	8.9850	8.1166
7.9	-0.7350	-12.2000	-6.4666
7.10	4.3000	14.5650	9.4333
7.11	-13.2000	4.8300	-4.2000
7.12	2.4300	3.3850	2.9000
7.13	10.7000	6.7650	8.7333*
7.14	-10.4700	-9.9350	-10.2000
7.15	-13.4000	9.0500	-2.1666
8.9	-4.2300	10.1150	3.7666
8.10	-9.9000	6.9350	-1.4000
8.11	5.9700	8.4350	7.2000
8.12	-2.7000	-0.8350	-1.7666
8.13	2.0000	4.0000	3.0000
8.14	12.3000	7.6000	9.9500
8.15	-13.9650	2.6500	-5.6500
9.10	5.2700	1.8650	3.5333

Contd.,

Table 4.26 Contd.,

Parents/ Hybrids	Capsules/plant		
	1980 kharif	1981 summer	Pooled
P9.11	-11.5000	16.2000	2.4000
9.12	4.9000	-11.8000	-3.4500
9.13	1.8350	13.3000	7.5666
9.14	-11.3650	-5.8000	-8.5833
9.15	0.6350	-2.4650	-0.9166*
10.11	-12.7200	-13.9000	-13.3000
10.12	6.8650	-2.4700	2.2000
10.13	-10.4650	1.3350	-4.5666
10.14	2.4000	-7.4800	-2.5500
10.15	-3.4000	2.3350	-0.5333
11.12	1.6650	-4.6350	-1.5000
11.13	-3.8500	-4.2650	-4.0500
11.14	-7.3700	1.8000*	-2.7166**
11.15	-4.4650	-28.0500*	-16.2666**
12.13	3.5500	-3.7000	-0.0833
12.14	-1.4000	3.7700	1.1833
12.15	1.3000	10.6000	5.9500
13.14	-15.5350	-3.3350	-9.4333
13.15	-5.1650	0.1000	-2.6500
14.15	0.2000	11.7700	5.6500
SE(rij)	9.2062	10.7642	5.1735

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.27. gca, sca and reciprocal effects

Parents/ Hybrids	Seed yield		
	1980 kharif	1981 summer	Pooled
gca effects of parents			
1	-1.4318**	1.1210*	-0.0694**
2	0.0971	2.4113**	1.1849*
3	-0.3081**	-0.3640	-0.4383**
4	1.5751*	-0.2750	0.6671**
5	-1.1965*	-1.4150**	-1.1972**
6	-0.7231**	1.0040*	4.9629**
7	1.7468**	-0.5500	0.7294
8	-0.1411	0.5663*	0.1794**
9	-0.3985	-0.8916*	-0.6483*
10	-0.4295	-0.6736	-0.5105*
11	0.9118	0.0970	0.5294
12	-0.1438	-0.1510	-0.1461
13	-0.6565	0.1836	-0.2417
14	0.5104	-0.4236	0.0177
15	0.5878	-0.6393	-0.0611
SE (gi)	0.4561	0.3934	0.1838
sca effects of hybrids			
p1.2	1.0898	-1.2506	-0.0882
1.3	0.7951	-0.8403	0.5017
1.4	0.3968	-0.0843	0.0794
1.5	2.0335	-1.2093	0.2272
1.6	1.0901	2.4016	1.9250**
1.7	-2.6898	-2.1093	-2.6160
1.8	-0.9018	-0.6406	-0.8160
1.9	-1.2944	1.7823	0.1783
1.10	-0.2334	2.2643	0.8905
1.11	-0.7248	0.9286	-0.0327
1.12	-0.1691	-1.7733	-1.0405
1.13	0.2435	0.8570	0.4883
1.14	1.1115	-0.4806	0.2662
1.15	0.6141	1.5500	1.0411
2.3	0.5161	-0.7356	-0.1527**
2.4	3.0338	0.8253	2.0083
2.5	-1.0254	3.3333	-0.5105**
2.6	0.0161	-2.9186	-1.9460
2.7	-0.4588	-0.6796	-0.6205
2.8	-0.0358	0.4540	0.3294

Contd.,

Table 4.27 Contd.,

Parents/ Hybrids	Seed yield		
	1980 kharif	1981 summer	Pooled
P2.9	1.2915	0.2420	0.8739
2.10	-0.0974	0.8240	0.3861
2.11	-0.1538	0.0233	-0.0205
2.12	1.4018	0.6513	1.0883
2.13	-1.4554	0.1716	-0.5494
2.14	-1.1874	0.8940	-0.0421
2.15	-1.6148	1.0746	-0.4466*
3.4	0.1881	2.7706	1.5983
3.5	-0.3751	-0.2543	-0.3038
3.6	-0.4634	0.2216	0.1105
3.7	-0.7534	1.0406	0.1361
3.8	-0.7604	-0.7056	-0.5971
3.9	0.0268	0.7023**	0.4805
3.10	0.4578	-6.6666	0.3094
3.11	-0.9634	-0.2713	-0.5471
3.12	1.0921	-0.1883	0.5617
3.13	-0.5951	2.4420	1.0239
3.14	-0.4471	-2.2156	-1.2021
3.15	1.1985	-0.9700	-1.1566
4.5	-0.8934	0.1366	-0.4927*
4.6	-1.9318	-1.1323	-1.3949*
4.7	0.1631	-0.1283	-0.1527
4.8	-0.3088	-1.8096	-1.0194
4.9	-2.1914	0.5283	-0.8416
4.10	0.2295	-0.8046	-0.3294
4.11	-0.9168	-0.8253	-0.9027
4.12	-0.0411	2.0226	0.9894
4.13	0.0365	-1.4970	-0.7316
4.14	-0.8604	1.8753	0.5255
4.15	1.9721	-1.2840	0.4378
5.6	0.1398	0.7576	0.5028
5.7	0.6398	1.7816	0.9783
5.8	0.3578	0.5453	0.3783*
5.9	0.4801	-3.3966	-1.5438*
5.10	-0.7688	0.9853	0.3850
5.11	-0.3951	1.2846	0.3117
5.12	-0.3894	1.6626	0.5539
5.13	0.5581	-1.9520	-0.7838
5.14	1.7561	-0.9346	0.3400
5.15	0.6861	1.5160	1.3355
6.7	0.2665	1.4776	0.8928
6.8	-0.2304	-0.9036	-0.3905
6.9	-0.8231	0.4343	-0.0627

Contd.,

Table 4.27 Contd.,

Parents/ Hybrids	Seed yield		
	1980 kharif	1981 summer	Pooled
P6.10	-0.7071	-2.1836	-1.3338
6.11	1.6665	-0.0693	0.9094
6.12	-0.9428	8.6666**	-0.3316
6.13	0.0348	0.8240	0.5972
6.14	-1.9121	0.1963	-0.6955
6.15	1.9755	1.8170	0.4667
7.8	0.5495	-1.9346	-0.7816
7.9	1.5268	-0.1466	0.5794
7.10	0.6228	-1.5296	-0.6249
7.11	2.4115	0.1496	1.1350
7.12	0.0871	0.6176	0.2272
7.13	0.5148	-2.4870	-1.0605
7.14	0.8521	2.3853	0.6133*
7.15	-1.0094	0.4060	1.5255
8.9	0.4598	2.1220	1.3461
8.10	1.2108	0.9399	1.0750
8.11	-0.0304	0.1533	0.0683
8.12	-0.8448	-0.6486	-0.7227
8.13	1.1378	-0.7333	0.2561
8.14	-0.7641	1.3690	0.3800
8.15	0.1735	-1.1803	-1.0744
9.10	-1.2368	-0.1380	-0.7138
9.11	-1.6581	-0.1236	-0.9038
9.12	-0.2674	-0.1456	-0.1949
9.13	0.9451	-0.2453	0.3672
9.14	0.8081	-1.2530	-0.1921
9.15	1.9008	-2.0923	-0.2632**
10.11	2.7578	2.3733	2.5250
10.12	-0.4364	-0.6436	-0.5660
10.13	-0.2788	-1.5133	-0.9205
10.14	4.1777	1.2090	0.6200
10.15	0.8818	-1.8753	-0.4844
11.12	1.6721	-1.1843	0.2272
11.13	-0.4501	0.4460	-0.1438
11.14	0.1978	0.0433	0.1300
11.15	-1.8944	-0.3110	-0.6577
12.13	-0.5244	0.1640	-0.1682
12.14	1.3685	-0.4486	0.4889
12.15	-1.3688	1.5870	0.0678
13.14	-0.9788	-1.3483	-1.1155
13.15	-0.1761	0.4823	0.0967
14.15	-0.2581	-0.0553	-0.5710
SE(Sij)	2.1154	1.8244	0.6896

Table 4.27 Contd.,

Parents/ Hybrids	Seed yield		
	1980 kharif	1981 summer	Pooled
Reciprocal effects of hybrids			
Pl.2	1.8200	-4.4650*	-1.3333
1.3	2.3800	0.0000	1.1666**
1.4	-3.0350	-1.3850	-2.2166**
1.5	0.7300	0.0500	0.4000
1.6	-0.3000	2.1500	0.8000
1.7	-0.3500	-0.6150	-0.4833
1.8	0.4500	1.5000	0.9666
1.9	-1.0000	1.2650	0.1333
1.10	-0.6300	1.5350	0.4500
1.11	-0.5500	-1.5700	-1.0000
1.12	-0.5800	0.0800	-0.2500
1.13	-1.1500	1.9850	0.4166
1.14	-2.3850	0.4000	-0.9833
1.15	-0.3350	2.0150	0.8500*
2.3	-1.1300*	-1.6350*	-1.6000**
2.4	-4.2700*	-3.1150	-3.7000
2.5	-0.4000	-2.2500	-1.2833
2.6	0.1850	-0.6800	0.4833
2.7	-1.6500	-0.1350	-0.9000
2.8	1.8150	0.1150	0.9666**
2.9	2.6150	2.7850	2.7500
2.10	0.3350	-1.8150	-0.7333
2.11	0.9500	-1.4850	-0.2666**
2.12	-1.2800	-1.5350	-1.9000**
2.13	0.6500	-1.8500	-0.6000
2.14	-0.4850	-2.1350	-1.3000
2.15	0.3350	-1.0700	-0.6500
3.4	-2.5500	0.0150	-1.2666
3.5	-0.7850	-2.0500	-1.4000
3.6	0.9000	-1.2150	-0.1500
3.7	0.2500	-1.7500	-0.7666
3.8	-0.7850	-1.4200	-1.0833
3.9	-0.2850	1.9700	0.8666
3.10	0.9850	-0.4150	0.3000
3.11	0.8650	1.6150	1.2500
3.12	-2.6350	1.5500	-0.5500**
3.13	-0.8650	-3.0150	-1.9500**
3.14	-1.1200	-0.0200	-0.5500
3.15	2.7350	0.4500	0.1500
4.5	0.9500	-1.3300	-0.1833
4.6	1.2850	0.1500	0.7166
4.7	0.0500	1.5700	0.7833

Contd.,

Table 4.27 Contd.,

Parents/ Hybrids	Seed yield		
	1980 kharif	1981 summer	Pooled
P4.8	2.3500	0.5650	1.4666*
4.9	-1.1500	1.3850	0.1166
4.10	-1.1000	-0.9300	-1.0000
4.11	1.1650	1.6200	1.4000
4.12	2.6150	0.5800	1.6166
4.13	-0.0200	-0.1650	-0.1000
4.14	0.2500	-0.2000	0.0166
4.15	0.0000	0.0350	0.0166
5.6	2.4850	0.4300	1.4166**
5.7	-2.7150	-2.3000	-2.5166**
5.8	2.7850	-0.1200	1.3333
5.9	-1.1500	-0.2500	-0.7166*
5.10	-0.1300	-1.9500	-1.4500
5.11	-0.6150	-1.9500	-1.2833
5.12	0.2350	0.5800	0.4166
5.13	0.0700	-1.4000	-0.6500
5.14	0.8650	-1.7500	-0.4333
5.15	-0.1700	-2.9850	-0.5833
6.7	0.0150	-1.5150	-0.7666
6.8	-1.4000	-1.3500*	-1.3666
6.9	-0.5800	3.4700	1.4333
6.10	-0.8650	2.6000	0.8666
6.11	-0.2200	1.7850	0.7833
6.12	-0.1850	-1.5850	-0.9000
6.13	1.2500	-1.0650	0.1000
6.14	-1.2000	0.4000	-0.4000
6.15	3.1650	0.7650	0.3500
7.8	0.4500	1.3350	0.9000
7.9	2.0000	-0.7350	0.6333
7.10	1.5350	0.5000	1.0333
7.11	-2.9350	0.7500	-1.1000
7.12	2.0150	1.2000	1.6166
7.13	3.2700	-0.0500	1.6000
7.14	0.1300*	-1.8650	-0.8000
7.15	-3.9500	1.8000	0.8333
8.9	1.1150	-0.0800	0.5166
8.10	-0.8350	-0.9150	-0.8833
8.11	0.7350	0.0000	0.3500
8.12	-0.8350	-0.5500	-0.6833
8.13	1.5650	0.2300	0.9000
8.14	2.2300	-0.0650	1.0833
8.15	-0.6150	0.7700	-0.7666
9.10	-0.7000	1.4800	0.4000
9.11	-2.1800	1.6300	-0.2833

Contd.,

Table 4.27 Contd.,

Parents/ Hybrids	Seed yield		
	1980 kharif	1981 summer	Pooled
9.12	2.2150	-2.3350	-0.0500
9.13	-0.5850	1.9300	0.6833
9.14	-1.8850	-0.3150	-1.0833
9.15	-1.2150	0.1000	-0.7666
10.11	-0.4350	1.2200	-1.3166
10.12	-1.4850	-1.0150	-0.2500
10.13	-1.0000	1.1500	0.1000
10.14	-0.2500	-1.6350	-1.2000
10.15	0.2350	-0.7350	0.2833
11.12	-0.7000	-0.4850	0.1500
11.13	-0.5300	-0.1500	-0.1166
11.14	-1.8150	0.1000	0.8500
11.15	-0.4700	-1.1700	-0.3833
12.13	0.3000	-1.4000	-1.3500
12.14	-1.3000	1.4000	1.3333
12.15	-0.4700	-1.2800	0.7666
13.14	-1.5000	0.7350	-0.4000
13.15	0.1800	0.8500	0.4000
14.15	0.9650	1.3650	0.7083
SE(rij)	1.7670	1.5239	0.7370

* Significant at 5 per cent level

** Significant at 1 per cent level

Table 4.28. Per se performance (status) score values - Kharif, 1980

Character	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Plant height	0	0	0	+1	-1	0	+1	0	-1	-1	-1	-1	0	+1	+1
Days to first flower	+1	+1	+1	+1	-1	+1	+1	0	-1	-1	0	-1	0	+1	0
Capsules-main stem	-1	-1	-1	+1	+1	-1	+1	-1	0	+1	-1	0	0	+1	0
Capsules-branches	0	0	0	+1	-1	+1	0	+1	-1	-1	0	-1	0	0	+1
Capsules/plant	0	0	0	+1	-1	0	+1	0	-1	0	-1	-1	0	+1	+1
Seed yield	+1	-1	-1	+1	-1	0	+1	0	0	-1	0	0	0	+1	+1
Total score	+1	-1	-1	+6	-4	+1	+5	0	-4	-3	-3	-4	0	+5	+4
Rank	5	9	10	1	13	6	2	7	14	11	12	15	8	3	4
Grade	H	L	L	H	L	H	H	L	L	L	L	L	L	L	H

H = High
L = Low

Table 4.29. Per se performance (status) score values - Summer, 1981

Character	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Plant height	+1	+1	-1	0	-1	+1	0	+1	0	0	-1	-1	+1	-1	0
Days to first flower	+1	+1	+1	+1	-1	+1	+1	0	-1	-1	0	-1	0	+1	0
Capsules-main stem	0	-1	-1	-1	0	0	0	-1	+1	+1	-1	+1	-1	-1	-1
Capsules-branches	+1	+1	+1	0	-1	+1	0	+1	-1	-1	0	-1	+1	0	0
Capsules/plant	+1	+1	0	0	-1	+1	0	+1	+1	0	-1	0	0	-1	-1
Seed yield	0	+1	-1	0	0	0	0	+1	0	0	-1	-1	+1	-1	-1
Total score	+4	+4	-1	0	-4	+4	+1	+3	0	-1	-4	-3	+2	-3	-3
Rank	1	2	9	7	14	3	6	4	8	10	15	11	5	12	13
Grade	H	H	L	L	L	H	H	H	L	L	L	L	H	L	L

H = High
L = Low

Table 4.30. gca effects score values - Kharif, 1980

Character	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Plant height	0	+1	-1	0	-1	+1	+1	+1	-1	-1	-1	-1	-1	+1	0
Days to first flower	0	+1	+1	-1	-1	+1	+1	+1	-1	-1	0	-1	0	+1	0
Capsules-main stem	-1	-1	-1	+1	+1	-1	+1	-1	0	+1	-1	+1	0	+1	0
Capsules-branches	0	+1	0	+1	-1	+1	0	0	-1	-1	+1	-1	-1	0	+1
Capsules/plant	-1	0	0	+1	-1	-1	+1	-1	-1	+1	0	0	-1	+1	+1
Seed yield	-1	0	0	+1	-1	-1	+1	0	-1	-1	+1	0	-1	+1	+1
Total score	-3	+2	-1	+3	-4	0	+5	0	-5	-2	0	-2	-4	+5	+3
Rank	12	5	9	3	13	6	1	7	15	10	8	11	14	2	4
Grade	L	H	L	H	L	L	H	L	L	L	L	L	L	L	H

H = High
L = Low

Table 4.31. gca effects score values - Summer, 1981

Character	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Plant height	+1	+1	-1	0	-1	+1	-1	+1	-1	-1	0	-1	0	-1	0
Days to first flower	0	+1	+1	-1	-1	+1	+1	+1	-1	-1	0	-1	0	+1	-1
Capsules-main stem	0	0	-1	-1	0	0	+1	0	+1	+1	-1	+1	0	-1	-1
Capsules-branches	+1	+1	0	0	-1	+1	-1	+1	-1	-1	+1	-1	0	0	-1
Capsules/plant	+1	+1	-1	0	-1	+1	-1	+1	-1	-1	0	-1	-1	0	-1
Seed yield	+1	+1	0	0	-1	+1	-1	+1	-1	-1	0	0	0	-1	-1
Total score	+4	+5	-2	-2	-5	+5	-2	+5	-4	-4	0	-3	-1	-2	-5
Rank	4	1	7	8	14	2	9	3	12	13	5	11	6	10	15
Grade	H	H	L	L	L	H	L	H	L	L	L	L	L	L	L

H = High
L = Low

Table 4.32. Ranks for parents based on per se performance and gca effects - Kharif, 1980

Character	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Plant height	A 8	6	10	3	15	5	1	7	14	11	13	12	9	2	4
	B 7	2	10	6	14	5	1	4	15	12	9	13	11	3	8
Days to first flower	A 6	5	2	7	15	3	1	9	13	16	8	12	10	4	11
	B 8	3	5	11	14	2	1	6	13	15	7	12	9	4	10
Capsules-main stem	A 14	12	10	5	3	12	2	13	8	4	15	7	9	1	6
	B 14	13	10	4	6	15	1	12	7	3	11	5	9	2	8
Capsules-branches	A 7	6	8	1	14	4	10	3	15	12	11	13	9	5	2
	B 8	4	7	1	15	5	10	6	14	11	2	12	13	9	3
Capsules/plant	A 11	9	10	1	13	7	4	5	14	6	15	12	8	2	3
	B 15	9	7	1	12	11	2	10	13	5	6	8	14	4	3
Seed yield	A 1	12	13	2	15	6	4	8	10	14	7	11	9	3	5
	B 15	6	9	2	14	13	1	7	10	11	3	8	12	5	4
Total score	A 47	50	53	19	75	36	22	45	74	61	69	67	54	17	31
	B 67	37	48	25	75	51	16	45	72	57	38	58	68	27	36
Rank	A 7	8	9	2	15	5	3	6	14	10	12	11	10	1	4
	B 12	5	8	2	15	9	1	7	14	10	6	11	13	3	4
Grand Total	114	87	101	44	150	87	38	90	146	118	107	125	122	144	67
Rank	10	5	8	2	15	6	1	7	14	11	9	13	12	3	4

A : Per se performance; B : gca effects

Table 4.33. Ranks for parents based on per se performance and yca effects--Summer, 1981

Character	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Plant height	A 1	4	12	10	15	3	6	2	7	9	11	13	5	14	8
	B 1	4	14	7	15	3	10	2	9	12	5	11	6	13	8
Days to first flower	A 5	4	2	7	15	3	1	9	13	14	8	12	10	6	11
	B 7	3	5	10	14	2	1	6	12	15	9	13	8	4	11
Capsules-main stem	A 7	12	11	8	5	6	4	9	1	2	15	3	10	13	14
	B 6	10	14	7	8	5	3	11	1	4	13	2	9	12	15
Capsules-branches	A 1	2	5	10	14	4	11	3	15	13	7	12	6	9	8
	B 1	2	8	7	15	3	10	5	13	12	4	14	9	6	11
Capsules/plant	A 1	2	6	11	15	4	8	5	3	10	14	9	7	12	13
	B 1	2	8	7	15	3	10	4	11	13	5	12	9	6	14
Seed yield	A 5	1	11	9	6	4	7	3	8	10	15	12	2	14	3
	B 2	1	9	8	15	3	11	4	14	13	6	7	5	10	12
Total score	A 20	25	47	55	70	24	37	31	47	58	70	61	40	68	57
	B 18	22	58	46	82	19	45	32	60	69	42	59	46	51	71
Rank	A 1	3	7	9	14	2	5	4	8	11	15	12	6	13	10
	B 1	3	10	7	15	2	6	4	12	13	5	11	8	9	14
Grand Total	38	47	105	101	152	43	82	63	107	127	112	120	86	119	128
Rank	1	3	8	7	15	2	5	4	9	13	10	12	6	11	14

A : Per se performance; B : yca effects

Table 4.34. Test of wr. Vr by t^2 test

Character	Season	t^2 value
Plant height	kharif 1980	0.0486**
	summer 1981	10.0176**
	pooled	2.1308
Days to first flower	kharif 1980	0.0428
	summer 1981	0.0219
	pooled	0.0243
Capsules on main axis	kharif 1980	5.7035**
	summer 1981	0.0205
	pooled	0.1748
Capsules on branches	kharif 1980	0.7941
	summer 1981	0.6848
	pooled	0.0117
Capsules/plant	kharif 1980	2.5460
	summer 1981	2.9411
	pooled	0.1176
Seed yield	kharif 1980	2.0641
	summer 1981	0.7089
	pooled	1.2678

* Significant at 5% level

** Significant at 1% level

Table 4.35. Test of the W_r-V_r slope for unity 't' values

Character	Season	b±SE	b/SE	t-b/SE
Plant height	kharif 1980	0.9501 ± 0.1057	9.0403**	0.4743**
	summer 1981	0.5578 ± 0.0770	8.5076**	4.4245
	pooled	0.8559 ± 0.0698	12.2516	2.0624
Days to first flower	kharif 1980	0.8358 ± 0.1371	6.0934**	1.1967
	summer 1981	0.8874 ± 0.1397	6.3525**	0.8053
	pooled	0.8791 ± 0.1447	7.0745	0.8352
Capsules on main axis	kharif 1980	0.4614 ± 0.1233	3.7406**	4.3656**
	summer 1981	0.9738 ± 0.0749	12.9939**	0.3483
	pooled	0.8961 ± 0.0950	9.4264	1.0927
Capsules on branches	kharif 1980	0.9772 ± 0.1588	6.1516**	0.1430
	summer 1981	0.8384 ± 0.1003	8.3543**	1.6099
	pooled	0.9813 ± 0.0622	15.7723	0.2990
Capsules/plant	kharif 1980	0.9076 ± 0.2919	3.1091**	0.3164*
	summer 1981	0.7778 ± 0.0866	8.9744**	2.5630
	pooled	0.8036 ± 0.1407	5.7087	1.3949
Seed yield	kharif 1980	0.7098 ± 0.1480	3.6338**	3.1197**
	summer 1981	0.7498 ± 0.2593	2.8914	0.9643*
	pooled	0.0193 ± 0.3771	0.0513	2.7029

* Significant at 5% level

** Significant at 1% level

Table 4.36. Estimate of genetic parameters (Plant height)

Parameter	1980 kharif	1981 summer	Pooled
D	251.557** ± 7.755	187.628** ± 19.360	145.001** ± 6.344
F	101.083** ± 17.233	30.385 NS ± 43.022	49.193** ± 14.098
H ₁	59.527** ± 14.407	103.924** ± 35.967	31.803** ± 11.786
H ₂	29.541* ± 11.633	101.650** ± 29.041*	22.958** ± 9.517
h ²	57.536** ± 7.770	66.424** ± 19.398	68.714** ± 6.357
E	39.421** ± 1.938	62.275** ± 4.840	26.030** ± 1.586
(H ₁ /D) ^{1/2}	0.486	0.744	0.468
H ₂ /4H ₁	0.123	0.244	0.180
KD/KR	2.407	1.244	2.135
² h/H ₂	1.953	0.653	2.992
Heritability (NS) (%)	69.6	56.1	66.7
r(Wr ± Vr), Yr	0.545*	0.418	0.794**

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

Table 4.37. Estimate of genetic parameters (Days to first flower

Parameter	1980 kharif	1981 summer	Pooled
D	13.826** ± 0.700	13.609** ± 0.712	13.466** ± 0.727
F	4.453** ± 1.555	5.874** ± 1.582	5.257** ± 1.616
H ₁	3.661** ± 1.300	3.714** ± 1.322	3.646** ± 1.351
H ₂	2.708** ± 1.050	2.366* ± 1.068	2.473* ± 1.091
h ²	0.383 NS ± 0.701	0.294 NS ± 0.713	0.369 NS ± 0.728
E	1.836** ± 0.175	1.597** ± 0.178	1.605** ± 0.181
(H ₁ /D) ^{1/2}	0.514	0.522	0.520
H ₂ /4H ₁	0.184	0.159	0.169
KD/KR	1.911	2.407	2.200
h ² /H ₂	0.141	0.124	0.149
Heritability (NS) (%)	73.7	73.9	74.5
r(Wr ± Vr), Yr	0.735**	0.673*	0.704**

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

Table 4.38. Estimate of genetic parameters (Capsules-main stem)

Parameter	1980 kharif	1981 summer	Pooled
D	92.363** ± 18.333	258.052** ± 10.363	93.904** ± 5.513
F	13.263 NS ± 40.739	408.126** ± 23.029	85.587** ± 12.252
H ₁	40.259 NS ± 34.059	231.603** ± 19.253	56.458** ± 10.243
H ₂	40.767 NS ± 27.500	66.874** ± 15.545	28.652** ± 8.270
h ²	6.349 NS ± 18.369	62.866** ± 10.383	30.410** ± 5.524
E	31.752** ± 4.583	16.197** 2.590	11.778** ± 1.378
(H ₁ /D) ^{1/2}	0.660	0.947	0.775
H ₂ /4H ₁	0.253	0.072	0.126
KD/KR	0.803	11.100	3.851
h ² /H ₂	0.155	0.940	1.061
Heritability (NS) (%)	62.3	31.1	60.5
r(Wr ± Vr), Yr	0.702**	0.899**	0.823**

* Significant at 5% level

** Significant at 1% level

Table 4.39. Estimate of genetic parameters (Capsules-branches)

Parameter	1980 kharif	1981 summer	Pooled
D	145.149** ± 19.178	375.100** ± 33.001	224.872** ± 10.060
F	92.272* ± 42.617	136.565 NS ± 73.333	136.375** ± 22.355
H ₁	97.970** ± 35.728	184.825** ± 61.307	132.671** ± 18.689
H ₂	74.843** ± 28.768	159.435** ± 49.502	91.898* ± 15.090
h ²	119.680** ± 19.215	49.125** ± 33.065	278.673** ± 10.079
E	57.316** ± 4.794	84.362** ± 8.250	33.811** ± 2.515
(H ₁ /D) ^{1/2}	0.831	0.701	0.768
H ₂ /4H ₁	0.190	0.215	0.173
KD/KR	1.599	1.700	2.304
h ² /H ₂	2.262	2.816	3.032
Heritability (NS) (%)	39.8	61.0	65.6
r(Wr ± Vr), Yr	0.807**	0.771**	0.912**

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

Table 4.40. Estimate of genetic parameters (Capsules/plant)

Parameter	1980 kharif	1981 summer	Pooled
D	154.558** ± 22.028	203.130** ± 26.399	60.941** ± 11.035
F	79.455 NS ± 48.949	4.674 NS ± 58.661	24.825 NS ± 24.521
H ₁	27.331 NS ± 40.992	193.645** ± 49.042	61.849** ± 20.500
H ₂	7.482 NS ± 33.042	154.585** ± 39.598	41.880* ± 16.552
h ²	31.613 NS ± 22.070	148.814** ± 26.450	94.655** ± 11.056
E	103.614** ± 5.507	124.339** ± 6.599	55.472** ± 2.758
(H ₁ /D) ^{1/2}	0.420	0.976	1.007
H ₂ /4H ₁	0.068	0.199	0.169
KD/KR	4.225	0.976	1.506
h ² /H ₂	4.144	0.962	2.260
Heritability (NS) (%)	34.6	49.8	33.5
r(Wr + Vr), Yr	0.032	0.150	0.726**

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

Table 4.41. Estimate of genetic parameters (Seed yield)

Parameter	1980 kharif	1981 summer	Pooled
D	3.880 ^{**} ± 0.481	5.252 ^{**} ± 0.727	1.875 ^{**} ± 0.315
F	0.441 ± 1.069	3.334 [*] ± 1.616	1.052 ± 0.700
H ₁	0.079 ± 0.894	4.429 ^{**} ± 1.351	1.236 [*] ± 0.581
H ₂	0.151 ± 0.721	2.996 ^{**} ± 1.091	0.774 ± 0.472
h ²	0.253 ± 0.482	0.569 ± 0.728	0.246 ± 0.315
E	2.779 ± 0.120	2.315 ^{**} ± 0.181	1.265 ^{**} ± 0.078
(H ₁ /D) ^{1/2}	0.142	0.918	0.811
H ₂ /4H ₁	0.477	0.169	0.159
KD/KR	1.677	2.056	2.055
h ² /H ₂	2.324	0.190	0.318
Heritability (NS) (%)	37.7	41.9	33.6
r(Wr ± Vr), Yr	0.048	0.150	0.260

* Significant at 5% level

** Significant at 1% level

Table 4.42. F_2 - Summer, 1982 (Plant height)

Generation	Number of observations	Mean	Range	PCV	GCV	GCV/PCV (Broad sense)	Heritability (Broad sense)	Genetic advance	G.a.as% of mean
High x high - 1									
KRR 2 x TMV 6									
P ₁	30	108.66±11.01	93-131						
F ₁	30	114.73±9.41	94-125						
P ₂	30	94.76±11.45	81-126						
F ₂	240	97.08±22.20	50-166	11.11	8.52	76.69	59.88	13.08	13.48
High x high - 2									
KRR 2 x S.i.2277 (Australia)									
P ₁	30	96.66±8.18	79-110						
F ₁	30	99.53±11.67	78.113						
P ₂	30	88.20±14.29	41-108						
F ₂	240	92.26±4.36	40-172	10.64	5.32	50.00	25.00	5.61	5.49
High x low - 1									
KRR 2 x S.i.2631 (Rajasthan)									
P ₁	30	97.30±14.48	54-124						
F ₁	30	104.96±11.20	84.129						
P ₂	30	68.40±16.67	41-93						
F ₂	240	91.88± 5.75	40-169	15.35	4.31	28.08	7.88	2.24	2.49
High x low - 1									
TMV 6 x S.i.2631 (Rajasthan)									
P ₁	30	97.66±12.54	70-17						
F ₁	30	104.20±12.59	80-127						
P ₂	30	68.46±13.78	43-90						
F ₂	240	88.36± 5.22	30-182	7.99	4.93	61.70	38.04	5.36	6.27
Low x low - 1									
S.i.2141 (Canada) x S.i.2631 (Rajasthan)									
P ₁	30	73.20±11.07	55-96						
F ₁	30	89.20± 6.46	67-95						
P ₂	30	73.60±13.90	45-96						
F ₂	240	75.74± 5.28	15-180	10.45	4.86	46.50	21.64	3.53	4.66
Low x low - 2									
S.i.2340 (Morocco) x S.i.2631 (Rajasthan)									
P ₁	30	88.83±11.80	70-108						
F ₁	30	93.03±10.02	59-116						
P ₂	30	78.00±14.11	43-98						
F ₂	240	79.66± 5.46	23-166	9.76	5.28	54.10	29.78	4.70	5.89

Table 4.43. F₂ - Summer, 1982 (Capsules - main stem [number])

Generation	Number of observations	Mean	Range	PCV	GCV	GCV/PCV (Broad sense)	Heritability (Broad sense)	Genetic advance	G.a.as% of mean
High x high - 1									
KRR 2 x TMV 6									
P	30	22.76±3.59	14-29						
F ₁	30	29.16± 2.47	25-34						
F ₁	30	23.03± 3.14	15-30						
F ₂	240	23.68± 2.28	5-73	15.03	6.08	40.45	16.37	1.20	5.07
High x high - 2									
TMV 2 x S.i.2277 (Australia)									
P	30	23.20± 6.28	10-32						
F ₁	30	28.83± 3.87	21-36						
F ₁	30	26.26± 9.75	11-61						
F ₂	240	24.20± 2.54	6-73	14.59	8.59	58.87	34.70	2.53	10.44
High x low - 1									
KRR 2 x S.i.2631 (Rajasthan)									
P	30	20.36± 9.07	11-42						
F ₁	30	31.73± 4.04	22-38						
F ₁	30	52.06±17.64	17-81						
F ₂	240	26.28± 2.01	3-56	12.39	4.24	34.22	11.69	0.78	2.99
High x low - 2									
TMV 6 x S.i.2631 (Rajasthan)									
P	30	24.36± 2.94	21-32						
F ₁	30	26.43± 4.68	20-36						
F ₁	30	54.70± 9.66	34-71						
F ₂	240	26.11± 5.08	3-47	24.02	10.25	42.67	57.71	7.44	28.58
Low x low - 1									
S.i.2141 (Canada) x S.i.2631 (Rajasthan)									
P	30	53.53±14.12	23-91						
F ₁	30	69.26± 9.44	49-88						
F ₁	30	63.30±14.24	33-88						
F ₂	240	65.77± 8.98	3-95	20.36	9.62	47.25	22.31	6.16	9.37
Low x low - 2									
S.i.2340 (Morocco) x S.i.2631 (Rajasthan)									
P	30	24.90± 2.59	20-30						
F ₁	30	25.46± 3.86	20-34						
F ₁	30	64.80±10.61	39-85						
F ₂	240	28.80± 2.28	3-96	21.54	14.42	66.94	44.82	13.68	19.88

Table 4.44. F₂ - Summer, 1982 (Capsules-branches (Number))

Generation	Number of observations	Mean	Range	PCV	GCV	GCV/PCV	Heritability (Broad sense)	Genetic advance	G.a.as% of mean
High x high - 1									
KRR 2 x TMV 6									
P ₁	30	89.16±16.21	66-124						
F ₁	30	94.13±12.09	73-113						
P ₂	30	59.43±16.52	38-119						
F ₂	240	68.14±14.33	0-150	28.31	17.63	62.27	38.77	15.42	22.63
High x high - 2									
KRR 2 x S.i.2277 (Australia)									
P ₁	30	82.16±23.04	30-126						
F ₁	30	82.90±15.00	49-116						
P ₂	30	60.36±24.42	15-105						
F ₂	240	79.78±14.63	7-107	23.70	16.13	68.06	46.31	18.05	22.63
High x low - 1									
KRR 2 x S.i.2631 (Rajasthan)									
P ₁	30	75.93±32.36	23-156						
F ₁	30	88.50±14.57	64-121						
P ₂	30	0	0						
F ₂	240	58.19± 9.73	0-178	23.94	13.39	55.93	31.25	8.98	15.43
High x low - 2									
TMV 6 x S.i.2631 (Rajasthan)									
P ₁	30	66.56±17.32	33-105						
F ₁	30	83.80±16.06	50-110						
P ₂	30	0	0						
F ₂	240	71.81±10.72	0-97	19.78	12.76	64.51	41.62	12.19	16.97
Low x low - 1									
S.i.2141 (Canada) x S.i.2631 (Rajasthan)									
P ₁	30	8.43±6.95	0-29						
F ₁	30	4.10± 5.22	0-24						
P ₂	30	0	0						
F ₂	240	5.74± 2.38	0-63	72.14	12.85	17.81	3.17	0.27	4.72
Low x low - 2									
S.i.2340 (Morocco) x S.i.2631 (Rajasthan)									
P ₁	30	51.80± 7.11	37-68						
F ₁	30	57.40± 9.49	41-75						
P ₂	30	0	0						
F ₂	240	7.07± 2.28	0-65	43.60	27.00	61.92	38.36	2.45	34.48

Table 4.45. F_2 - Summer, 1992 (Capsules/plant [Number])

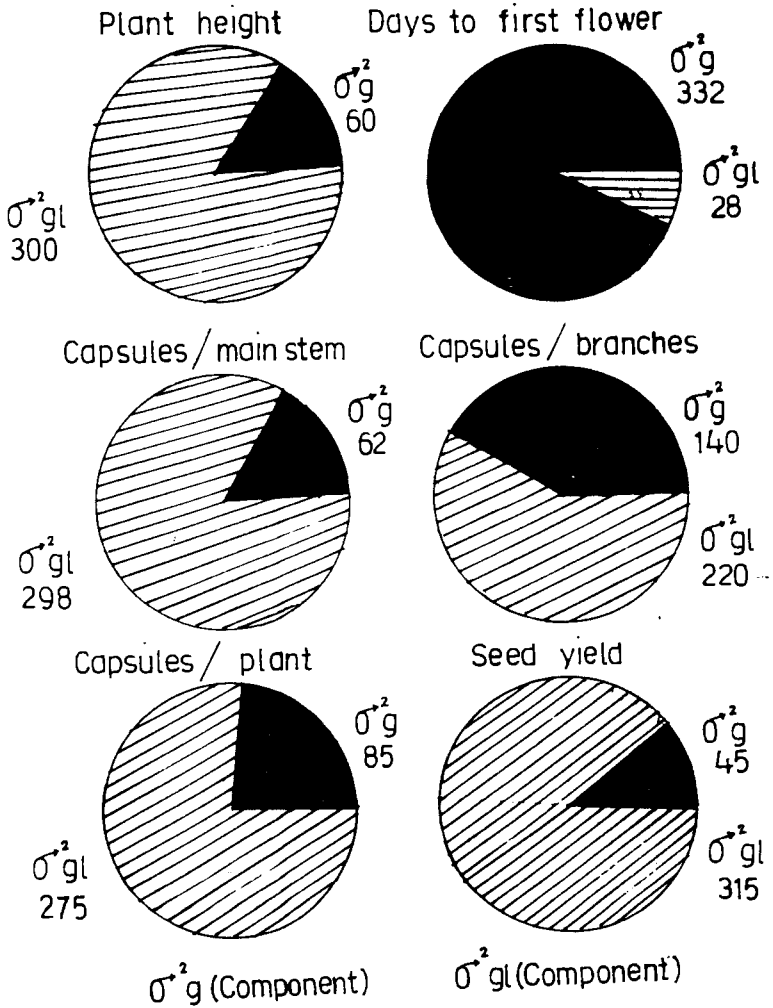
Generation	Number of observations	Mean	Range	PCV	GCV	GCV/PCV	Heritability (Broad sense)	Genetic advance	G.a.as% of mean
High x high - 2									
KRR 2 x TMV 6									
P ₁	30	111.93+17.70	83-153						
F ₁	30	123.30+13.72	101-146						
P ₂	30	82.80+17.16	60-149						
F ₂	240	91.81+14.63	13-173	22.14	12.78	57.74	33.32	13.96	15.21
High x high - 2									
KRR 2 x S.i.2277 (Australia)									
P ₁	30	105.36+27.85	46-155						
F ₁	30	111.73+17.19	80-150						
P ₂	30	86.63+27.34	37-130						
F ₂	240	104.05+16.73	16-165	20.38	14.43	70.80	50.16	21.93	21.07
High x low - 1									
KRR 2 x S.i.2631 (Rajasthan)									
P ₁	30	96.30+37.76	35-176						
F ₁	30	120.23+16.59	93-159						
P ₂	30	52.06+24.11	17-122						
F ₂	240	84.48+9.47	13-196	17.16	7.34	42.77	10.32	5.47	6.48
High x low - 2									
TMV 6 x S.i.2631 (Rajasthan)									
P ₁	30	90.33+18.24	58-133						
F ₁	30	110.23+16.01	75-134						
P ₂	30	54.70+9.66	34-71						
F ₂	240	97.85+10.19	5-146	14.60	8.26	56.57	31.99	9.42	9.63
Low x low - 1									
S.i.2141 (Canada) x S.i.2631 (Rajasthan)									
P ₁	30	61.96+17.08	26-100						
F ₁	30	73.36+9.93	53-91						
P ₂	30	63.30+16.10	33-101						
F ₂	240	71.51+10.32	1-123	21.60	10.08	46.66	21.79	6.94	9.70
Low x low - 2									
S.i.2340 (Morocco) x S.i.2631 (Rajasthan)									
P ₁	30	76.70+7.03	62-96						
F ₁	30	82.86+12.01	61-108						
P ₂	30	64.80+10.48	43-88						
F ₂	240	75.88+13.20	8-113	22.16	15.61	70.44	49.61	17.21	22.67

Table 4.45. F_2 - Summer, 1982 (Seed yield)

Generation	Number of observations	Mean	Range	PCV	GCV	GCV/PCV	Heritability (Broad sense)	Genetic advance	G.a.as% of mean
High x high - 2									
KRR 2 x TMV 6									
P	30	7.86± 1.77	4.90-12.15						
F ₁	30	9.88± 1.68	6.70-12.10						
F ₁	30	5.76± 1.00	4.20- 8.75						
F ₂	240	9.74± 1.86	1.15-14.00	26.16	15.64	59.71	35.76	1.88	19.29
High x high - 2									
KRR 2 x S.i.2277 (Australia)									
P	30	8.17± 2.23	3.20-12.20						
F ₁	30	10.27± 1.55	7.80-13.30						
F ₁	30	7.71± 2.53	3.40-12.60						
F ₂	240	9.13± 2.27	1.50-13.15	24.42	18.93	77.52	60.09	3.38	30.26
High x low - 1									
KRR 2 x S.i.2631 (Rajasthan)									
P	30	6.54± 3.88	2.20-15.50						
F ₁	30	8.68± 1.30	6.20-11.50						
F ₁	30	4.25± 1.84	1.40- 7.70						
F ₂	240	6.78± 1.03	1.35- 9.50	19.30	6.09	31.55	9.97	0.35	13.97
High x low - 2									
TMV 6 x S.i.2631 (Rajasthan)									
P	30	5.98± 1.41	3.55-8.70						
F ₁	30	7.82± 1.02	5.65-9.55						
F ₁	30	3.41± 0.90	1.40-5.30						
F ₂	240	7.54± 0.74	0.55-10.20	22.05	14.25	65.62	41.73	2.03	18.98
Low x low - 1									
S.i.2141 (Canada) x S.i.2631 (Rajasthan)									
P	30	3.05± 0.91	1.80-5.90						
F ₁	30	4.87± 0.54	3.80-5.70						
F ₁	30	3.23± 0.97	1.90-6.10						
F ₂	240	4.85± 0.71	0.30-9.10	25.55	11.68	45.71	20.92	0.71	11.02
Low x low - 2									
S.i.2340 (Morocco) x S.i.2631 (Rajasthan)									
P	30	4.15± 0.60	3.15-5.35						
F ₁	30	5.28± 0.65	3.80-7.50						
F ₁	30	3.11± 0.44	2.10-3.90						
F ₂	240	5.06± 0.66	0.80-9.30	23.98	16.16	67.39	45.39	1.50	22.50

FIGURES

Fig.A. PROPORTION OF σ^2_g (GENOTYPIC) AND σ^2_{gl} (GENOTYPIC x ENVIRONMENT) COMPONENTS



PERCENTAGE DEVIATION OVER MID PARENT VALUE

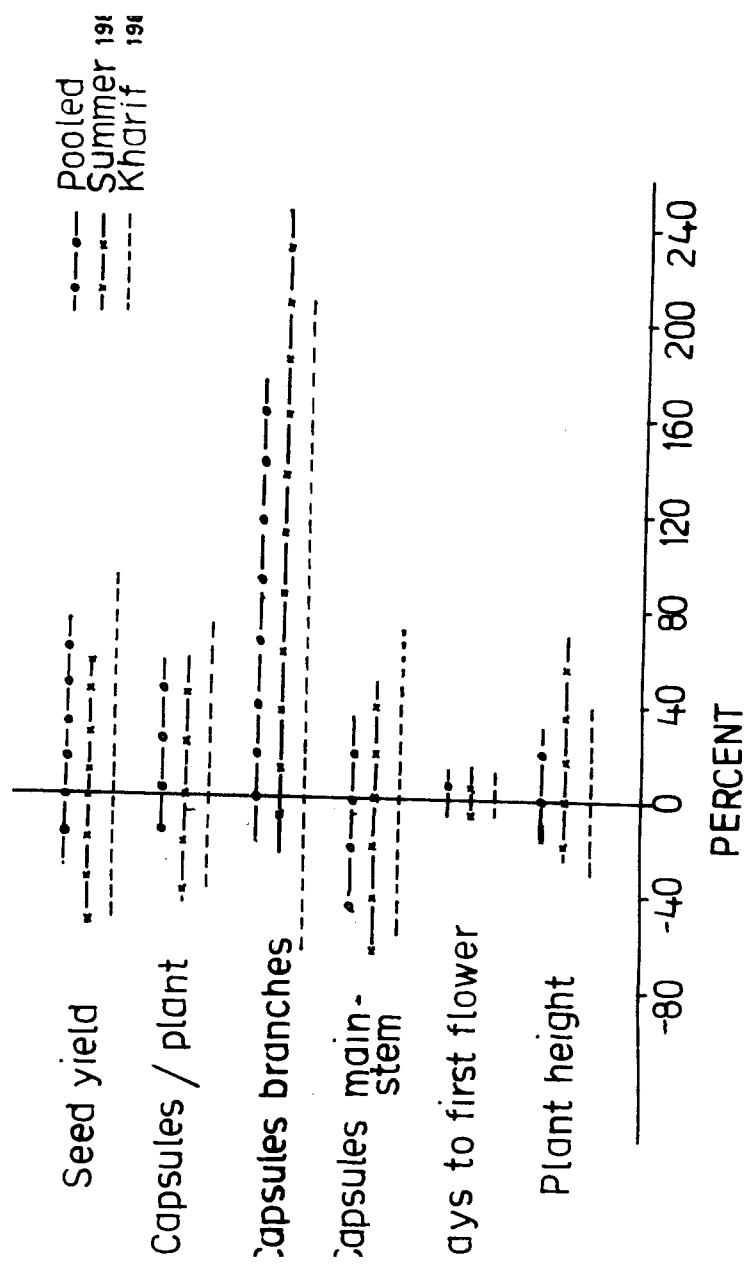


FIG. C. RANGE OF HETEROISIS OVER BETTER PARENT VALUE

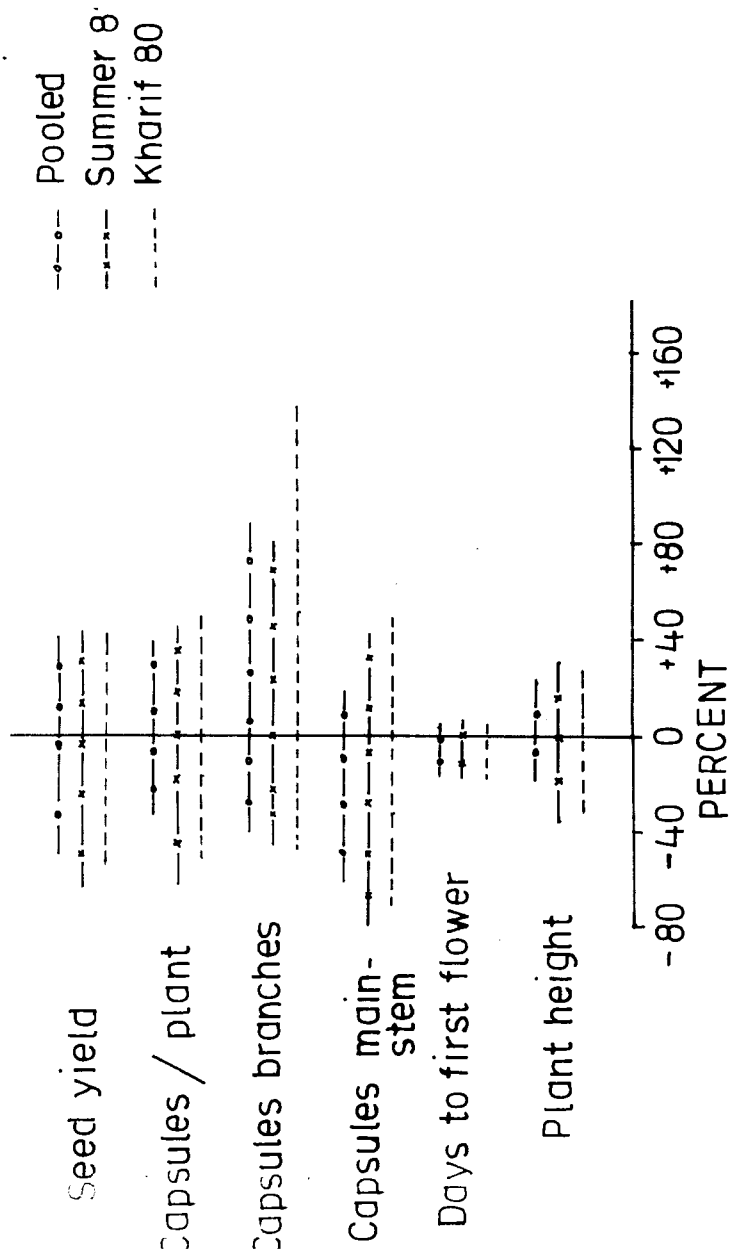


Fig.D. $(H_1/D)^{1/2}$ RATIO

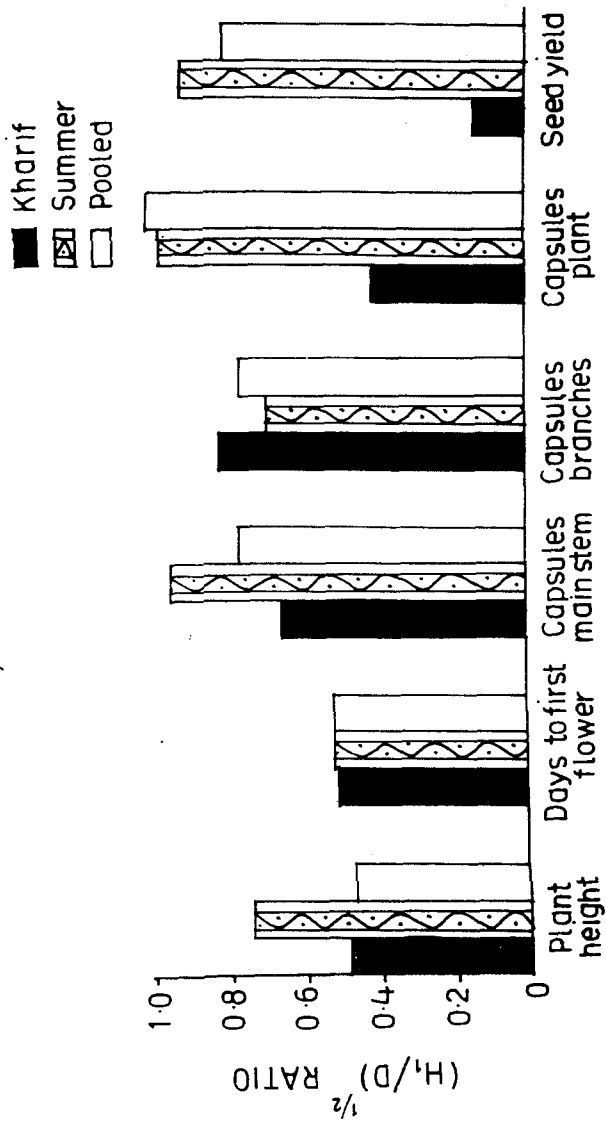


Fig.E. HERITABILITY PER CENT (Narrow sense)

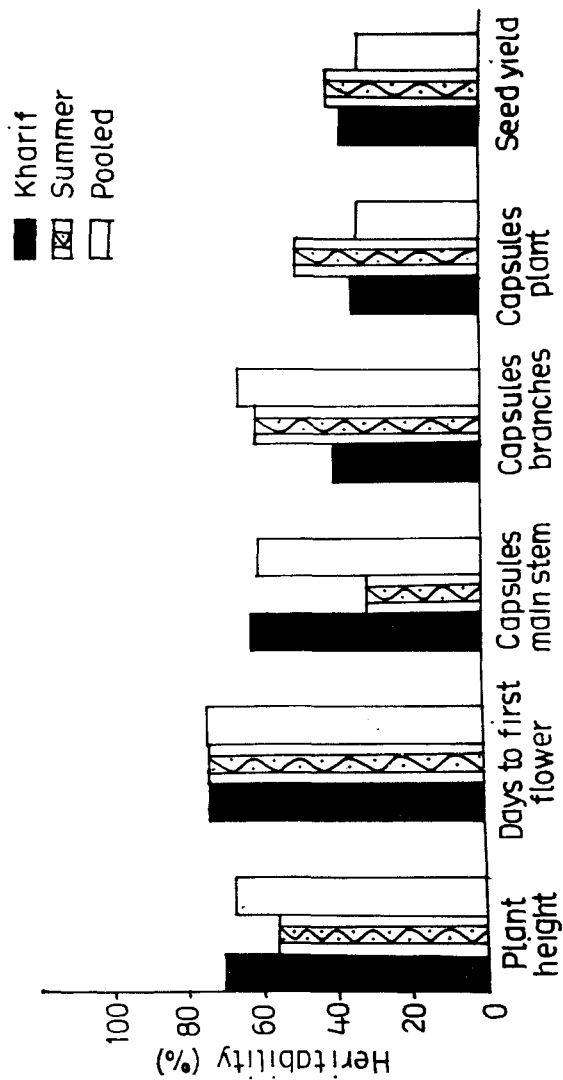


Fig.1.
PLANT HEIGHT 1980 KHARIF

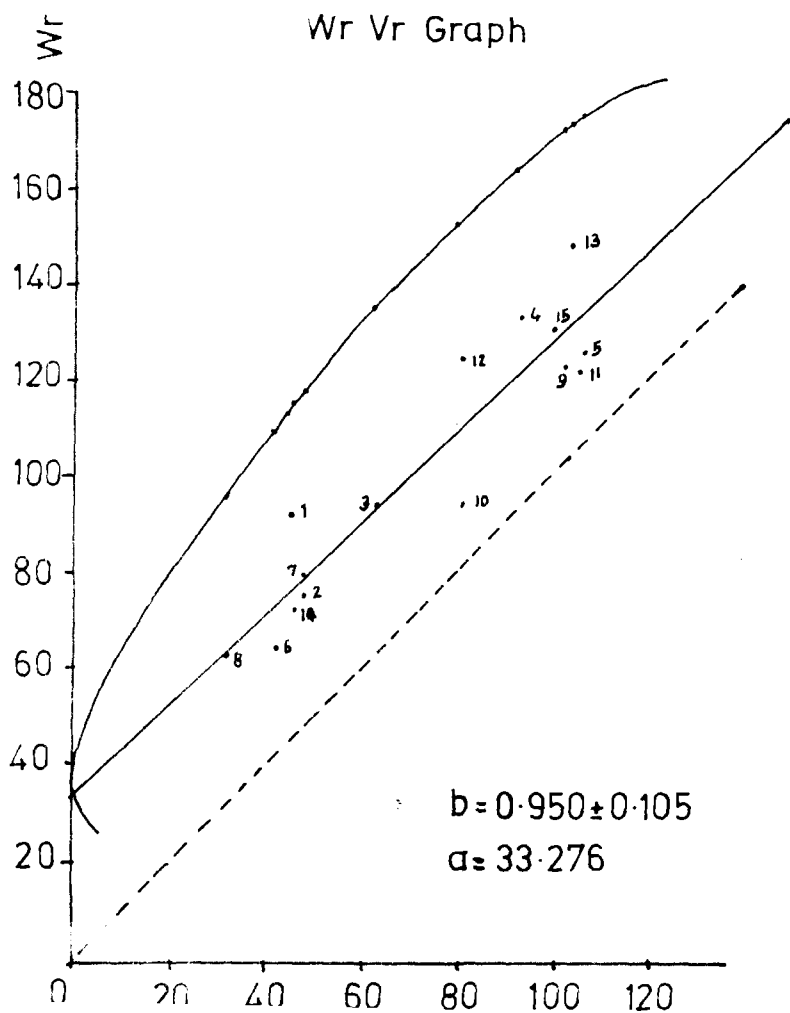


Fig.2.
 PLANT HEIGHT 1981 SUMMER

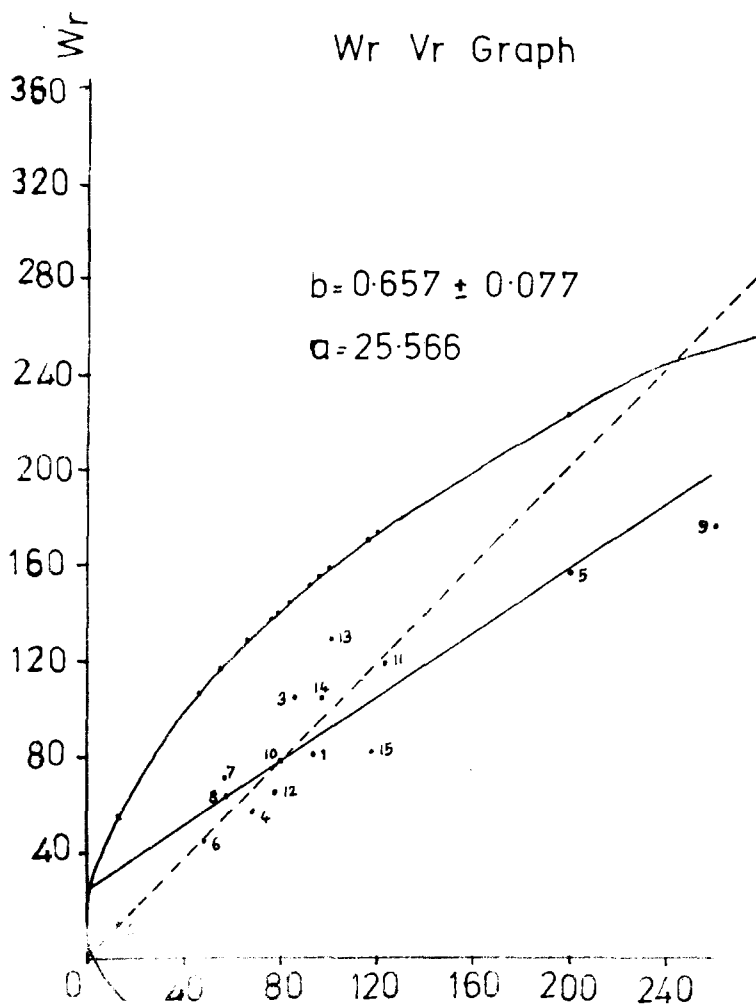


Fig.3.
PLANT HEIGHT POOLED

Wr Vr Graph

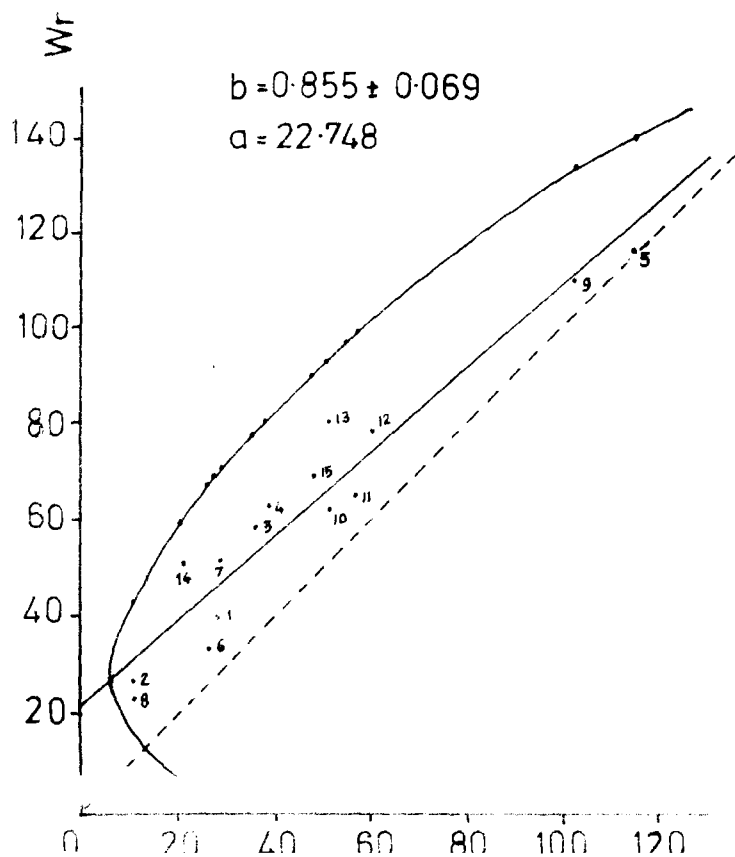


Fig.4.
PLANT HEIGHT 1980 KHARIF

WrWr' Graph

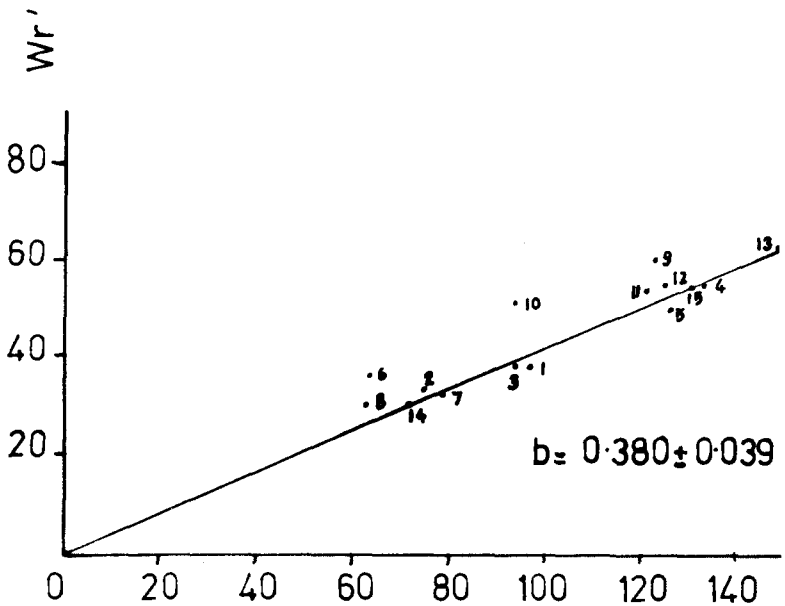


Fig.5.
PLANT HEIGHT 1981 SUMMER

Wr Wr' Graph

$$b = 0.412 \pm 0.038$$

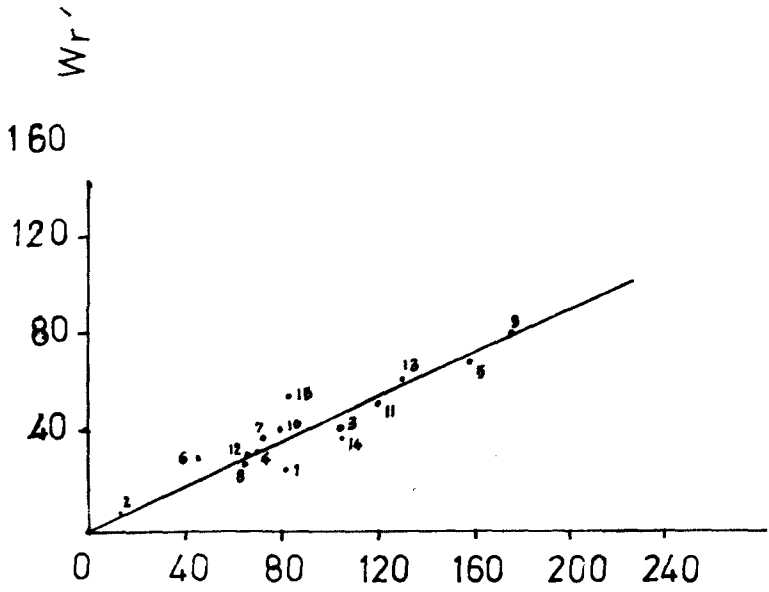


Fig.6.
PLANT HEIGHT POOLED

Wr Wr' Graph

$$b = 0.423 \pm 0.041$$

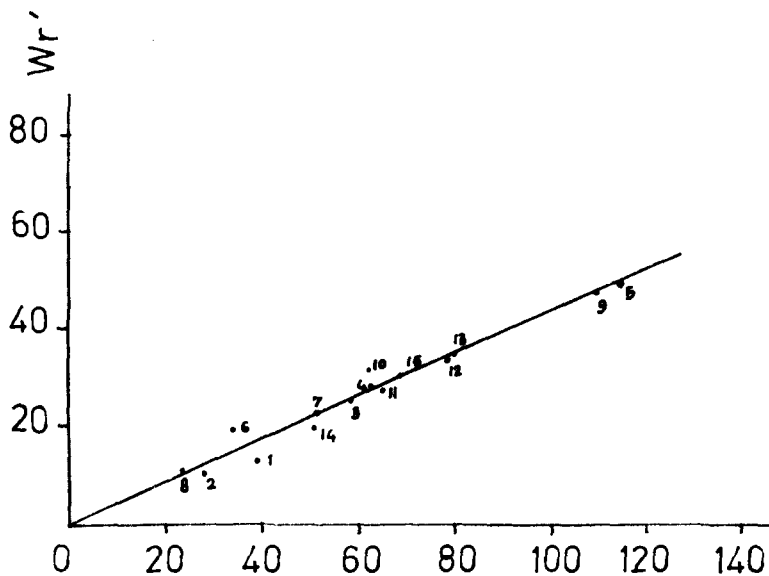


Fig.7.
 PLANT HEIGHT 1980 KHARIF

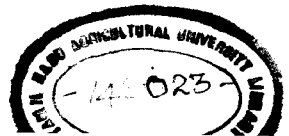
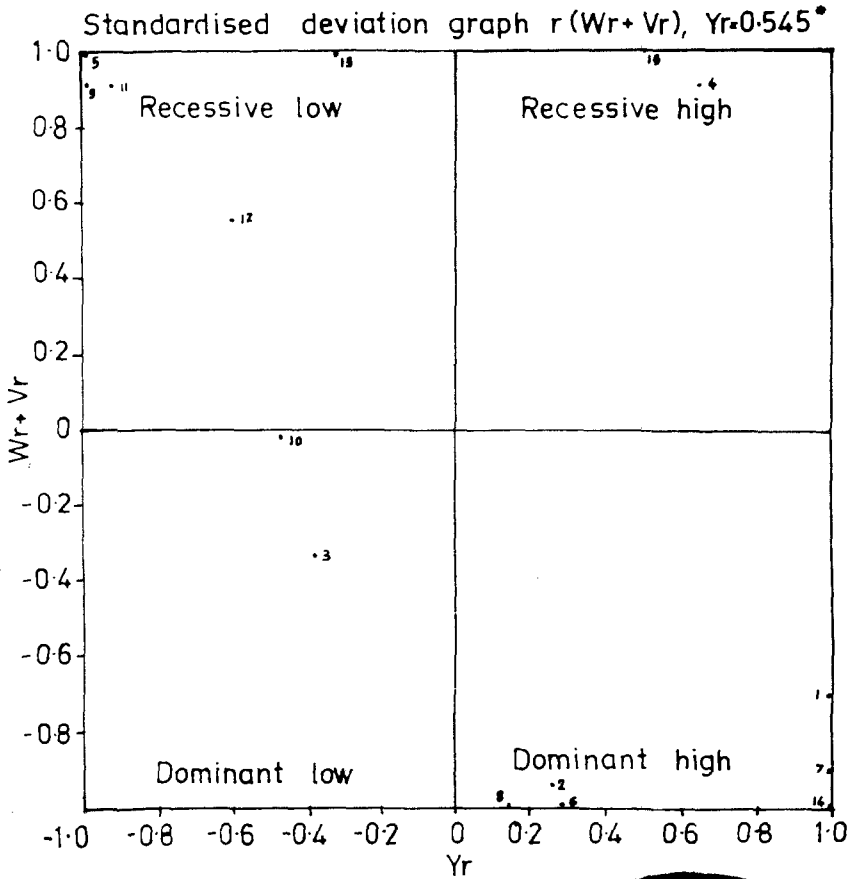


Fig.8.
 PLANT HEIGHT 1981 SUMMER

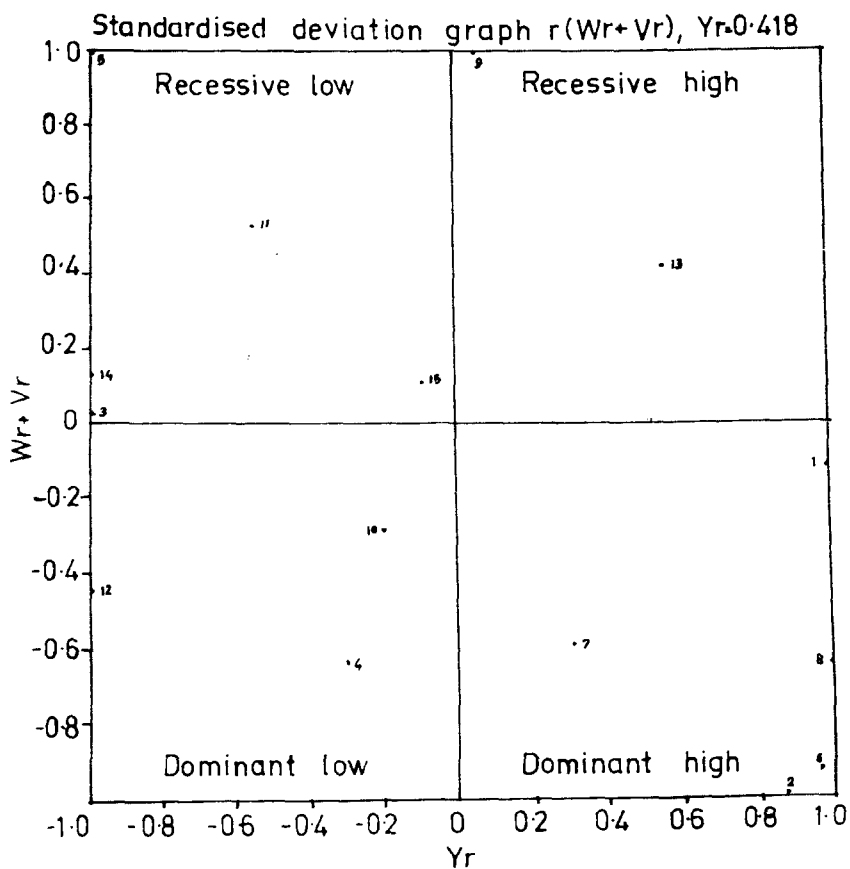


Fig9.
PLANT HEIGHT POOLED

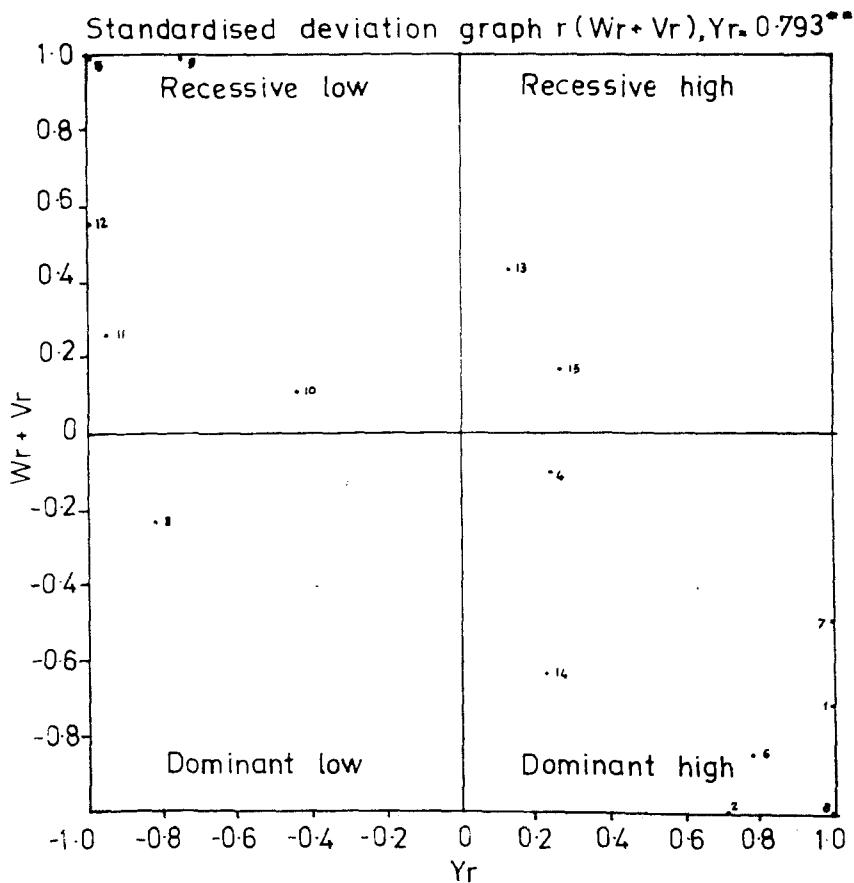


FIG. 10.
DAYS TO FIRST FLOWER 1980 KHARIF

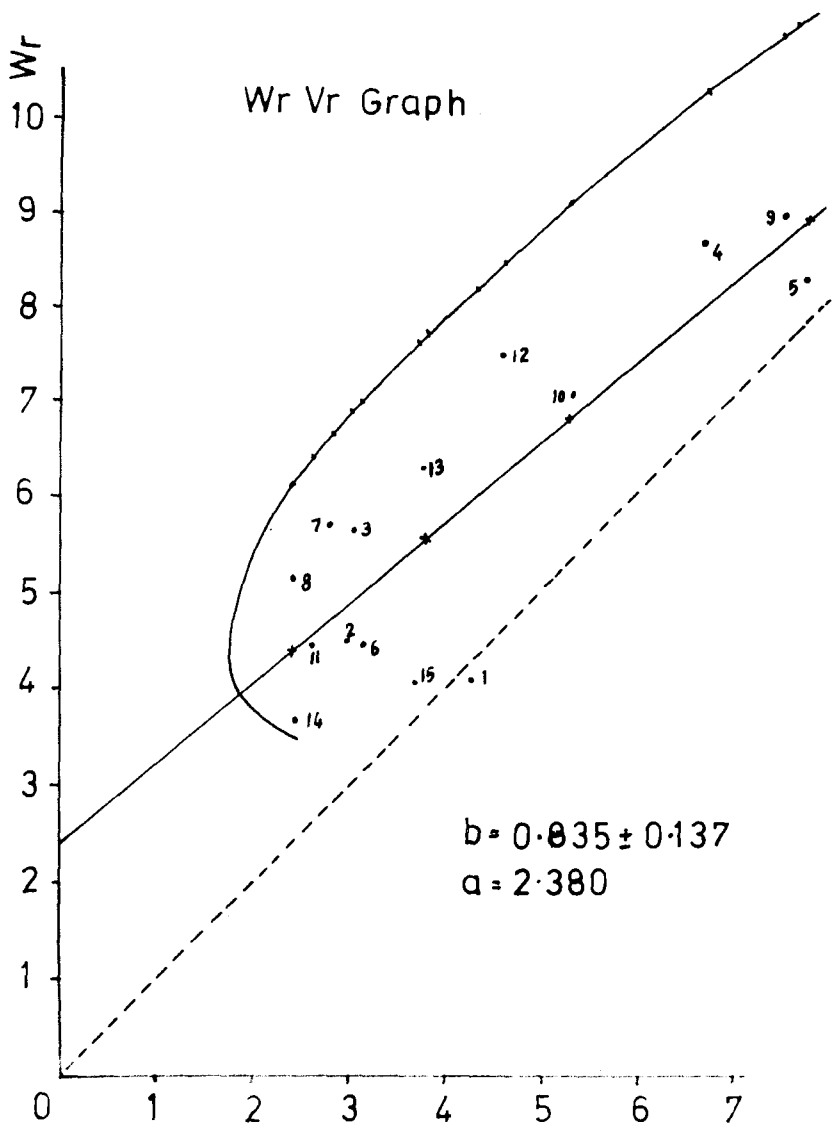


Fig.11.

DAYS TO FIRST FLOWER 1981 SUMMER

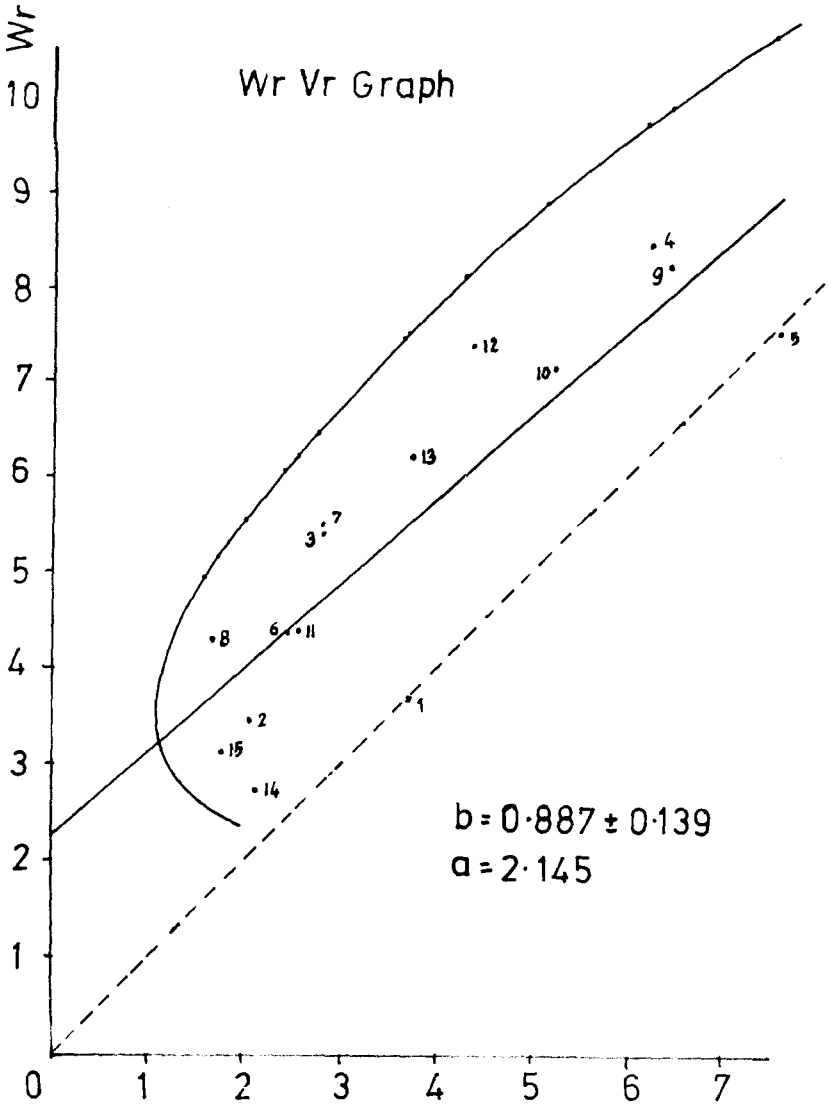


FIG. 12.
DAYS TO FIRST FLOWER POOLED

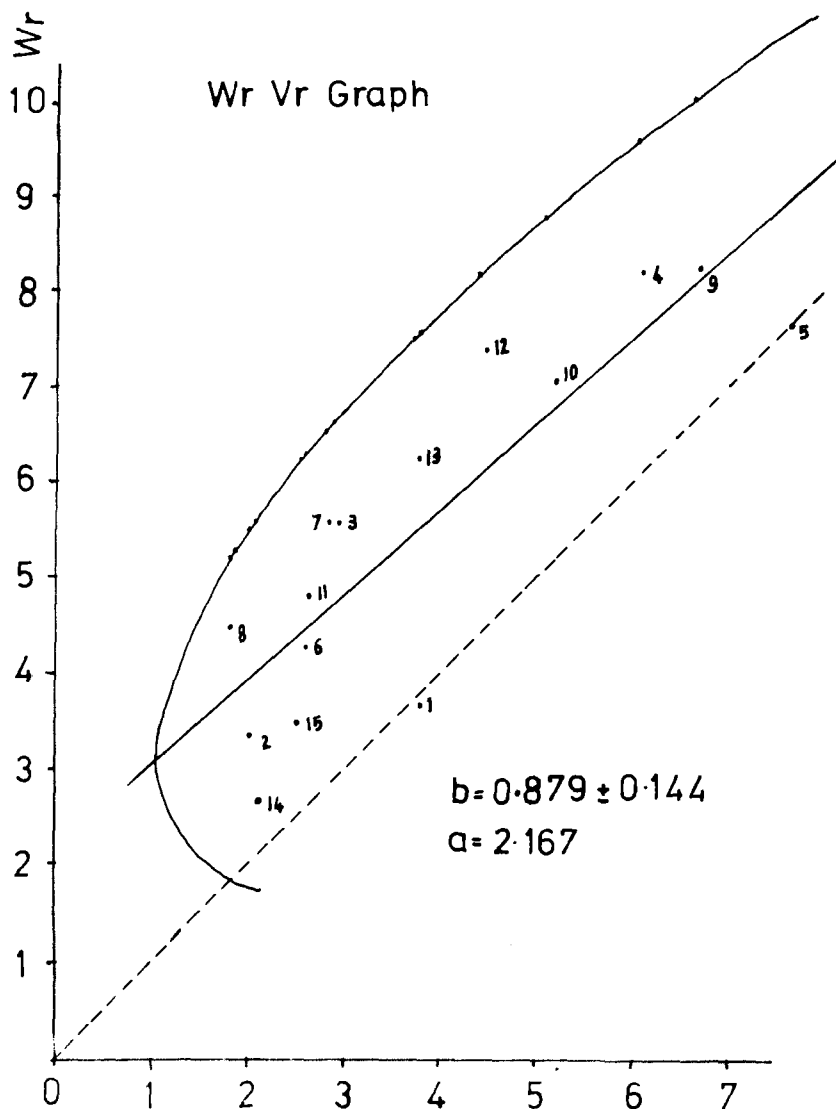


Fig.13.
DAYS TO FIRIST FLOWER 1980 KHARIF

Wr Wr' Graph

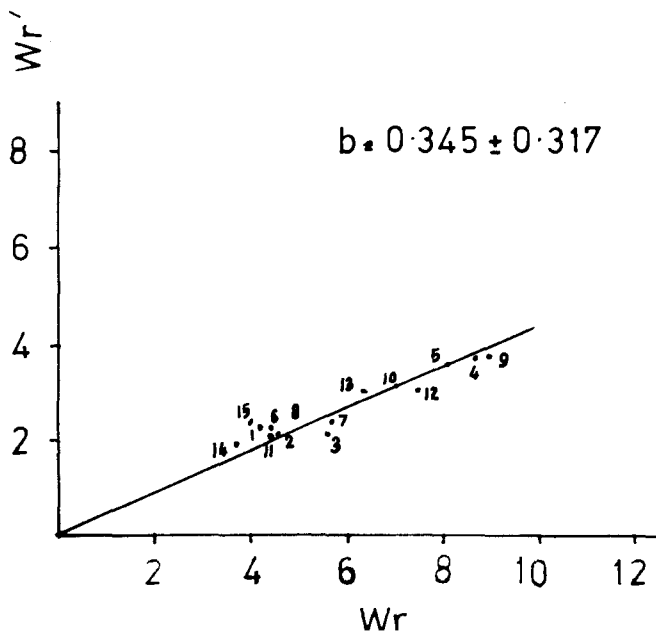


Fig.14.
 DAYS TO FIRST FLOWER 1981 SUMMER
 Wr Wr'Graph

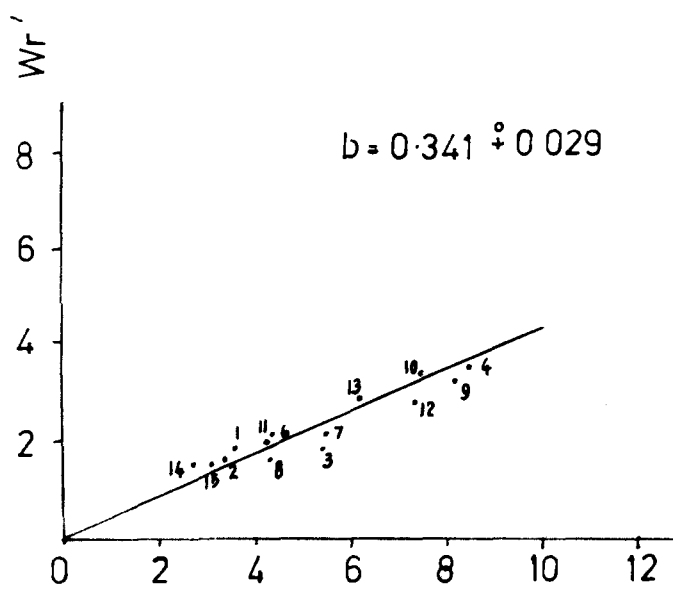


Fig.15.
DAYS TO FIRST FLOWER POOLED

Wr Wr' Graph

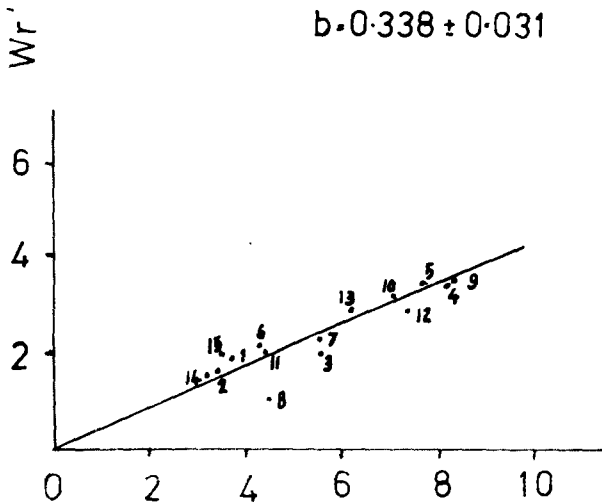


Fig.16.
 DAYS TO FIRST FLOWER 1980 KHARIF

Standardised deviation graph $r(Wr+Vr), Yr=0.735^{**}$

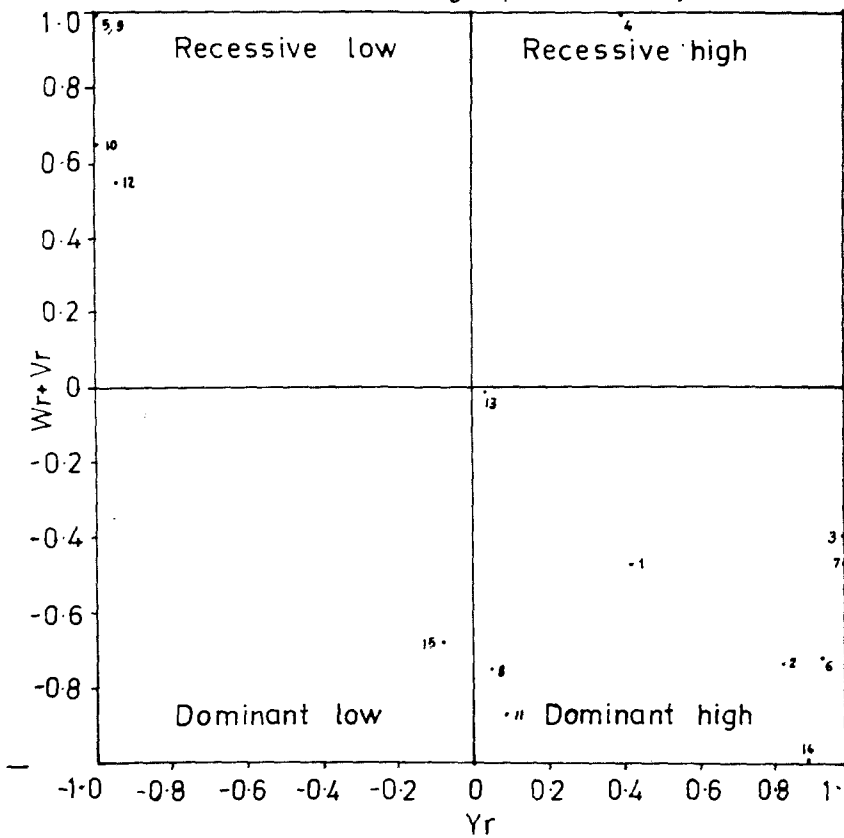


Fig.17.
DAYS TO FIRST FLOWER 1981 SUMMER

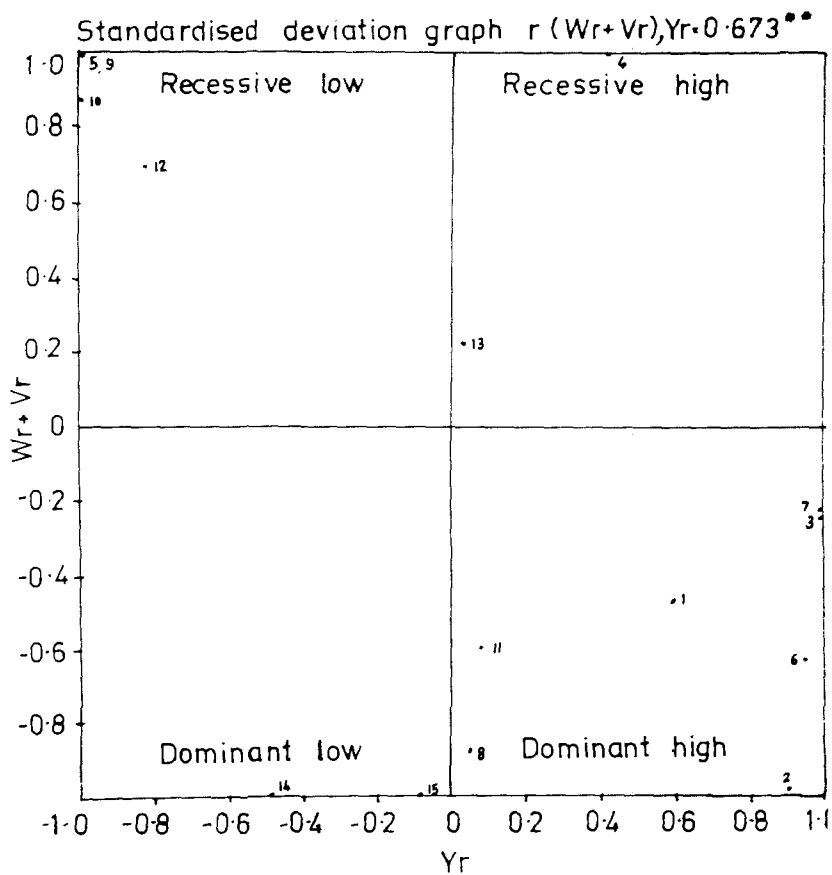


Fig.18.
DAYS TO FIRST FLOWER POOLED

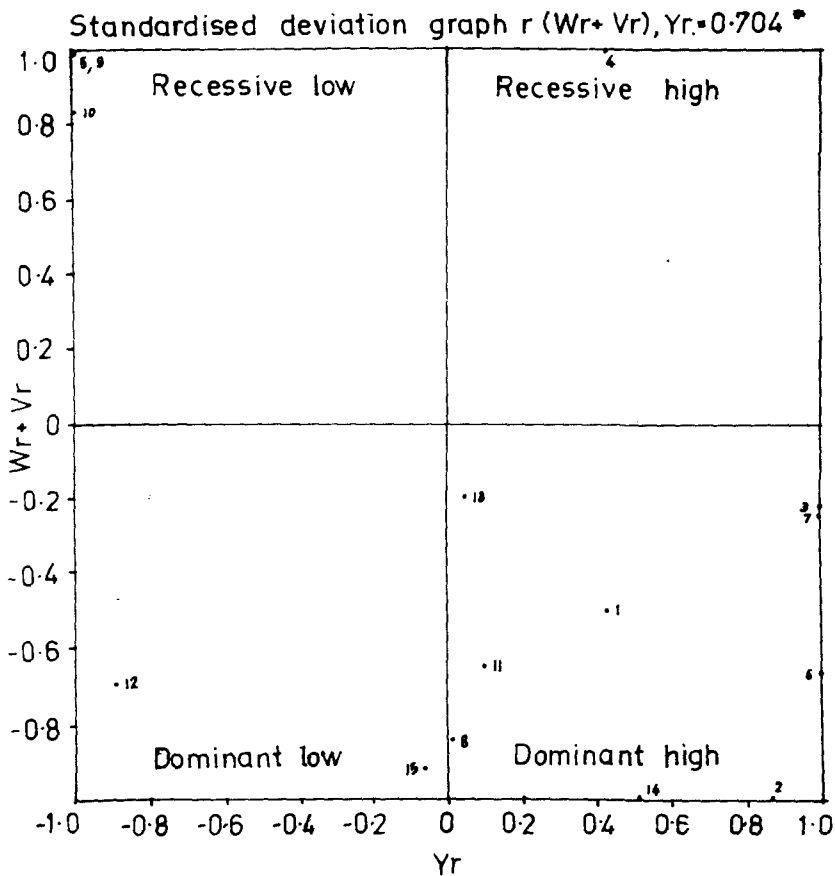


Fig.19.
CAPSULES / MAIN STEM 1980 KHARIF

Wr Vr Graph

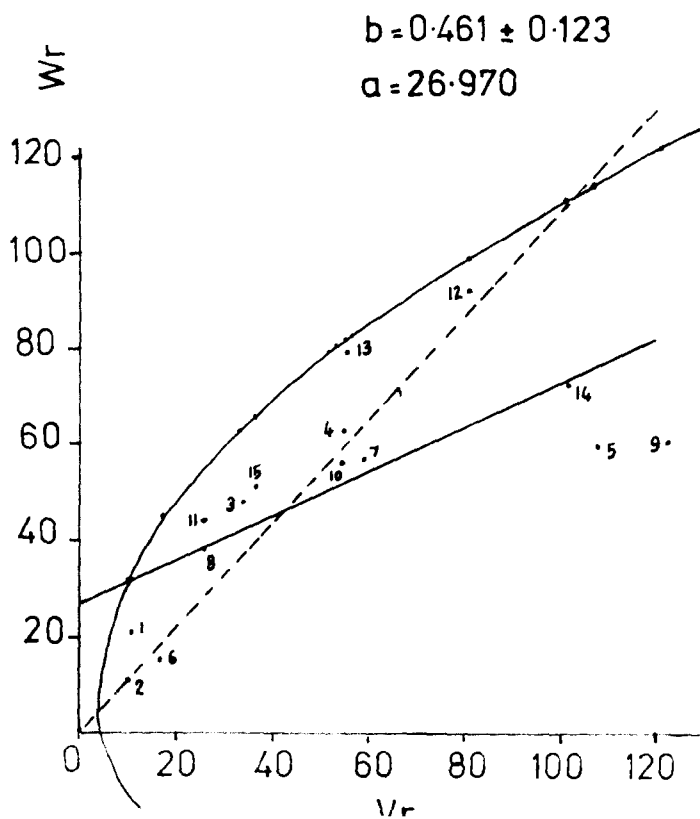


Fig.20.
CAPSULES / MAIN STEM 1981 SUMMER

Wr Vr Graph

$$b = 0.973 \pm 0.074$$

$$a = 0.188$$

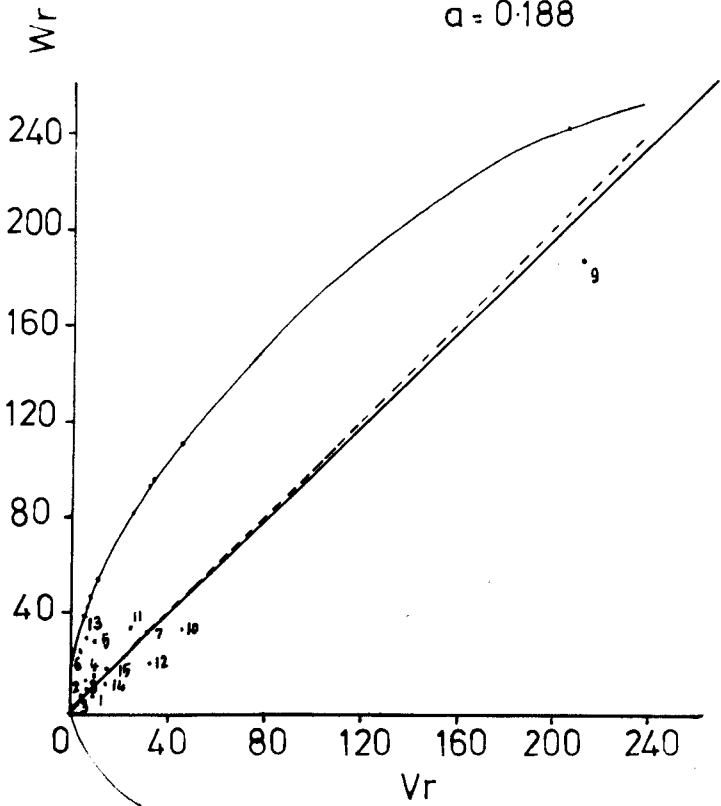


Fig.21.
CAPSULES / MAIN STEM POOLED

Wr Vr Graph

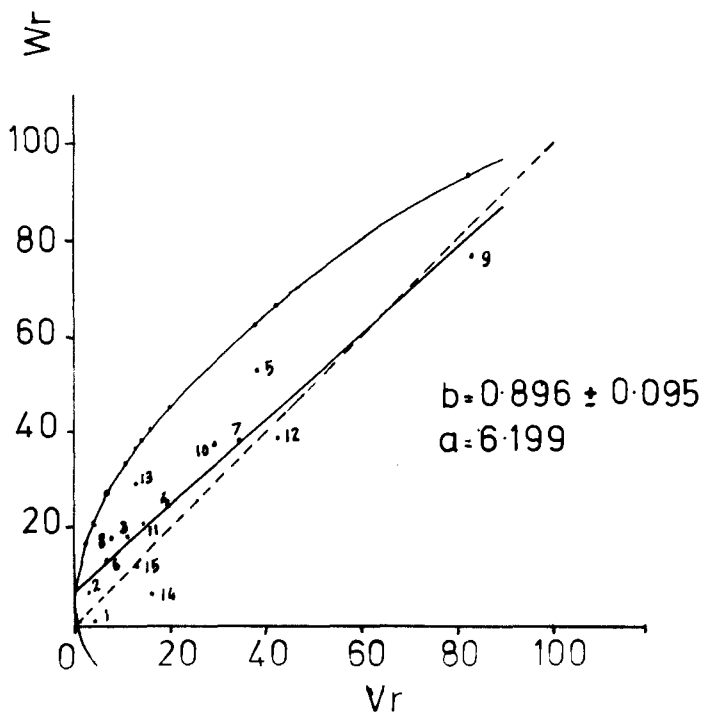


Fig.22.
CAPSULES / MAINSTEM 1980 KHARIF

Wr Wr' Graph

$$b = 0.465 + 0.030$$

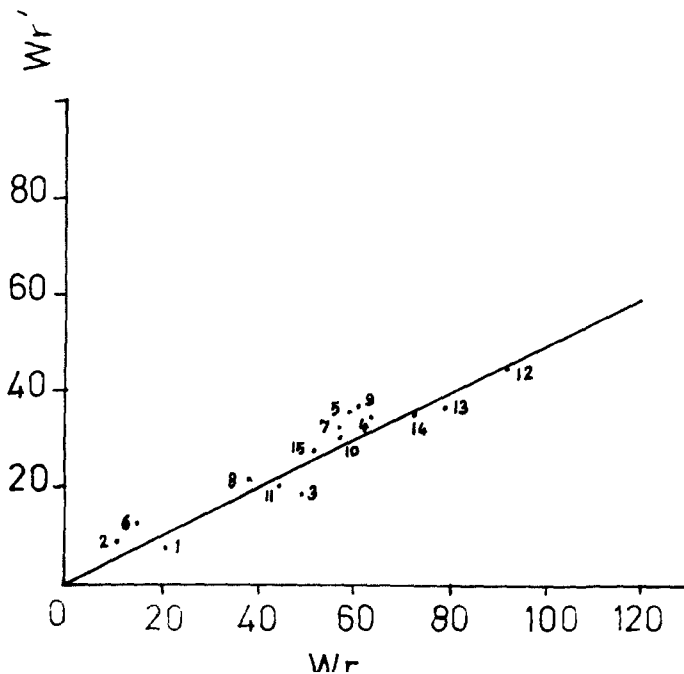


Fig.23.
CAPSULES / MAIN STEM 1981 SUMMER

Wr Wr' Graph

$$b = 0.095 \pm 0.008$$

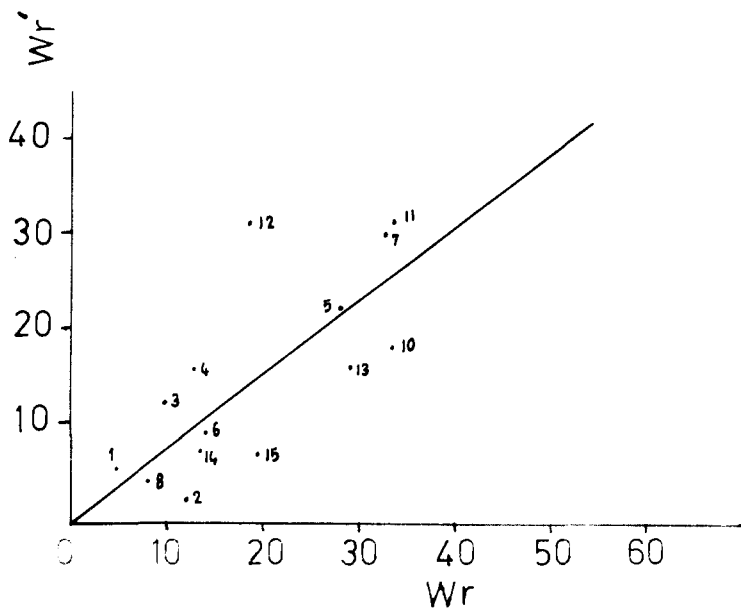


Fig.24.CAPSULES / MAIN STEM POOLED

Wr Wr' Graph

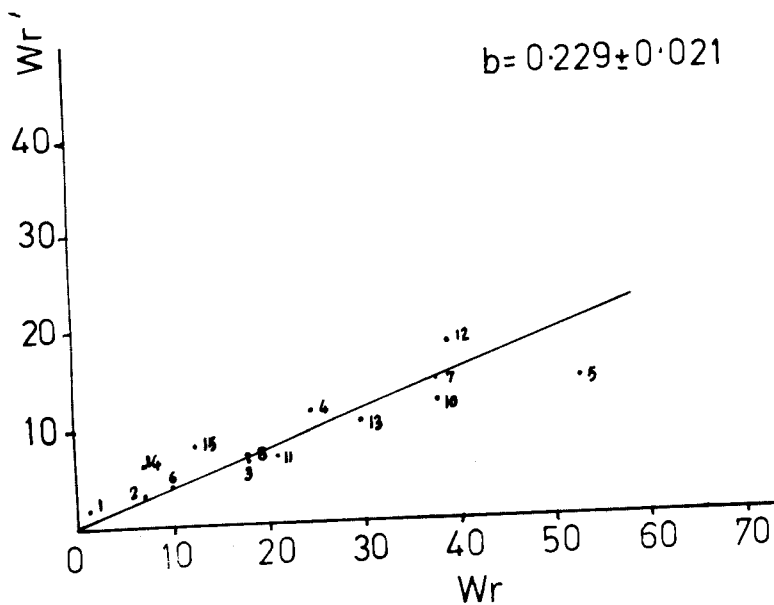


Fig. 25.
CAPSULES / MAIN STEM 1980 KHARIF

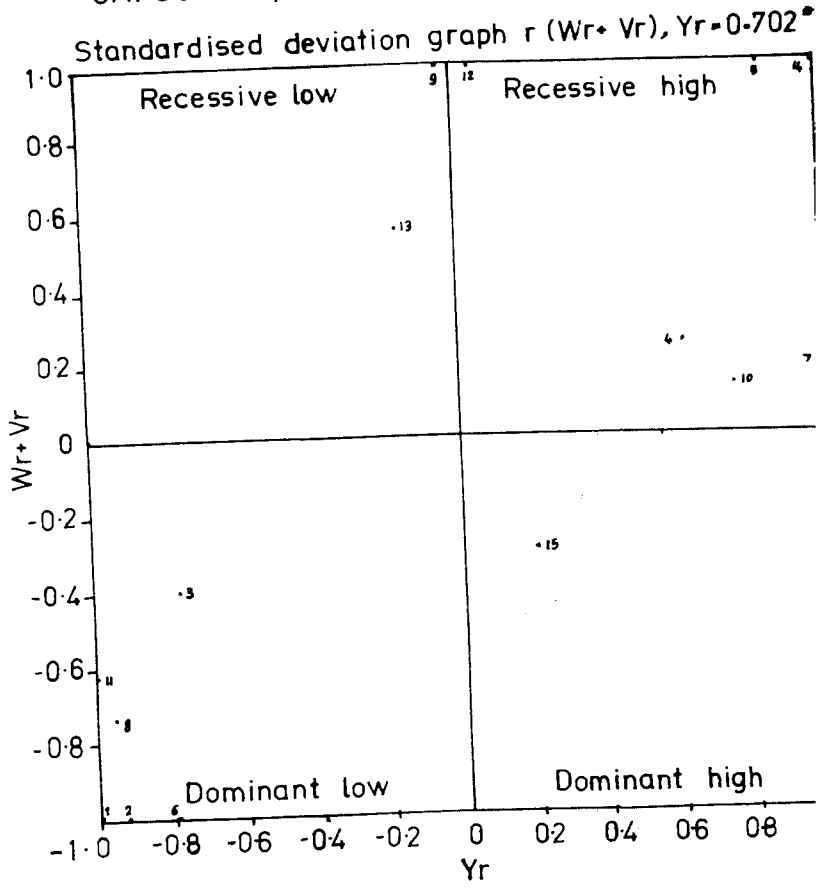


Fig. 26.
CAPSULES / MAIN STEM 1981 SUMMER

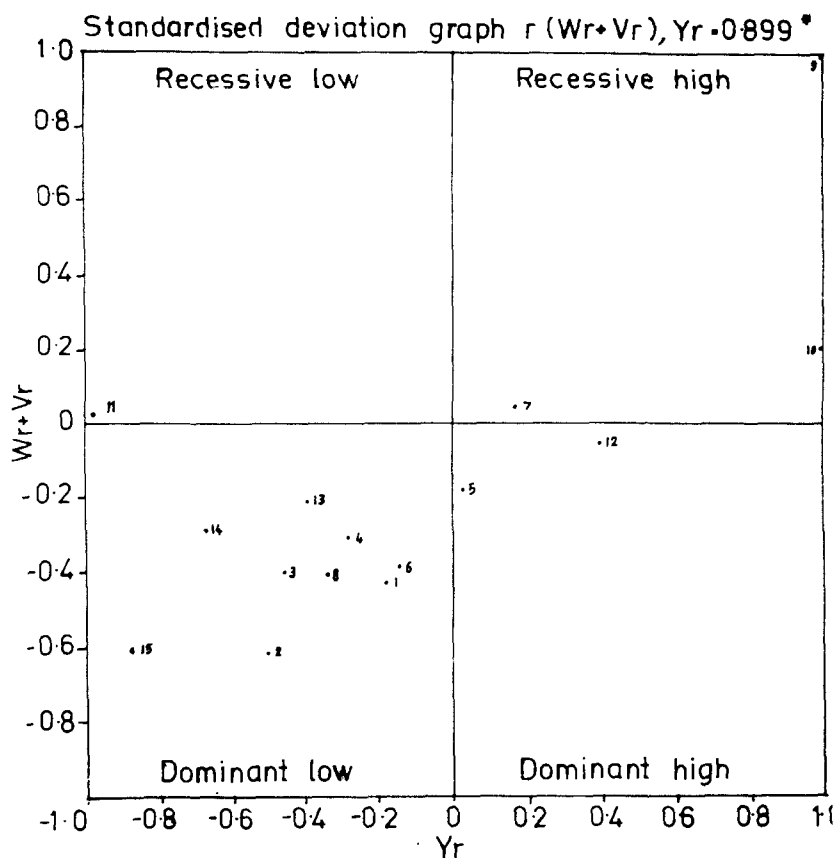


Fig.27. CAPSULES / MAINSTEM POOLED

Standardised deviation graph $r(Wr+Vr), Yr=0.0823$

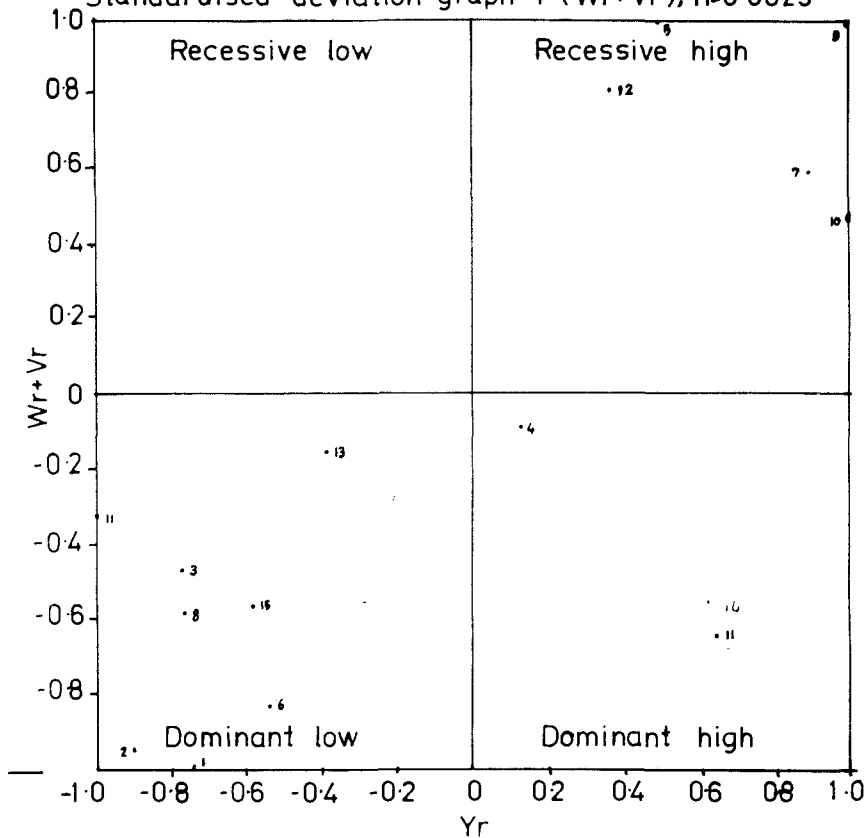


Fig.28.

CAPSULES / BRANCHES 1980 KHARIF

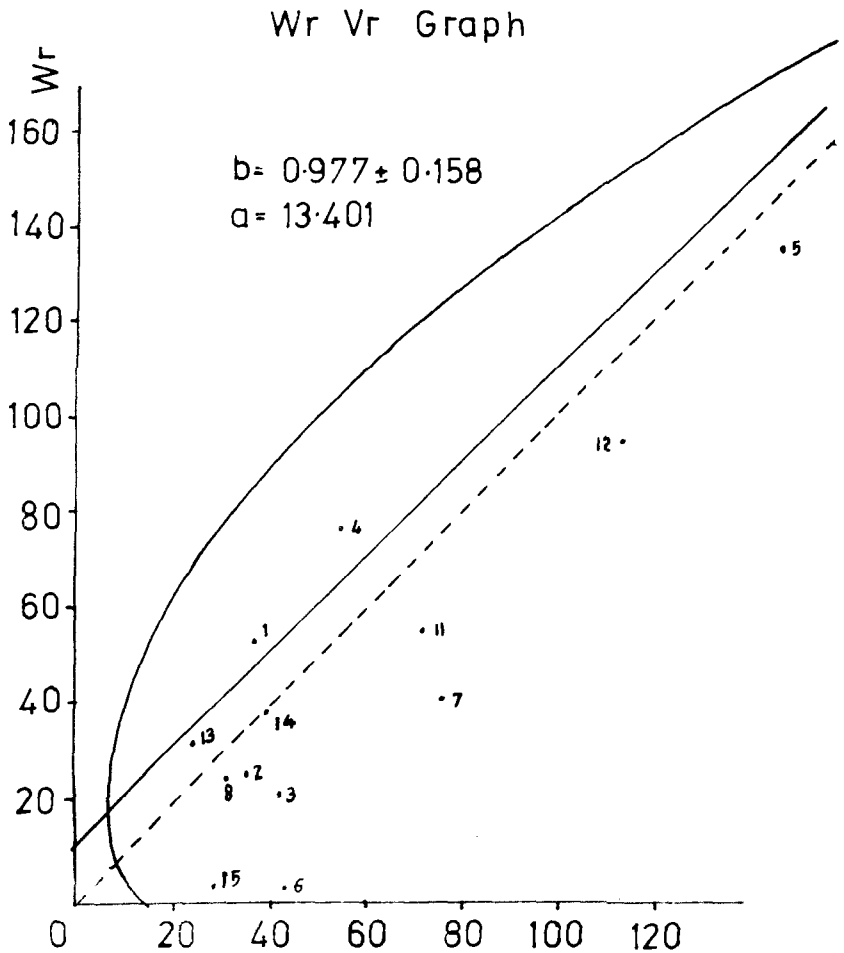


Fig. 29.
CAPSULES / BRANCHES 1981 SUMMER

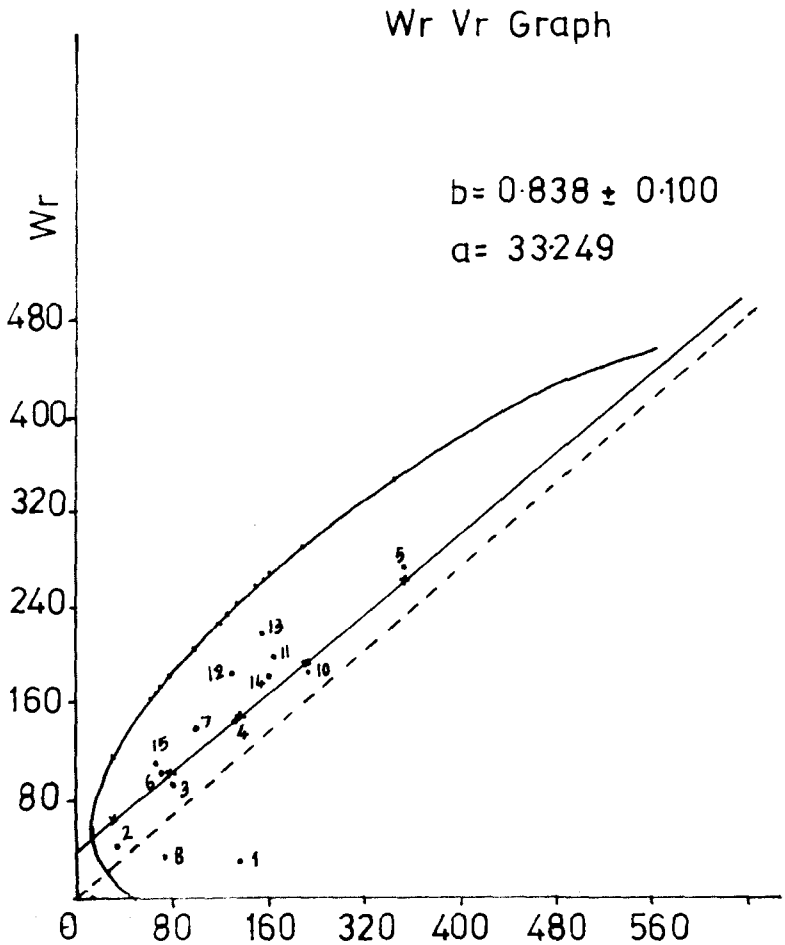


Fig.30.
CAPSULES / BRANCHES POOLED

Wr Vr Graph

$$b = 0.981 \pm 0.062$$

$$a = 8.635$$

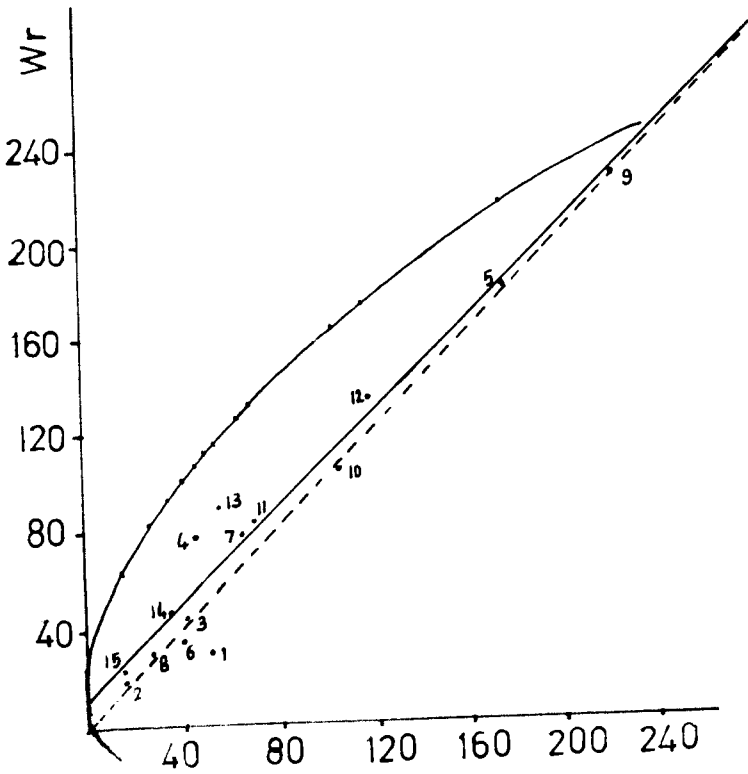


Fig.31.
CAPSULES / BRANCHES 1980 Kharif

Wr Wr'Graph

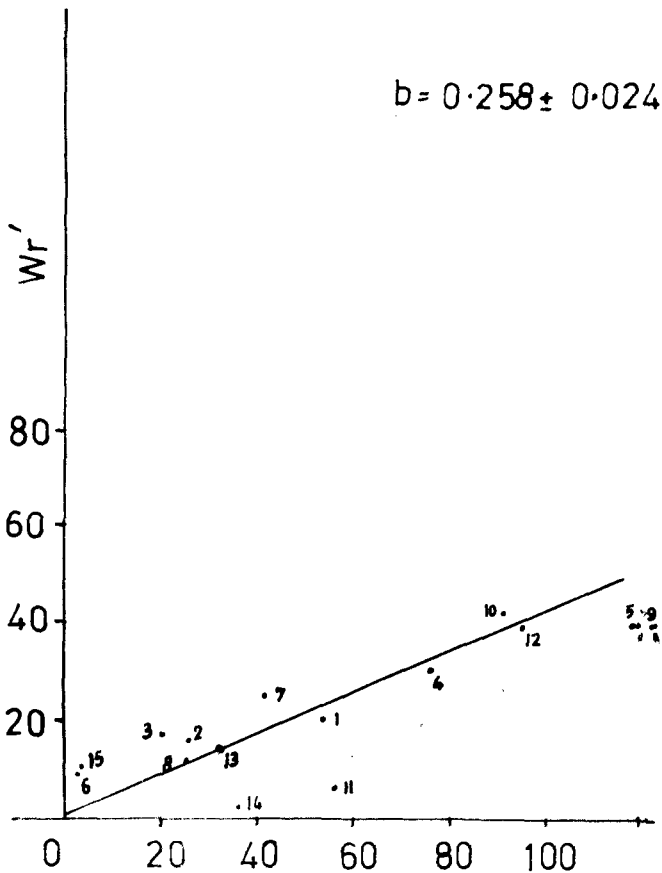


Fig.32.
CAPSULES / BRANCHES 1981 SUMMER

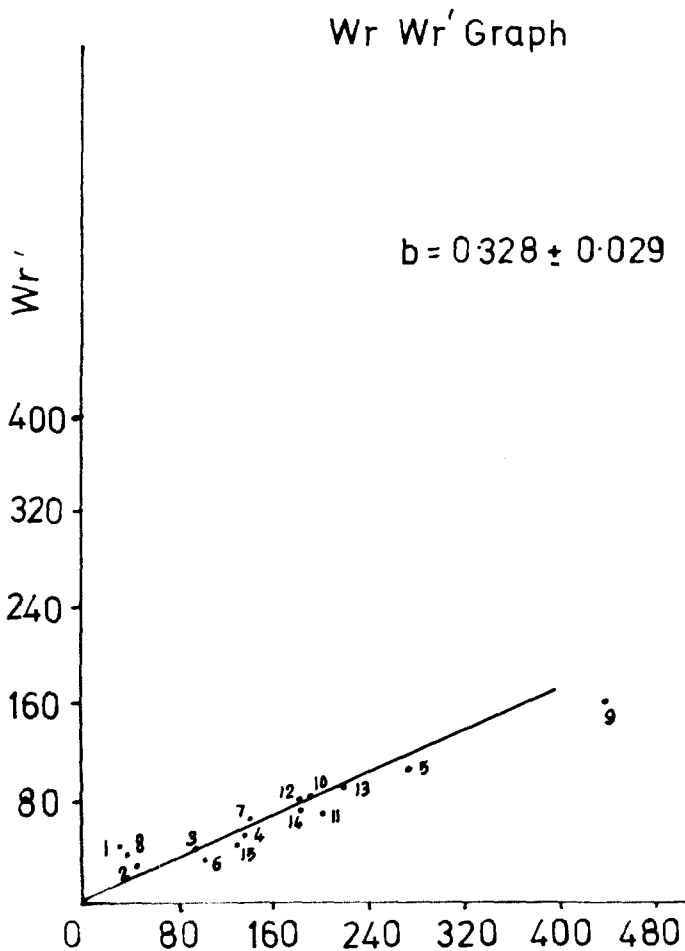


Fig. 33.
CAPSULES / BRANCHES POOLED

Wr Wr' Graph

$$b = 0.319 \pm 0.029$$

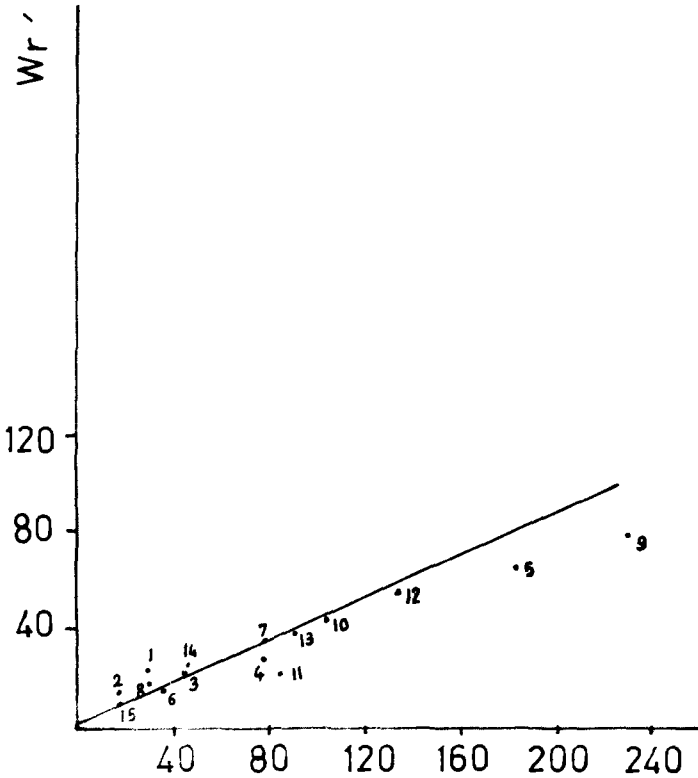


Fig.34.
CAPSULES / BRANCHES 1980 KHARIF

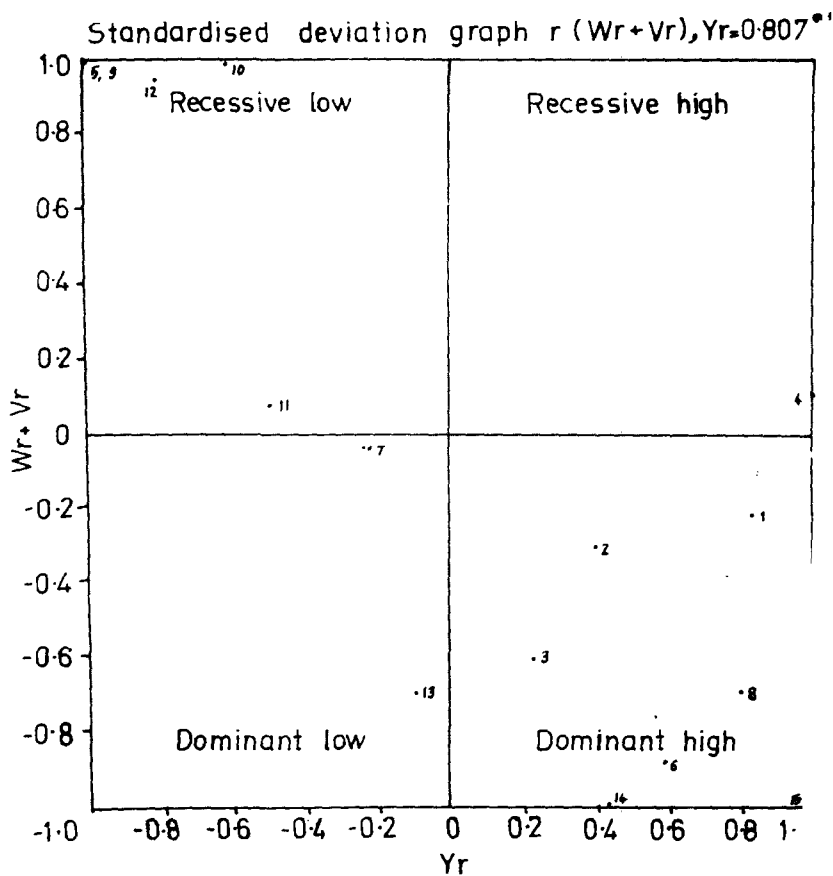


Fig.35.
CAPSULES / BRANCHES 1981 SUMMER

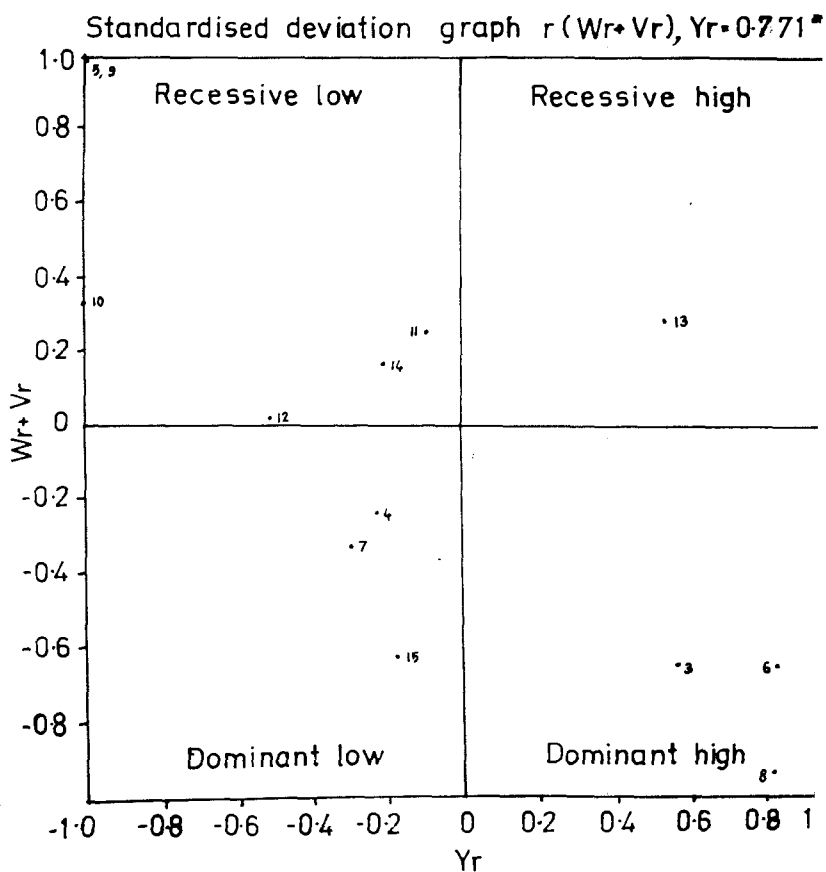
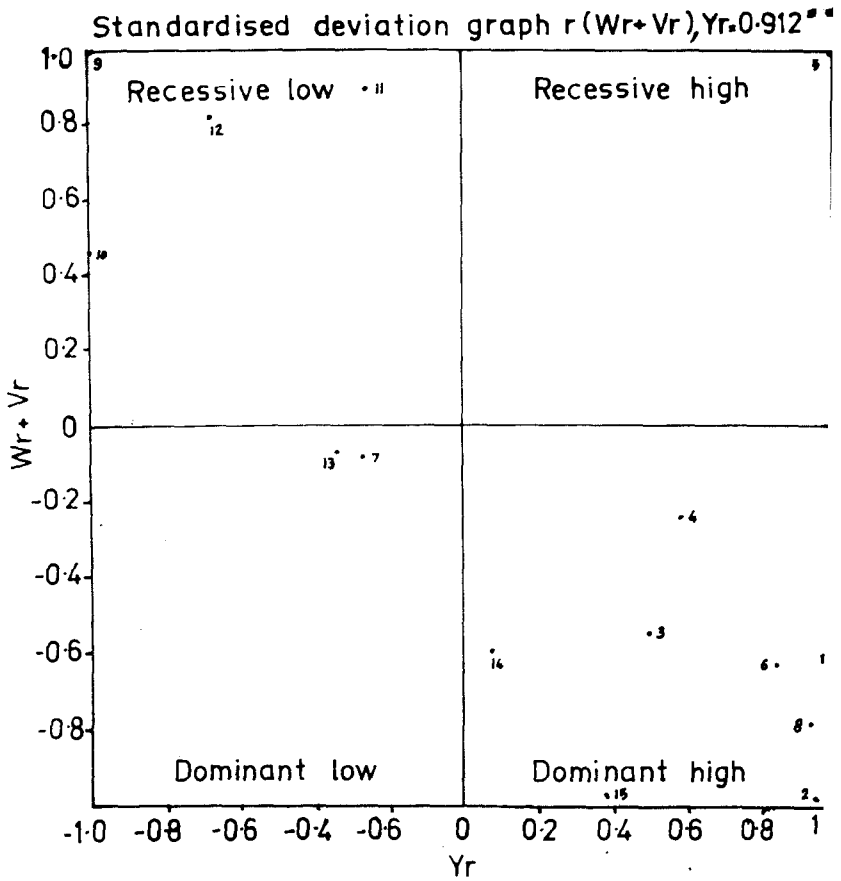


Fig.36.
CAPSULES / BRANCHES POOLED



19-57.
CAPSULES PER PLANT 1980 KHARIF

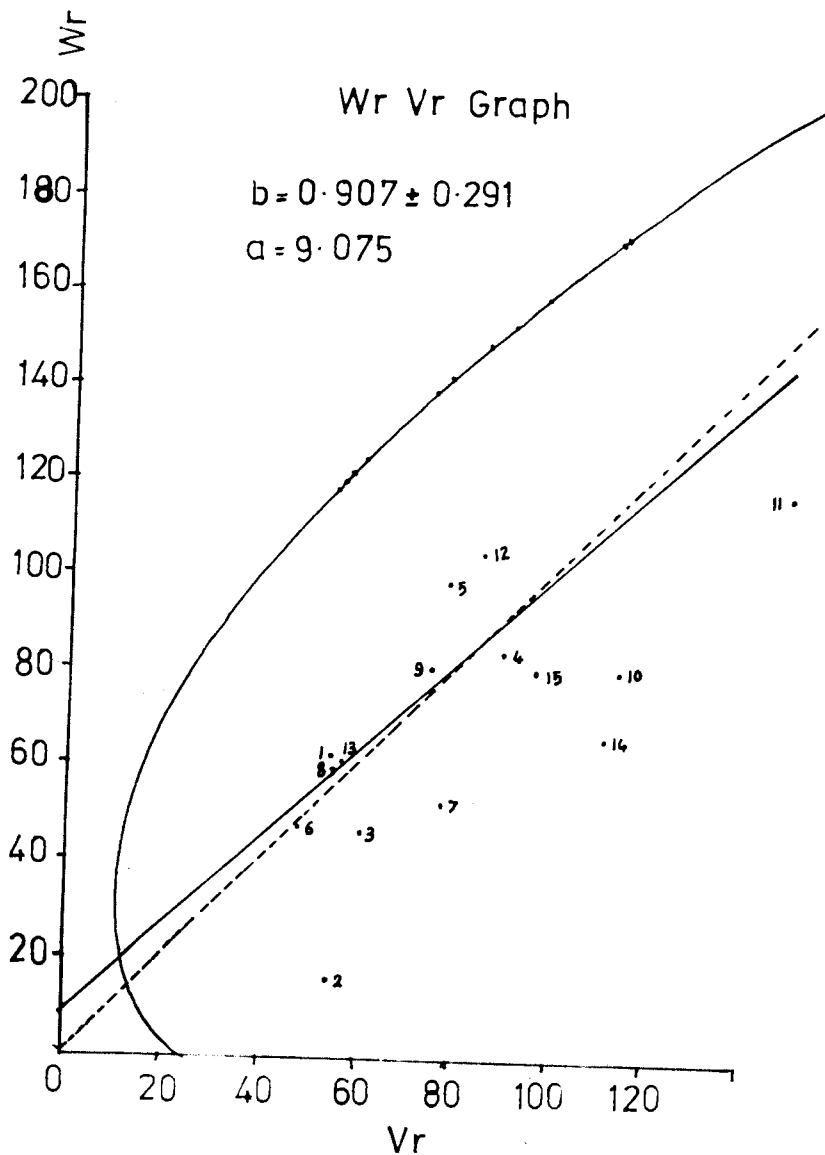


Fig.38.

CAPSULES PER PLANT 1981 SUMMER

Wr Vr Graph

$$b = 0.777 \pm 0.086$$

$$a = 18.626$$

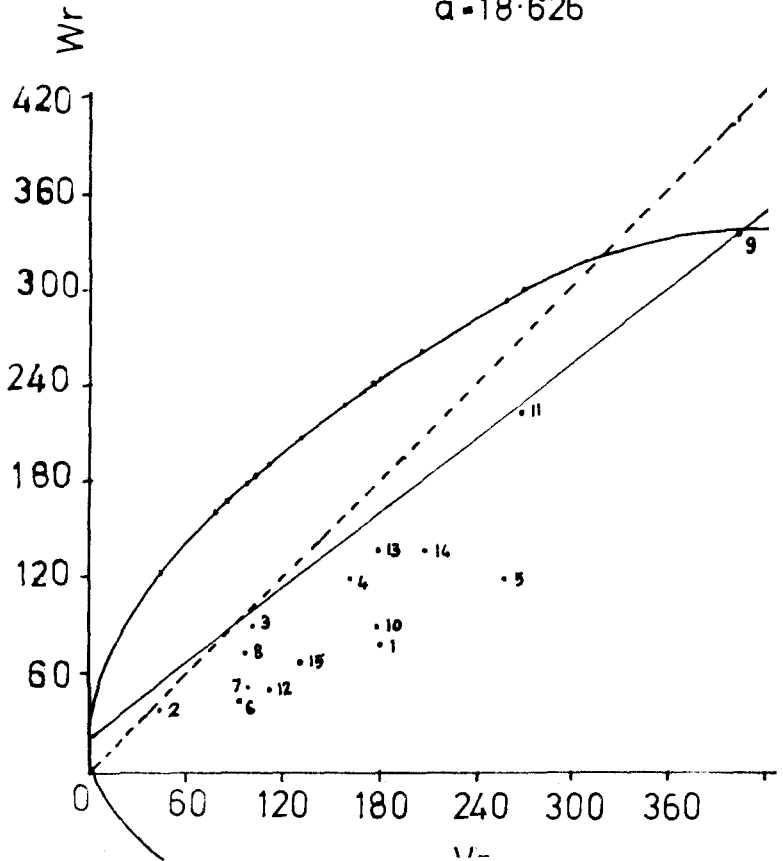


Fig.39.
CAPSULES PER PLANT POOLED

Wr Vr Graph

$$b = 0.803 \pm 0.140$$

$$a = 15.494$$

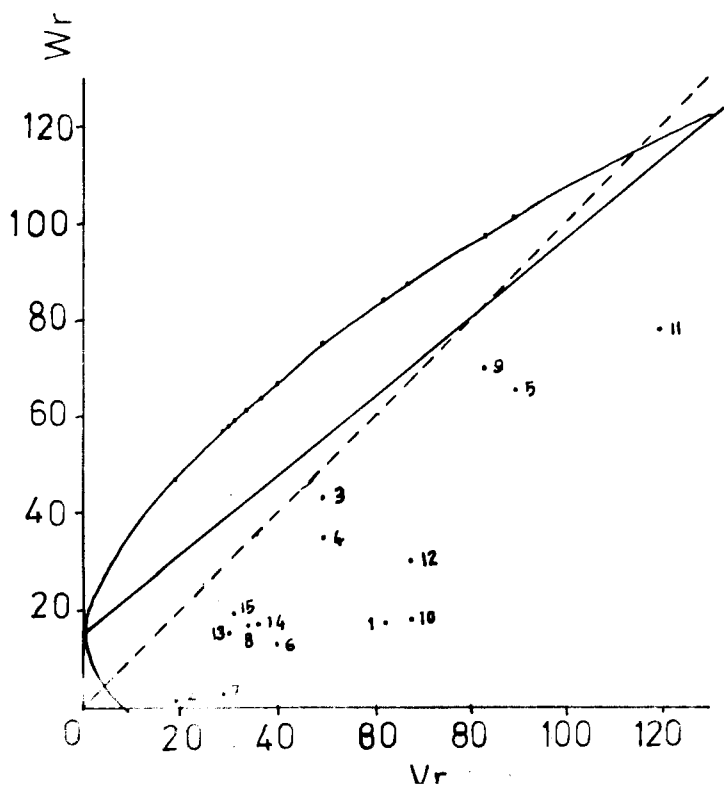


Fig.40.
CAPSULES PER PLANT 1980 KHARIF

Wr Wr' Graph

$$b=0.183 \pm 0.0169$$

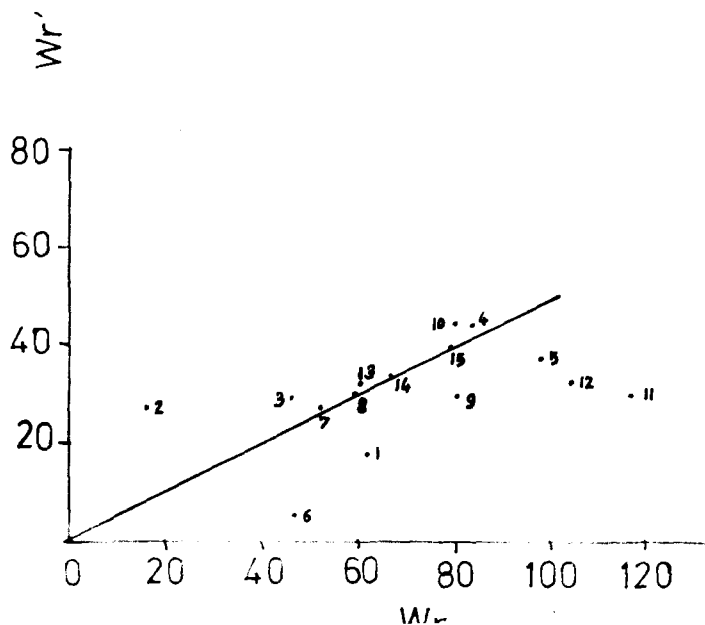


Fig.41.
CAPSULES PER PLANT 1981 SUMME

Wr Wr' Graph

$$b = 0.325 \pm 0.031$$

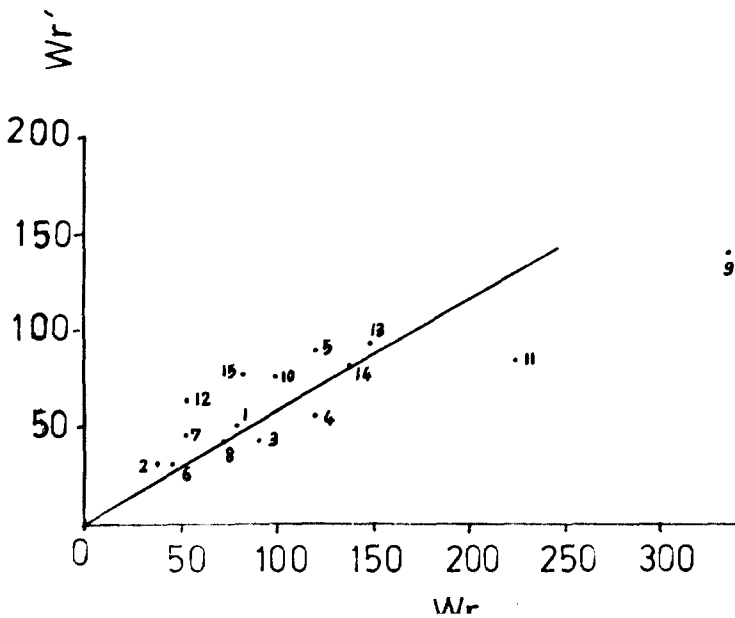


Fig.42.
CAPSULES PER PLANT POOLED

Wr Wr' Graph

$$b = 0.194 \pm 0.018$$

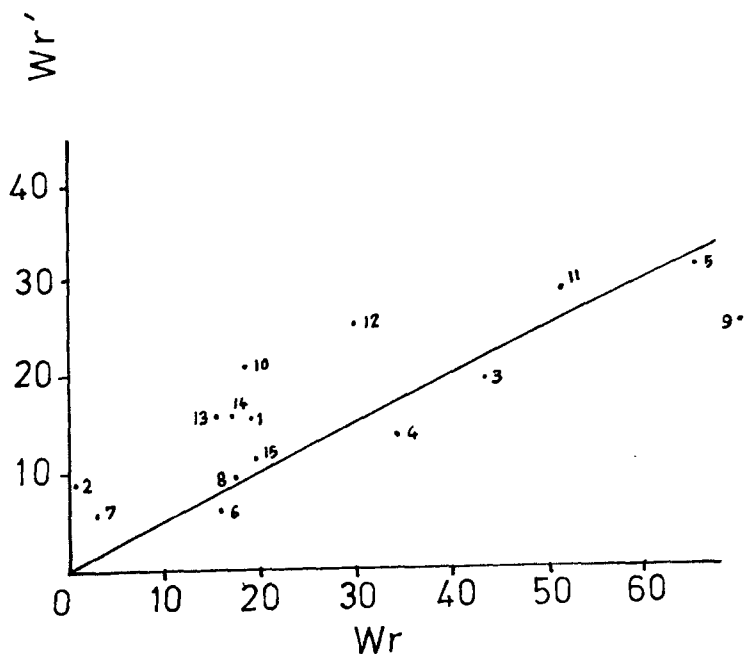


Fig. 43.

CAPSULES PER PLANT 1980 KHARIF

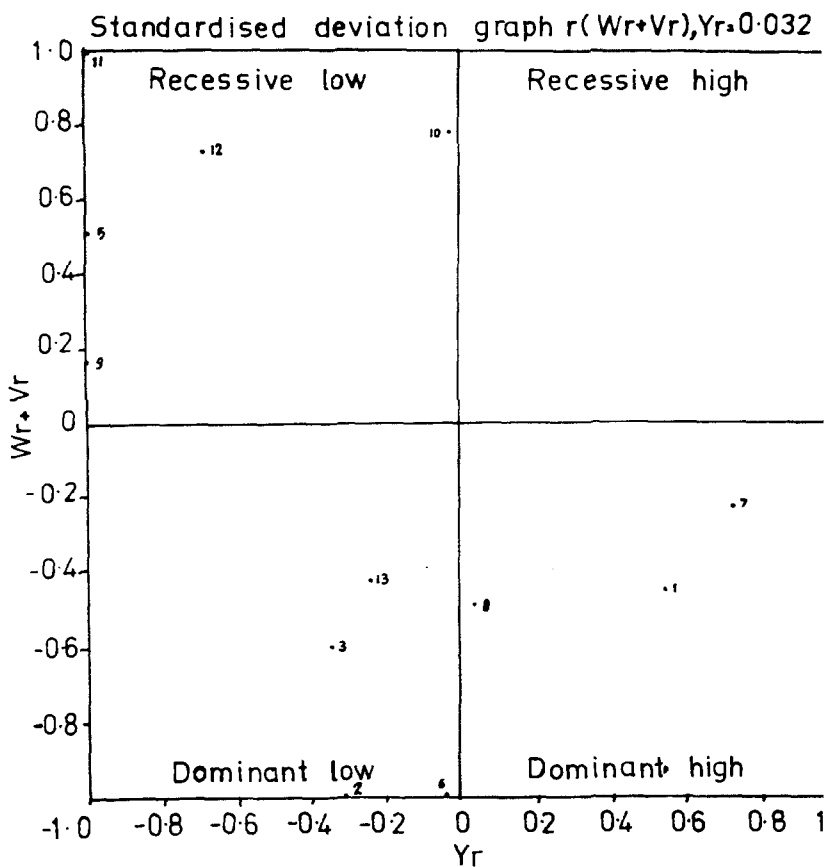


Fig. 44.

CAPSULES PER PLANT 1981 SUMMER

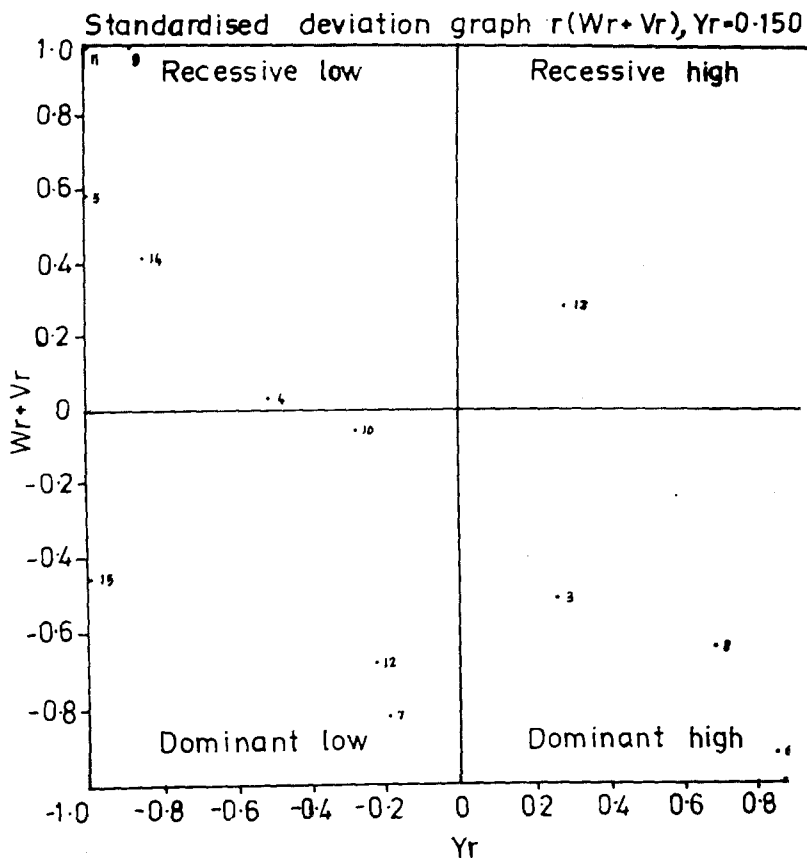


Fig.45.

CAPSULES PER PLANT POOLED

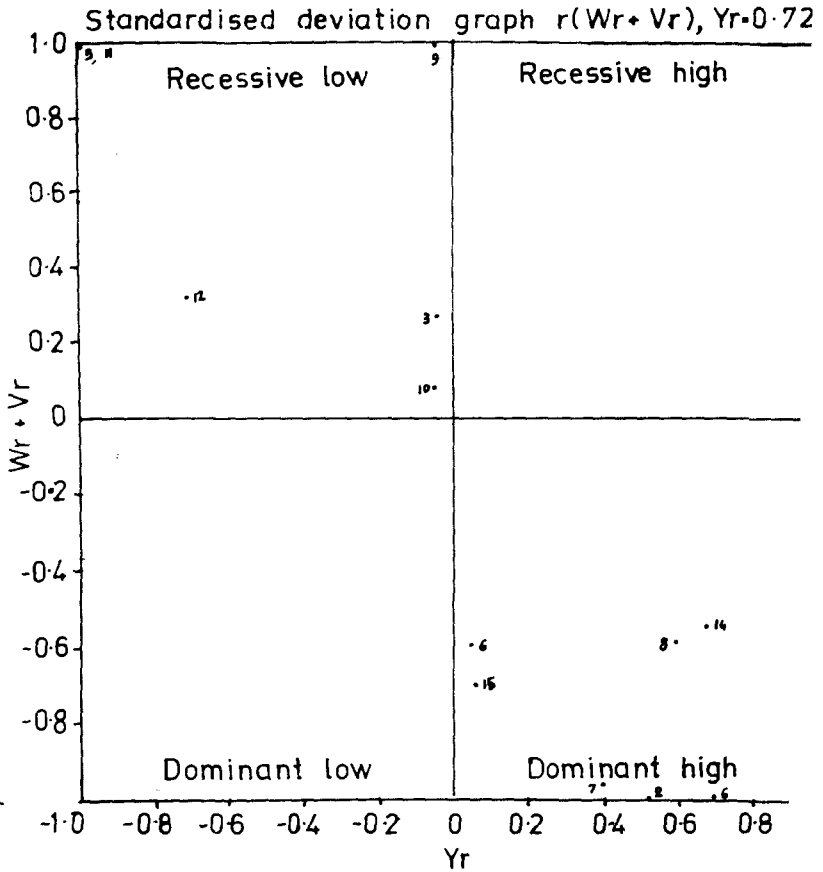


Fig.46.
SEED YIELD 1980 KHARIF

Wr Vr Graph

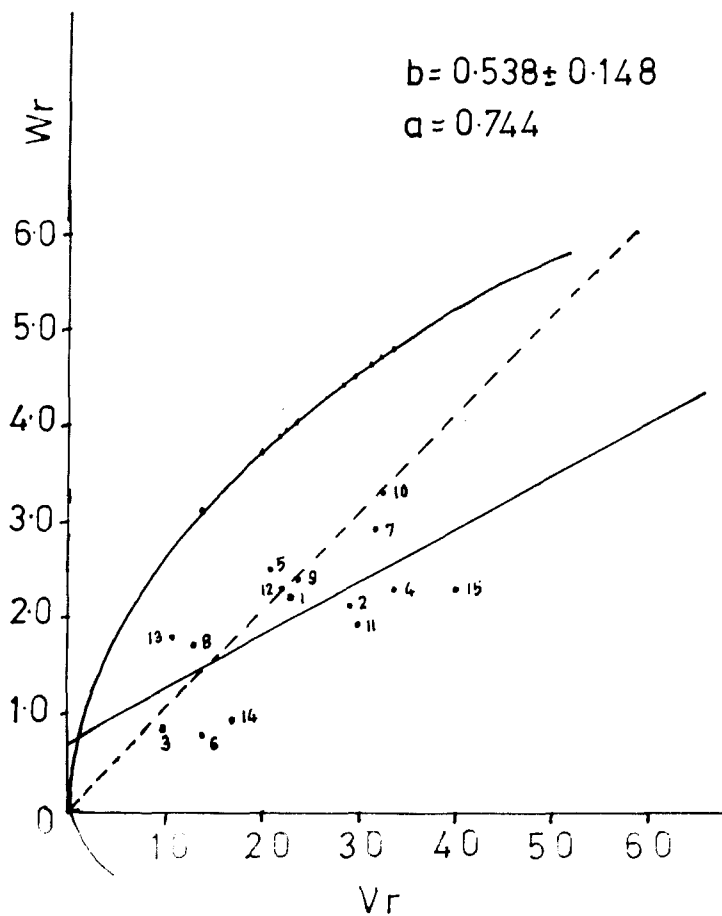


FIG.47.
SEED YIELD 1981 SUMMER

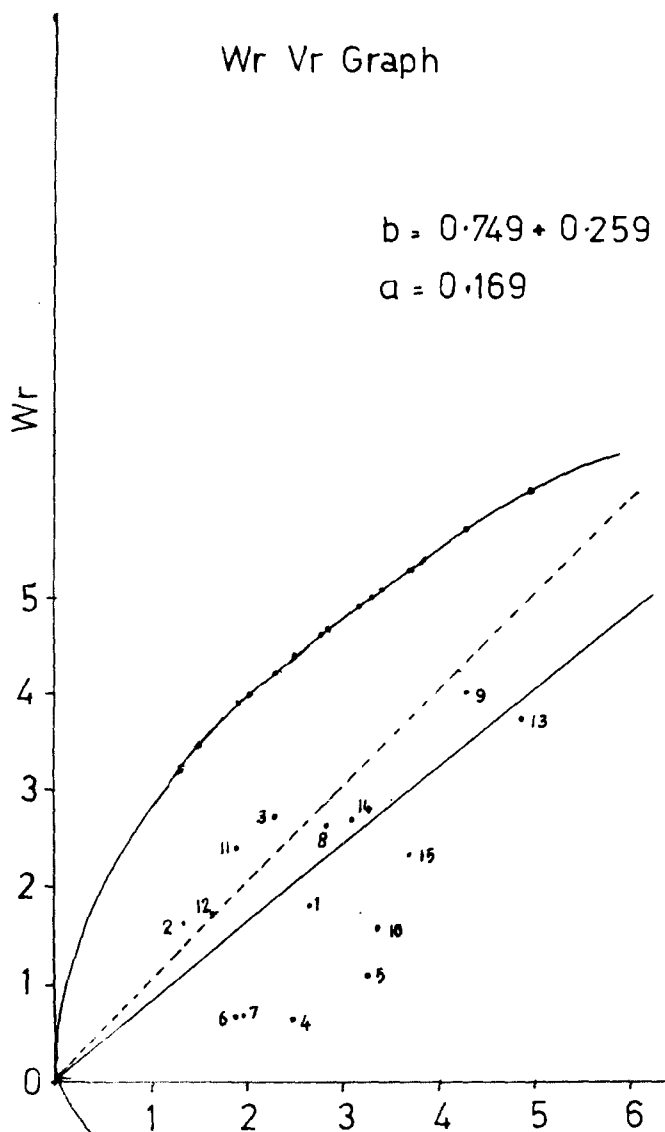


Fig. 48.
SEED YIELD - POOLED

Wr Vr Graph

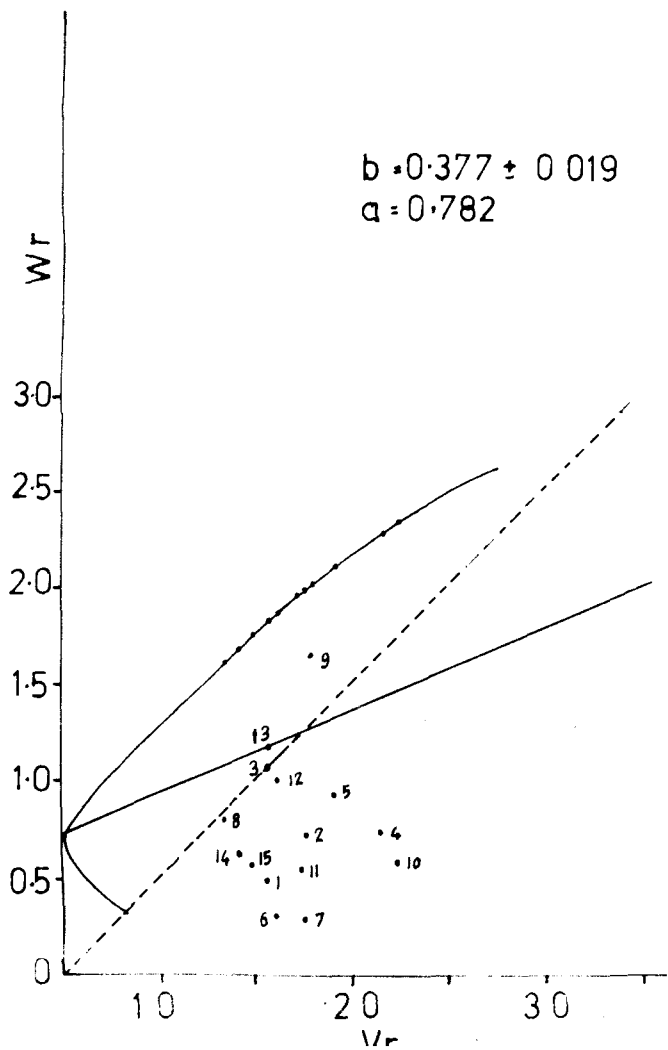


Fig.49.
SEED YIELD 1980 KHARIF

Wr Wr' Graph

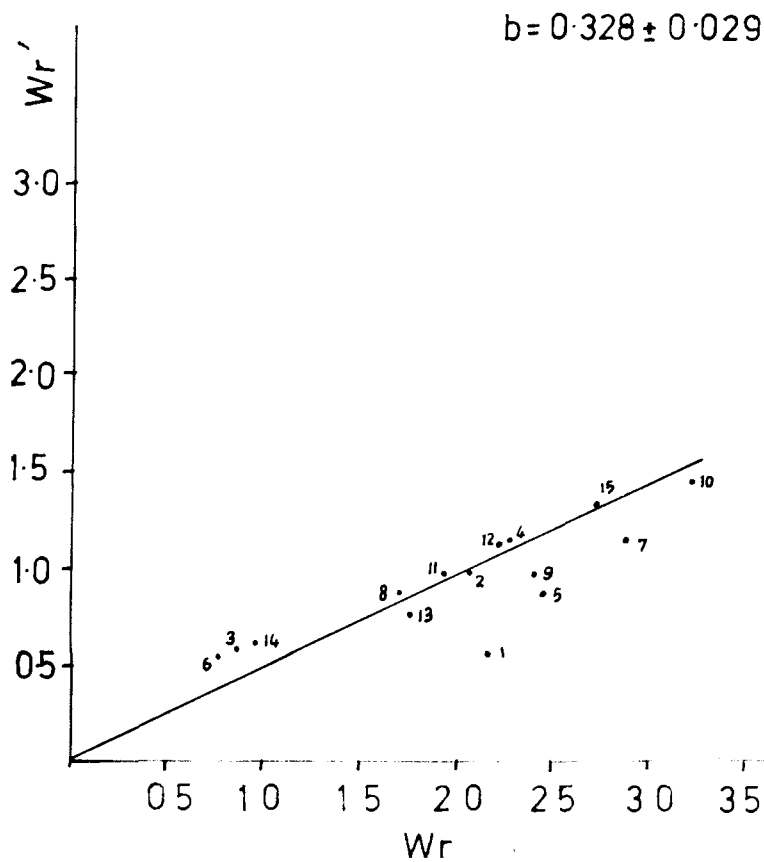


Fig. 50.
SEED YIELD 1981 SUMMER

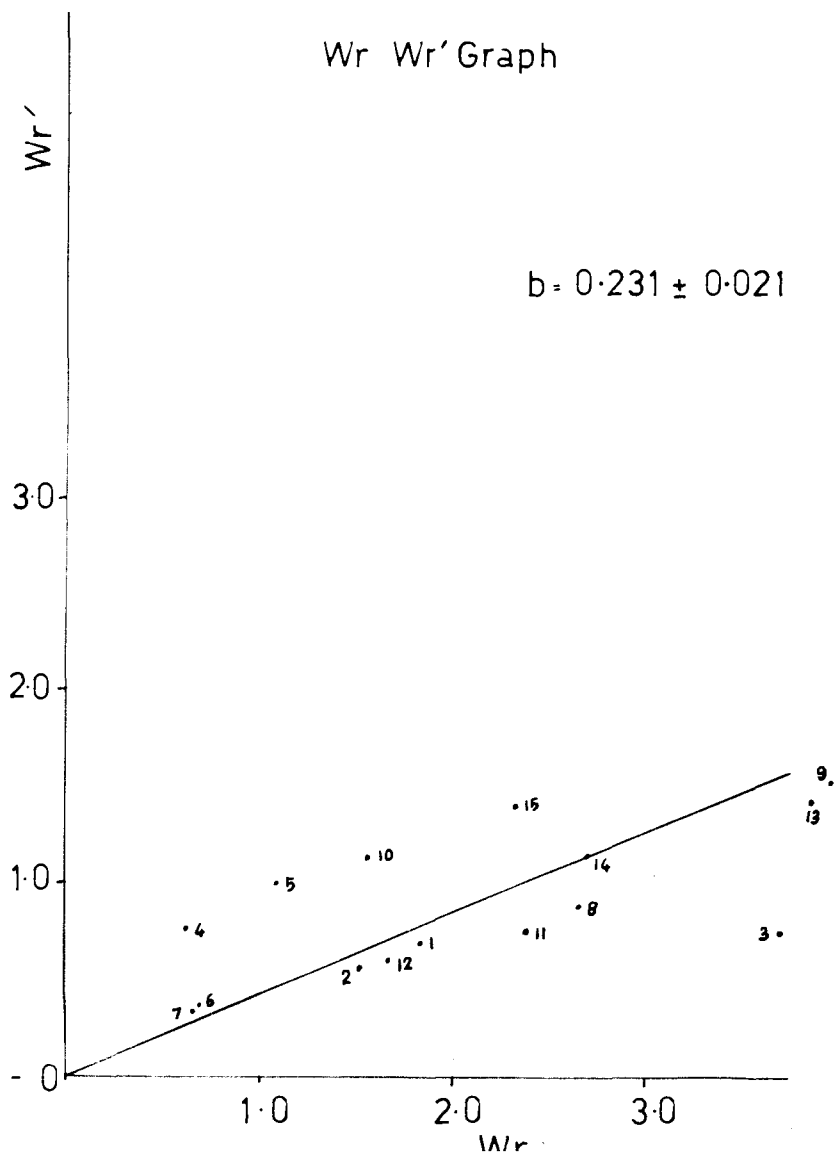


Fig.51.
SEED YIELD-POOLED
Wr Wr' Graph

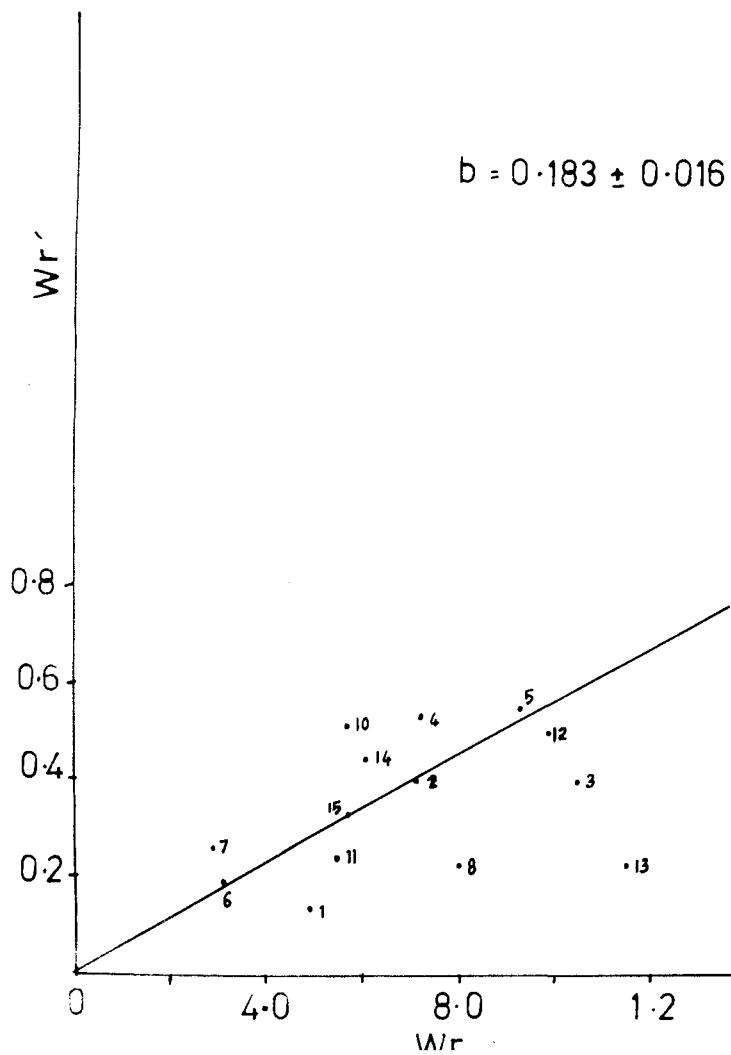


Fig.52. SEED YIELD 1980 KHARIF

Standardised deviation graph $r(Wr+Vr)$, $Yr=0.041$

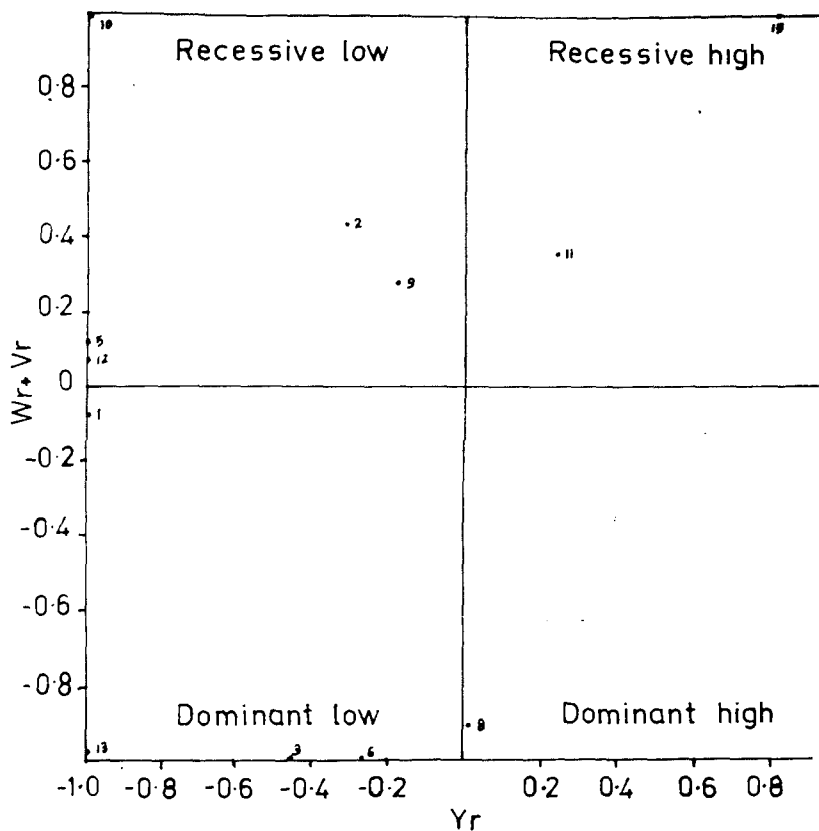


Fig. 53
SEED YIELD 1981 SUMMER

Standardised deviation graph $r(Wr+Vr), Yr=0.158$

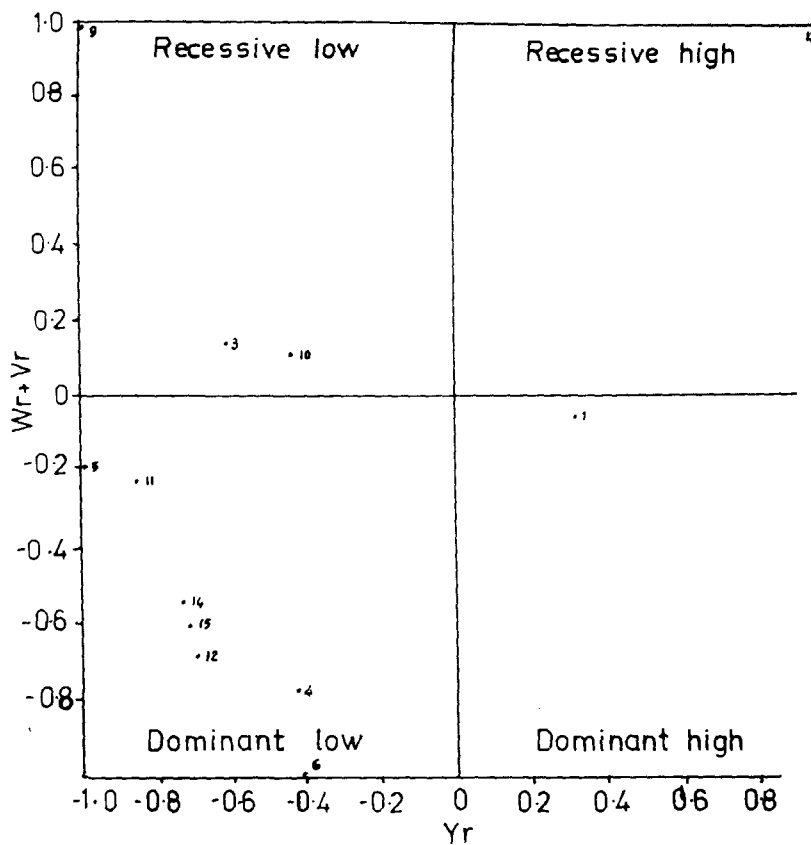
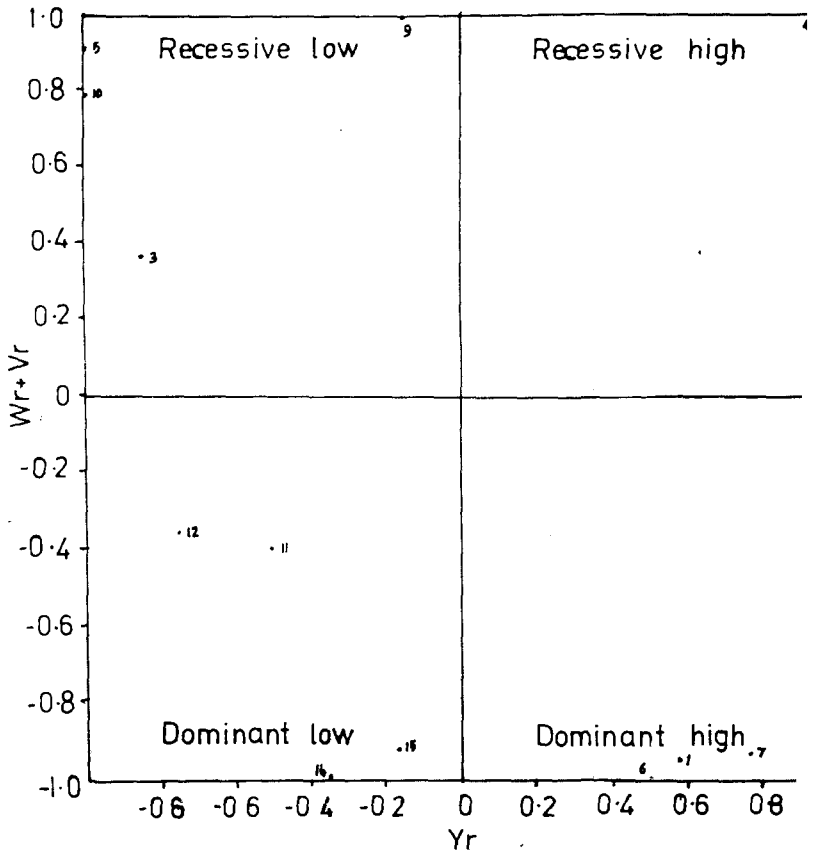


Fig.54. SEED YIELD - POOLED

Standardised deviation graph $r(W_r + V_r), Yr = 0-261$



**FREQUENCY DISTRIBUTION
OF F2 SEGREGANTS FOR
FIVE CHARACTERS**

Fig.55.

PLANT HEIGHT KRR2 X TMV6

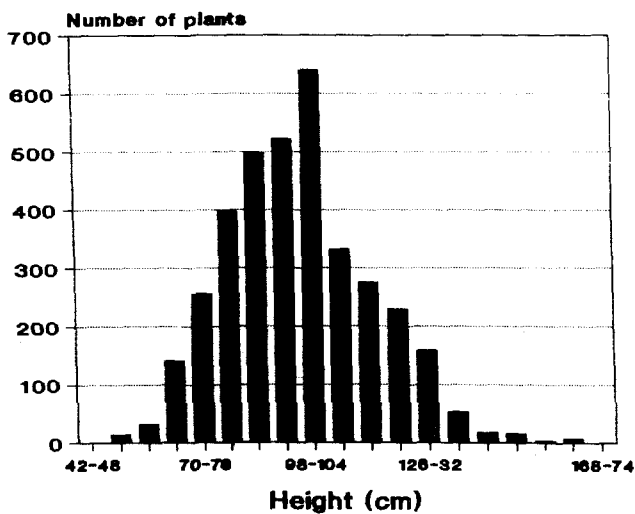


Fig.56.

PLANT HEIGHT KRR2 X S.i.2277

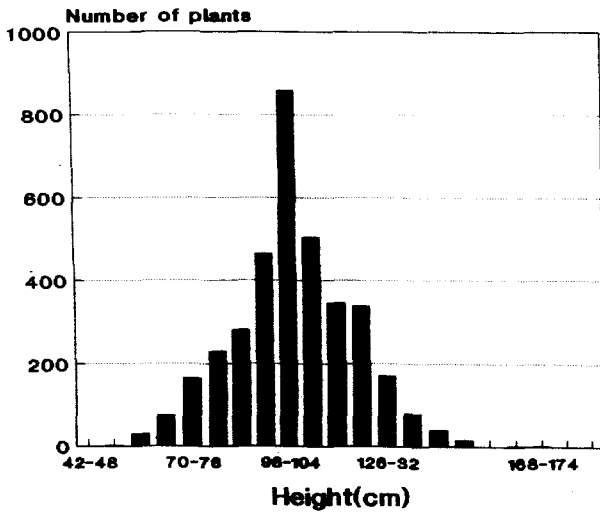


Fig.57.

PLANT HEIGHT KRR2 X S.i.2631

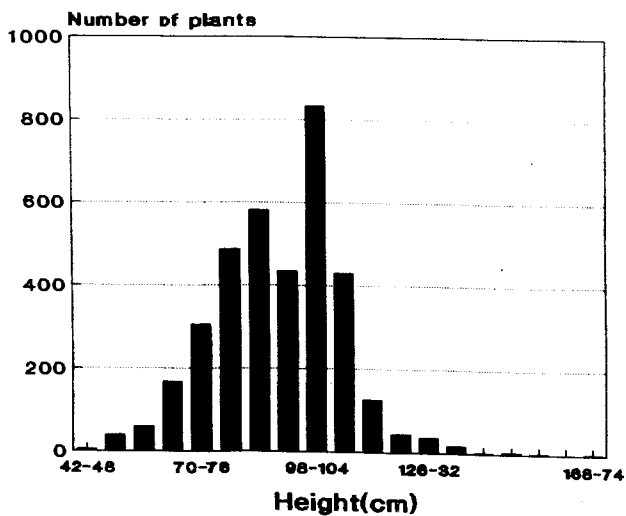


Fig.58.

PLANT HEIGHT TMV6 X S.i.2631

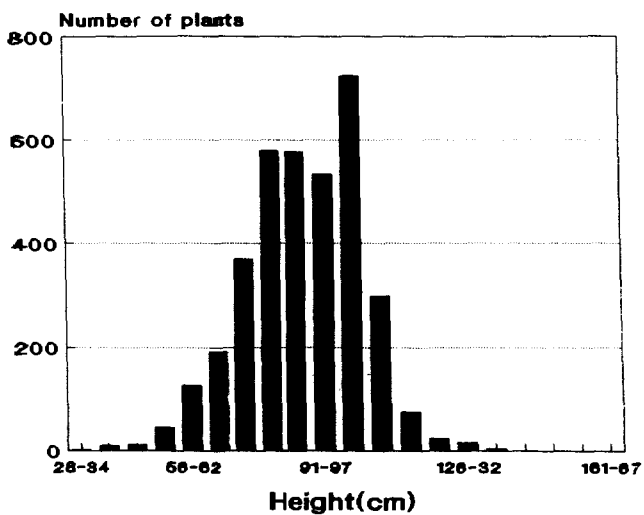


Fig.59.

PLANT HEIGHT

S.i.2141 X S.i.2631

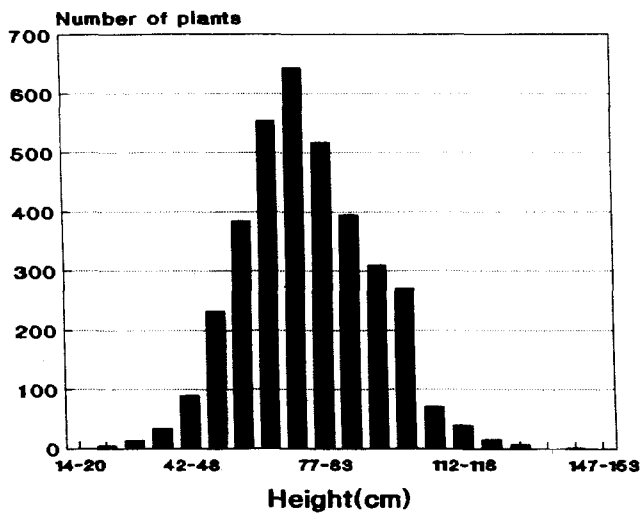


Fig.60.

PLANT HEIGHT S.i.2340 X S.i.2631

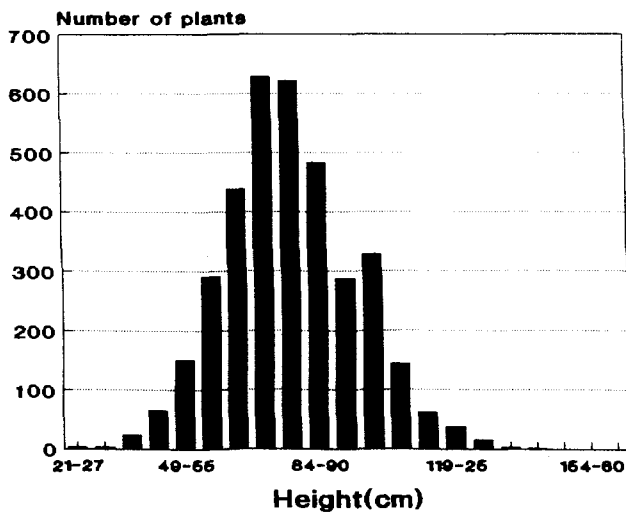


Fig. 61.

CAPSULES-MAINSTEM KRR2 X TMV6

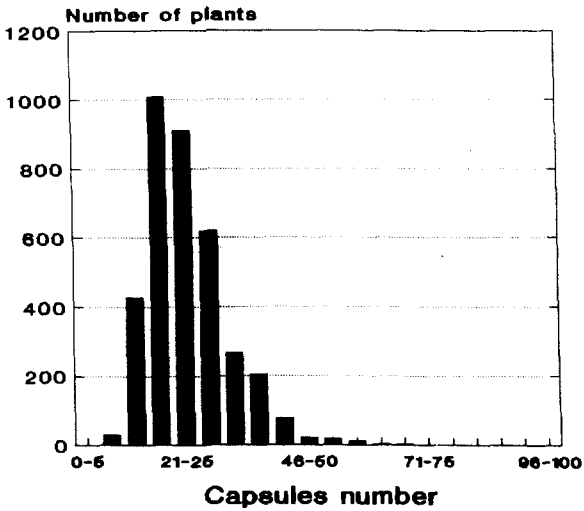


Fig. 62.

CAPSULE MAINSTEM KRR2 X S.i.2277

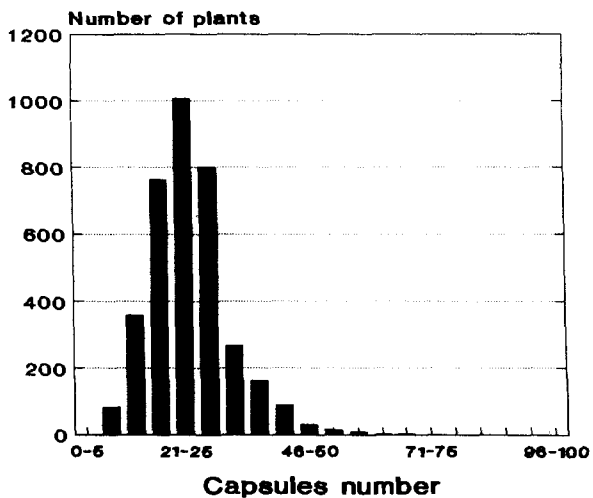


Fig.63.

CAPSULES MAINSTEM KRR2 X S.i.2631

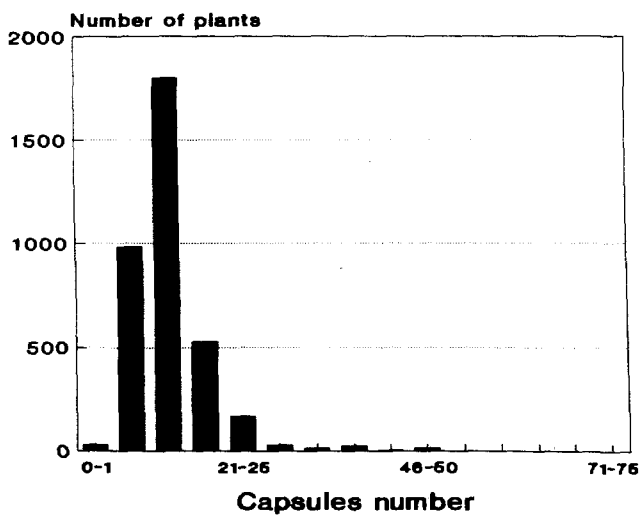


Fig.64.

CAPSULES MAINSTEM TMV6 X S.i.2631

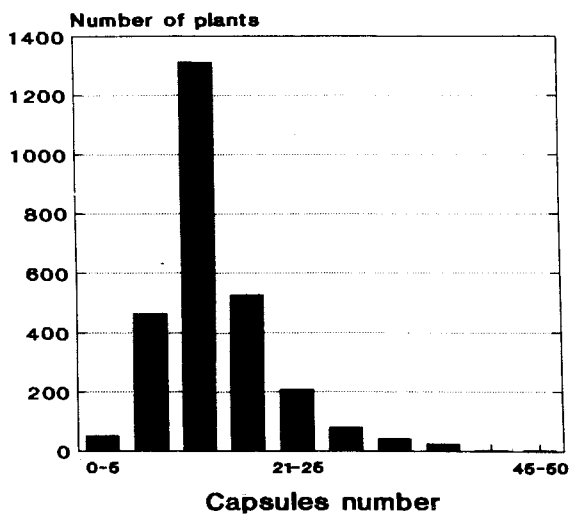


Fig.65.

CAPSULES MAINSTEM S.i.2141 X S.i.2631

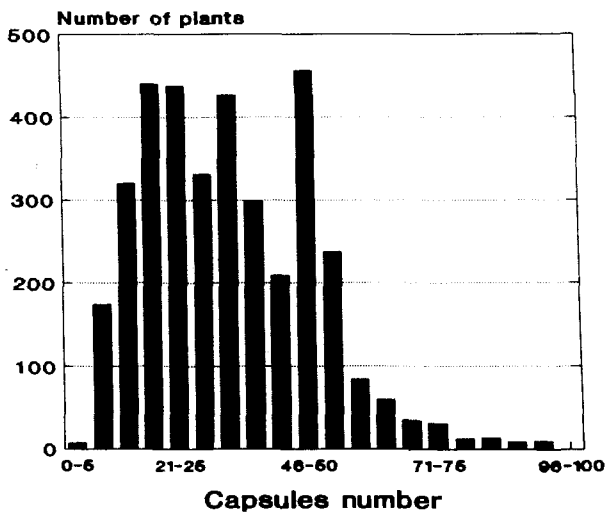


Fig.66.

CAPSULES MAINSTEM S.i.2340 X S.i.2631

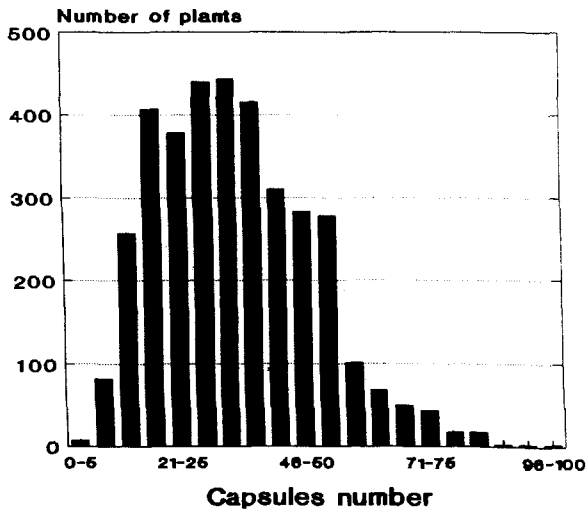


Fig.67.

CAPSULES branches KRR2 X TMV6

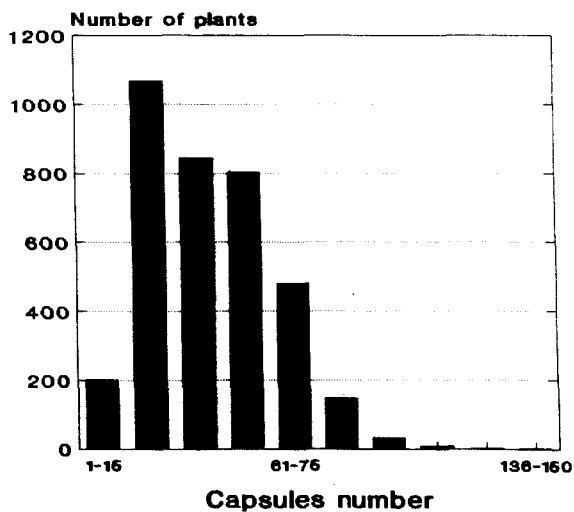


Fig.68

CAPSULES branches KRR2 X S.i.2277

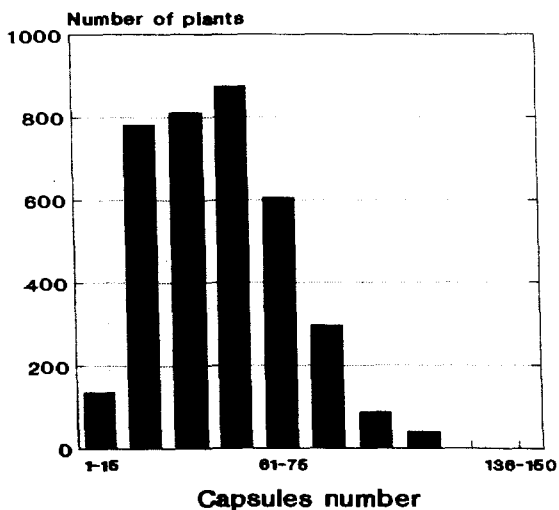


Fig.69.

CAPSULES branches KRR2 X S.i.2631

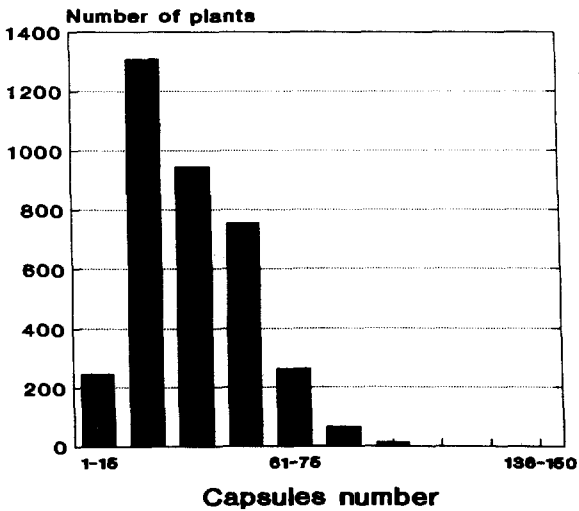


Fig.70

CAPSULES branches TMV6 X S.i.2631

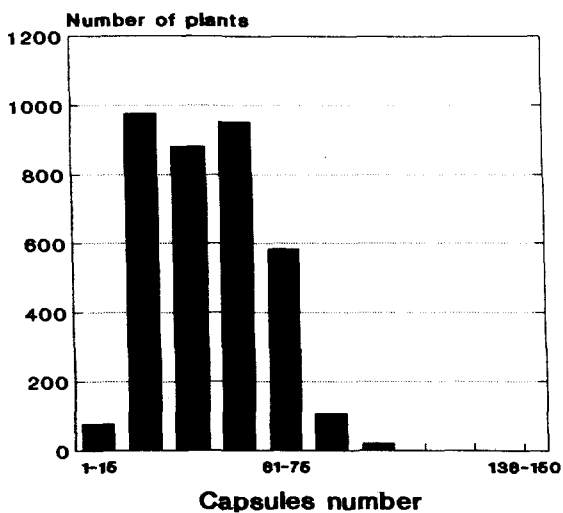


Fig.71.

CAPSULES branches S.i.2141 X S.i.2631

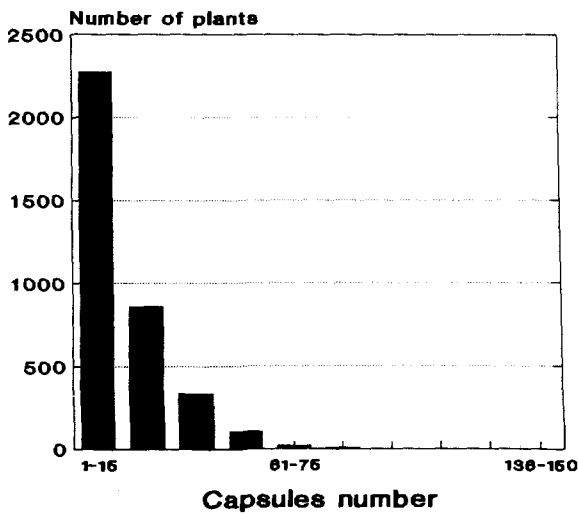


Fig.72.

CAPSULES branches S.i.2340 X S.i.2631

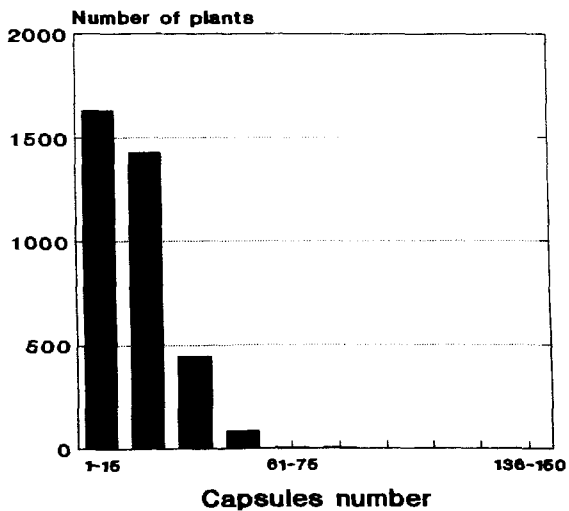


Fig.73.

CAPSULES plant KRR2 X TMV 6

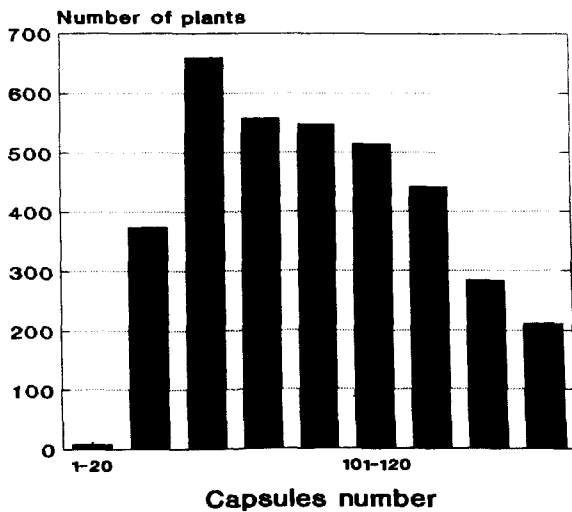


Fig.74.

CAPSULES plant KRR2 X S.i.2277

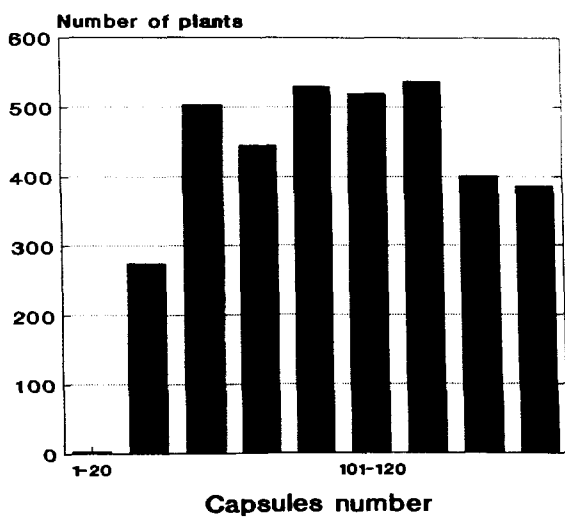


Fig.75.

CAPSULES plant KRR2 X S.i.2631

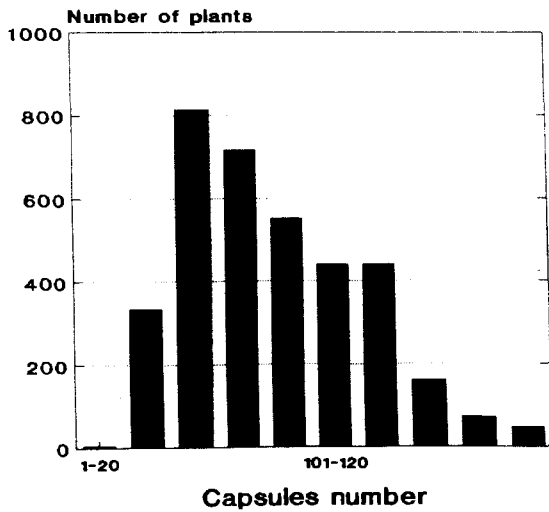


Fig.76

CAPSULES plant TMV6 X S.i.2631

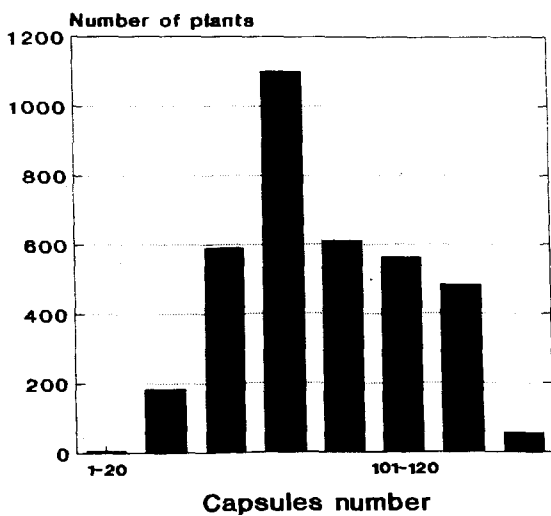


Fig.77.

CAPSULES plant S.i.2141 X S.i.2631

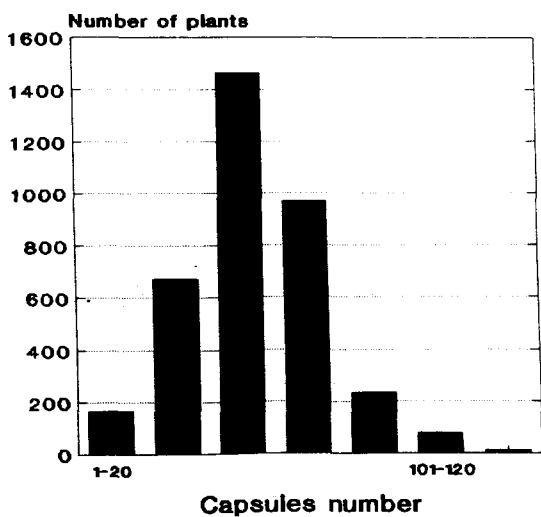


Fig.78.

CAPSULES plant S.i.2340 X S.i.2141

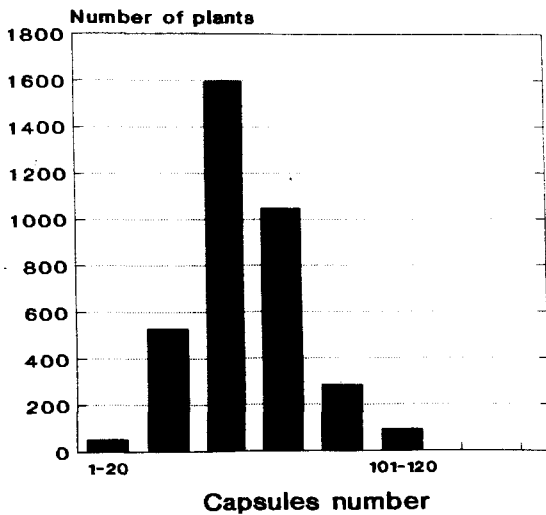


Fig.79.

SEED YIELD KRR2 X S.i.2277

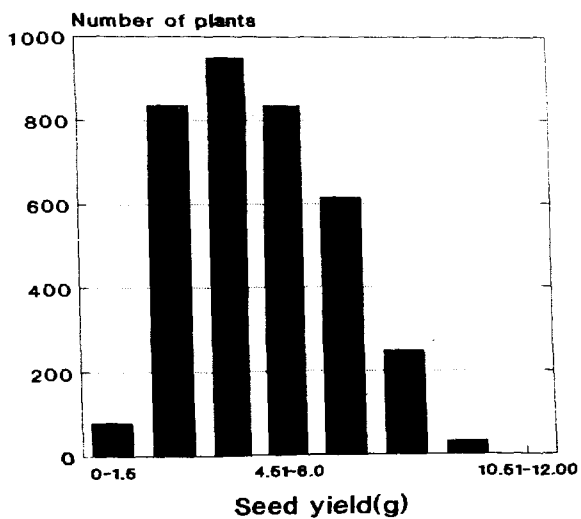


Fig.80.

SEED YIELD KRR2 X TMV 6

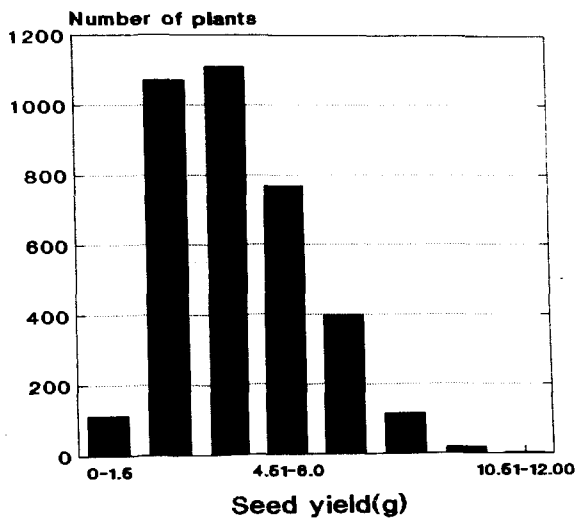


Fig.81.

SEED YIELD KRR2 X S.i.2631

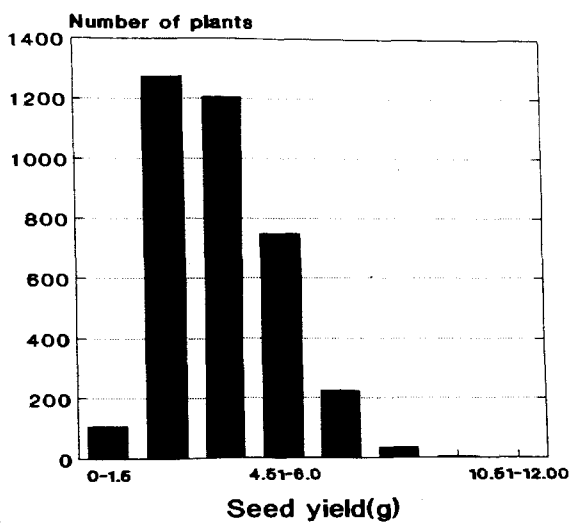


Fig.82.

SEED YIELD TMV6 X S.i.2631

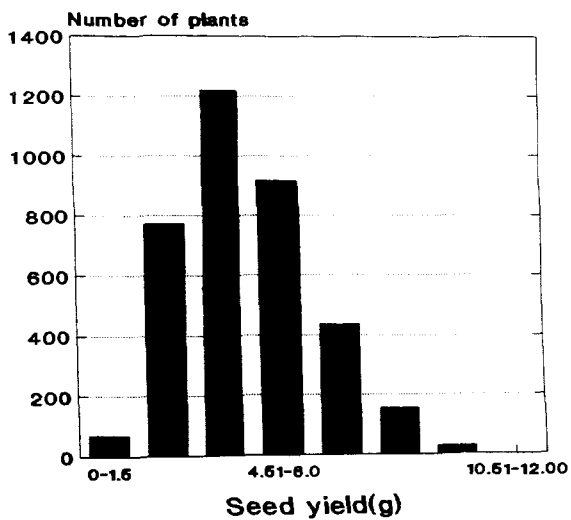


Fig. 83.

SEED YIELD S.i.2141 X S.i.2631

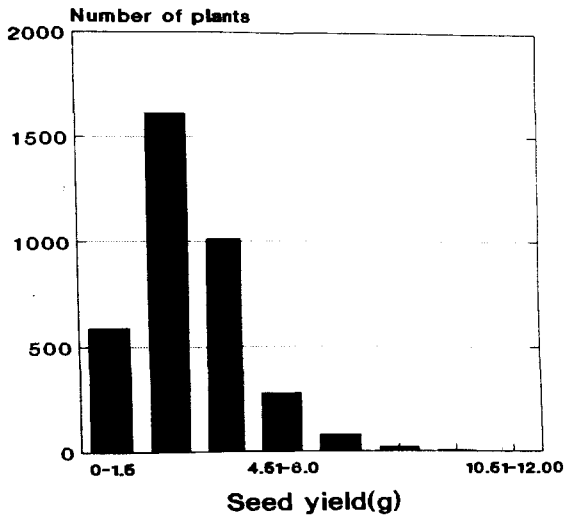


Fig.84.

SEED YIELD

S.i.2340 X S.i.2631

