Dedicated to

My beloved parents

GENETIC MAKE UP OF YIELD AND YIELD ATTRIBUTES IN A SIX PARENT DIALLEL CROSS OF TOMATO (*Lycopersicon esculentum* Mill.)

BY
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DECLARATION

I hereby declare that this thesis, entitled **'GENETIC MAKE UP OF YIELD AND YIELD ATTRIBUTES IN A SIX PARENT DIALLEL CROSS OF TOMATO (Lycopersicon esculentum Mill.)',** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar titles, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled **'GENETIC MAKE UP OF YIELD AND YIELD ATTRIBUTES IN A SIX PARENT DIALLEL CROSS OF TOMATO (Lycopersicon esculentum Mill.)'** is a record of research work done independently by Shri SIBY VARGHESE, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship.

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(SIBY VARGHESE)

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INTRODUCTION

Tomato (Lycopersicon esculentum Mill.) belonging to the family Solanaceae, of tropical American origin is one of the most popular and extensively grown vegetables in the world. It ranks second in commercial importance in many countries including India. Its versatile use as an important protective food consumed raw, cooked or processed elevates tomato to an enviable position among all vegetable crops. Tomato is a rich source of vitamins A, B and C and accomplishes taste, colour and flavour to a host of dishes all over the world.

In India, tomato is cultivated in different regions over an area of about 0.29 million hectares with an estimated production of 4.6 million tonnes annually. The average yield per hectare is only 15.85 tonnes (Chhabra, 1992).

Among flowering plants tomato is exceptionally well endowed with genetic and cytogenetic research possibilities. Its foremost attribute to such purposes, despite a relatively high haploid chromosome number (12) is its basic diploid nature. Recent researches has bridged tomato genetics and tomato breeding techniques to a great extent to their improvements and mutual benefit.

The phenomenon of heterosis found common in crop plants could be exploited for higher productivity in tomato. Choudhury et al. (1965) reported manifestation of hybrid vigour in F1 and F2 generations of tomato. The culture of hybrid vegetables in the country started with the evolution of the hybrid tomato 'Karnataka' in 1973. Hybrid tomatoes offer a very high yield of 70 - 80 tonnes per hectare. Hence development of hybrid variety is an ideal method to tackle the problem of low productivity.

In Kerala bacterial wilt caused by Pseudomonas solanacearum is a major handicap to tomato cultivation. To suit the conditions of Kerala, the high yielding varieties must be resistant to bacterial wilt. Only a few varieties of tomato are known to be resistant to bacterial wilt.

In all breeding procedures that involve hybridization, it is desirable to study and compare the performance of parental lines for combining abilities. The combining ability analysis furnishes not only information regarding selection of suitable parents for hybridization, but also elucidates to some extent the nature and magnitude of gene action involved.

Diallel crossing is an important mating system of universal application in plant breeding programmes. The present investigation was undertaken to study the combining ability, gene action and heterosis in tomato. A basic

understanding of the genetic phenomenon underlying the mode of inheritance of different characters and the sorting out of elite parents and superior combinations based on general combining ability (g.c.a.) and specific combining ability (s.c.a) effects will help to launch suitable plant breeding programmes.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

PLANT HEIGHT

a) COMBINING ABILITY AND GENE ACTION

From a study on inter-varietal hybrids of tomato in the F4,F5 and F6 generations Svanosio and Vandoni (1974) reported significant s.c.a. effects for plant height.

Singh and Singh (1980) in a combining ability analysis for plant height reported that g.c.a. variances were higher than s.c.a. variances in the F1 and F2 generations and so additive gene action was predominant for this character.

In a line x tester analysis Govindarasu et al. (1981) reported that s.c.a variances were higher than g.c.a. variances. They suggested the involvement of non-additive gene action for this character in tomato.

Combining ability analysis of pear shaped tomato was done by Sidhu et al. (1981). They reported higher estimates of g.c.a compared to those of s.c.a. They also showed the importance of additive and non-additive gene effects for plant height.

Moya et al. (1986) in an estimation of combining ability of nine tomato varieties reported significant g.c.a. and s.c.a. effects for fruiting height.

Sonone et al. (1986) in a combining ability analysis for yield and its components in tomato revealed that non-additive effects were important for plant height.

Younis et al. (1987) reported that two gene pairs with dominance was involved in the inheritance of tallness in tomato.

Combining ability analysis of tomato involving several crosses revealed the significance of positive s.c.a. effects in six crosses for plant height (Chandrasekhar & Rao 1989).

In a six parent diallel cross of tomato Ali et al. (1989) studied the combining ability for plant height and reported highly significant g.c.a and s.c.a. effects and involvement of additive and non-additive gene effects.

Natarajan, S. (1990) in a six parent full diallel cross indicated the presence of both additive and non-additive gene action for plant height.

Brahma et al. (1991) studied the inheritance of plant height in tomato in the parental, F1, F2, BC1 and BC2 generations of two crosses and they reported that in the cross Jap x CTI, the dominance effects were pronounced.

From a combining ability analysis of tomato including nine parents and their 36 F1's, Ghosh and Symal (1994) recorded high g.c.a. variance and predominant additive gene action for plant height. They suggested that crosses involving poor and good general combiners could give better expression for this trait.

b) HETEROSIS

Rema Bai (1975) studied heterosis in inter-varietal hybrids of tomato and reported that all the hybrids exhibited heterotic effects for plant height.

Babu (1978) in a 6 x 6 diallel cross of tomato including parents and F1 hybrids reported heterosis for plant height.

Govindarasu et al. (1982) studied heterosis in tomato and reported that heterosis was moderate for plant height.

In a study of heterosis in tomato Ahmed et al. (1988) reported that most of the hybrids showed positive heterosis over the better parent for plant height.

Brahma _et al._ (1991) studied the inheritance of plant height in the parental F1, F2, BC1 and BC2 generations of tomato and reported heterosis for this trait.

Dod _et al._ (1992) reported pronounced heterosis for plant height in a 12 x 12 diallel cross involving parents, and 66 F1 hybrids in tomato.

In a study of combining ability in tomato Seeja (1995) reported heterosis for plant height.

NUMBER OF BRANCHES PER PLANT

a) COMBINING ABILITY AND GENE ACTION

Gurdalbir Singh and Nandpuri (1974) in an estimation of combining ability in tomato reported that additive gene effects were important for branch number per plant. They also suggested that the cultivars Suttons, Best of All, Pusa Ruby and Red Belt exhibited high g.c.a for this trait.

In a line x tester analysis in tomato Dudi _et al._ (1979) reported that certain varieties exhibited high g.c.a for this trait.

Singh and Singh (1980), in a combining ability analysis indicated that g.c.a. variances were higher than s.c.a. variances for primary branches.

In a diallel analysis of tomato Natarajan (1990) reported the presence of both additive and non additive gene action for number of branches per plant.

In a line x tester analysis of tomato Seeja (1995) reported predominant role of additive gene action for the expression of this trait.

b. HETEROSIS

Rema Bai (1975) studied heterosis in inter-varietal hybrids and revealed that all the hybrids exhibited heterotic effects for number of branches per plant.

From a study of heterosis in pear shaped tomato Sidhu et al. (1981) reported that the crosses Gamed x Chicogrande and Punjab Chhuhara x KAL exhibited heterotic effect for this trait.

In a study of heterosis in tomato Singh and Singh (1993) reported that the heterosis for the hybrid Punjab Chhuhara x 84-8 was superior over the better parent for number of branches per plant.

SPREAD OF THE PLANT

Inheritance of growth habit components was studied by Daskaloff _et al._ (1975). They revealed that self pruning in tomato, which is controlled by the gene was independent of growth habit components such as the number and length of internodes. The number of leaves per stem was partially dominant and more than 3 genes control growth habit.

In a combining ability analysis in tomato Chandrasekhar and Rao (1989) noticed positive s.c.a. effects for spread of the plant.

Seeja (1995) studied combining ability aspects in tomato and reported that non-additive gene action has predominant role in the expression of this trait.

NUMBER OF LEAVES PER PLANT

a) COMBINING ABILITY AND GENE ACTION.

From a diallel cross involving six lines, Konstantinova _et al._ (1990) reported that leaf number between inflorescences was affected by growing conditions. Dominance and epistasis were found in the inheritance of this character.

b) HETEROSIS

Rema Bai (1975) studied heterosis in inter-varietal hybrids of tomato and indicated that all the hybrids exhibited heterotic effects for number of leaves per plant.

NUMBER OF DAYS FOR FIRST FLOWERING

a) COMBINING ABILITY AND GENE ACTION

Nandpuri et al. (1975) studied the combining ability aspects in a set of top crosses of male sterile lines x pollinators and reported that g.c.a and s.c.a variances were important for earliness in flowering.

In a study of inheritance of earliness in first generation of tomato hybrids Egiyan and Luk'yanenko (1979) reported that earliness for flowering was dominant.

Khatyleva (1980) proposed that inter-varietal hybridization in tomato using the lines with the best combining ability should be employed to produce early hybrids.

In a combining ability analysis of tomato, Swamy and Mathai (1982) reported significant g.c.a. effects and predominant additive gene action for early flowering.

Younis _et al._ (1987) reported that additive gene action was important in the inheritance of earliness.

In a diallel cross involving homozygous lines differing in performance Natarajan (1992) revealed the importance of additive gene action for days to flowering.

Shrivastava _et al._ (1993) in an estimation of combining ability in 6 cultivars reported that Pusa Ruby x Money Maker was the best combination for earliness in flowering.

In a 13 x 13 diallel analysis, the parents and the hybrids were evaluated for number of days to first flowering and significant additive gene effects were observed for this trait (Perera and Liyanaraachchi 1993)

(b) HETEROSIS

Heterosis was reported for earliness for flowering in certain tomato hybrids by Zubeldia and Neuz (1974).

In an estimation of heterosis in tomato Trinklein (1975) reported that heterotic effects were significant for early flowering.

Egiyan and Luk'yanenko (1979) reported heterosis for earliness for flowering in some hybrids of inter-varietal crosses of tomato. Heterosis for earliness was exhibited by the hybrids V729 x cross 525, Cross 525 x sort 123 and sort 123 x Podarok 105.

Govindarasu _et al._ (1982) studied heterosis in tomato involving 11 lines, four testers and their hybrids and reported that heterosis was moderate for earliness.

In a diallel cross involving 8 cultivars Singh and Singh (1993) reported that hybrids Punjab Chhuhara x 84-8, HS103 x Pusa Ruby, HS 102 x 84-8 and Pusa Ruby x 84-10 showed significant positive heterosis for days to first flowering over the better parent indicating their potential for producing an early crop.

Suresh Kumar _et al._ (1995) studied heterosis in tomato involving 7 tomato lines, their 21 F1's and 3 commercial hybrid standards and reported that greatest heterosis over superior parents was observed for early flowering.

Heterosis was studied in tomato by Pujari and Kale (1994) and they reported high heterosis for earliness.

NUMBER OF DAYS FOR FIRST HARVEST

(a) COMBINING ABILITY AND GENE ACTION.

Diallel analysis for morphological and production traits in elongated and round varieties of tomato was done by Scossiroli _et al._ (1976) and they reported that fruit maturity had additive and dominant effects.

Singh and Singh (1980) studied combining ability of tomato and suggested that non-additive variance was involved for number of days to fruit maturity in the F1 generation.

F1 hybrids of tomato cultivars were evaluated by Gibrel _et al._ (1982) at three growth stages. They reported that g.c.a. variance was larger than s.c.a. variance for earliness from first fruit set to first ripe fruit stage.

In a diallel analysis of tomato including 7 cultivars and 21 F1 hybrids Kalf-Allah and Kaseem (1985) reported that Pace Setter 502 had the highest g.c.a. for early yield. They also suggested the involvement of additive. dominance and epistatic effects in the expression of this character.

Diallel analysis for combining ability in tomato was conducted by Ghosh and Symal (1994). They reported that g.c.a variances were greater

than s.c.a variances and heavy additive gene action was predominant for days to ripening.

(b) HETEROSIS

Narcisco and Rosario (1988) studied processing quality of tomato hybrids and reported that hybrids exhibited standard heterosis and heterobeltiosis for days to first harvest.

In a 12 x 12 diallel cross involving parents and 66 F1 hybrids in tomato Dod _et al._ (1992) reported pronounced heterosis for days to first harvest.

PERIOD OF HARVEST

(a) COMBINING ABILITY AND GENE ACTION

Ali _et al._ (1989) from their studies on combining ability for harvesting period in a 6 parent diallel cross of tomato, reported that g.c.a and s.c.a effects were significant and the additive and non-additive gene effects were also significant for this trait.

In a study of combining ability in tomato Seeja (1995) reported that both additive and non-additive effects were important for period of harvest.

(b) HETEROSIS

In a study of seven inbred lines and their twenty one F1 hybrids of tomato, Lobo and Marin (1975) reported heterosis for harvesting period.

Heterosis was studied for harvesting period in a 6 parent diallel cross of tomato by Ali et al. (1989) and they suggested that the crosses Japanese x World Champion, World Champion x FR2 and World Champion x CTI exhibited high heterosis for this trait.

INDIVIDUAL FRUIT WEIGHT

COMBINING ABILITY AND GENE ACTION

In a combining ability analysis of tomato Gurdalbir Singh and Nandpuri (1974) reported that the cultivars and the line 19-5 exhibited high g.c.a for fruit weight . Crosses obtained from cultivars with high g.c.a showed high s.c.a for this trait. They suggested the importance of additive as well as non-additive gene effects for this trait.

Svanosio and Vandoni (1974) studied combining ability in the F4, F5 and F6 generations of inter-varietal hybrids of tomato and indicated significant g.c.a effects for mean fruit weight.

In a diallel cross involving six cultivars of tomato Trinklein (1975) found significant s.c.a. effect and also involvement of dominance and epistasis in the inheritance of fruit weight.

In a line x tester analysis of tomato Dixit _et al._(1980) revealed that g.c.a and s.c.a variances were significant and g.c.a variances were higher than s.c.a. variances and hence there is predominance of additive gene action for average fruit weight.

Progeny from diallel crosses among 9 inbred lines were evaluated by Swamy and Mathai (1982) and they reported significant g.c.a effects and predominant additive gene action for fruit weight.

Dholaria and Qadri (1983) studied combining ability for fruit weight in a 6 x 6 diallel cross of tomato and they revealed highly significant g.c.a. and s.c.a. variances and predominant additive gene action for the above character.

Khalil _et al._(1983) studied heritability of fruit weight in tomato and indicated that this trait is quantitatively inherited with predominance of additive gene action.

In an estimation of g.c.a. and s.c.a. of 9 tomato varieties including 36 F1's derived from a diallel cross Moya _et al._ (1986) reported that the g.c.a. and s.c.a effects were significant for fruit weight.

Sonone _et al._ (1986) studied combining ability effects of tomato crosses derived from 13 lines and four testers and reported high g.c.a. effects and predominant additive gene action for this trait.

In an analysis of combining ability Lonkar and Borikar (1988) reported predominance of g.c.a. effects for fruit weight.

Omara _et al._ (1988) reported that in a 6 x 6 diallel cross of tomato g.c.a and s.c.a. effects were significant in the parents and F1 hybrids. The components of variance analysis revealed predominant additive gene action for fruit weight.

Chandrasekhar and Rao (1989) reported significant positive s.c.a. effects for fruit weight in eight crosses of tomato.

Diallel analysis to study the inheritance of yield and its components in tomato was conducted by Natarajan (1992) and reported that both additive and non-additive gene action were important for fruit weight.

Szwadiak and Kordus (1992) crossed four tomato lines in complete diallel design and reported significant g.c.a and s.c.a. variances for single fruit weight.

Diallel analysis for combining ability in tomato was conducted by Ghosh and Symal (1994). They reported that the variety Flora Dade was the best general combiner. They suggested that crosses involving poor general combiners could give better expression for this trait.

(b) HETEROSIS

Sidhu et al. (1981) studied heterosis in pear shaped tomato involving seven varieties and their hybrids from a non-reciprocal diallel cross and reported that the hybrid from the cross Roma x Punjab Chhuhara exhibited high heterosis for average fruit weight.

Heterosis for fruit weight was studied in tomato by Alvarez (1985) and he reported significant positive heterosis for this trait. The hybrid from the cross INCA 21 X INCA 3 was superior to the better parent.

Ahmed et al. (1988) studied heterosis in tomato and reported that most of the hybrids showed positive heterosis over the better parent for fruit weight.

Araujo and Campos (1991), from an evaluation of prostrate cultivars of tomato and F1 hybrids in diallel crosses, reported significant positive heterosis for fruit weight.

In a study of seven tomato lines, their 21 F1's and three commercial hybrid standards Suresh Kumar _et al._ (1995) reported that greatest heterosis over superior parents was observed for average fruit weight.

NUMBER OF FRUITS PER PLANT

(a) COMBINING ABILITY AND GENE ACTION

Conti (1974) reported that for the character total number of fruits per plant in tomato dominance effects accounted for most of the genetic variance in tomato.

In an estimation of combining ability in tomato Guardalbir Singh and Nandpuri (1974) reported that the male sterile line 19-5, the cultivars and their crosses exhibited high g.c.a. and s.c.a. effects. They also suggested that both additive and non-additive effects were important for fruit number per plant.

In tomato combining ability analysis in a set of top cross of male sterile lines x pollinators was conducted by Nandpuri _et al._ (1975). They reported significant g.c.a. and s.c.a. variance for number of fruits per plant.

Trinklein and Lambeth (1975) while analysing combining ability of tomato hybrids derived from a 6 x 6 reciprocal diallel set found that the small fruited line, PJ 1189 & 785, showed the greatest g.c.a. effect for fruit number and it was mainly controlled by additive gene effects.

Combining ability in tomato was studied by Maggiore _et al._ (1976) and they reported that g.c.a. effects were significant for this trait and they suggested the involvement of additive gene effects.

Singh and Mittal (1978) in a combining ability analysis of tomato reported significant g.c.a. variance for fruit number per bunch in the F1 generation.

Combining ability analysis for five yield components in the winter and summer seasons was conducted by Dhillon _et al._ (1979) and they reported significant g.c.a variances in the male and female parents in both seasons for fruit number.

Dudi _et al._ (1979) carried out line x tester analysis in tomato and reported that, of the 21 crosses, certain hybrids showed high s.c.a. for number of fruits per plant.

In a line x tester analysis Dixit _et al._ (1980) revealed that g.c.a. variances and s.c.a. variances were significant for this trait. But g.c.a.

variances were higher than s.c.a. variances indicating that additive gene action was predominant.

In a study of combining ability in pear shaped tomato Sidhu _et al_ (1981) reported predominance of non-additive gene effects for number of fruits per plant.

Combining ability analysis of tomato involving progenies from a diallel set of crosses was conducted by Swamy and Mathai (1982) and they reported significant g.c.a. effect and predominant additive gene action for this character.

In an analysis of combining ability, Dholaria and Qadri (1983) recorded significant g.c.a. and s.c.a. variances and predominant additive gene effects for the character number of fruits per plant.

Khalil _et al._ (1983) studied heritability of number of fruits per plant and indicated that the character was quantitatively inherited with predominance of additive effects and partial dominance.

Sonone _et al._ (1986) estimated combining ability in a 13 x 4-line x tester combination in tomato and reported high g.c.a effects and predominant additive gene action for fruit number.

Combining ability analysis in a line x tester model, was done by Lonkar and Borikar (1988) and they reported that high g.c.a. for fruit yield was associated with high or medium g.c.a. for fruit number.

Omara _et al._ (1988) in a 6 x 6 diallel analysis of tomato showed that both g.c.a. and s.c.a. effects were high in the F1 hybrids. Additive and non-additive gene effects were found to be significant with predominant role of additive component of genetic variance for this trait.

A diallel cross with five cultivars of tomato revealed that the parents IPA-3 and Roma VFN showed high g.c.a. and hybrids with Roma VFN as one of the parents showed high s.c.a. for total number of fruits per plant (Araujo and Campos, 1991).

The inheritance of number of fruits per plant was studied in the parental, F1, F2, BC1 and BC2 generations of two crosses involving three parents and reported that in the cross Jap x CTI, the dominance and the additive x dominant gene effects were predominant (Brahma _et al._, 1991).

Natarajan (1992) from a diallel analysis of tomato reported that both additive and non-additive gene action were important for the number of fruits per plant.

Ghosh and Symal (1994) from their studies on combining ability reported that the variety BT-1 was the best general combiner for number of fruits per plant. They suggested that for getting better of this trait good and poor general combiners should be crossed.

(b) HETEROSIS

Heterosis was reported for number of fruits in tomato hybrids by Zubeldia and Neuz (1974) and they recorded that the hybrid from the cross Marmande x Tonda Sioux exhibited high heterosis for this trait.

Babu (1978) studied heterosis in a 6 x 6 diallel cross of tomato including parents and F1 hybrids and showed heterosis for fruit number.

In tomato a line x tester analysis was carried out by Anbu et al. (1981) and they estimated the relative heterosis and heterobeltiosis for number of fruits per plant.

Govindarasu et al. (1982) studied heterosis in tomato involving 11 lines, four testers and their hybrids and reported that heterosis was high for number of fruits per plant.

Jamwal et al. (1984) reported hybrid vigour for fruit number per plant in a line x tester analysis of tomato involving ten foreign lines and three local testers.

Ahmed _et al._ (1988) studied heterosis in tomato and reported that most of the hybrids showed positive heterosis over the better parent for number of fruits per plant.

Brahma _et al._ (1991) studied the inheritance of number of fruits per plant in the parental, F1, F2, BC1 and BC2 generations of tomato and reported heterosis for this trait.

In a 12 x 12 diallel cross involving parents and F1 hybrids in tomato Dod _et al._ (1992) reported pronounced heterosis for number of fruits per plant.

Singh and Singh (1993) studied heterosis in tomato and they reported that the hybrid Punjab Chhuhara x 84-8 showed the highest heterosis for number of fruits per plant.

In a line x tester analysis of 30 F1 hybrids, 10 lines and 3 testers Dev _et al._ (1994) reported maximum heterosis for number of fruits per plant. They also reported that the best F1 hybrid for this trait was EC 156 x Marglobe.

Pujari and Kale (1994), from a 8 x 8 half diallel cross reported high heterosis for number of fruits per plant.

In a study of 7 tomato lines, their 21 F1's and 3 commercial hybrid standards, Suresh Kumar _et al._ (1995) reported that greatest heterosis over superior parents was observed for number of fruits per plant.

FRUIT YIELD PER PLANT

(a) COMBINING ABILITY AND GENE ACTION

Gurdalbir Singh and Nandpuri (1974) analysed the combining ability of eight tomato cultivars and two male sterile lines 19-5 and 26-5 and observed that the cultivars and the line 19-5 showed significant g.c.a. for yield. The results indicated the importance of additive gene effects.

Combining ability analysis using a set of top crosses of male sterile lines with pollinators in tomato for yield components showed the importance of g.c.a and s.c.a. effects for yield (Nandpuri et al. 1975).

Trinklein and Lambeth (1975) recorded from a 6 x 6 reciprocal diallel cross using inbred lines of tomato, that the line Mosaje had the greatest g.c.a. effect for total yield and this trait was mainly controlled by additive effects.

Maggiore et al. (1976) reported significant g.c.a. effects and additive gene action for total yield.

Singh and Mittal (1978) in a combining ability analysis of tomato involving parents, F1 and F2 generations recorded significant g.c.a. and s.c.a. variances for yield per plant.

Dudi et al. (1979) conducted a line x tester analysis in tomato with parents and their 21 crosses and reported that certain varieties and hybrids showed high g.c.a. and s.c.a. for total yield.

In a line x tester analysis, Dixit et al. (1980) revealed that g.c.a. variances of the female parent were significant and higher than g.c.a. variances with regard to yield per plant in tomato. The variety HS 120 had the highest g.c.a. for yield.

In a line x tester analysis of tomato Borikar et al. (1982) reported high g.c.a. in the tester Pusa Ruby and in four lines and high s.c.a. in ten cross combinations for yield.

Combining ability analysis of 44 F1 hybrids using 11 lines and four testers in tomato was done by Govindarasu et al. (1983). They suggested that the two lines LE 758 and LE 68 were good general combiners for yield.

Combining ability analysis of tomato for yield was carried out by Dholaria and Qadri (1983). They reported that both g.c.a. and s.c.a. variances were significant and additive gene action was predominant for the expression of this trait.

Kalf-Allah and Kaseem (1985) from their studies on combining ability using seven cultivars and 21 F1 hybrids of a diallel set in tomato, suggested

that the cultivar VFN8 was a good general combiner for total yield. They reported significant additive, dominance and epistatic effects for total yield.

In a combining ability analysis of tomato in a line x tester model Raijadhav and Kale (1985) reported that parents and hybrids exhibited significant g.c.a. and s.c.a. effects for yield.

Moya et al. (1986) conducted combining ability analysis with 36 F1's derived from a diallel set of crosses involving nine varieties of tomato and reported significant g.c.a. and s.c.a. effects for yield.

Lonkar and Borikar (1988) in a line x tester analysis involving 16 male sterile lines and three pollinators recorded predominance of g.c.a. effects and they suggested that Pusa Ruby was a good general combiner for yield in tomato. They also reported that in general high g.c.a for fruit yield was associated with high or medium g.c.a. for fruit number.

In a genetic analysis of yield and its components in tomato using parents, F1's and F2's of a 6 x 6 diallel set Omara et al. (1988) recorded that both additive and non-additive effects were significant and there was predominance for the additive component of genetic variances for the total yield per plant.

Chandrasekhar and Rao (1989) reported significant s.c.a. effect for yield in seven crosses of tomato and identified Pusa Early Dwarf as the best general combiner for yield.

Combining ability analysis for fruit yield per plant in a six parent diallel cross of tomato was carried out by Ali et al. (1989) and they indicated that g.c.a. and s.c.a. variances were highly significant and additive and non-additive gene effects were involved for the inheritance of this trait. The best general combiners identified were C1-143-0-10-3 and World Champion.

Natarajan (1992) reported that both additive and non-additive gene action were important for fruit yield per plant. He also reported that LE 76 was the best general combiner for yield per plant.

Combining ability for yield was studied in a diallel set involving 11 varieties and their hybrids by Kryuchkov et al. (1992) and they indicated that yield was polygenically controlled with predominance of dominant genes.

Four tomato lines were crossed in a complete diallel design by Szwadiak and Kordus (1992) and they reported significant g.c.a. and s.c.a variances suggesting the involvement of an additive dominance model of gene action for the total yield.

Ghosh and Symal (1994) conducted combining ability analysis in tomato and reported that s.c.a. variance was significant for fruit yield per

plant and hence the involvement of non-additive gene action. Flora Dade, BT-1, Punjab Chhuhara and Arka Vikash showed excellent g.c.a. for fruit yield. Crosses involving poor general combiners gave high fruit yield per plant.

In a line x tester analysis of tomato Seeja (1995) reported that the significant g.c.a and s.c.a. variances indicated involvement of both additive and non-additive gene action for the expression of this trait.

(b) HETEROSIS

Avdeev (1974) recorded positive heterosis for fruit yield in tomato and also observed that certain hybrids with low yield could show positive heterosis for other characters.

Conti (1974) from his studies on tomato hybrids reported that the hybrids gave a mean increase in yield per hectare of 8.2%.

Szwadiak (1974) reported that heterosis for yield per plant observed in the tomato hybrids was due to the increase in the number of fruits per plant and not at all due to the large fruit size.

Lobo and Marin (1975) studied heterosis for yield in tomato including seven inbred lines and their 21 F1 hybrids. They reported that the average

value of heterosis for yield per plant based on the highest yielding parent was 120%.

Rema Bai (1975) studied heterosis in inter-varietal hybrids of tomato and reported that all the hybrids exhibited heterotic effects for yield per plant.

Babu (1978) studied heterosis in a 6 x 6 diallel cross of tomato including parents and F1 hybrids and reported heterosis for fruit yield. The yield was maximum in the hybrid Pusa Ruby x Tiny Tim.

Palaniappan et al. (1981) conducted growth analysis for fruit yield in tomato involving six varieties and their nine F1 hybrids and reported heterosis for this trait. The best hybrid identified was LE 719 x LE 573.

In a preliminary estimation of hybrid vigour in tomato Sonone et al. (1981) found that out of 197 hybrids, 13 gave 80 - 155% higher yield than the control Pusa Ruby.

Govindarasu et al. (1982) studied heterosis in tomato involving 11 lines, four testers and their hybrids and reported that heterosis was high for yield and the best hybrid was LE 758 x LE413.

Jamwal et al. (1984) reported hybrid vigour for fruit yield per plant in the hybrids obtained from line x tester cross involving ten foreign lines and three local testers of tomato. The hybrids EC 6050 x Lalmani, EC 122156 x Lalmani and EC 121193 x Gola were having very good yield.

In a study of tomato involving seven parental cultivars and their 21 F1's derived from a diallel set Bhuiyan et al. (1986) observed that Fujuki x World Champion exhibited maximum heterosis for yield per plant.

Ahmed et al. (1988) studied heterosis in tomato including six varieties and their 15 F1's and reported that most of the hybrids showed postive heterosis over the better parent for yield per plant.

Narcisco and Rosario (1988) studied the processing qualities of tomato hybrids and reported that the hybrids exhibited heterosis and heterobeltiosis for the fruit yield.

Kanthaswamy and Balakrishnan (1989) reported that among the different hybrids studied the hybrid from the cross LE3 x LE 1036 was outstanding giving the highest yield of 1.646 Kg per plant with a relative heterosis estimate of 29.81%.

Mandal et al. (1989) observed heterobeltiosis for fruit yield and quality and reported that the hybrid from the cross Pusa Early Dwarf x KSI was the highest yielding hybrid having 46.9 fruits per plant on an average.

In a 12 x 12 diallel cross involving parents and 66 F1's in tomato. Dod et al. (1992) reported pronounced heterosis for yield per plant.

Kryuchkov et al. (1992) reported that maximum heterosis for fruit yield in tomato was achieved by a successful combination of high g.c.a. and high s.c.a. effects.

In a study of eight parental tomato varieties and their 19 F1's Bora _et al._ (1993) reported that significant heterosis for yield over the better parent was exhibited by 11 hybrids. The hybrid from the cross BT10 x K10 showed highest heterosis for yield.

Hybrids from a diallel set of crosses between 11 varieties of tomato were evaluated by Sidhu and Surjan Singh (1993) for yield and they reported that heterosis ranged from 0.7% to 71.7%.

Kanthaswamy (1994) in a study of hybrid vigour in tomato reported that the hybrid of the cross LE 3 x LE 1036 was outstanding giving the highest yield of 1.6 kg per plant with the high relative heterosis estimate of 29.8%.

Heterosis was studied in tomato from a 8 x 8 half diallel cross by Pujari and Kale (1994) and they recorded high heterosis for yield per plant. They also reported that Punjab Chhuhara x Roma was the best yielding hybrid.

Suresh Kumar _et al._ (1995) studied heterosis for yield and its components in tomato and they reported that greatest heterosis over superior parents was observed for total yield, which in turn was associated with fruit weight and fruit number.

PERICARP THICKNESS

(a) COMBINING ABILITY AND GENE ACTION

Patil and Bojappa (1968) conducted combining ability analysis of 10 varieties of tomato and indicated significant g.c.a. and s.c.a. variances.

Higher s.c.a. effect for pericarp thickness was observed in the cross San Merzano x NTDR-1.

Study of inheritance of pericarp thickness in tomato was conducted by Nandpuri and Tyagi (1976) and they reported that thick pericarp was partially dominant to thin pericarp and they suggested the importance of additive effects for the control of this trait.

The combining ability analysis of 36 hybrids from the crosses of three testers and 12 lines in tomato revealed significant g.c.a. and s.c.a. differences, for pericarp thickness. The best general combiners identified were Gamed, Sioux and Improved Meeruti and the best specific combiner was Gamed x Sioux (Bagrawat Singh et al., 1980).

Combining ability analysis of 15 varieties of tomato from a line x tester cross revealed significant g.c.a. variances for pericarp thickness (Dixit et al., 1980).

Bhutani (1981) conducted combining ability analysis in tomato and recorded predominant role of non-additive gene action and partial dominance for the pericarp thickness in both F1 and F2 generations.

In a study of combining ability in pear shaped tomato involving seven varieties and their hybrids on a diallel set Sidhu et al., 1981) reported that estimate of s.c.a. was higher than that of g.c.a. indicating the predominance of non-additive gene action for pericarp thickness. The best general

combiner for this trait was Roma and the best specific combiner was Chicogrande x Labonita.

Patil and Patil (1988) studied combining ability from a line x tester cross involving two testers and 10 lines and revealed that the contribution of g.c.a. variances was more predominant for pericarp thickness. The best general combiner was the line 'SM' for this trait.

Combining ability analysis involving parents and their F1's was conducted by Ghosh and Symal (1994) and they reported greater g.c.a. variances and predominant additive gene action for the inheritance of pericarp thickness. They suggested that crosses involving poor and average general combiners gave better expression for this trait.

(b) HETEROSIS

Nandpuri and Tyagi (1976) reported heterosis for pericarp thickness in the F1 hybrids of tomato.

In a line x tester study of tomato involving 10 lines, two testers and 20 crosses, Patil and Patil (1988) recorded high heterosis for pericarp thickness in most of the hybrids.

In a study of heterosis for certain quality traits in tomato Dod and Kale (1992) reported that heterosis was observed for pericarp thickness. The highest value of heterosis for the trait was observed in the cross Pusa Early Dwarf x S12.

LOCULES PER FRUIT

(a) COMBINING ABILITY AND GENE ACTION

In a study of inheritance of locule number of tomato Nandpuri and Tyagi (1976) reported that low number of locules per fruit was dominant to higher number and he suggested that dominance effects were more important in the control of locule number.

Singh and Mittal (1978) studied combining ability in tomato and reported that g.c.a variance was greater than s.c.a variance and the parent K. Kuber exhibited high g.c.a. for this trait.

The combining ability analysis of 36 hybrids from a line x tester cross of tomato revealed significant g.c.a and s.c.a. differences for locule number per fruit (Bagrawat Singh et al., 1980).

Dholaria and Qadri (1983) from a 6 x 6 diallel cross of tomato reported significant g.c.a. and s.c.a. variances and predominant additive gene effects for number of locules per fruit.

Tarrega and Nuez (1983) conducted combining ability analysis of parents and F1's of a 7 x 7 half diallel cross of tomato and reported that g.c.a. and s.c.a. variances were significant for number of locules per fruit.

Inheritance of locule number was studied by Bhutani and Kalloo (1991) in tomato including 28 F1's and F2's from a diallel cross and reported that additive gene action was important for this trait.

In a combining ability analysis of tomato Ghosh and Symal (1994) reported greater g.c.a. variances and predominant additive gene action for number of locules per fruit. Crosses with poor general combiners gave higher expression for this traif.

(b) HETEROSIS.

In a study of heterotic effects of parental, F1, F2, BC1 and BC2 populations of tomato Ahmed and Patroscu (1983) reported positive heterosis for locules per fruit.

Dod and Kale (1992), in a study of heterosis for certain quality traits in tomato, reported that highest value of heterosis was observed in the cross Punjab Chhuhara x Punjab Kesari for number of locules per fruit.

SIZE OF FRUITS

(a) COMBINING ABILITY AND GENE ACTION

Dominance was noticed for large size of fruit over small size in a study of inter-varietal hybrids of tomato conducted by Rema Bai (1975).

Inheritance of fruit size in tomato was studied by Nandpuri and Tyagi (1976) in the cross EC 55055 x Punjab Tropic and they reported that small fruit size was partially dominant over large fruit size. They suggested the predominance of additive effects in the inheritance of this trait.

Inheritance of fruit shape in tomato was studied by Hanna and Hernandez (1979). They reported that fruit diameter was controlled by a minimum of two pairs of genes.

Singh and Singh (1980) in a combining ability analysis of tomato involving parents, F1's and F2's of line x tester crosses reported that g.c.a. variances were higher than s.c.a. variances in the F1 and F2 generations for fruit size. They also reported predominance of additive gene action for this trait.

Govindarasu _et al._ (1981) reported from a line x tester analysis of tomato that additive gene action was involved in the inheritance of fruit size.

Dholaria and Qadri (1983) conducted a combining ability analysis on a diallel set of crosses in tomato and recorded that the g.c.a. and s.c.a. variances were significant for the character fruit volume. They indicated that the character is predominantly controlled by additive gene action.

Combining ability analysis using the parents and F1's of a 7 x 7 half diallel cross of tomato was carried out by Tarrega and Nuez (1983) and they reported that g.c.a. and s.c.a. effects were highly significant for fruit diameter.

In an estimation of combining ability of nine tomato varieties and their 36 F1's as a diallel set, significant g.c.a. and s.c.a. effects were reported by Moya _et al._ (1986).

Combining ability analysis of tomato was carried out by Ghosh and Symal (1994). They reported that for polar fruit diameter 'Flora Dade' was the best general combiner. Crosses with poor and average general combiners gave better expression for this trait.

(b) HETEROSIS

In a preliminary estimation of hybrid vigour in tomato Sonone _et_ _al._ (1981) reported that certain hybrids exhibited heterotic effects for fruit size.

Alvarez (1985) reported heterosis for equatorial diameter of fruit.

BACTERIAL WILT RESISTANCE

Ferrer (1976) studied inheritance of resistance to _Pseudomonas Solanacearum_ in tomato and suggested that resistance was polygenically inherited and the genes involved were additive and no dominance was involved.

Graham and Yap (1976) studied inheritance of resistance to _Pseudomonas solanacearum_ in tomato in a diallel cross of six cultivars and indicated that the g.c.a. was more important than s.c.a. They suggested that inheritance of resistance was mainly due to additive gene action.

Cinar (1978) reported that differences in resistance were related to the number of bacteria present in the leaf cells four days after infection.

Rema Devi (1978) reported that _Pseudomonas solanacearum_ existed in different races coming under race 1 or race 3.

Sunarjono (1980) reported that the breeding lines AVRDC 33, AVRDC 15 and CL 32-d-0-1-25 were resistant to _Pseudomonas solanacearum._

Sonoda _et al._ (1980) observed that the better sources of resistance to _Pseudomonas solanacearum_ are Hawaii 7997, CRA 66 and PI 126408A.

Bell (1981) stated that the factors which influence resistance to bacterial wilt include intensity, duration and quality of light, moisture levels, nutrient levels and agricultural and industrial chemicals.

Celine (1981) reported that CL-32-d-0-19GS is a bacterial wilt resistant variety. The resistant line Sakthi has been developed in the Horticultural College, Vellanikkara.

Rajan (1985) reported that in Kerala bacterial wilt caused by the soil borne pathogen Pseudomonas solanacearum EF Smith was a handicap which affected the tomato cultivars very seriously.

Performance of local tomato varieties against bacterial wilt disease was conducted by Ho (1988) and he reported that disease incidence in the field peaked in approximately the ninth week after transplanting. High rainfall, especially towards the middle and end of growing season favoured high disease incidence.

Narcisco and Rosario (1988) studied bacterial wilt resistance of tomato hybrids and reported that hybrids exhibited heterosis and heterobeltiosis in bacterial wilt resistance.

Varietal resistance to bacterial wilt in tomato was carried out by Kapoor et al. (1991) and they reported that of the 62 varieties screened, 9 were immune, 26 were resistant, 5 were moderately resistant, 4 were moderately susceptible and 18 were susceptible. Environmental factors were found to be involved in the stability of resistance.

In a study of bacterial wilt resistance in tomato Sreelatha Kumari and Peter (1992) reported that a complementary and hypostatic type of digenic gene action was responsible for resistance.

Opena _et al. (1992) made a number of back-crosses to recover adequate resistance to bacterial wilt and reported that two back-crosses are enough to recover resistant progeny. They suggested that resistance belongs to the class of 'quasi-quantitative' traits controlled by a few major genes modified by an undefined number of minor genes.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study was undertaken in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, during 1994-96 with a view to estimate the gene action through combining ability analysis for yield and yield attributes in Tomato and to determine the extent of heterosis manifested by the hybrids for each character.

MATERIALS

The first part of the experiment consisted of pot culture where the selected varieties were grown for hybridization. The materials consisted of six varieties of tomato, of which three were bacterial wilt resistant ones already identified and the other three were popular high yielders. The six varieties were crossed in a 6 x 6 diallel pattern. The six parents and the 15 hybrids are listed in Table 1.

TABLE 1

Parents and hybrids

Sl.No.	Treatment No.	Name of variety/cross.
1.	T1	Sakthi (P1)
2.	T2	LE 79-5 (P2)
3.	T3	LE 373 (P3)
4.	T4	Arka Alok (P4)
5.	T5	Arka Abha (P5)
6.	T6	PKM1 (P6)
7.	T7	P1 x P2
8.	T8	P1 x P3
9.	T9	P1 x P4
10.	T10	P1 x P5
11.	T11	P1 x P6
12.	T12	P2 x P3
13.	T13	P2 x P4
14.	T14	P2 x P5
15.	T15	P2 x P6
16.	T16	P3 x P4
17.	T17	P3 x P5
18.	T18	P3 x P6
19.	T19	P4 x P5
20.	T20	P4 x P6
21.	T21	P5 x P6

METHODOLOGY

A. Pot Culture

All the six varieties were grown in pots for collection of selfed and hybrid seeds. For hybrid seed production ten plants each of the six varieties were grown in pots following the standard pot culture method. Staggered planting was followed to obtain synchronised flowering for crossing. Sufficient number of flowers in each variety were selfed to produce true to type plants for the experiment. The techniques followed for the production of selfed and crossed seeds were as follows.

Selfing

For getting selfed seeds mature flower buds which would open on the next day were covered with paper bags and labelled in the evening. The paper bags were retained till the end of fruit setting.

Crossing

From the female parents mature flower buds which would open on the next day were selected in the evening and emasculation was done by standard manual method using forceps. The emasculated flower buds were covered with paper bags. Next morning between 9 and 10 a.m., the emasculated flowers were pollinated by pollen collected from the male

parent. For collecting pollen grains, the anther walls were split open with a needle and pollen grains were scooped out and transfered to the stigmatic surface. After pollination, the flowers were protected with paper bags. Labels with the details of crossing were attached and kept till the fruits ripen.

The fully ripened fruits of both selfed and crossed flowers were harvested and seeds were extracted separately. For collection of seeds, pulp with seeds were kept for fermentation in separate containers for one day, and seeds were separated by washing with water eight to ten times to remove slimy materials. Seeds were dried in shade for one day and then under sun for two to three days before storing.

B. Field experiement.

In the second part of the programme, the evaluation of the diallel hybrids and parents were carried out as a replicated field trial. Precautions were taken to avoid wilt through heat sterilization of each planting pit and application of higher dose of organic manure.

Well developed good quality seeds of six parents and 15 hybrids were sown in nursery and thirty days after sowing the seedlings were transplanted to the main field in Randomised Block Design with three replications. In a replication, each treatment consisted of 10 plants planted at a spacing of 60 x 60 c.m. The cultural and management practices were done as per package

of practices (KAU, 1993) except the heat treatment and higher dose of organic manure applied to avoid wilt.

Observations on the following characters were recorded.

1. Plant height
2. Number of branches per plant
3. Spread of the plant
4. Number of leaves per plant
5. Number of days for first flowering
6. Number of days for first harvest
7. Duration of harvest (first to final harvest)
8. Single fruit weight
9. Fruit size
10. Number of fruits per plant
11. Fruit yield per plant
12. Pericarp thickness
13. Locules per fruit
14. Number of seeds per fruit
15. Reaction to pests and diseases
16. Colour at collar of fruits
17. Fruit cracking.

Observations from all the 10 plants in a treatment were taken in each plot

The details of observations are given below.

1 Plant height

The height of the plant was measured in centimeters from the base of the main shoot to the tip of the leaf bud of the largest branch using a meter scale and the mean plant height was estimated.

2. Number of branches per plant.

Total number of primary, secondary and tertiary branches were counted and the mean was estimated.

3. Spread of the plant.

Measured between the farthest two opposite leaf buds in the side branches in centimeters and average was worked out.

4. Number of leaves per plant.

Number of leaves from each plant in a plot was counted and the average number of leaves per plant was estimated.

5 Number of days for first flowering.

Number of days from sowing to first flowering and the mean was estimated.

6. Number of days for first harvest.

Total number of days from sowing to first harvest was recorded and the mean was estimated.

7. Duration of harvest.

Number of days from first to final fruit harvest and the mean was estimated.

8. Individual fruit weight.

Weight of five fruits from each plant was taken and the mean weight was recorded as the mean single fruit weight in gram.

9. Size of fruits.

Five random fruits from each plant was taken and their volume was measured by the water displacement method using a measuring cylinder. The mean volume of fruit per plant was estimated in cubic centimeter.

10. Number of fruits per plant.

The number of fruits of each plant in a plot was noted and average was estimated.

11. Fruit yield per plant.

Total weight of all the fruits harvested periodically from each plant in a plot was recorded and the mean yield in grams per plant was estimated

12. Pericarp thickness.

The pericarp thickness was measured in millimeters from five random fruits from each plant in a plot after cutting the fruits transversely

13. Locules per fruit.

From each plant, five random fruits were selected and number of locules was counted and mean number of locules per fruit was estimated.

14. Number of seeds per fruit.

From each plant, five random fruits were selected and number of seeds was counted and mean number of seeds per fruit was estimated.

15. Observation on pests and diseases.

a) Tomato fruit borer (Heliothis armigera)

The number of fruits attacked by the fruit borer in a plot was recorded and expressed as percentage.

b) Mosaic

The number of plants infected by mosaic in a plot was recorded and expressed as percentage.

c) Fruit rot

The number of fruits infected by fruit rot in a plot was recorded and expressed as percentage.

STATISTICAL TECHNIQUES.

Data from the parents and hybrids were subjected to statistical analyses. The following parameters were estimated.

(1) Combining ability.

a) General combining ability

b) Specific combining ability

(2) Gene action

a) Additive gene action

b) Non-additive gene action.

(3) Heterosis

a) Heterosis over mid parent

b) Heterosis over better parent

c) Heterosis over standard parent

The experimental material consists of p inbreds and $\frac{p(p-1)}{2}$ F1s The data collected were subject to ANOVA. If significant genotypic differences were observed. combining ability analysis was performed with mean values as follows.

ANOVA
(Griffings Method 2)

Source	df	MS	E(MS)
Genotypes	$p+\frac{p(p-1)}{2}-1$	M	$\sigma^2 e + \sigma^2 g$
gca	p-1	Mg	$\sigma^2 e + \sigma^2 sca + (p+2)\sigma^2 gca$
sca	$\frac{p(p-1)}{2}$	Ms	$\sigma^2 e + \sigma^2 sca$
Error	$\left[p+\frac{p(p-1)}{2}-1\right](r-1)$	Me	$\sigma^2 e$

where $Me = \frac{MSE}{r}$ MSE = Error Mean Square

If significant difference among gca and among sca effects were obtained their effects were estimated as follows:

gi = gca effect of i^{th} parent

$$= \frac{1}{p+2}\left[\sum(Yi. + Yii) - \frac{2Y..}{p}\right]$$

Sij = sca effect of i x j^{th} cross

$$= Yij - \frac{1}{p+2}(Yi. + Yii + Yj. + Yjj) + \frac{2Y..}{(p+1)(p+2)}$$

where

Y_{ij} = mean of the character with respect to $(i \times j)^{th}$ cross

$Y_{i.}$ = total mean corresponding to i^{th} parent over the other crosses

$Y_{..}$ = grand mean.

The significance of gi and Sij effects are tested using t - test

$$SE(gi) = \left[\frac{(p-1)}{p(p+2)} Me\right]^{1/2}$$

$$SE(Sij) = \left[\frac{p^2+p+2)}{(p+1)(p+2)} Me\right]^{1/2}$$

SE for the difference of gca and sca effects are

$$SE(gi - gj) = \left[\frac{2}{(p+2)} Me\right]^{1/2}$$

$$SE(sij - sik) = \left[\frac{2\ (p+1)}{(p+2)} Me\right]^{1/2}$$

$$SE(sij - skl) = \left[\frac{2p}{(p+2)} Me\right]^{1/2}$$

The significance of gca effects implies that additive heritable variance is responsible for variation for the observed character. The significance of sca effect reveals the importance of non additive variance for the inheritance of the character

The gca and sca components of variance were estimated as

$$\sigma^2 gca = \frac{Mg - Ms}{(p+2)}$$

$$\sigma^2 sca = Ms - Me.$$

Then additive variance $\sigma^2 a = 2\ \sigma^2$ gca

dominant variance $\sigma^2 d = \sigma^2$ sca.

Heterosis

The overall mean value of each parent and hybrid in all the three replications for each character was taken for the estimation of heterosis. Heterosis was calculated as the percent deviation of the mean performance of F1's from its midparent (M.P). better parent (B.P) and standard parent Sakthi (C.P) for each cross combination.

(I) Deviation of the hybrid mean from the mid parent value

(Relative heterosis)

$$= \frac{\overline{F1} - \overline{M.P}}{\overline{M.P}} \times 100$$

(ii) Deviation of the hybrid mean from the better parental value

(Heterobeltiosis)

$$= \frac{\overline{F1} - \overline{B.P}}{\overline{B.P}} \times 100$$

(iii) Deviation of the hybrid mean from the standard parental value

(Standard heterosis)

$$= \frac{\overline{F1} - \overline{C.P}}{\overline{C.P}} \times 100$$

For each character, the average value of the two parents involved in each cross combination was taken as the mid parental value (M.P) and the superior between those of the parents in each cross as better parental value (B.P.).

To test the significance of difference of F1 mean over mid and better parent, critical difference (C.D) was calculated from their standard error of differences as mentioned below.

To test the significance over mid parent

$$C.D_{(0.05)} = t_{\alpha} \times \sqrt{\frac{3 \times MSE}{2r}}$$

To test the significance over better parent and standard parent

$$C.D_{(0.05)} = t_{\alpha} \times \sqrt{\frac{2\,MSE}{r}}$$

where

α = Error degrees of freedom

MSE = Error mean square

r = Number of replications.

RESULTS

RESULTS

The field experiment was conducted using the parental lines and their fifteen hybrids in RBD with three replications. The mean performance, combining ability and gene action of the parents and their hybrids were analysed. The heterosis of the hybrids was also analysed and the results are presented below.

MEAN PERFORMANCE

The mean performance of parents and their fifteen hybrids for the different morphological and yield related characters are given in tables 2 and 3 respectively.

The mean plant height was minimum in PKM1 (47.47 c m) and maximum in LE 373 (105.54 c.m) among parents. Among hybrids the minimum and maximum plant height were recorded by Sakthi x Arka Abha (58.26 c.m) and LE 79-5 x LE 373 (96.70 c.m.) respectively.

The lowest mean number of branches/plant was recorded in Arka Alok (7.22) and the highest number of branches was recorded by LE 373 (18.11). Among the hybrids the minimum and maximum number of branches/plant were recorded by Arka Alok x PKM1 (7.44) and Sakthi x LE 79-5 (18.78) respectively.

TABLE - 2

Mean performance of parents and hybrids for various characters.

Treatments	Plant height (c.m.)	Number of branches/plant	Number of leaves/plant	Spread of the plant (c.m.)	Number of days for first flowering	Number of days for first harvest	Duration of Harvest
P1	44.64	13.56	64.110	23.49	58.67	78.22	17.11
P2	86.98	15.78	203.78	34.79	50.67	69.00	25.22
P3	105.54	18.11	208.33	44.32	53.89	70.67	21.33
P4	52.73	7.220	97.891	25.41	56.00	71.22	20.00
P5	44.91	8.220	77.893	20.67	52.11	68.11	23.56
P6	47.47	7.673	109.66	23.41	55.11	74.22	20.89
P1 x P2	95.01	18.78	169.67	43.02	57.33	78.38	21.66
P1 x P3	88.19	17.00	159.78	42.37	57.22	75.00	18.11
P1 x P4	65.72	11.00	106.89	41.29	55.44	72.33	19.00
P1 x P5	58.26	12.56	81.780	32.30	52.89	68.22	23.78
P1 x P6	66.65	11.56	109.67	50.07	58.89	78.44	16.11
P2 x P3	96.70	15.33	214.78	71.36	51.89	69.00	23.56
P2 x P4	95.57	9.112	145.11	52.26	56.44	72.22	19.00
P2 x P5	75.03	10.45	173.67	44.70	57.22	77.00	21.33
P2 x P6	65.85	9.560	161.33	63.03	52.89	71.78	24.22
P3 x P4	83.63	9.004	163.44	40.10	55.11	77.33	18.66
P3 x P5	95.50	12.89	204.45	71.44	55.77	75.33	20.55
P3 x P6	86.08	7.550	160.11	52.68	57.89	77.56	17.34
P4 x P5	64.35	11.00	113.44	43.20	60.66	83.89	11.00
P4 x P6	86.17	7.441	216.56	53.07	57.45	79.45	15.67
P5 x P6	75.67	7.890	97.310	34.36	58.89	80.78	12.67
F 20, 40	1463.67**	22.19**	170.25**	293.03**	3.950**	8.790**	20.36**
S.E	0.690	1.110	5.310	1.190	1.890	2.140	1.170
C.D	1.165	1.870	8.940	2.014	3.190	3.610	1.970

** Significant at 1% level

TABLE - 3

Mean performance of Parents and hybrids for various yield related characters.

Treatments	Single fruit weight(g)	Number of fruits/plant	Fruit yield/plant(g)	Size of fruits	Number of locules/fruit	Number of seeds/fruit	Pericarp thickness
P1	30.26	36.00	1247.2	27.94	3.76	41.33	3.67
P2	24.30	20.66	501.66	24.27	3.56	39.07	3.27
P3	36.92	10.56	360.00	34.13	4.65	50.60	4.20
P4	45.99	7.330	331.67	43.95	3.07	65.57	3.27
P5	54.36	7.780	422.22	52.04	4.96	65.67	4.47
P6	42.30	13.44	537.76	39.87	4.59	55.20	3.80
P1 x P2	25.47	25.34	647.22	27.85	3.84	39.77	3.24
P1 x P3	32.90	18.34	646.33	31.39	4.69	45.73	3.51
P1 x P4	39.93	21.56	881.66	42.73	5.55	51.03	3.44
P1 x P5	44.59	27.22	1227.22	45.80	4.73	51.33	4.20
P1 x P6	43.00	29.56	1276.66	40.50	4.16	49.90	3.53
P2 x P3	30.74	21.89	673.89	30.80	4.09	46.87	3.20
P2 x P4	34.57	13.44	464.44	44.02	3.80	50.93	4.13
P2 x P5	42.17	12.78	543.33	40.81	4.98	45.70	3.66
P2 x P6	35.12	14.33	522.22	41.93	4.16	44.67	3.70
P3 x P4	45.29	8.782	388.33	42.91	4.13	59.50	3.20
P3 x P5	49.87	9.440	471.66	47.16	5.00	61.93	4.80
P3 x P6	41.54	12.67	527.22	41.60	4.67	52.67	3.87
P4 x P5	51.65	7.110	430.56	53.66	4.16	65.97	4.40
P4 x P6	55.84	14.89	790.56	51.75	4.07	61.27	3.60
P5 x P6	51.75	17.22	881.11	50.59	5.00	60.47	4.53
F 20,40	166.74**	34.79**	170.03**	211.98**	1.87 ns	395.04**	8.18**
S E	1.00	1.910	31.680	0.83	0.55	0.620	0.24
C.D	1.69	3.210	53.340	1.39		1.030	0.41

ns - Not Significant

** - Significant at 1% level

The average number of leaves/plant varied from 64.11 in Sakthi to 208.33 in LE 373 among parents. Number of leaves/plant ranged from 81.78 in Sakthi x Arka Abha to 216.56 in Arka Alok x PKM1 in the hybrids.

For spread of the plant wide variation was observed among parents and hybrids. The parent Arka Abha exhibited minimum spread of 20.67 c.m. and LE 373 exhibited maximum spread of 44.32 c.m. In hybrids minimum and maximum spread were recorded by Sakthi x Arka Abha (32.30 c.m.) and LE 373 x Arka Abha (71.44 c.m) respectively.

Number of days taken for first flowering was minimum for LE 79-5 (50.67) and maximum for Sakthi (58.67) among the parents. Among the hybrids LE 79-5 x LE 373 recorded minimum days for flowering (51.89) and Arka Alok x Arka Abha recorded maximum days for first flowering (60.66).

Number of days for first harvest ranged from 68.11 days in Arka Abha to 78.22 days in Sakthi among the parents. Among the hybrids Sakthi x Arka Abha recorded minimum number of days for first harvest (68.22 days) and Arka Alok x Arka Abha recorded maximum number of days for first harvest (83.89 days).

Mean duration of harvest varied from 17.11 days in Sakthi to 25.22 days in LE 79-5 among parents. But in hybrids it ranged from 11.00 days in Arka Alok x Arka Abha to 24.22 days in LE 79-5 x PKM 1.

Individual fruit weight was minimum in LE 79-5 (24.30 g) and maximum in Arka Abha (54.36g) among parents. In hybrids this range was from 25.47g in Sakthi x LE 79-5 to 55.84 g in Arka Alok x PKM1.

Average number of fruits per plant was minimum in Arka Alok (7.33) and maximum in Sakthi (36.00) among the parents. Among the hybrids the lowest and highest values were recorded by Arka Alok x Arka Abha (7.11) and Sakthi x PKM1 (29.56) respectively.

Among the parents average fruit yield per plant ranged from 331.67g per plant in Arka Alok to 1247.22g per plant in Sakthi. This range was from 388.33g per plant in LE 373 x Arka Alok to 1276.66g per plant in Sakthi x PKM1 among the hybrids.

Size of the fruit in the parents ranged from 24.27 c.c in LE 79-5 to 52.04 c.c in Arka Abha. In the hybrids it ranged from 27.85 c.c in Sakthi x LE 79-5 to 53.66 c.c in Arka Alok x Arka Abha.

The mean number of locules per fruit among parents was minimum in LE 79-5 (3.56) and maximum in Arka Abha (4.96). Minimum and maximum values in hybrids were shown by LE 79-5 x Arka Alok (3.80) and Sakthi x Arka Alok (5.55) respectively.

The minimum number of seeds per fruit was recorded by LE 79-5 (39.07) and maximum was recorded by Arka Abha (65.67). Among the hybrids this was minimum for Sakthi x LE 79-5 (39.77) and maximum for Arka Alok x Arka Abha (65.97).

The minimum and maximum pericarp thickness were recorded by LE 79-5 (3.27 mm) and Arka Abha (4.47 mm) respectively among the parents LE 79-5 x LE 373 and LE 373 x Arka Alok recorded the minimum pericarp thickness of 3.20 m.m and LE 373 x Arka Abha recorded the maximum pericarp thickness of 4.80 m.m among the hybrids.

COMBINING ABILITY AND GENE ACTION

Analysis of variance of different morphological characters studied are presented in tables 4 and 5.

Highly significant differences were observed among the genotypes for all the characters except for number of locules per fruit. hence proceeded to combining ability analysis in a diallel model and the results are given below

TABLE - 4

ANOVA for combining ability analysis.

		Mean squares						
Source	**df**	**Plant height**	**Number of branches/plant**	**Number of leaves/plant**	**Spread of the plant**	**Number of days for first flowering**	**Number of days for first harvest**	**Duration of harvest**
g.c.a	5	893.78**	42.31**	6732.37**	242.55**	8.83**	14.26**	21.08**
s.c.a	15	168.72**	4.12**	952.84**	198.48**	6.51**	22.15**	11.60**
Error	40	0.239	0.62	14.08	0.72	1.79	2.29	0.69
σ^2 gca		90.633	4.77	722.44	5.51	0.29	n.e	1.19
σ^2 sca= σ^2 d		168.48	3.50	938.76	197.76	4.72	19.86	10.91
σ^2 a		181.266	9.54	1444.88	11.02	0.58	n.e	2.38
σ gca/σ sca		0.538	1.36	0.77	0.13	0.061	n.e	0.11

** Significant at 1% level
n.e - not estimable

TABLE - 5

ANOVA for combining ability analysis.

Source	df	Mean Squares					
		Single fruit weight	Number of fruits/plant	Fruit yield/plant	Size of fruits	Number of seeds/fruit	Pericarp thickness
gca	5	305.61**	219.87**	244516.46**	248.60**	282.21**	0.59**
sca	15	9.43*	11.15**	32283.34**	13.36**	4.56**	0.12**
Error	40	0.50	1.82	501.91	0.34	0.18	0.03
σ^2 gca		37.02	26.09	26529.14	29.41	34.71	0.06
σ^2 sca = σ^2 d		8.93	9.33	31781.43	13.02	4.38	0.09
σ^2 a		74.04	52.18	53058.28	58.82	69.42	0.12
σ^2 gca/ σ^2 sca		4.15	2.79	0.84	2.26	7.92	0.67

** Significant at 1% level

The general combining ability (g.c.a) effects of parents and the specific combining ability (s.c.a) effects of hybrids for morphological and yield related characters are given in tables 6.7.8 and 9 respectively.

Combining ability analysis of plant height revealed that variance due to parents and hybrids was significant. All the parents have significant g.c.a. effects which ranged from -3.25 (Arka Alok) to 16.79 (LE 373). Significant positive s.c.a. effect was shown by hybrids Arka Alok x PKM-1 (20.59). Sakthi x LE 79-5 (18.31). Arka Abha x PKM 1 (15.37). LE 79-5 x Arka Alok (14.14). LE 373 x Arka Abha (11.98). Sakthi x PKM 1 (5.80). Sakthi x LE 373 (4.10). Sakthi x Arka Alok (1.67) and Arka Alok x Arka Abha (0.86). Hybrids LE 79-5 x PKM1 (-12.38). LE 373 x Arka Alok (-5.18). LE 79-5 x LE 373 (-4.76) and LE 79-5 x Arka Abha (-1.11) exhibited significant negative s.c.a. effect. The g.c.a. and s.c.a effects for plant height are presented in figure 1.

The g.c.a. and s.c.a effects for number of branches per plant are presented in figure 2. Variance for number of branches per plant was significant for both parents and hybrids. The maximum positive g.c.a. effect was recorded by the parents Sakthi and LE 373 (2.18) and minimum g.c.a. effect was recorded on PKM 1 (-2.65). Among the hybrids significant positive s.c.a. effects were shown by Sakthi x LE 79-5 (3.31) and Arka Alok x Arka Abha (2.98). Hybrids LE 373 x PKM 1 (-3.48). LE 373 x Arka Alok (-2.37). LE 79-5 x Arka Alok (-1.86) and LE 79-5 x Arka Abha (-1.67) exhibited significant negative s.c.a. effect.

TABLE - 6

G.C.A. effects of parents with respect to various characters.

Parents	Plant height	Number of branches/plant	Number of leaves/plant	Spread of the plant	Number of days for first flowering	Number of days for first harvest	Duration of harvest
P1	-7.97 *	2.18*	-32.15 *	-5.80 *	1.04*	0.76*	-0.50
P2	9.40*	1.78*	32.36*	5.19*	-1.71 *	-2.05 *	2.91*
P3	16.79*	2.18*	38.25*	8.09*	-0.64	-0.89	0.50
P4	-3.25*	-2.32 *	-9.00 *	-2.71 *	-0.79	0.62	-1.70 *
P5	-8.53*	-1.17 *	-23.35 *	-4.39 *	-0.14	-0.16	-0.06
P6	-6.44 *	-2.65 *	-6.11 *	-0.30 *	0.68	1.72*	-1.14 *
SE	0.158	0.253	1.212	0.273	0.432	0.489	0.267
SE d	0.245	0.392	1.876	0.423	0.669	0.758	0.414

* - Significant at 5% level

TABLE - 7

G.C.A effects of parents with respect to various characters.

Parents	Single fruit weight	Number of fruits/plant	Fruit yield/plant	Size of fruits	Number of Seeds/fruit	Pericarp thickness
P1	-4.97 *	9.65*	322.82*	-5.13*	-5.99 *	-0.16 *
P2	-8.69 *	1.54*	-92.07 *	-6.14 *	-7.79 *	-0.26 *
P3	-1.50 *	-3.07 *	-145.44 *	-2.89 *	-0.06	0.05
P4	4.13*	-4.54 *	-121.51 *	4.72*	6.43*	-0.16 *
P5	7.82*	-3.43 *	-24.08 *	7.11*	6.04*	0.50*
P6	3.21*	-0.15	60.29*	2.61*	1.37*	0.30
SE	0.228	0.435	7.230	0 188	0.14	0 06
SE d	0 350	0.674	11.20	0 292	0 22	0 09

* - Significant at 5% level

TABLE - 8

S.C.A. effects of hybrids with respect to various characters.

Hybrids	Plant height	Number of branches/plant	Number of leaves/plant	Spread of the plant	Number of days for first flowering	Number of days for first harvest.	Duration of harvest.
P1 x P2	18.31**	3.31**	24.71**	0.43	2.18	4.95**	-0.30
P1 x P3	4.10**	1.13	8.94**	-3.05**	1.00	0.46	-1.44 *
P1 x P4	1.67**	-0.37	3.30	6.60**	-2.21	-3.72**	1.64*
P1 x P5	-0.51	0.03	-7.47 *	-0.72	-3.83**	-7.05**	4.78**
P1 x P6	5.80**	0.52	3.49	12.97**	1.34	1.29	-1.80 *
P2 x P3	-4.76**	-0.13	-0.58	14.94**	-1.58	-2.73 *	0.59
P2 x P4	14.14**	-1.86 **	-22.99 *	6.58**	1.54	-1.02	-1.77 *
P2 x P5	-1.11 *	-1.67 *	19.91**	0.69	3.25**	4.53**	-1.08
P2 x P6	-12.38 **	-1.08	-9.66 *	14.94**	-1.91	-2.57	2.89**
P3 x P4	-5.18 **	-2.37 **	-10.55 **	-8.41**	-0.87	2.93*	0.31
P3 x P5	11.98**	0.36	44.80**	24.61**	0.73	1.71	0.56
P3 x P6	0.46	-3.48 **	-16.77 **	1.76*	2.03	2.06	-1.58 *
P4 x P5	0.86*	2.98**	1.05	7.10**	4.19	8.75**	-6.80**
P4 x P6	20.59**	0.91	86.92**	12.88**	0.15	2.44	-1.05
P5 x P6	15.37**	0.20	-17.97 **	-4.16 **	2.53*	4.55**	-5.69**
SE	0.434	0.696	3.326	0.749	1.187	1.343	0.734
SE(same parent line)	0.464	1.038	4.963	1.119	1.771	2.004	1.096
SE(different parents)	0.599	0.961	4.595	1.036	1.640	1.856	1.015

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

TABLE - 9

S.C.A. effects of hybrids with respect to various characters.

Hybrids	Single fruit weight	Number of fruits/plant	Fruit yield/plant	Size of fruits	Number of seeds/fruit	Pericarp thickness.
P1 x P2	-1.75**	-2.54*	-239.39**	-1.35**	0.92*	-0.13
P1 x P3	-1.51*	-4.93**	-186.90**	-1.33*	-0.84 *	-0.17
P1 x P4	-0.11	-0.24	24.50	2.40**	-2.03 **	-0.03
P1 x P5	0.86	4.32**	272.63**	3.08**	-1.34 **	0.07
P1 x P6	3.88**	3.37**	237.70**	2.28**	1.90**	-0.13
P2 x P3	0.05	6.74**	255.55**	-0.65	2.09**	-0.38 *
P2 x P4	-1.76**	-0.24	22.17	4.97**	-0.33	0.76**
P2 x P5	2.15**	-2.02	3.630	-0.64	-5.18 **	-0.37 *
P2 x P6	-0.28	-3.74**	-101.85**	4.99**	-1.54 **	0.13
P3 x P4	1.77**	-0.29	-0.570	0.33	0.5	-0.49 **
P3 x P5	2.66**	-0.74	-14.66	2.19**	3.32**	0.46**
P3 x P6	-1.05	-0.79	-43.48*	1.13*	-1.27 **	-0.01
P4 x P5	-1.19	-1.60	-79.70**	1.08*	0.87*	0.27
P4 x P6	7.62**	2.90*	195.92**	3.68**	0.84*	-0.07
P5 x P6	-0.16	4.12**	189.05**	0.12	0.42	0.21
SE	0.627	1.196	19.858	0.517	0.384	0.151
SE(same parent line)	0.936	1.785	29.637	0.772	0.572	0.225
SE(different parents)	0.867	1.652	27.438	0.715	0.529	0.209

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

FIGURE-1

G.C.A. & S.C.A. PLANT HEIGHT

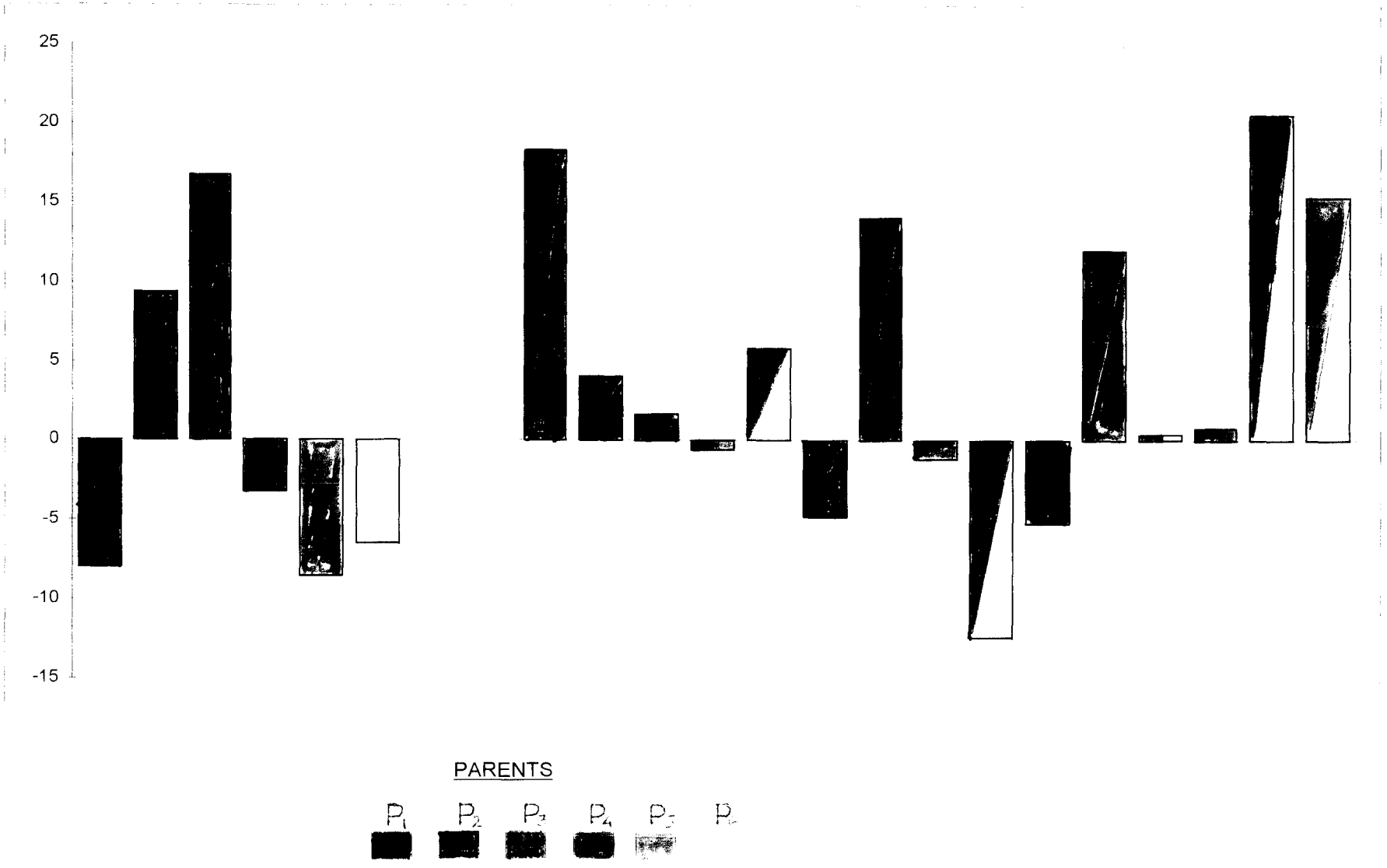
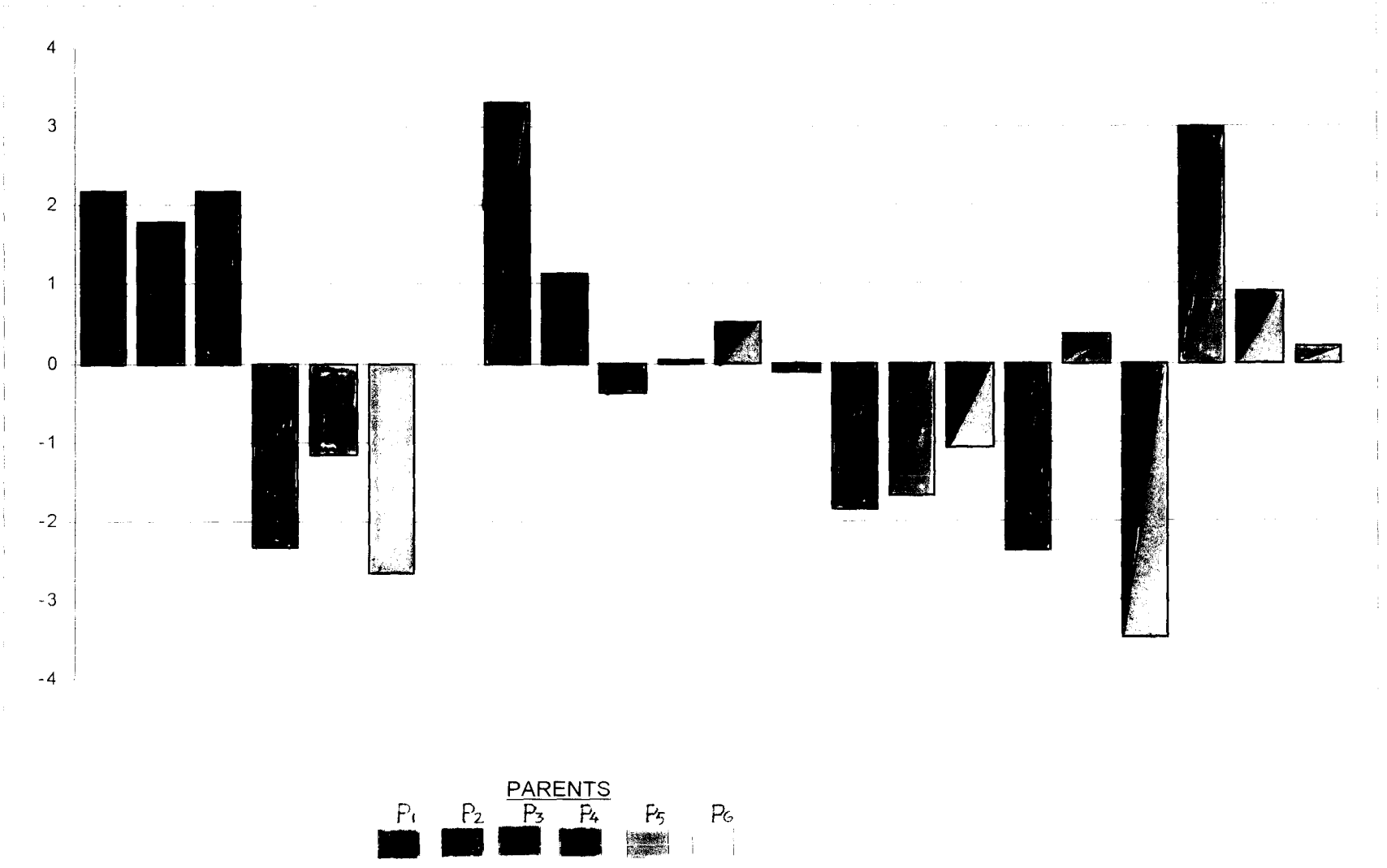


FIGURE 2
G.C.A. and S.C.A. Number of branches/plant



Number of leaves per plant varied significantly among parents and hybrids. Among the parents all the varieties exhibited significant g.c.a. effect i.e. LE 373 (38.25). LE 79-5 (32.36). Sakthi (-32.15). Arka Abha (-23.35). Arka Alok (-9.00) and PKM 1 (-6.11). Significant positive s.c.a. effects were observed in Arka Alok x PKM 1 (86.92). LE 373 x Arka Abha (44.80). Sakthi x LE 79-5 (24.71). LE 79-5 x Arka Abha (19.91) and Sakthi x LE 373 (8.94). The g.c.a. and s.c.a effects are presented in figure 3.

Analysis of variance for spread of the plant showed significant differences among parents and hybrids. The parents LE 79-5 (5.19) and LE 373 (8.09) recorded positive g.c.a effects and Sakthi (-5.80) Arka Abha (-4.39). Arka Alok (-2.71) and PKM1 (-0.30) recorded negative significant g.c.a effects. The s.c.a effect was positve and high in hybrids LE 373 x Arka Abha (24.61). LE 79-5 x LE 373 and LE 79-5 x PKM 1 (14.94) Arka Alok x PKM1 (12.88). Arka Alok x Arka Abha (7.10). Sakthi x Arka Alok (6.60). LE 79-5 x Arka Alok (6.58) and LE 373 x PKM1 (1.76). Negative significant s.c.a. effects were recorded by LE 373 x Arka Alok (-8.41). Arka Abha x PKM1 (-4.16) and Sakthi x LE 373 (-3.05). The g.c.a. and s.c.a. effects for this trait are presented in figure 4.

Analysis of variance for number of days for first flowering showed that the variances due to the parents and hybrids were significant. Only two parents showed significant g.c.a. effects i.e., Sakthi (1.04) and LE 79-5

FIGURE 3
G.C.A.and S.C.A Number of leaves/plant

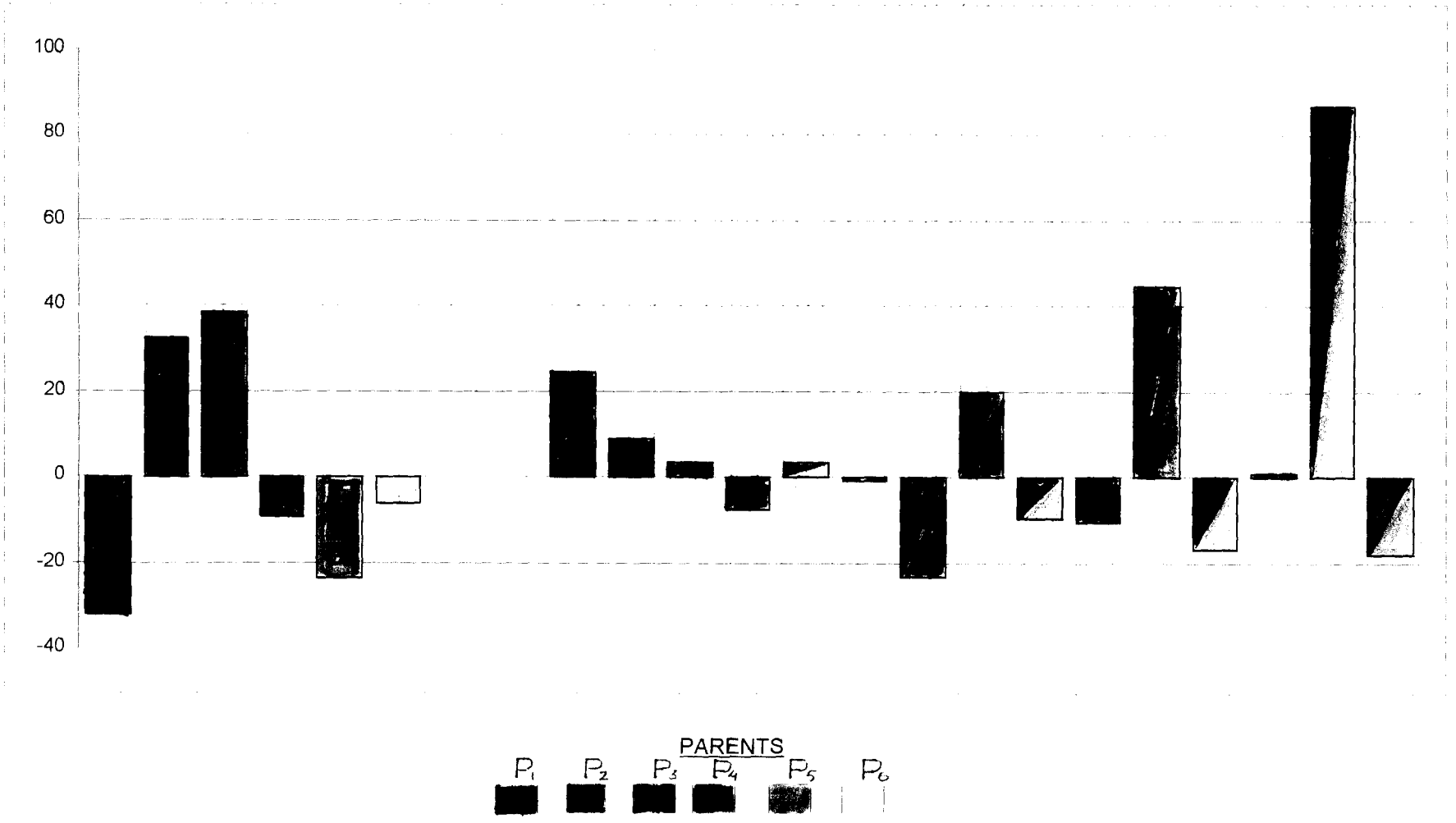
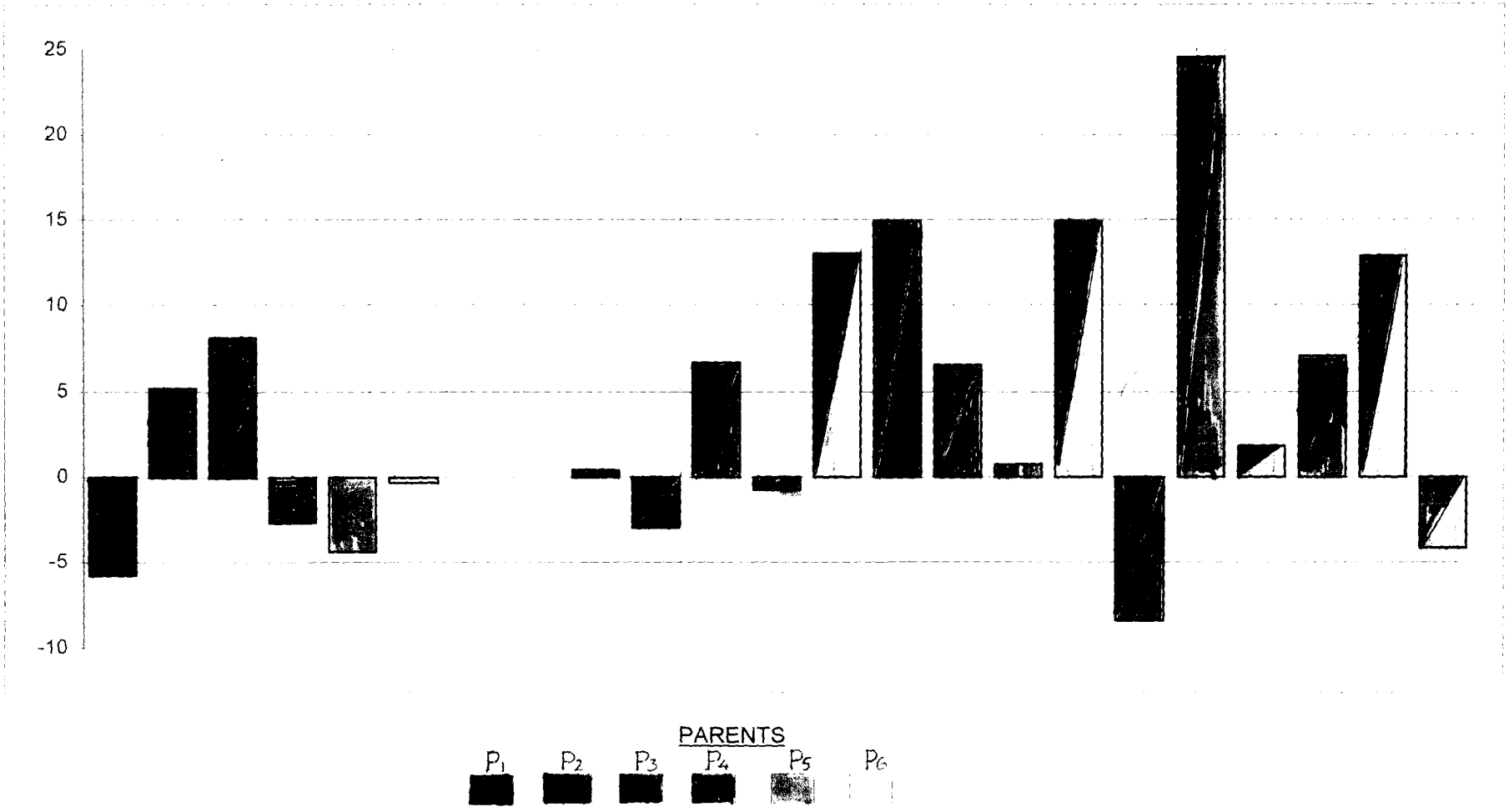


FIGURE 4
G.C.A. and S.C.A Spread of the plant



(-1.71). Among the hybrids positive significant s.c.a. effects were recorded by LE 79-5 x Arka Abha (3.25) and Arka Abha x PKM 1 (2.53) and negative significant effect was recorded by the hybrid Sakthi x Arka Abha (-3.83). The g.c.a. and s.c.a. effects are presented in figure 5.

The g.c.a. and s.c.a. effects for number of days for first harvest are graphically represented in figure 6. Variance due to parents and hybrids were significant for this trait. Positive significant g.c.a. effect was recorded by PKM 1 (1.72). Sakthi (0.76) and negative g.c.a. effect by LE 79-5 (-2.05) The hybrids Arka Alok x Arka Abha (8.75). Sakthi x LE 79-5 (4.95). Arka Abha x PKM 1 (4.55). LE 79-5 x Arka Abha (4.53) and LE 373 x Arka Alok (2.93) showed significant positive s.c.a. effects and Sakthi x Arka Abha (-7.05). Sakthi x Arka Alok (-3.72) and LE 79-5 x LE 373 (-2.73) showed significant negative s.c.a. effects.

The g.c.a and s.c.a. effects for duration of harvest are presented in figure 7. Combining ability analysis for duration of harvest exhibited significant variances among the parents and the hybrids. The parents LE 79-5, Arka Alok and PKM 1 had g.c.a effect of 2.91, -1.70 and -1.14 respectively Hybrids Sakthi x Arka Abha (4.78). LE 79-5 x PKM 1 (2.89) and Sakthi x Arka Alok (1.64) had significant positive effect and Arka Alok x Arka Abha (-6.80). Arka Abha x PKM 1 (-5.69). Sakthi x PKM 1 (-1.80). LE 79-5 x Arka

FIGURE 5
G.C.A. and S.C.A. Number of days for first flowering

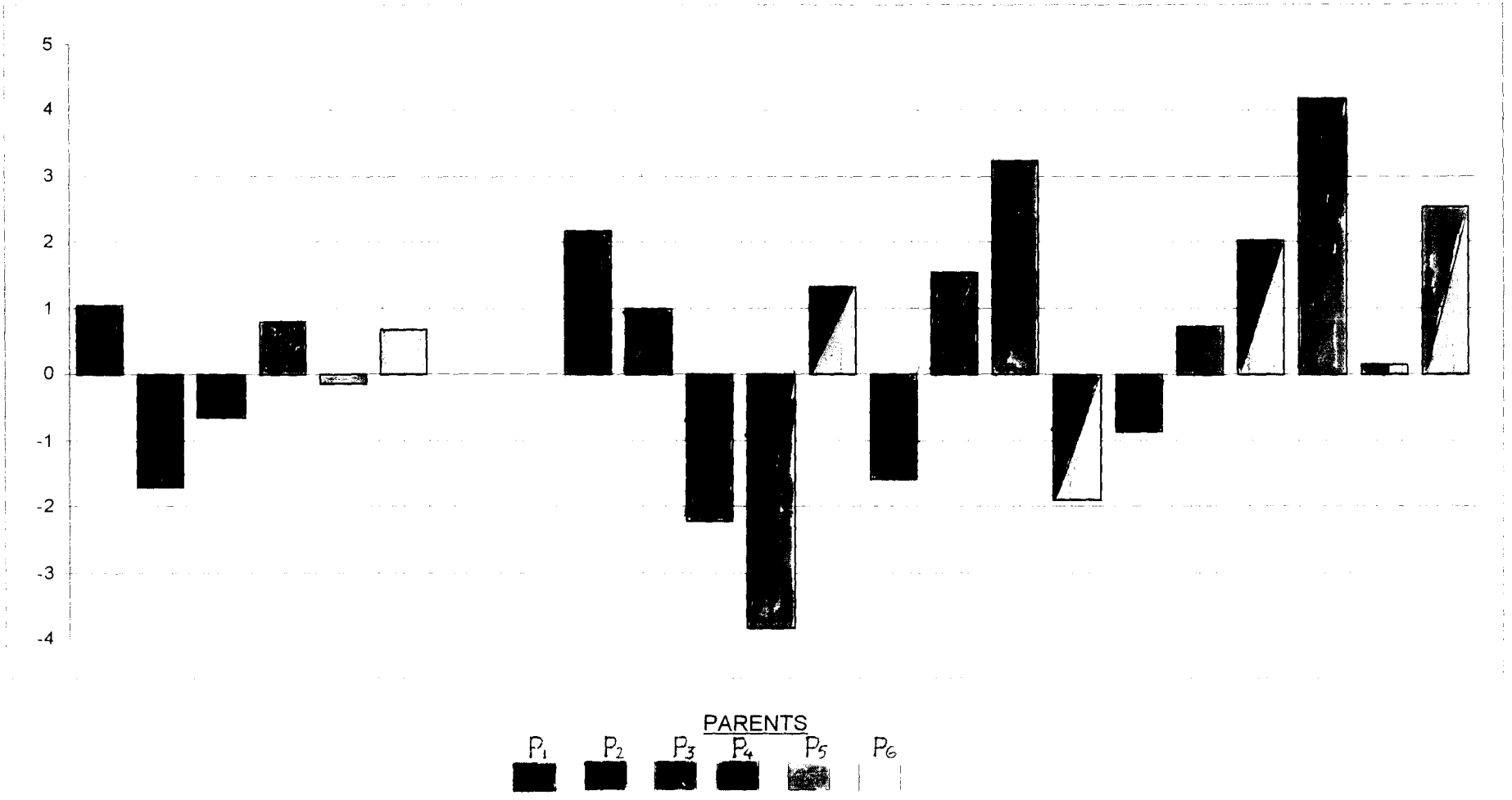


FIGURE 6
G.C.A. and S.C.A. Number of days for first harvest

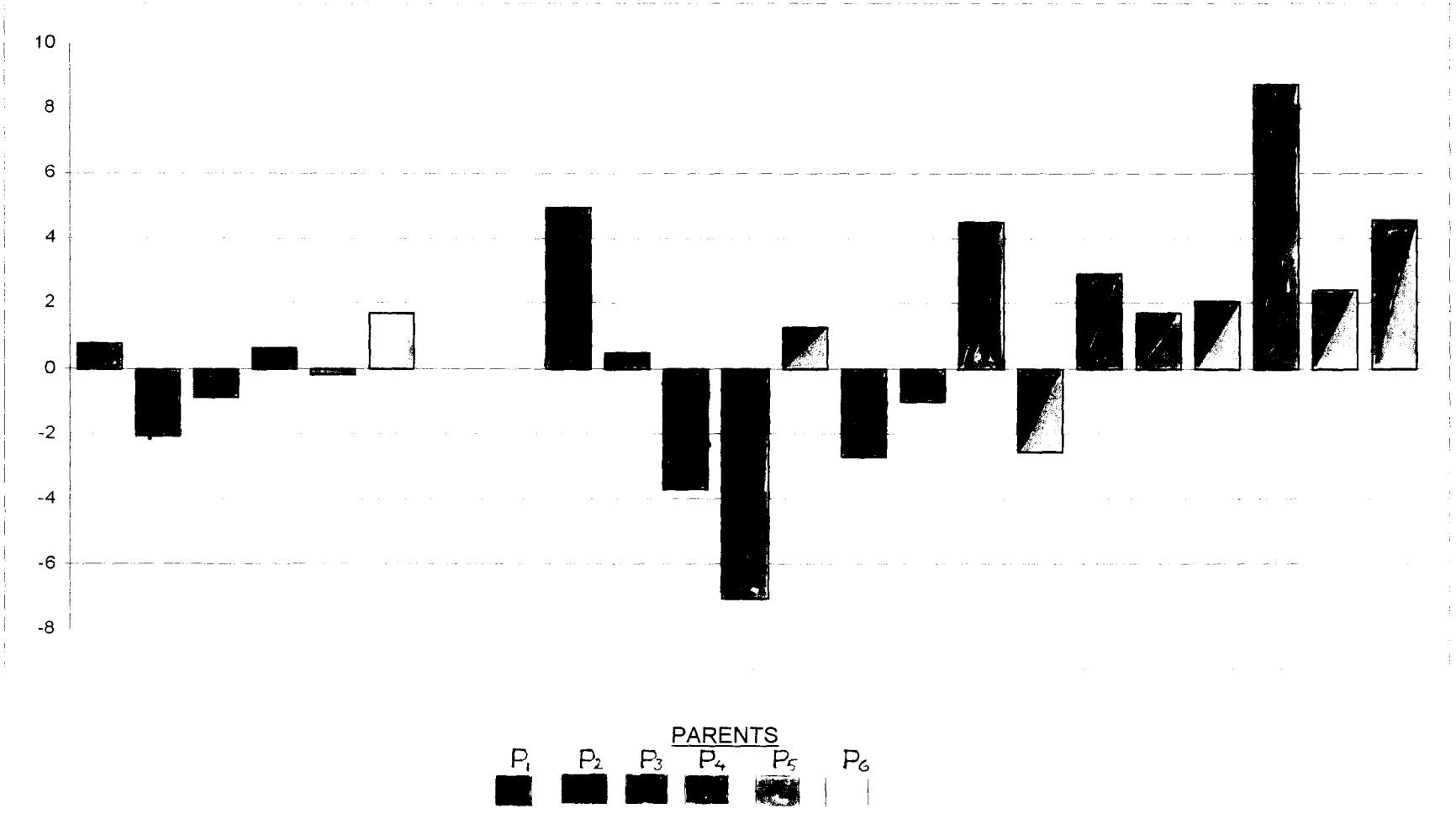
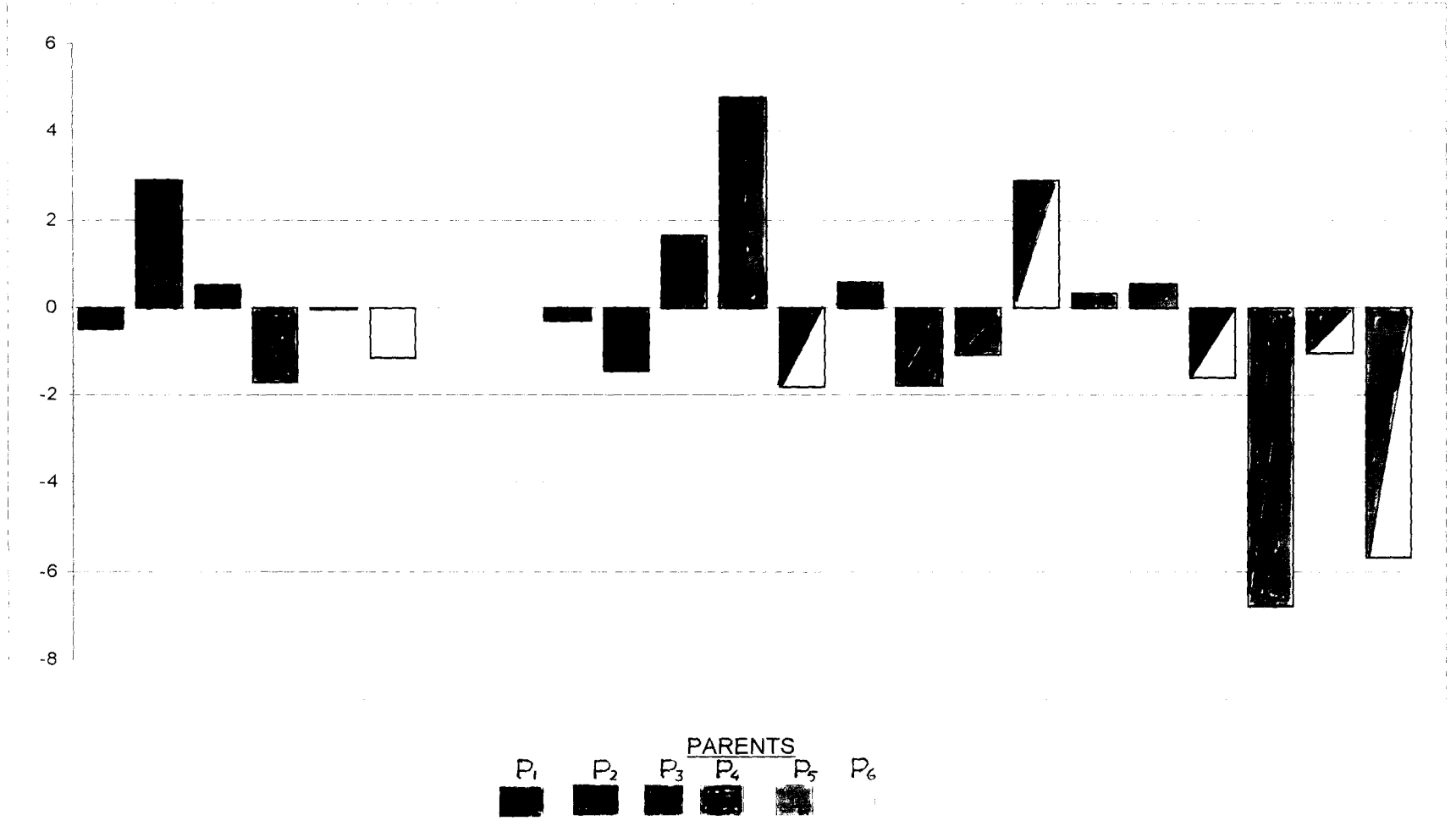


FIGURE 7
G.C.A. and S.C.A. duration of harvest



Alok (-1.77), LE 373 x PKM 1 (-1.58) and Sakthi x LE 373 (-1.44) had significant negative s.c.a. effects.

Analysis of variance for single fruit weight showed that variance due to parents and hybrids were significant. All the parents showed significant g.c.a. effects. It was positive in Arka Abha (7.82), Arka Alok (4.13) and PKM1 (3.21) and negative in LE 79-5 (-8.69), Sakthi (-4.97) and LE 373 (-1.50) Eight out of fifteen hybrids showed significant s.c.a. effects. Hybrids Arka Alok x PKM 1 (7.62), Sakthi x PKM 1 (3.88), LE 373 x Arka Abha (2.66), LE 79-5 x Arka Abha (2.15) and LE 373 x Arka Alok (1.77) had positive s.c.a. effects and LE 79-5 x Arka Alok (-1.76), Sakthi x LE 79-5 (-1.75) and Sakthi x LE 373 (-1.51) had negative s.c.a. effects. The g.c.a. and s.c.a effects are presented in figure 8.

The g.c.a. and s.c.a. effects for number of fruits/plant are given in figure 9. Both parents and hybrids showed significant variances for number of fruits/plant. Significant positive g.c.a. effects were observed in the parents Sakthi (9.65) and LE 79-5 (1.54). All the other parents exhibited significant negative g.c.a. effects i.e. Arka Alok (-4.54), Arka Abha (-3.43) and LE 373 (-3.07). Significant s.c.a. effect was observed in eight hybrids. Among these LE 79-5 x LE 373 (6.74), Sakthi x Arka Abha (4.32), Arka Abha x PKM 1 (4.12), Sakthi x PKM 1 (3.37) and Arka Alok x PKM 1 (2.90) exhibited positive s.c.a. effect and Sakthi x LE 373 (-4.93), LE 79-5 x PKM 1 (-3.74) and Sakthi x LE 79-5 (-2.54) had negative s.c.a. effect.

FIGURE 8
G.C.A. and S.C.A. Single fruit weight

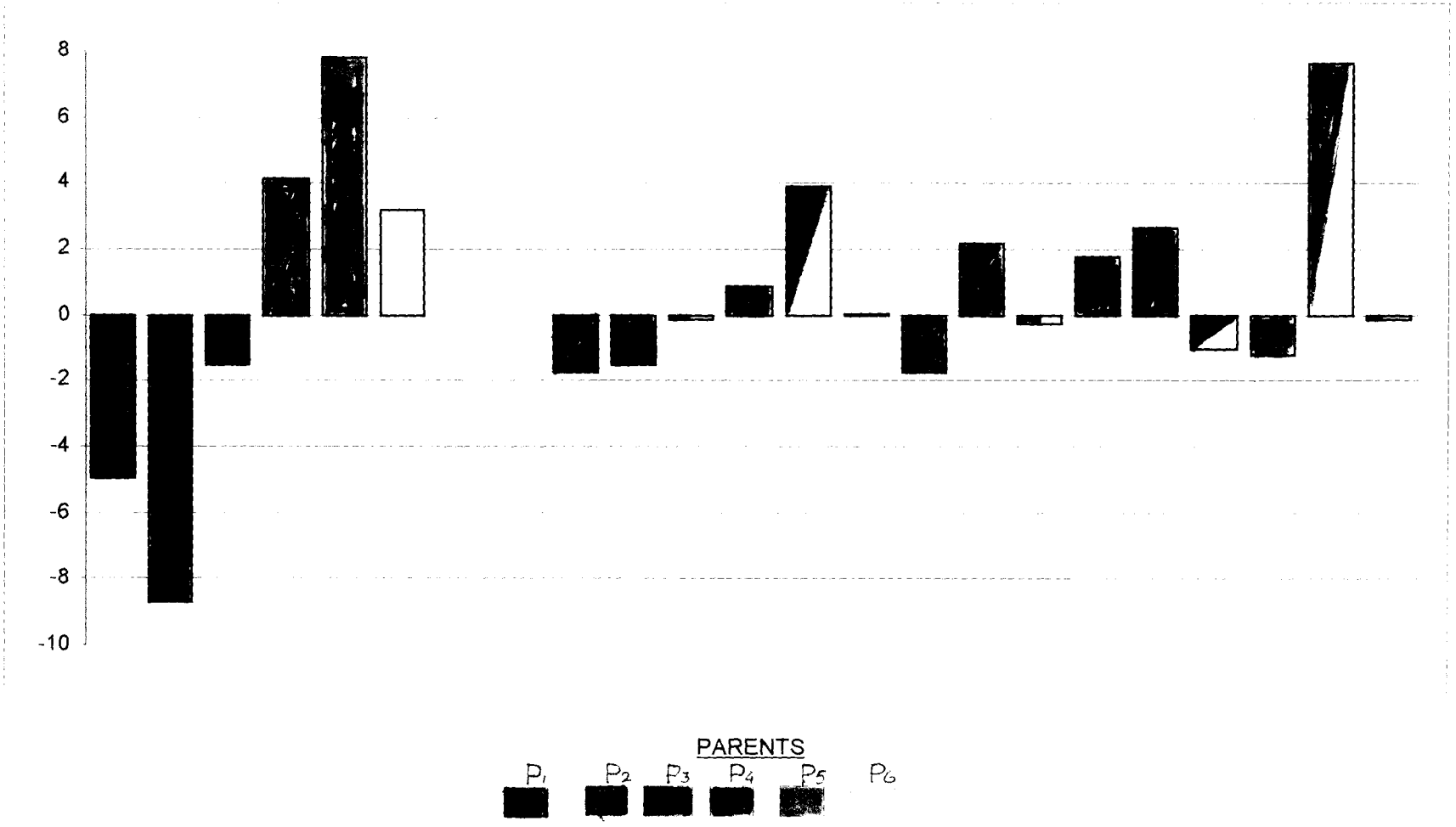
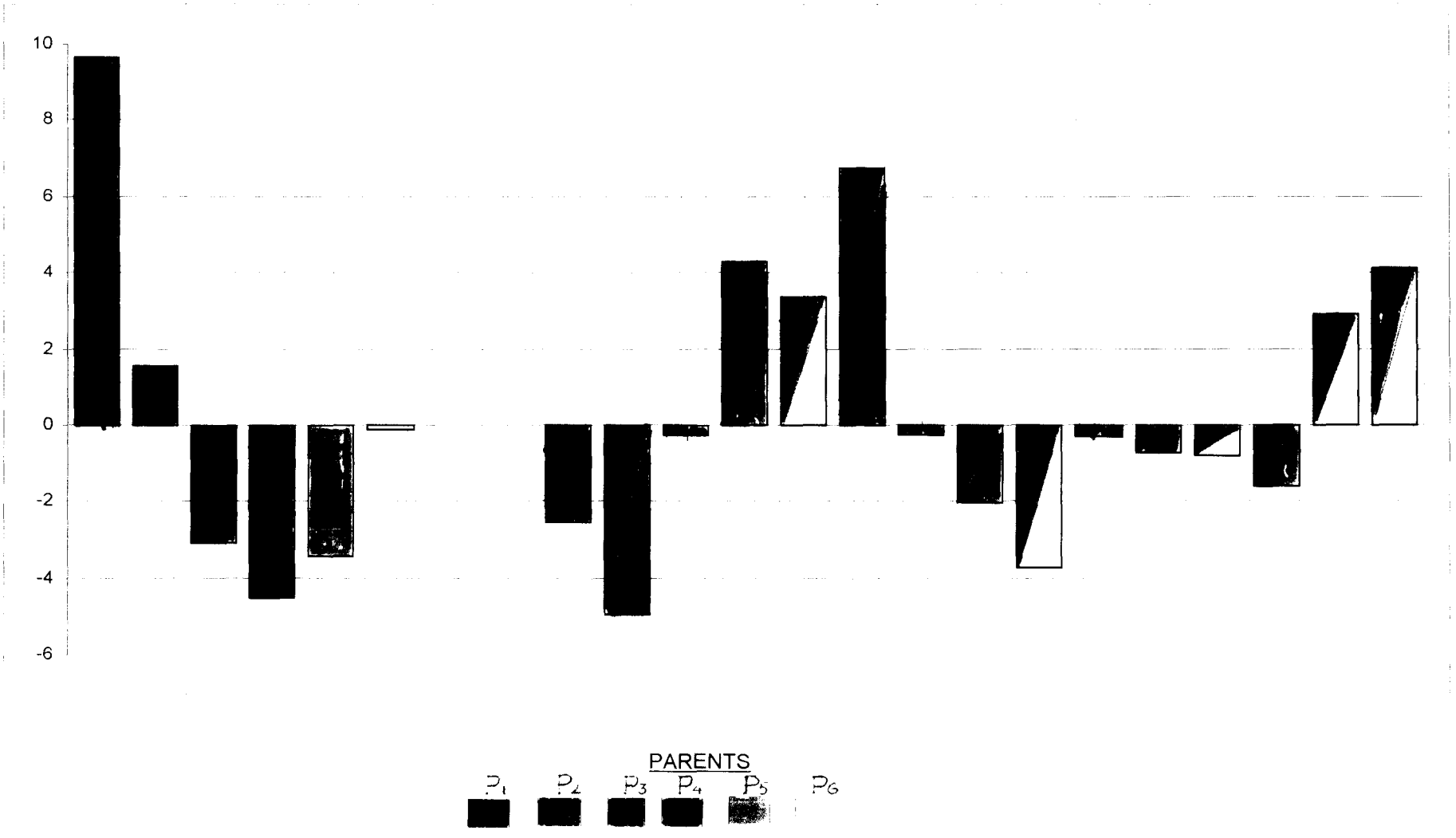


FIGURE 9
G.C.A. and S.C.A. Number of fruits/plant



Analysis of variance showed significant genotypic differences for fruit yield/plant in the parents and their hybrids. The parent Sakthi showed a significant positive g.c.a. effect of 322.82 and the parent PKM 1 showed positive g.c.a. effect of 60.29. All the other parents showed significant negative g.c.a. effects viz.. LE 373 (-145.44) Arka Alok (-121.51). LE 79-5 (-92.07) and Arka Abha (-24.08). Significant s.c.a. effects were recorded in Sakthi x Arka Abha (272.63). LE 79-5 x LE 373 (255.55). Sakthi x PKM 1 (237.70). Arka Alok x PKM 1 (195.92). Arka Abha x PKM1 (189.05). Sakthi x LE 79-5 (-239.39). Sakthi x LE 373 (-186.90). LE 79-5 x PKM1 (-101 85). Arka Alok x Arka Abha (-79.70) and LE 373 x PKM1 (-43.48). The s.c.a and g.c.a effects for fruit yield per plant are represented graphically in figure 10.

The g.c.a and s.c.a. effects for fruit size are represented in figure 11 Variance due to parents and hybrids were significant for fruit size. The parents Arka Abha (7.11). Arka Alok (4.72) and PKM1 (2.61) showed positive g.c.a effects and LE 79-5 (-6.14). Sakthi (-5.13) and LE 373 (-2.89) showed negative g.c.a. effects. The hybrids LE 79-5 x PKM 1 (4.99). LE 79-5 x Arka Alok (4.97). Arka Alok x PKM 1 (3.68). Sakthi x Arka Abha (3.08). Sakthi x Arka Alok (2.40). Sakthi x PKM 1 (2.28). LE 373 x Arka Abha (2.19) and LE 373 x PKM 1 (1.13) showed positive s.c.a. effects and Sakthi x LE 79-5 (-1.35) and Sakthi x LE 373 (-1.33) showed negative s.c.a. effects.

FIGURE 10
G.C.A. and S.C.A. Fruit yield/plant

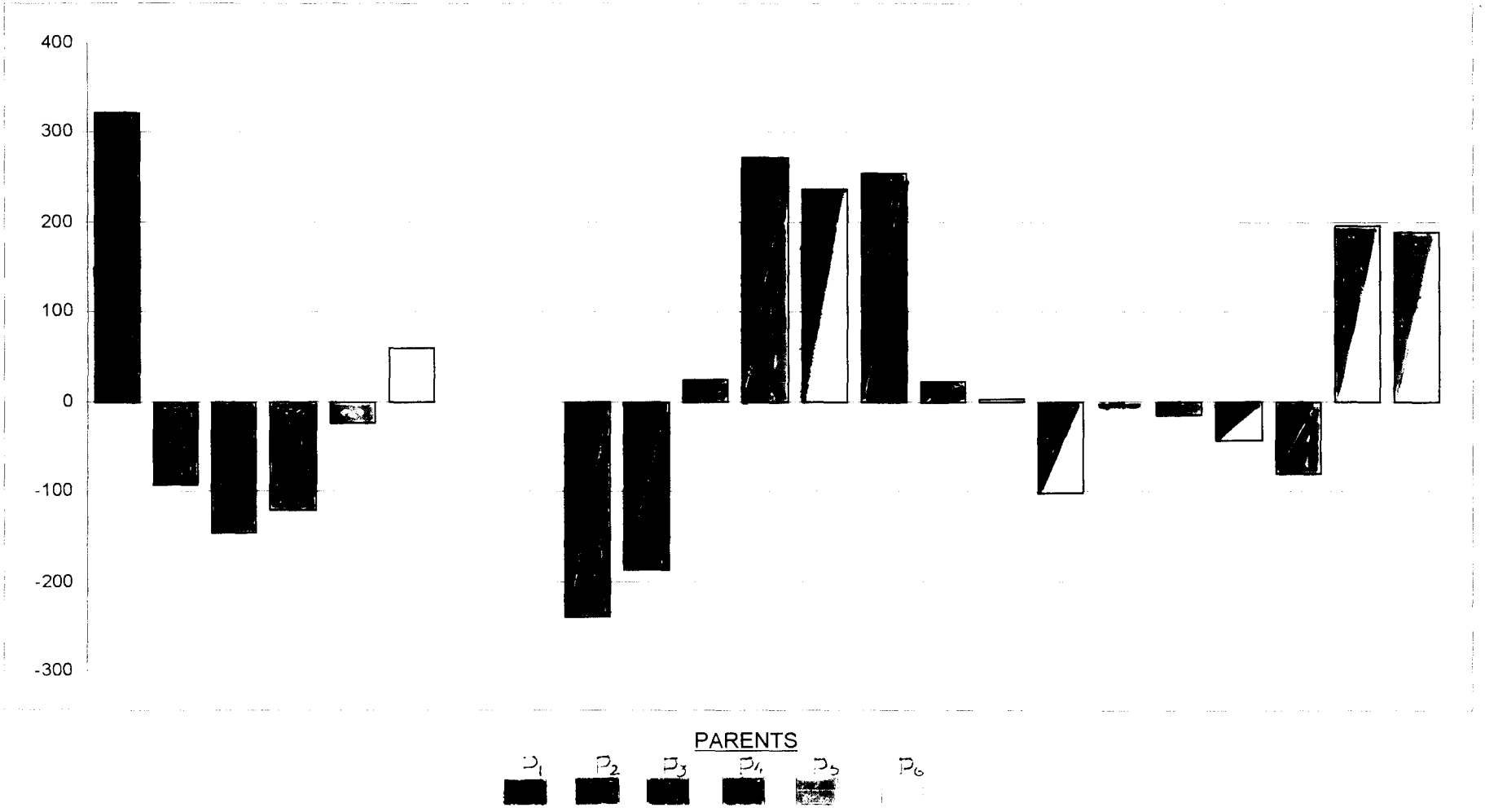
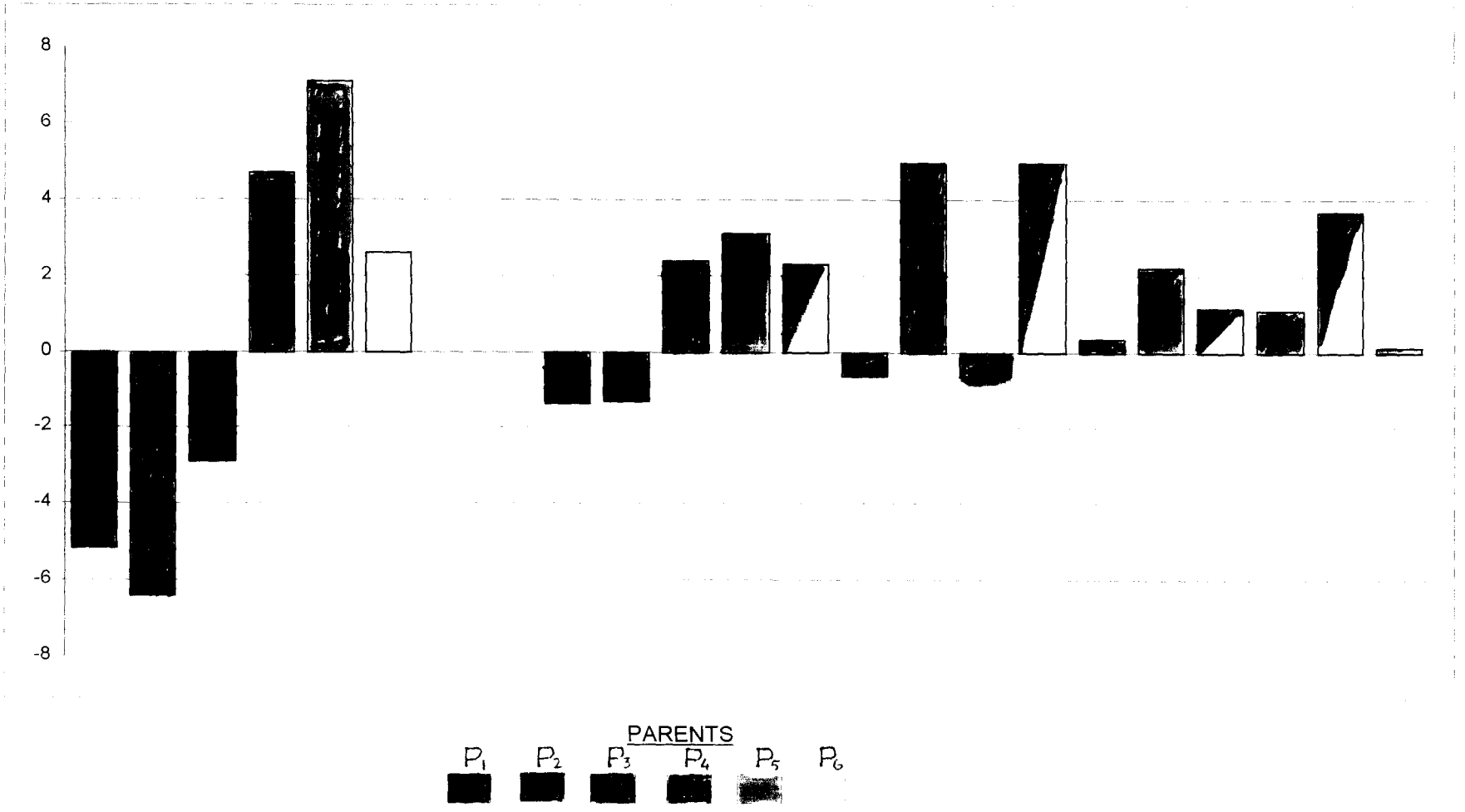


FIGURE 11
G.C.A and S.C.A. size of fruits



Analysis of variance for number of seeds/fruit showed significant differences among the parents and the hybrids. Parents Arka Alok (6.43) Arka Abha (6.04) and PKM 1 (1.37) showed significant positive g.c.a. effects and LE 79-5 (-7.79) and Sakthi (-5.99) showed significant negative g.c.a. effects. Among the hybrids LE 373 x Arka Abha (3.32). LE 79-5 x LE 373 (2.09), Sakthi x PKM1 (1.90), Sakthi x LE 79-5 (0.92), Arka Alok x Arka Abha (0.87) and Arka Alok x PKM 1 (0.84) expressed significant positive s.c.a. effects and LE 79-5 x Arka Abha (-5.18), Sakthi x Arka Alok (-2.03), LE 79-5 x PKM 1 (-1.54). Sakthi x Arka Abha (-1.34). LE 373 x PKM1 (-1.27) and Sakthi x LE 373 (-0.84) expressed significant negative s.c.a. effects. The g.c.a. and s.c.a. effects for number of seeds/fruit are represented graphically in figure 12

Pericarp thickness differed significantly among four parents and four hybrids. The parents which showed significant g.c.a. effects are Arka Abha (0.50). LE 79-5 (-0.26), Sakthi (-0.16) and Arka Alok (-0.16). Among the hybrids LE 79-5 x Arka Alok (0.76) and LE 373 x Arka Abha (0.46) exhibited significant positive s.c.a. effects and LE 373 x Arka Alok (-0.49). LE 79-5 x LE 373 (-0.38) and LE 79-5 x Arka Abha (-0.37) showed significant negative s.c.a. effects. The g.c.a. and s.c.a. effects for pericarp thickness are represented in figure 13.

FIGURE 12
G.C.A. and S.C.A. Number of Seeds/fruit.

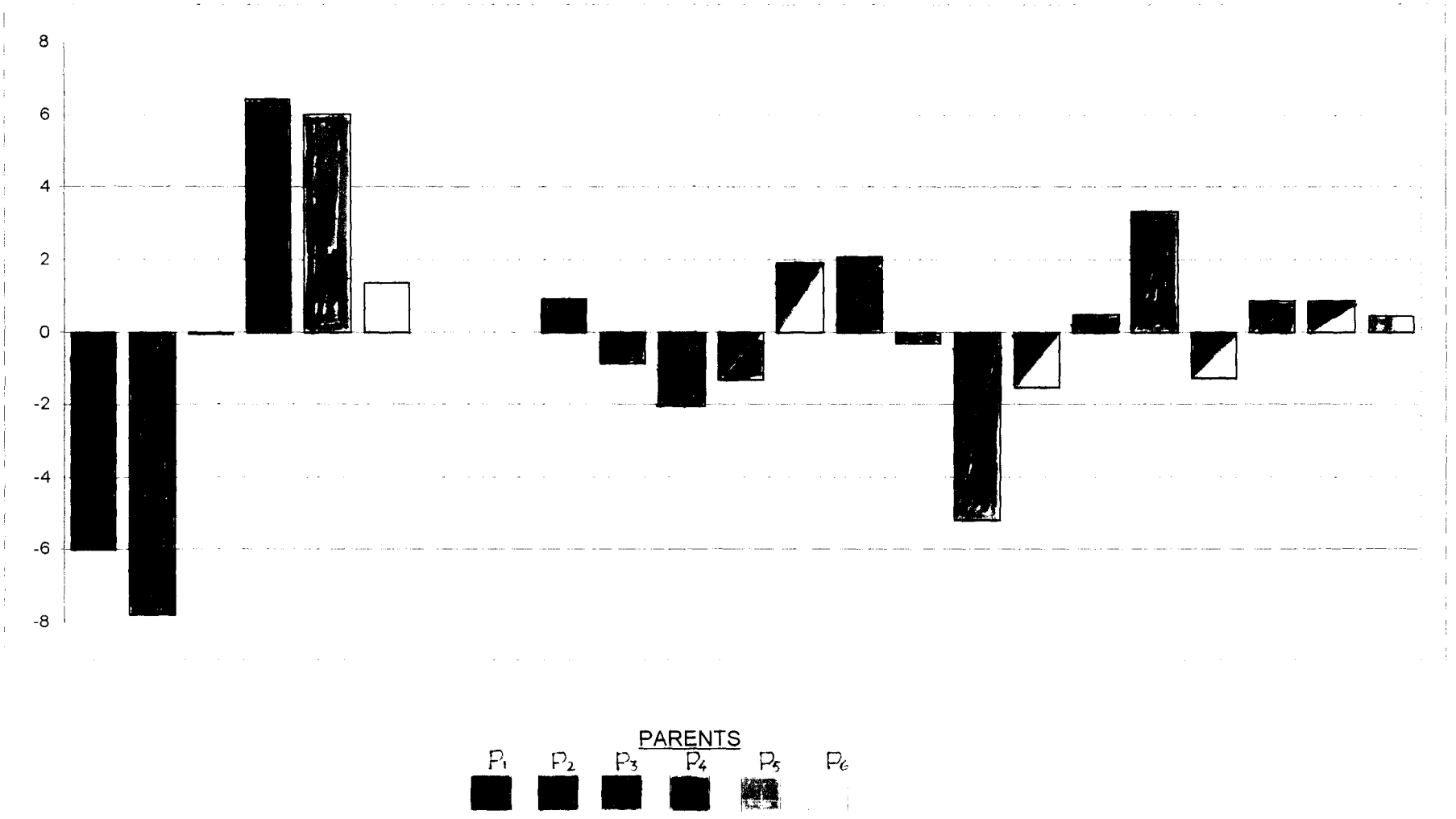
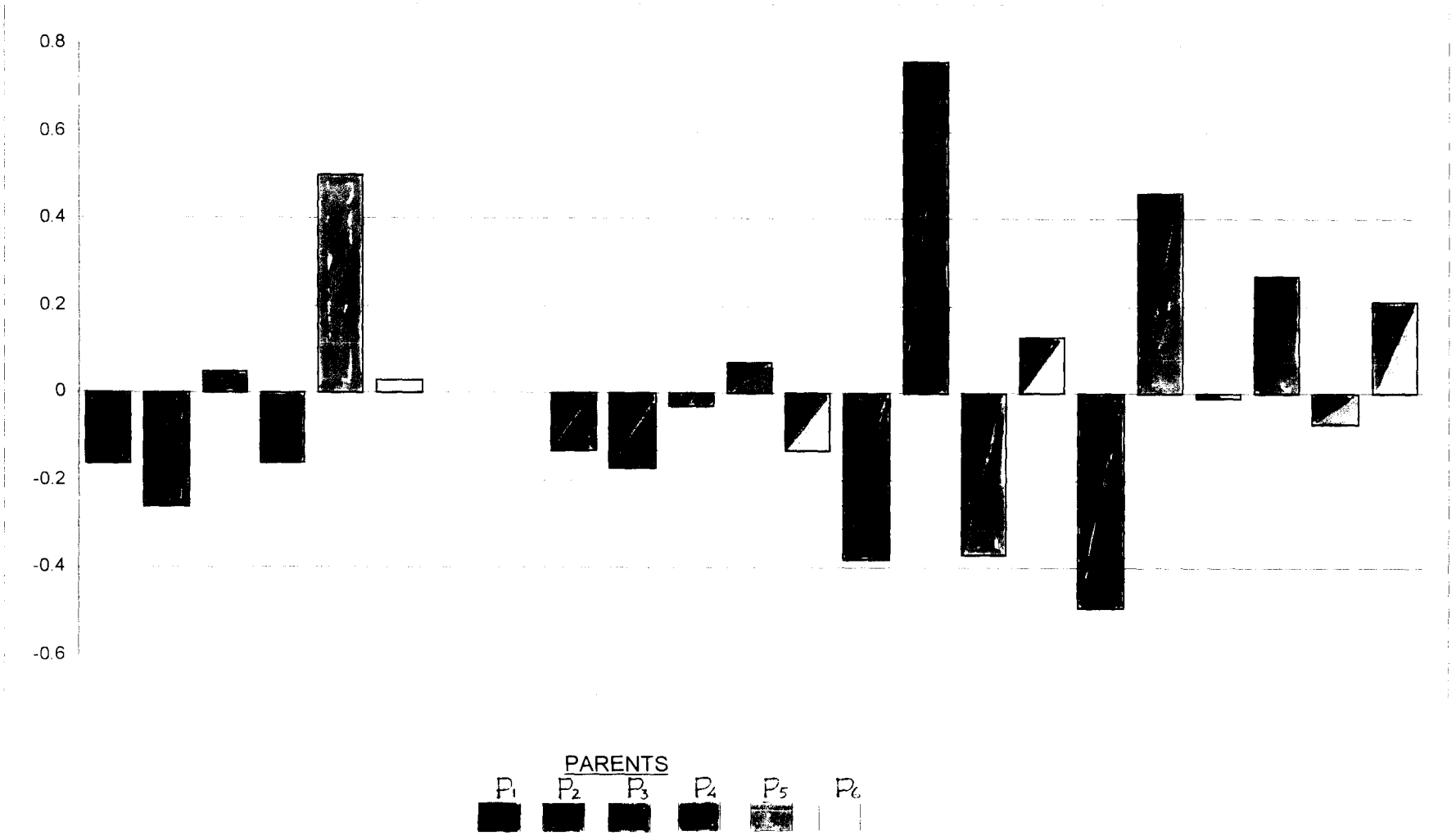


FIGURE 13
G.C.A. and S.C.A. Pericarp thickness



GENETIC COMPONENTS OF VARIANCE

The genetic components of variance such as additive variance (σ^2a) and dominance variance (σ^2d) were estimated and they are presented in table 10.

For all the characters under study additive variance was greater than dominance variance except for spread of the plant, number of days for first flowering, number of days for first harvest and duration of harvest for which the dominance variance was greater than additive variance.

The additive to dominance variance ratio ranged from a minimum of -0.09 for number of days for first harvest to a maximum of 15.85 for number of seeds/fruit. The ratio was low for four characters such as spread of the plant (0.06), number of days for first flowering (0.12) duration of harvest (0.22) and number of days for first harvest (n.e). Medium values were observed for plant height (1.08), number of branches per plant (2.72), number of leaves per plant (1.54), fruit yield per plant (1.67), pericarp thickness (1.33) and fruit size (4.52). Maximum values were observed for single fruit weight (8.29), number of fruits per plant (5.59) and number of seeds per fruit (15.85)

TABLE - 10

Genetic Components of Variance

Sl.No.	Characters	Additive variance $\sigma^2 a$	Dominance Variance $\sigma^2 d$	$\sigma^2 a / \sigma^2 d$
1.	Plant height (c.m.)	181.27	168.48	1 08
2.	Number of branches/plant	9.54	3.50	2.72
3.	Number of leaves/plant	1444.88	938.76	1.54
4.	Spread of the plant	11.02	197.76	0.06
5.	Number of days for first flowering	0.58	4.72	0.12
6.	Number of days for first harvest	n.e	19.86	n.e
7.	Duration of harvest	2.38	10.91	0.22
8.	Single fruit weight	74.04	8.93	8.29
9.	Number of fruits/plant	52.18	9.33	5.59
10.	Fruit yield/plant	53058.28	31781.43	1.67
11.	Fruit size	58.82	13.02	4.52
12.	Number of seeds/fruit	69.42	4.38	15.85
13.	Pericarp thickness	0.12	0.09	1.33

HETEROSIS

Percentage of relative heterosis, heterobeltiosis and standard heterosis were assessed from the mean value of parents and hybrids for the different morphological and yield related characters and the results are presented below.

PLANT HEIGHT

The mean values of parents and hybrids and percentage of heterosis for plant height are given in table 11.

The hybrids exhibited significant heterosis for plant height. Relative heterosis varied from -2.05 to 71.99 percent. Except one, all the hybrids exhibited positive heterosis. Relative heterosis was not significant in only one hybrid viz., LE 79-5 x LE 373 (0.46). Heterobeltiosis varied from -20.76 to 63.41 among the 15 hybrids. Significant positive heterosis was noticed in Sakthi x LE 79-5 (9.23), Sakthi x Arka Alok (24.63), Sakthi x Arka Abha (29.72), Sakthi x PKM1 (40.40), Arka Alok x Arka Abha (22.03) and Arka Alok x PKM 1 (63.41). All the hybrids exhibited significant standard heterosis which ranged from 30.51 in Sakthi x Arka Abha to 115.63 in LE 79-5 x LE373.

TABLE - 11

Mean Value of Parents and Hybrids and heterosis percentage for plant height and number of branches/plant.

Parents/ hybrids	Plant Height									
	Mean (c.m.)	MP Value	Heterosis (%)			Mean	MP	Heterosis(%)		
			RH	HB	SH			RH	HB	SH
P1	44.64					13.56				
P2	86.98					15.76				
P3	105.54					18.11				
P4	52.73					7.220				
P5	44.91					8.220				
P6	47.47					7.670				
P1 x P2	95.01	65.81	44.37*	9.23*	112.83*	18.78	14.67	28.02*	19.16	38.49*
P1 x P3	88.19	75.09	17.44*	-16.45*	97.56*	17.00	15.84	7.360	-6.15	25.36*
P1 x P4	65.72	48.69	34.98*	24.63*	47.22*	11.00	10.39	5.870	-18.86	-18.88 *
P1 x P5	58.26	44.78	30.10*	29.72*	30.51*	12.56	10.89	15.30*	-7.38	-7.37
P1 x P6	66.65	46.06	44.73*	40.40*	49.30*	11.56	10.62	8.890	-14.75	-14.74 *
P2 x P3	96.70	96.26	0.460	-8.38	115.63*	15.33	16.95	-9.510 *	-15.35	13.05*
P2 x P4	95.57	69.86	36.81*	9.88*	114.09*	9.110	11.50	-20.78 *	-42.26	-32.82 *
P2 x P5	75.03	65.95	13.78*	-13.73*	68.07*	10.45	12.00	-12.94 *	33.78	-22.94 *
P2 x P6	65.85	67.23	-2.050	-24.29*	47.51*	9.560	11.73	-18.48 *	-39.43	-29.49 *
P3 x P4	83.63	79.14	5.680*	-20.76*	87.43*	9.00	12.67	-28.96 *	-50.31	-33.63 *
P3 x P5	95.50	75.23	26.95*	-9.51*	113.93*	12.89	13.17	-2.140	-28.26	-4.94
P3 x P6	86.08	76.51	12.51*	-18.44*	92.03*	7.55	12.89	-41.41 *	-58.3	-44.32 *
P4 x P5	64.35	48.82	31.81*	22.03*	44.15*	11.00	7.720	42.47*	33.81	-18.88 *
P4 x P6	86.17	50.10	71.99*	63.41*	93.03*	7.440	7.450	-0.040	-2.99	-45.73 *
P5 x P6	75.67	46.19	63.82*	59.41*	69.51*	7.890	7.950	-0.760	-4.01	-41.81 *
CD(0.05)			0.91	1.11	1.11			1.17	1.39	1.39

MP - Mid parent RH - Relative heterosis HB - Heterobeltiosis SH - Standard heterosis
* - Significant at 5% level

FIGURE - 14

Heterosis. Plant height

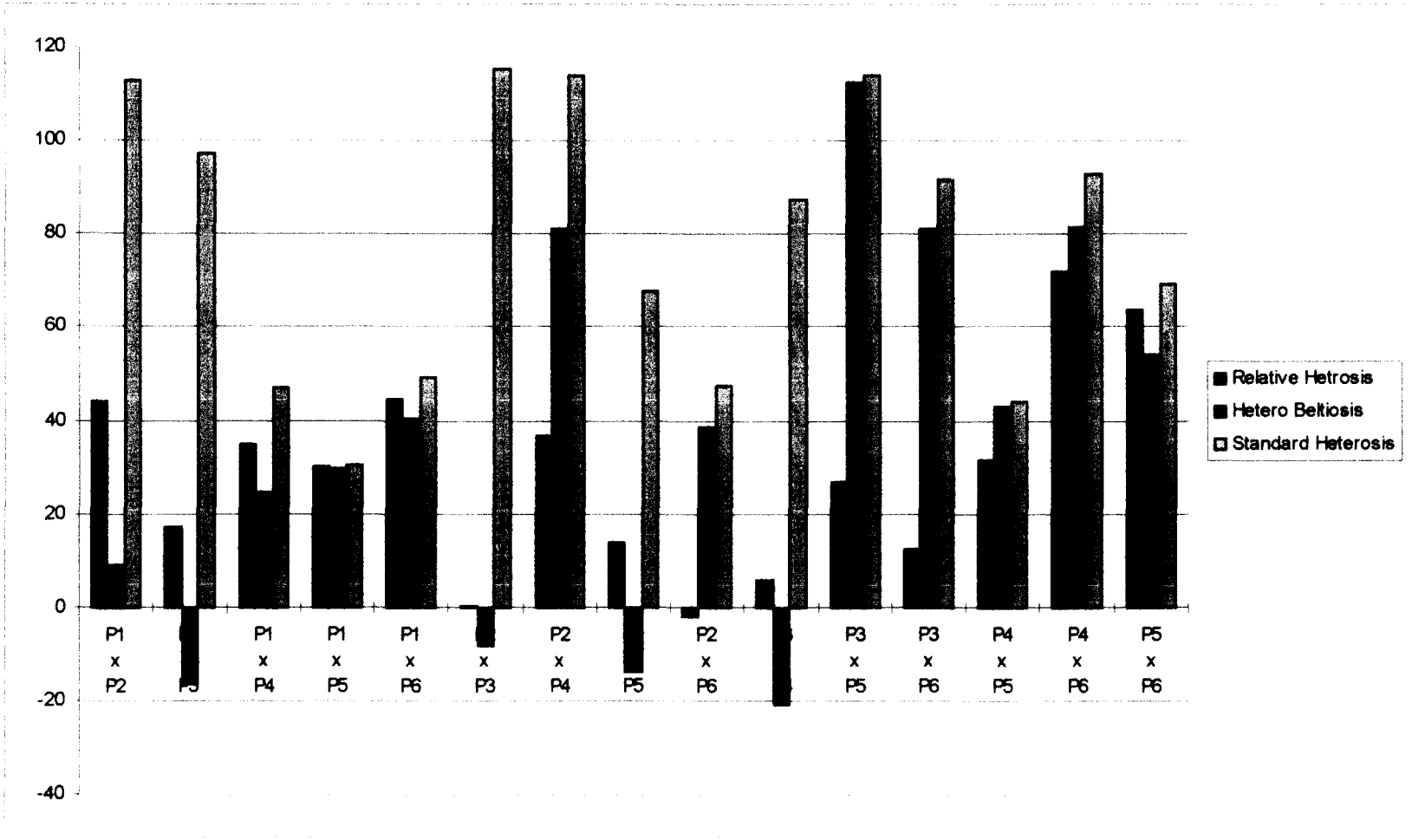
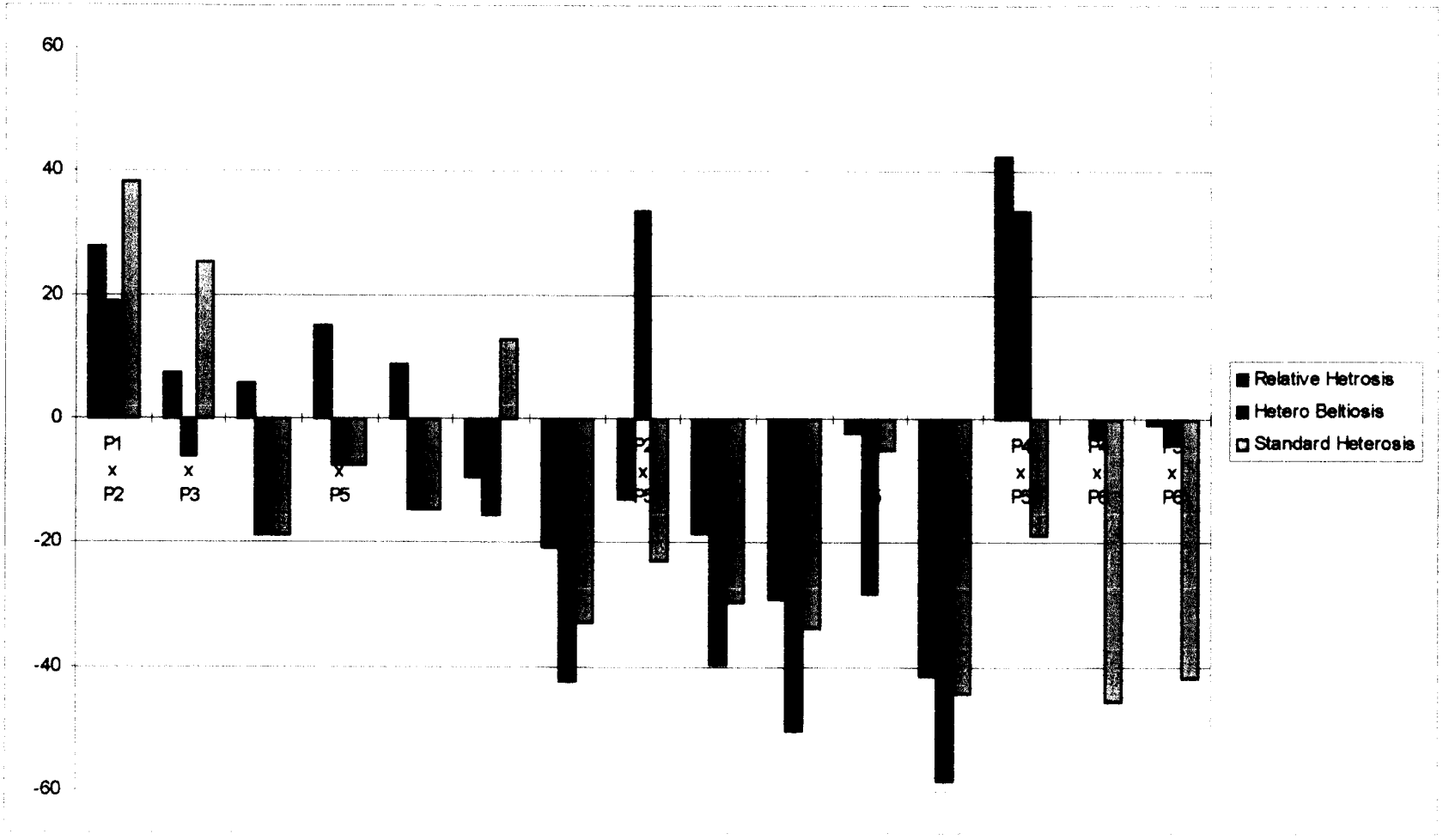


FIGURE - 15

Heterosis. Number of Branches per plant.



Ten hybrids showed significant positive relative heterosis, heterobeltiosis and standard heterosis and the highest was recorded by LE 373 x Arka Abha.

NUMBER OF BRANCHES PER PLANT

The mean values of parents and hybrids and heterosis percentage for number of branches per plant are given in table 11.

The hybrids exhibited significant heterosis for number of branches per plant. Significant positive relative heterosis was observed in only three hybrids viz., Sakthi x Arka Abha (15.30), Sakthi x LE 79-5 (28.02) and Arka Alok x Arka Abha (42.47). The value of heterobeltiosis ranged from -58.30 to 19.02. Significant positive heterobeltiosis was observed in only one hybrid viz., Sakthi x LE 79-5 (19.02). Majority of the hybrids exhibited negative standard heterosis. Significant positive standard heterosis was exhibited by LE 79-5 x LE 373 (13.05), Sakthi x LE 373 (25.36) and Sakthi x LE 79-5 (38.49). The highest relative heterosis and heterobeltiosis was exhibited by the hybrid Arka Alok x Arka Abha. The hybrid Sakthi x LE 79-5 showed positive significant relative heterosis, heterobeltiosis and standard heterosis.

NUMBER OF LEAVES PER PLANT

The mean values of parents and hybrids and heterosis percentage of hybrids for number of leaves per plant are given in table 12.

TABLE - 12

Mean Value of parents and hybrids and heterosis percentage for number of leaves/plant and spread of the plant.

Parents/ hybrids	Number of leaves/plant					Spread of the plant				
			Heterosis (%)					Heterosis(%)		
	Mean (c.m.)	MP Value	RH	HB	SH	Mean (c.m.)	MP	RH	HB	SH
P1	64.11					23.49				
P2	203.78					34.79				
P3	208.33					44.32				
P4	97.89					25.41				
P5	77.89					20.67				
P6	109.66					23.41				
P1 x P2	169.67	133.95	26.67*	-16.74 *	164.65*	43.02	29.14	47.63*	23.66*	83.14 *
P1 x P3	159.78	136.22	17.29*	-23.31 *	149.23*	42.37	33.91	24.96*	-4.410 *	80.37*
P1 x P4	106.89	81.00	31.96*	9.190*	66.730*	41.29	24.45	68.86*	62.47*	75.77*
P1 x P5	81.78	71.00	15.18*	4.990*	27.560*	32.30	22.08	46.28*	56.27*	37.50*
P1 x P6	109.67	86.890	26.22*	0.00	71.070*	50.07	23.45	113.50*	113.87*	113.15*
P2 x P3	214.78	206.06	4.230*	3.090*	235.02*	71.36	39.56	80.40*	61.00*	203.78*
P2 x P4	145.11	150.84	-3.790 *	-28.79 *	126.35*	52.26	30.10	73.62*	105.65*	122.47*
P2 x P5	173.67	140.84	23.31*	-14.78 *	170.89	44.70	27.73	61.21*	28.49*	90.29*
P2 x P6	161.33	156.72	2.940*	-20.83 *	151.65*	63.03	29.10	116.61*	81.17*	168.32*
P3 x P4	163.44	153.11	6.750*	-21.55 *	154.93*	40.10	34.87	15.01*	-9.520 *	70.71*
P3 x P5	204.45	143.11	42.86*	-1.870 *	218.90*	71.44	32.49	119.87*	245.69*	204.13*
P3 x P6	160.11	158.99	0.700	-23.15 *	149.74*	52.68	33.87	55.56*	125.03*	124.26*
P4 x P5	113.44	87.890	29.07*	15.89*	79.950*	43.20	23.04	87.50*	109.03*	83.90*
P4 x P6	216.56	103.78	108.68*	97.47*	237.79*	53.07	24.41	117.38*	108.85*	125.93*
P5 x P6	97.31	93.780	3.770*	-11.26 *	51.790*	34.36	22.04	55.90*	46.76*	46.22*
CD (0.05)			2.61	3.33	3.33			1.2	1.42	1.42

MP - Mid parent RH - Relative Heterosis HB - Heterobeltiosis SH - Standard heterosis.
* - Significant at 5% level

FIGURE - 16
Heterosis. Number of leaves per plant

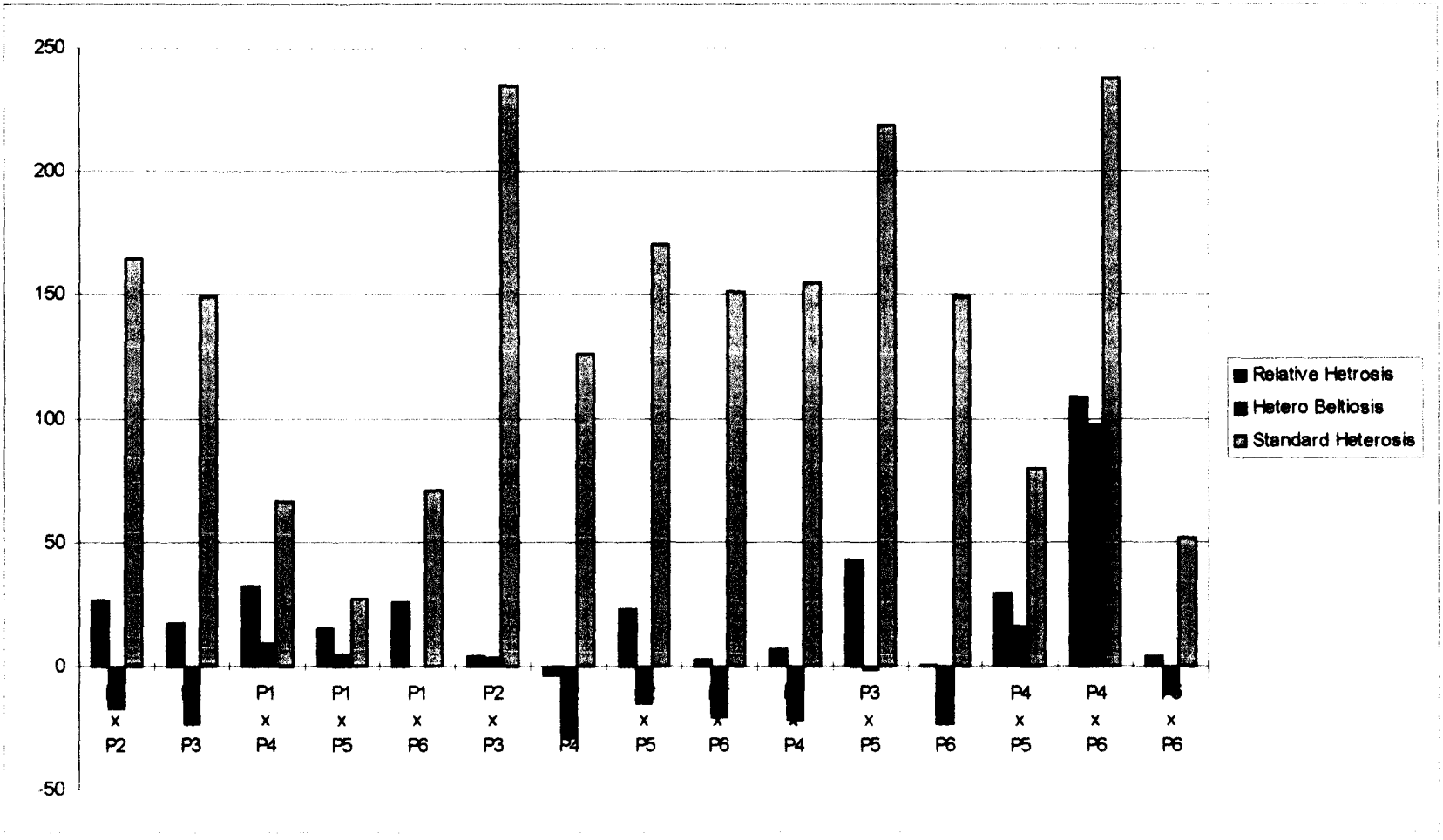
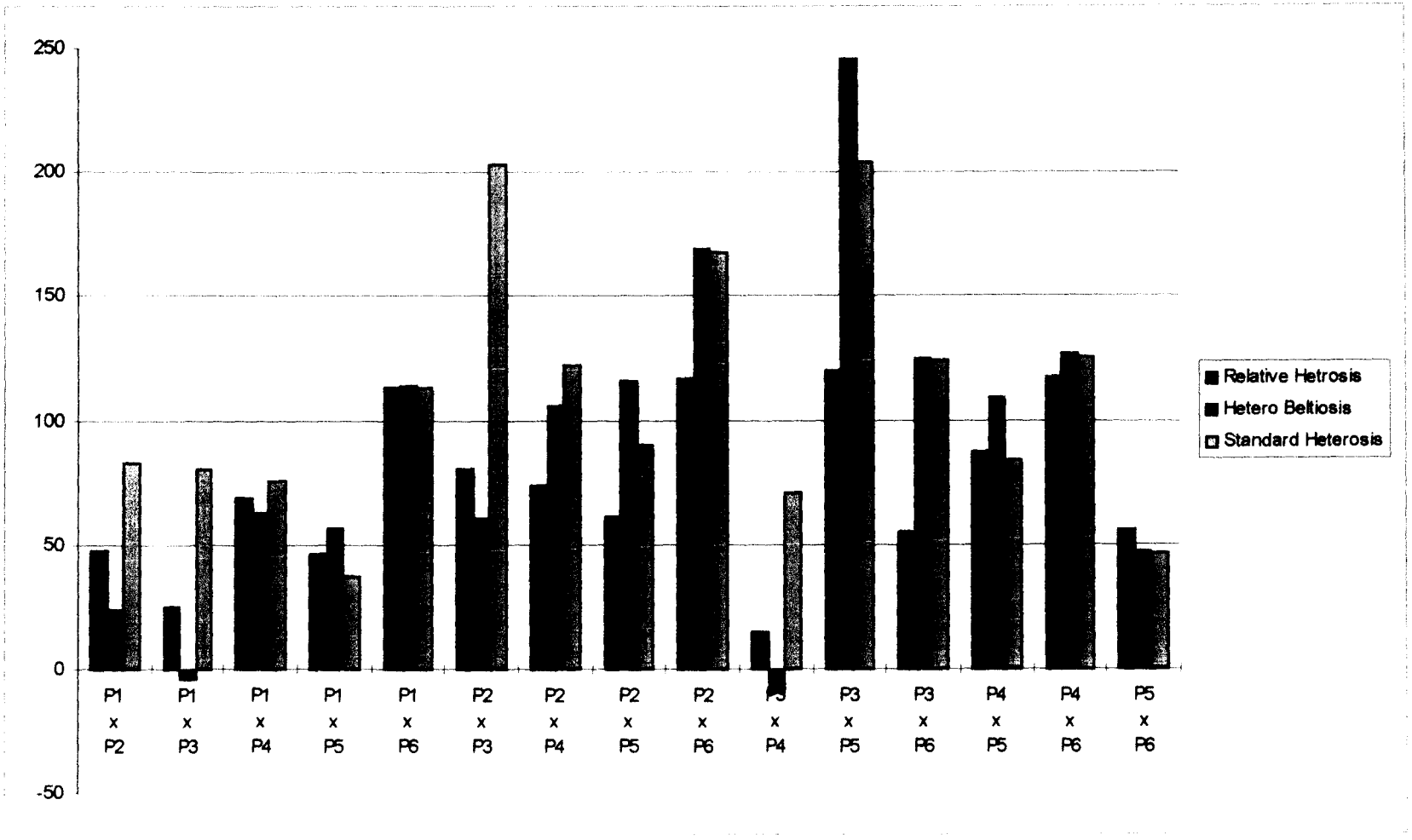


FIGURE - 17

Heterosis. Spread of the plant



Hybrids exhibited significant relative heterosis, heterobeltiosis and standard heterosis for this trait. Thirteen hybrids exhibited positive relative heterosis. Among them Arka Alok x PKM 1 (108.68) recorded the highest and LE 79-5 x PKM 1 (2.94) recorded the lowest relative heterosis. Eleven hybrids exhibited positive heterobeltiosis and the highest was recorded by Arka Alok x PKM 1 (97.47). Standard heterosis percentage ranged from 51.79 to 237.79 and was maximum for Arka Alok x PKM 1. With regard to number of leaves per plant the hybrid Arka Alok x PKM 1 expressed highest relative heterosis, heterobeltiosis and standard heterosis. Five hybrids, viz., Sakthi x Arka Alok, Sakthi x Arka Abha, LE 79-5 x LE 373, Arka Alok x Arka Abha and Arka Alok x PKM 1 showed significant positive relative heterosis, heterobeltiosis and standard heterosis.

SPREAD OF THE PLANT

The mean values of parents and hybrids and heterosis expressed for spread of the plant are given in table 12.

The hybrids exhibited significant heterosis for spread of the plant. Relative heterosis, heterobeltiosis and standard heterosis recorded signifciant values. All the hybrids showed significant positive relative heterosis and among these LE 373 x Arka Abha recorded the highest

(119.87) and LE 373 x Arka Alok recorded the lowest (15.01) values. Heterobeltiosis was significant and positive in thirteen hybrids and the highest was recorded by LE 373 x Arka Abha (245.69). Standard heterosis also was significant and positive in all the hybrids. Relative heterosis, heterobeltiosis and standard heterosis were maximum in LE 373 x Arka Abha. Thirteen hybrids showed significant positive relative heterosis, heterobeltiosis and standard heterosis.

NUMBER OF DAYS FOR FIRST FLOWERING

The mean values of parents and hybrids and heterosis for number of days for first flowering are given in table 13.

The hybrids exhibited significant relative heterosis heterobeltiosis and standard heterosis. Significant negative relative heterosis was exhibited by only two hybrids *viz*., Sakthi x Arka Alok (-3.30) and Sakthi x Arka Abha (-4.51). Heterobeltiosis was significant and negative in four hybrids *viz*. LE 79-5 x PKM 1 (-4.04), Sakthi x Arka Alok (-5.50), LE 79-5 x LE 373 (-8.43) and Sakthi x Arka Abha (-9.85) whereas standard heterosis was significant and negative in seven hybrids. They were LE 79-5 x Arka Alok (-3.80), LE 373 x Arka Abha (-4.94), Sakthi x Arka Alok (-5.50), LE 373 x Arka Alok (-6.06), Sakthi x Arka Abha (-9.85), LE 79-5 x PKM 1 (-9.85) and LE

TABLE - 13

Mean Value of parents and hybrids and heterosis percentage for number of days for first flowering and for first harvest.

Parents/ hybrids	Number of days for first flowering					Number of days for first harvest				
	Mean (c.m.)	MP Value	Heterosis (%)			Mean (c.m.)	MP	Heterosis(%)		
			RH	HB	SH			RH	HB	SH
P1	58.67					78.22				
P2	56.67					69.00				
P3	53.89					70.67				
P4	56.00					71.22				
P5	52.11					68.11				
P6	55.11					74.22				
P1 x P2	57.33	54.67	4.87*	-2.28	-2.28	78.38	73.61	6.41*	0.21	0.20
P1 x P3	57.22	56.28	1.68	-2.47	-2.47	75.00	74.45	0.75	-4.12 *	-4.11 *
P1 x P4	55.44	57.34	-3.30 *	-5.50 *	-5.50 *	72.33	74.72	-3.20 *	-7.53 *	-7.53 *
P1 x P5	52.89	55.39	-4.51 *	-9.85 *	-9.85 *	68.22	73.17	-6.76 *	-12.78 *	-12.78 *
P1 x P6	58.89	56.89	3.51*	0.37	0.37	78.44	76.22	2.91*	0.28	0.28
P2 x P3	51.89	52.28	-0.74	-8.43*	-11.56 *	69.00	69.84	-1.19	-2.36	-11.78 *
P2 x P4	56.44	53.34	5.83*	-0.41	-3.80 *	72.22	70.11	3.01*	1.40	-7.67 *
P2 x P5	57.22	51.39	11.34*	9.80*	-2.47	77.00	68.56	12.32	13.05*	-1.56 *
P2 x P6	52.89	52.89	-0.01	-4.04 *	-9.85*	71.78	71.61	0.24	-3.29 *	-8.23 *
P3 x P4	55.11	54.95	0.29	-1.60	-6.06 *	77.33	70.95	9.00*	8.57*	-1.14
P3 x P5	55.77	53.00	5.23*	3.49	-4.94 *	75.33	69.39	8.57*	6.59*	-3.69 *
P3 x P6	57.89	54.50	6.22*	5.04*	-1.33	77.56	72.45	7.06*	4.50*	-0.84
P4 x P5	60.66	54.01	12.22*	16.41*	3.39*	83.89	69.67	20.41*	23.16*	7.25*
P4 x P6	57.45	55.56	3.40*	4.23	-2.08	79.45	72.72	9.25*	7.05*	1.57
P5 x P6	58.89	53.61	9.84*	6.85*	0.37	80.78	71.17	13.51*	8.84*	3.27*
CD (0.05)			1.52	1.85	1.85			1.61	1.96	1.96

MP - Mid parent RH - Relative heterosis HB - Heterobeltiosis SH - Standard heterosis

* Significant at 5% level

FIGURE - 18

Heterosis. Number of days for first flowering

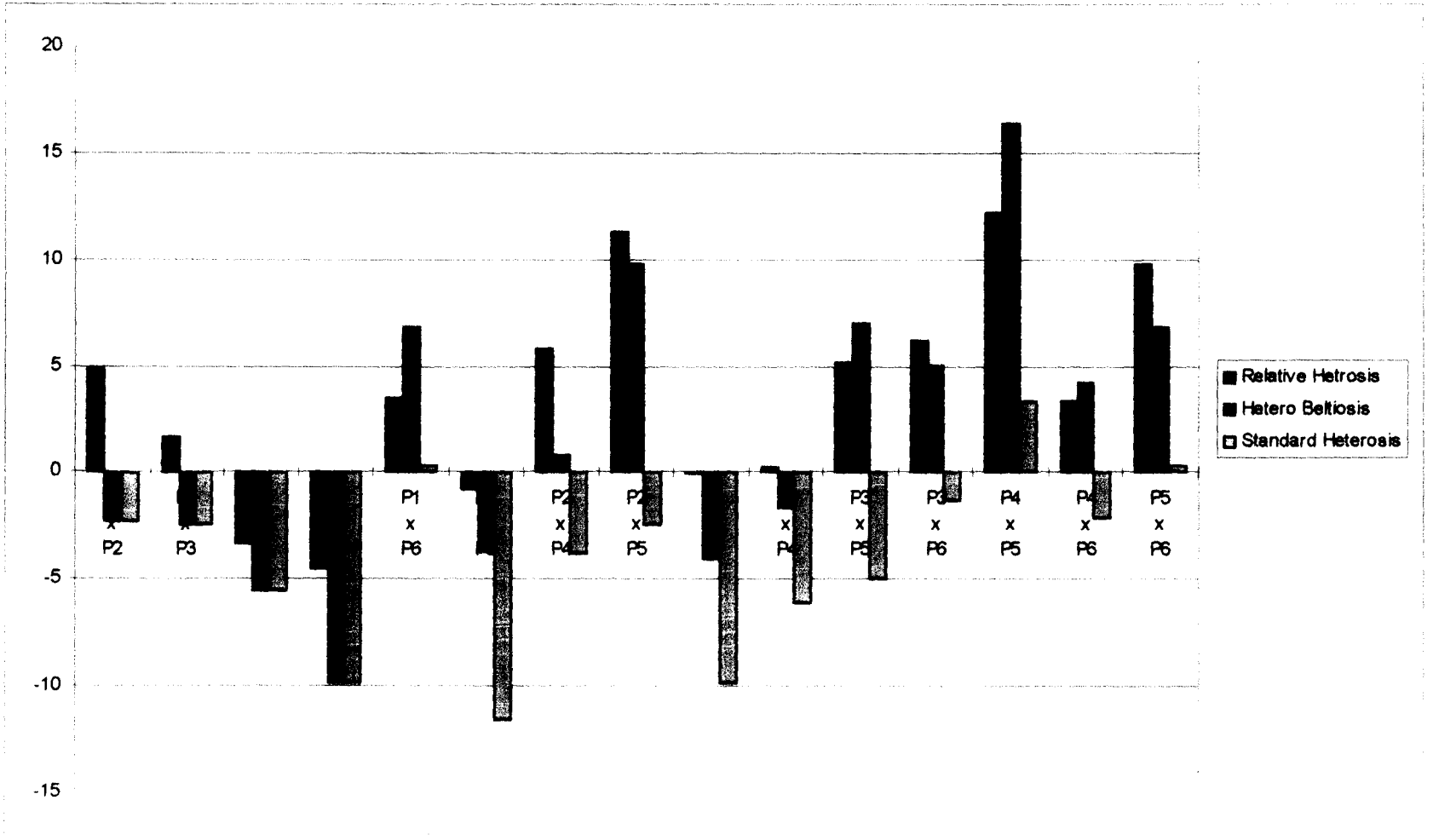
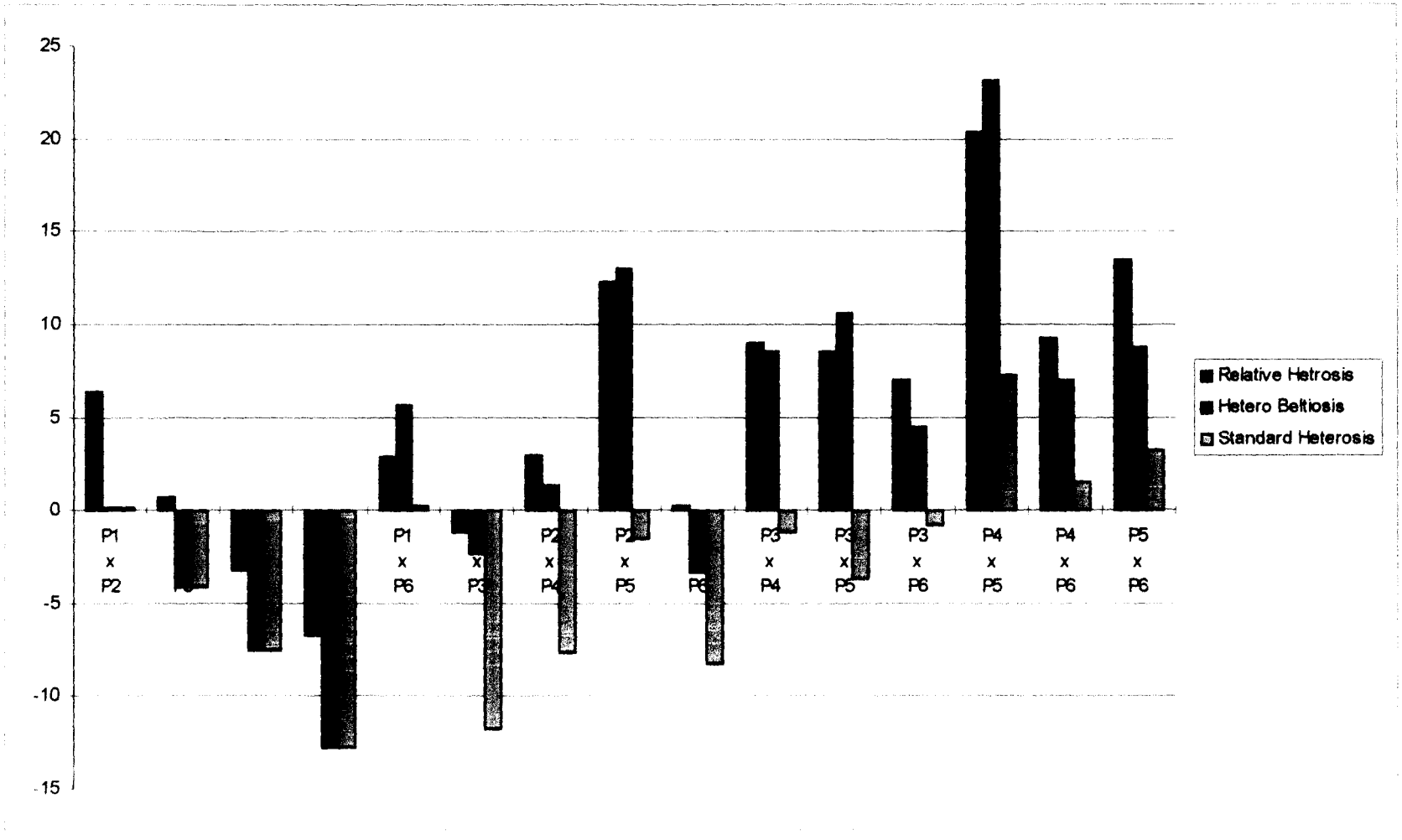


FIGURE - 19

Heterosis. Number of days for first harvest.



79-5 x LE 373 (-11.56). Maximum significant negative relative heterosis and heterobeltiosis were exhibited by Sakthi x Arka Abha. In four hybrids *viz.*, Sakthi x Arka Alok, Sakthi x Arka Abha, LE 79-5 x LE 373 and LE 79-5 x PKM1 significant negative relative heterosis, heterobeltiosis and standard heterosis were recorded.

NUMBER OF DAYS FOR FIRST HARVEST

The mean value of parents and hybrids and heterosis expressed for number of days for first harvest are given in table 13.

The hybrids exhibited significant heterosis for this trait. Relative heterosis, heterobeltiosis and standard heterosis recorded significant values. Only two hybrids exhibited significant negative relative heterosis viz., Sakthi x Arka Alok (-3.20) and Sakthi x Arka Abha (-6.76). Significant negative heterobeltiosis was exhibited by four hybrids. They were LE 79-5 x PKM 1 (-3.29), Sakthi x LE 373 (-4.12), Sakthi x Arka Alok (-7.53) and Sakthi x Arka Abha (-12.78). Standard heterosis was significant and negative in eight hybrids and the highest significant negative standard heterosis was recorded by Sakthi x Arka Abha (-12.78). Among the fifteen hybrids highest relative heterosis, heterobeltiosis and standard heterosis were recorded by Sakthi x Arka Abha.

DURATION OF HARVEST

Duration of harvest was recorded as number of days from first to last harvest. The mean value of parents and hybrids and heterosis for duration of harvest are given in table 14.

Relative heterosis was significant and negative in nine hybrids and the highest value was recorded by Arka Alok x Arka Abha (-49.49) Heterobeltiosis was significantly negative in ten hybrids and the highest value was recorded by Arka Alok x Arka Abha (-53.30). Only three hybrids exhibited significant negative standard heterosis viz., Arka Alok x PKM 1 (-8.41), Arka Abha x PKM 1 (-25.94) and Arka Alok x Arka Abha (-35.70). Maximum significant negative relative heterosis, heterobeltiosis and standard heterosis were recorded by the hybrid Arka Alok x Arka Abha. Four hybrids viz., Sakthi x PKM 1, Arka Alok x Arka Abha, Arka Alok x PKM 1 and Arka Abha x PKM 1 showed significant negative relative heterosis, heterobeltiosis and standard heterosis.

SINGLE FRUIT WEIGHT

The mean value of parents and hybrids and heterosis percentage for individual fruit weight are presented in table 14.

Significant heterosis was recorded in the hybrids for single fruit weigt. Eleven hybrids viz., Arka Alok x Arka Abha (2.94), LE 373 x PKM 1 (4.88), Sakthi x Arka Alok (4.95), Sakthi x Arka Abha (5.40), LE 79-5 x PKM 1 (5.48), Arka Abha x PKM 1 ((7.07), LE 79-5 x Arka Abha (7.22) LE 373 x Arka Alok

TABLE - 14

Mean Value of parents and hybrids and heterosis percentage for duration of harvest and single fruit weight.

Parents/ hybrids	Duration of harvest					Single fruit weight				
			Heterosis (%)					Heterosis(%)		
	Mean (c.m.)	MP Value	RH	HB	SH	Mean (c.m.)	MP	RH	HB	SH
P1	17.11					30.26				
P2	25.22					24.3				
P3	21.33					36.92				
P4	20.00					45.99				
P5	23.56					54.36				
P6	20.69					42.30				
P1 x P2	21.66	21.17	2.31	-14.11 *	26.59*	25.47	27.28	-6.64 *	-15.83 *	-15.83 *
P1 x P3	18.11	19.22	-0.579	-15.11 *	5.840	32.9	33.59	-2.05	-10.89 *	8.720*
P1 x P4	19.00	18.56	2.390	-5.00	11.04*	39.93	38.13	4.95*	-13.17 *	31.96*
P1 x P5	23.78	20.34	16.92*	0.93	38.98*	44.59	42.31	5.40*	-17.97 *	47.35*
P1 x P6	16.11	19.00	-15.20 *	-22.87 *	-5.84	43.00	36.28	18.53*	1.650	42.10*
P2 x P3	23.56	23.28	1.200	-6.61 *	37.69*	30.74	30.61	0.44	-16.73 *	1.590
P2 x P4	19.00	22.61	-15.97 *	-24.67 *	11.04*	34.57	35.15	-1.65	-24.84 *	14.24*
P2 x P5	21.33	24.39	-12.53 *	15.42*	24.66*	42.17	39.33	7.22*	-22.43 *	39.36*
P2 x P6	24.22	23.06	5.050	-3.98	41.55*	35.12	33.3	5.48*	-16.97 *	16.06*
P3 x P4	18.66	20.67	-9.69 *	-12.52 *	9.050*	45.29	41.46	9.25*	-1.520	49.66*
P3 x P5	20.55	22.45	-8.43 *	-12.75*	20.10*	49.87	45.64	9.26*	-8.260 *	64.80*
P3 x P6	17.34	21.11	-17.88 *	-18.37 *	1.340	41.54	39.61	4.88*	-1.790	37.28*
P4 x P5	11.00	21.78	-49.49 *	-53.30 *	-35.70 *	51.65	50.18	2.94*	-4.990 *	70.69*
P4 x P6	15.67	20.46	-23.37 *	25.00*	-8.410*	55.84	44.15	26.50*	32.02*	84.54*
P5 x P6	12.67	22.13	-42.75*	-46.23*	-25.94 *	51.75	48.33	7.07*	-4.80*	71.01*
CD (0.05)			1.19	1.44	1.44			1.12	1.42	1.42

MP - Mid parent RH - Relative heterosis HB - Heterobeltiosis SH - Standard heterosis

* Significant at 5% level

FIGURE - 20

Heterosis. Duration of harvest

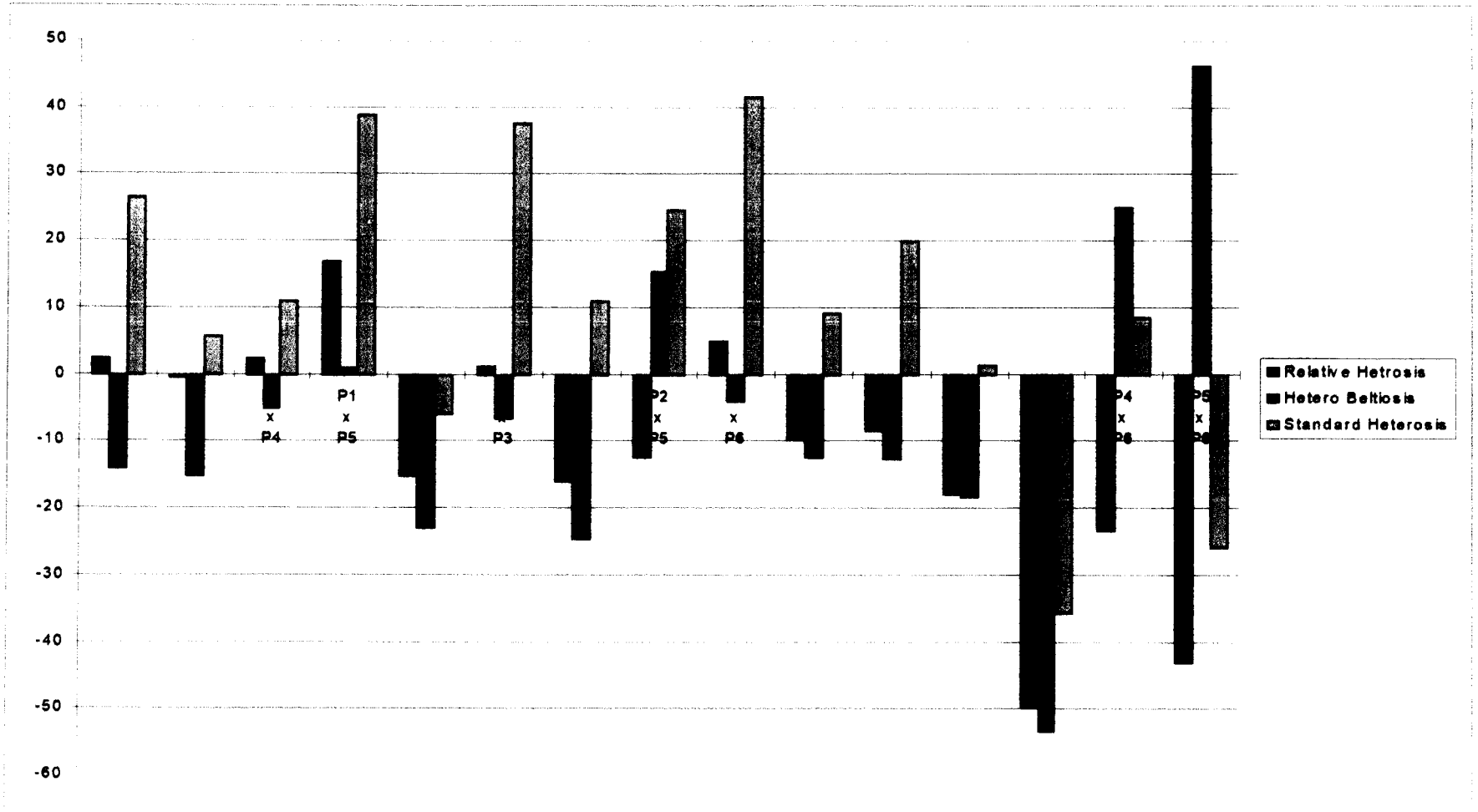
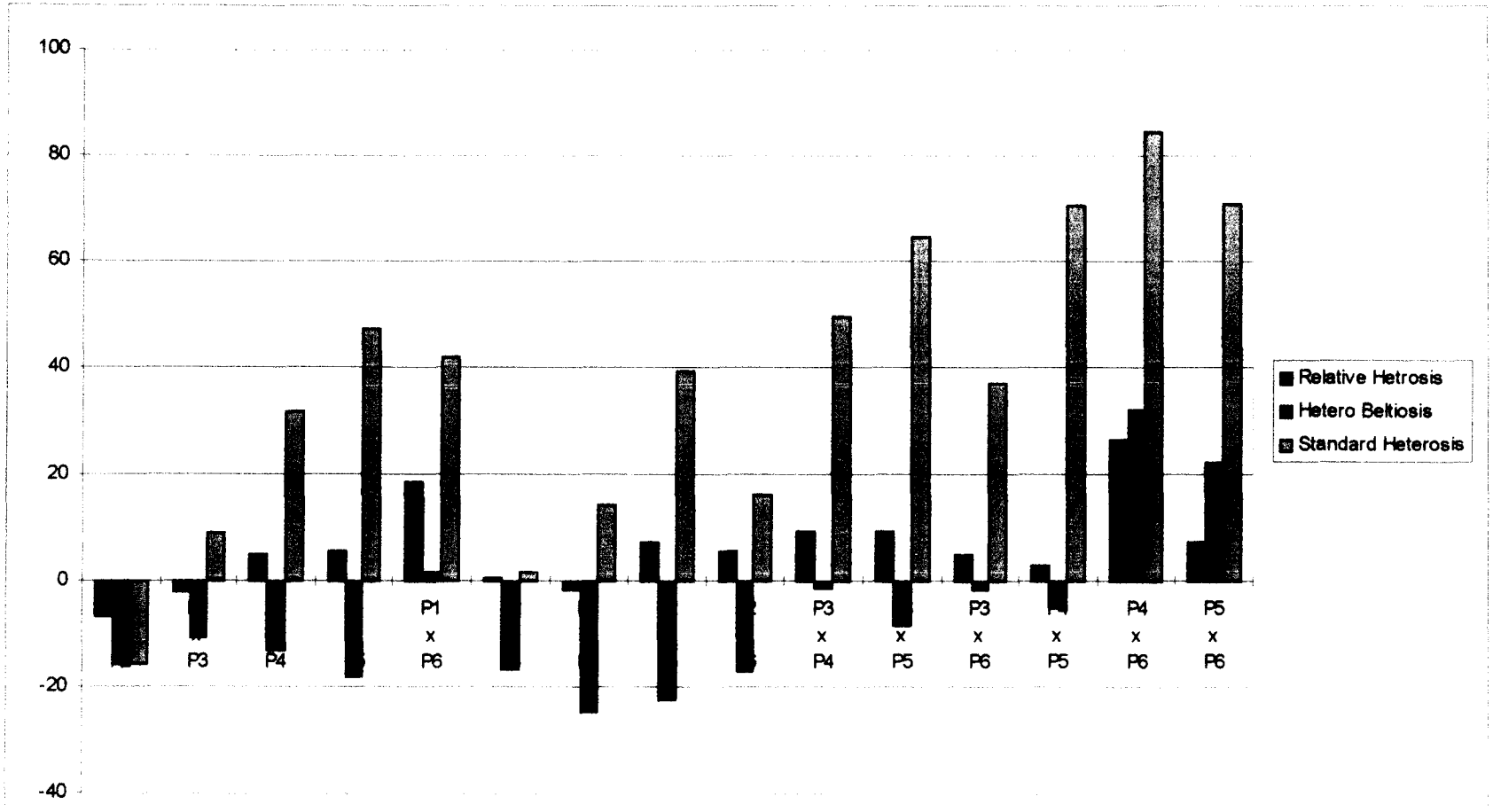


FIGURE - 21

Heterosis. Single fruit weight



(9.25), LE 373 x Arka Abha (9.26), Sakthi x PKM 1 (18.53) and Arka Alok x PKM 1 (26.50) exhibited significant positive relative heterosis. Only one hybrid, Arka Alok x PKM 1 (32.02) exhibited significant positive hetero-beltiosis. Thirteen out of fifteen hybrids recorded significant standard heterosis. Highest significant positive standard heterosis was exhibited by Arka Alok x PKM 1 (84.54) and the lowest by Sakthi x LE 373 (8.72). Among the fifteen hybrids Arka Alok x PKM 1 recorded the maximum relative heterosis, heterobeltiosis and standard heterosis. Three hybrids viz., Sakthi x PKM 1, Arka Alok x PKM 1 and Arka Abha x PKM 1 showed significant positive relative heterosis, heterobeltiosis and standard heterosis.

NUMBER OF FRUITS PER PLANT

The mean value of parents and hybrids and heterosis percentage for number of fruits per plant are presented in table 15.

Significant heterosis was recorded in the hybrids for number of fruits per plant. Out of fifteen hybrids five expressed significant positive relative heterosis. They were Sakthi x PKM 1 (19.56), Sakthi x Arka Abha (24.37), LE 79-5 x LE 373 (40.23), Arka Alok x PKM 1 (43.30) and Arka Abha x PKM 1 (62.30). Heterobeltiosis was significant and positive in only one hybrid *viz.*, Arka Abha x PKM 1 (28.09). None of the hybrids exhibited significant

TABLE - 15

Mean value of parents and hybrids and heterosis percentage for number of fruits/plant and fruit yield/plant.

Parents/ hybrids	Number of fruits/plant					Fruit yield /plant				
			Heterosis (%)					Heterosis(%)		
	Mean (c.m.)	MP Value	RH	HB	SH	Mean (c.m.)	MP	RH	HB	SH
P1	36.00					1247.22				
P2	20.66					501.66				
P3	10.56					360.00				
P4	7.330					331.67				
P5	7.780					422.22				
P6	13.44					537.76				
P1 x P2	25.34	28.33	-10.57 *	-29.62 *	-29.62 *	647.22	874.44	-25.98 *	-48.11 *	-48.11 *
P1 x P3	18.34	23.28	-21.23 *	-49.16 *	-49.06 *	646.33	803.61	-19.57 *	-48.18 *	-48.18 *
P1 x P4	21.56	21.67	-0.510	-40.12 *	-40.11 *	881.66	789.45	11.68*	-29.31 *	-29.30 *
P1 x P5	27.22	21.89	24.37*	-24.38 *	-24.39 *	1227.22	834.72	47.02*	-1.600 *	-1.600 *
P1 x P6	29.56	24.72	19.56*	-17.90 *	-17.89 *	1276.66	892.49	43.04*	2.360*	2.360*
P2 x P3	21.89	15.61	40.23*	5.94	-39.19 *	673.89	430.83	56.42*	34.33*	-45.97 *
P2 x P4	13.44	13.99	-3.960	-34.94 *	-62.67 *	464.44	416.67	11.47*	-7.420 *	-62.76 *
P2 x P5	12.78	14.22	-10.15*	-38.17 *	-64.50 *	543.33	461.94	17.62*	8.31*	-56.44 *
P2 x P6	14.33	17.05	-15.97 *	-30.65 *	-60.14 *	522.22	519.71	0.480	-2.890 *	-58.13 *
P3 x P4	8.780	8.950	-1.840	-16.83	-75.61 *	388.33	345.84	12.29*	7.86*	-68.86 *
P3 x P5	9.440	9.170	3.020	-10.55	-73.78 *	471.66	391.11	20.60*	11.71*	-62.18 *
P3 x P6	12.67	12.00	5.560	-5.780	-64.80 *	527.22	448.88	17.45*	-1.960 *	-57.73 *
P4 x P5	7.110	7.560	-5.890	-8.570 *	-80.25 *	430.56	376.95	14.22*	1.970*	-65.48 *
P4 x P6	14.89	10.39	43.30*	10.74	-58.64 *	790.56	434.72	81.86*	47.01*	-36.61 *
P5 x P6	17.22	10.61	62.30*	28.09*	-52.17 *	881.11	479.99	83.57*	63.85*	-29.35 *
CD (0.05)			1.57	2.01	2.01			6.11	7.44	7.44

MP - Mid parent RH - Relative heterosis HB - Heterobeltiosis SH - Standard heterosis
* - Significant at 5% level

FIGURE - 22

Heterosis. Number of fruits per plant.

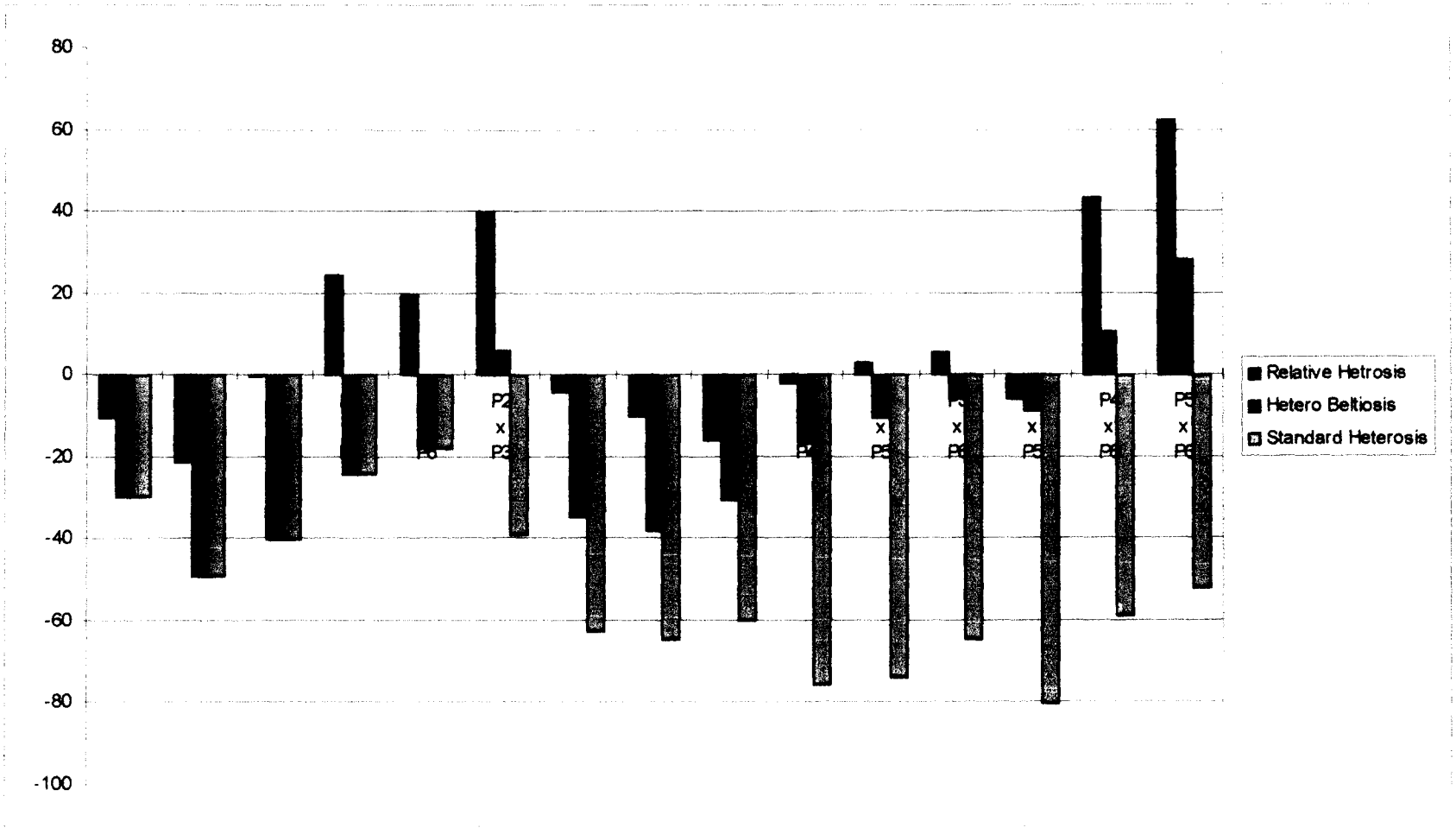
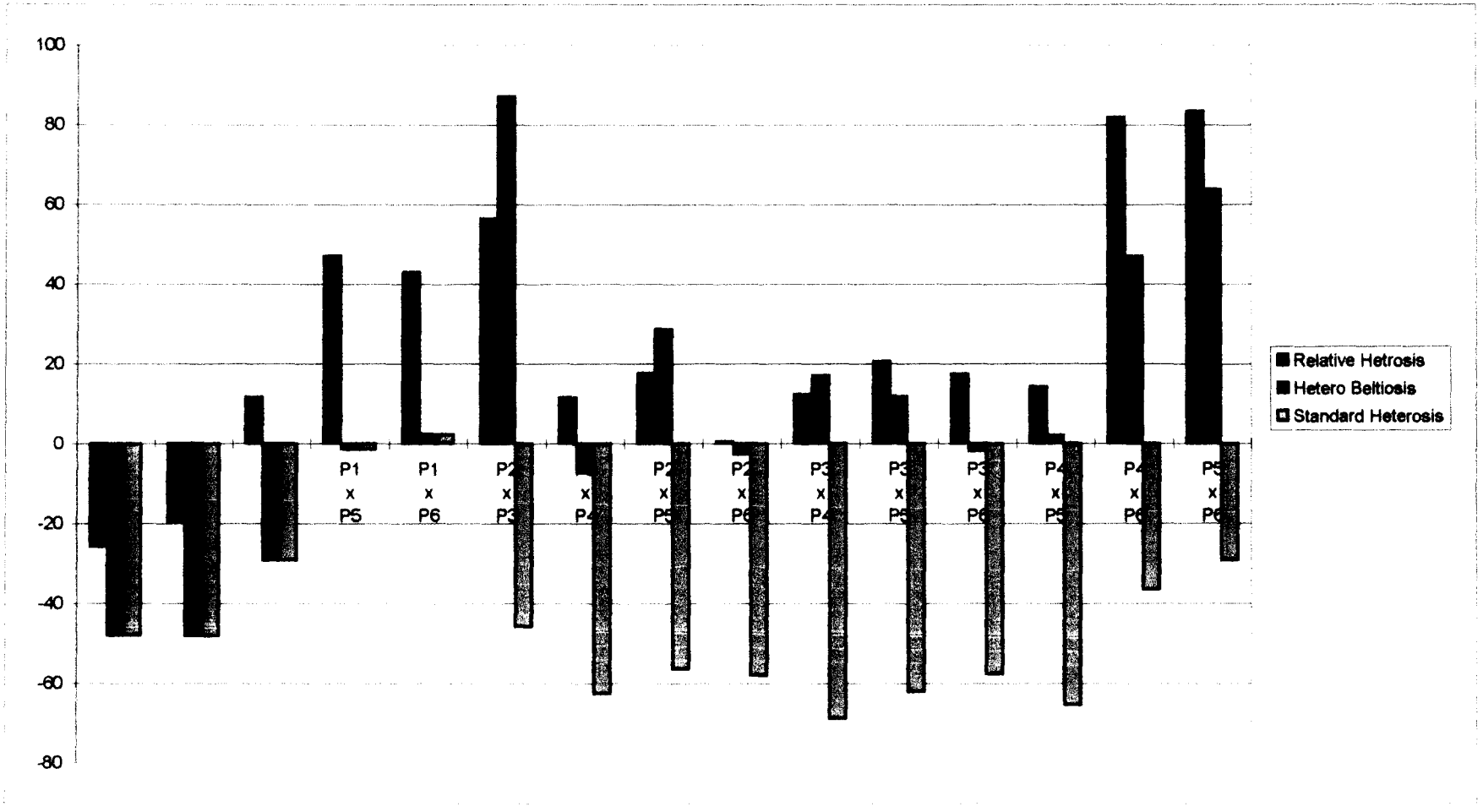


FIGURE - 23

Heterosis. Fruit yield per plant



positive standard heterosis. The hybrid Arka Abha x PKM 1 recorded highest significant positive relative heterosis and heterobeltiosis. Two hybrids *viz.*, Arka Alok x PKM 1 and Arka Abha x PKM 1 recorded significant positive relative heterosis and heterobeltiosis and standard heterosis.

FRUIT YIELD PER PLANT

The mean value of parents and hybrids and heterosis percentage are given in table 15.

Significant positive relative heterosis was recorded by twelve hybrids and the maximum value was recorded by Arka Abha x PKM 1 (83.57). Eight hybrids exhibited significant positive heterobeltiosis *viz.*, Arka Alok x Arka Abha (1.97), Sakthi x PKM 1 (2.36), LE 79-5 X Arka Abha (8.31), LE 373 x Arka Abha (11.71), LE 373 x Arka Alok (7.86), LE 79-5 x LE 373 (34.33), Arka Alok x PKM 1 (47.01) and Arka Abha x PKM 1 (63.85). Only one hybrid exhibited significant positive standard heterosis and it was Sakthi x PKM 1 (2.36). Highest relative heterosis and heterobeltiosis were recorded by the hybrid Arka Abha x PKM 1. Only one hybrid Sakthi x PKM 1 showed significant positive relative heterosis, heterobeltiosis and standard heterosis.

SIZE OF FRUITS

The mean value of parents and hybrids and percentage of heterosis for size of fruits are given in table 16.

TABLE - 16

Mean value of parents and hybrids and heterosis percentage for size of fruit and number of seeds/fruit.

Parents/ hybrids	Size of fruits					Number of seeds/fruit				
			Heterosis (%)					Heterosis(%)		
	Mean (c.c)	MP Value	RH	HB	SH	Mean (c.m.)	MP	RH	HB	SH
P1	27.94					41.33				
P2	24.27					39.07				
P3	34.13					50.60				
P4	43.95					65.57				
P5	52.04					65.67				
P6	39.87					55.20				
P1 x P2	27.85	26.11	6.700	-0.32	-0.320	39.77	40.20	-1.08	-3.77 *	-3.790 *
P1 x P3	31.39	31.04	1.130*	-8.04 *	12.34*	45.73	45.97	-0.51	-9.62 *	10.65*
P1 x P4	42.73	35.95	18.88*	-2.77	52.93*	51.03	53.45	-4.52 *	-22.17 *	23.46*
P1 x P5	45.80	39.99	14.52*	-12.00 *	63.92*	51.33	53.50	-4.05*	-21.83 *	24.19*
P1 x P6	40.50	33.91	19.45*	1.59	44.95*	49.90	48.27	3.38*	-9.60 *	20.74*
P2 x P3	30.80	29.2	5.480*	-9.77 *	10.23*	46.87	44.84	4.54*	-7.38 *	13.40*
P2 x P4	44.02	34.11	29.08*	0.16	57.55*	50.93	52.32	-2.64 *	22.32 *	23.23*
P2 x P5	40.81	38.16	6.960*	-21.6 *	46.06*	45.70	52.37	-12.73 *	-30.41 *	10.57*
P2 x P6	41.93	32.07	30.77*	5.18*	50.07*	44.67	47.14	-5.23 *	-19.08 *	8.080*
P3 x P4	42.91	39.04	9.910*	-2.36	53.58*	59.50	58.09	2.44*	-9.25 *	43.96*
P3 x P5	47.16	43.09	9.440*	-9.39 *	68.79*	61.93	58.14	6.54*	-5.69 *	49.84*
P3 x P6	41.60	37.00	12.43*	4.35*	48.89*	52.67	52.90	-0.44	-4.59 *	27.44*
P4 x P5	53.66	47.99	11.80*	3.10*	92.05*	65.97	65.62	0.53	0.46	59.61*
P4 x P6	51.75	41.91	23.50*	17.75*	85.22*	61.27	60.39	1.46*	-6.56 *	48.24*
P5 x P6	50.59	45.96	10.09*	-2.79	81.06*	60.47	60.44	0.05	-7.92 *	46.31*
CD (0.05)			0.98	1.21	1.21			0.85	1.01	1.01

MP - Mid parent RH - Relative heterosis HB - Heterobeltiosis SH - Standard heterosis

* - Significant at 5% level

FIGURE - 24

Heterosis. Size of fruits

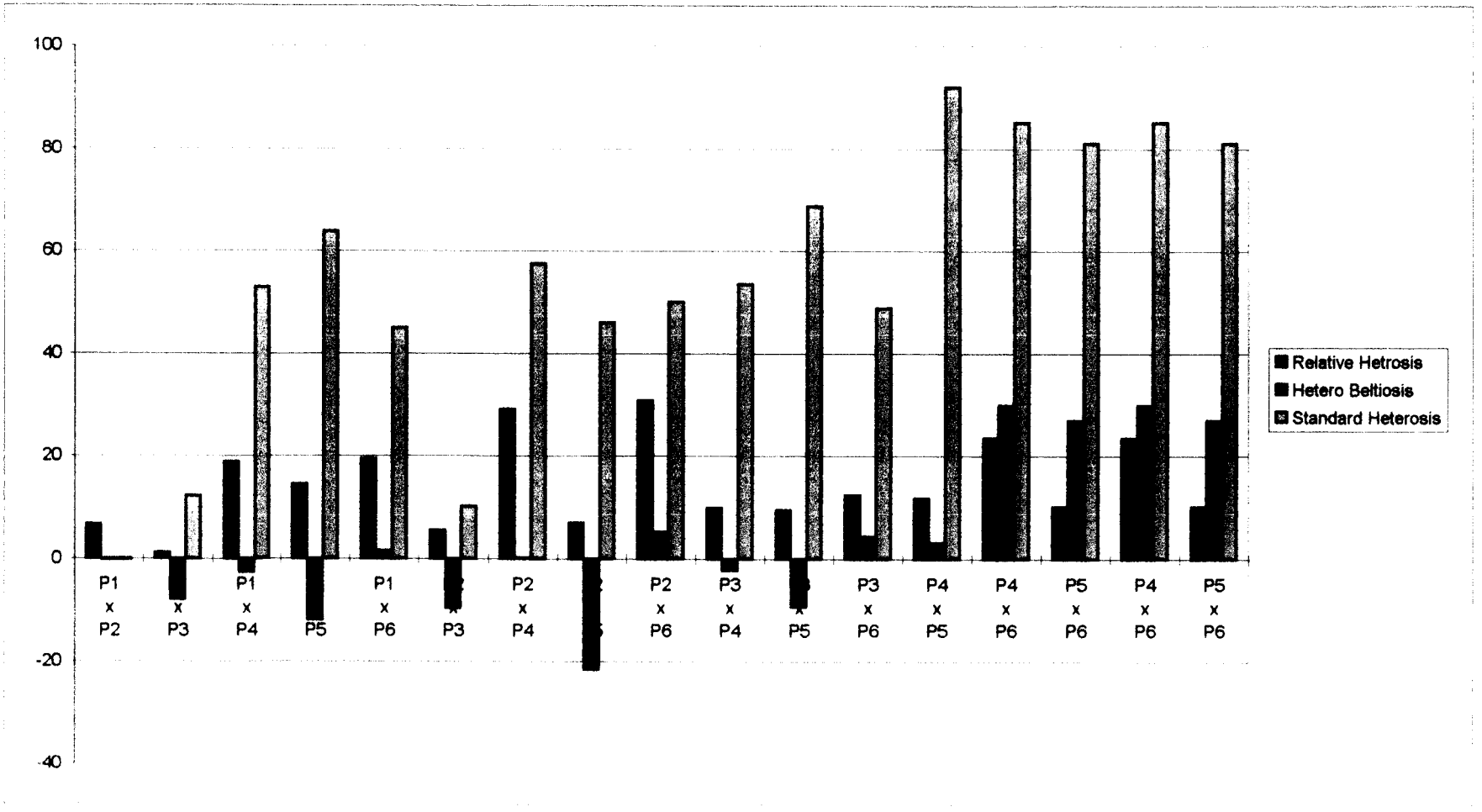
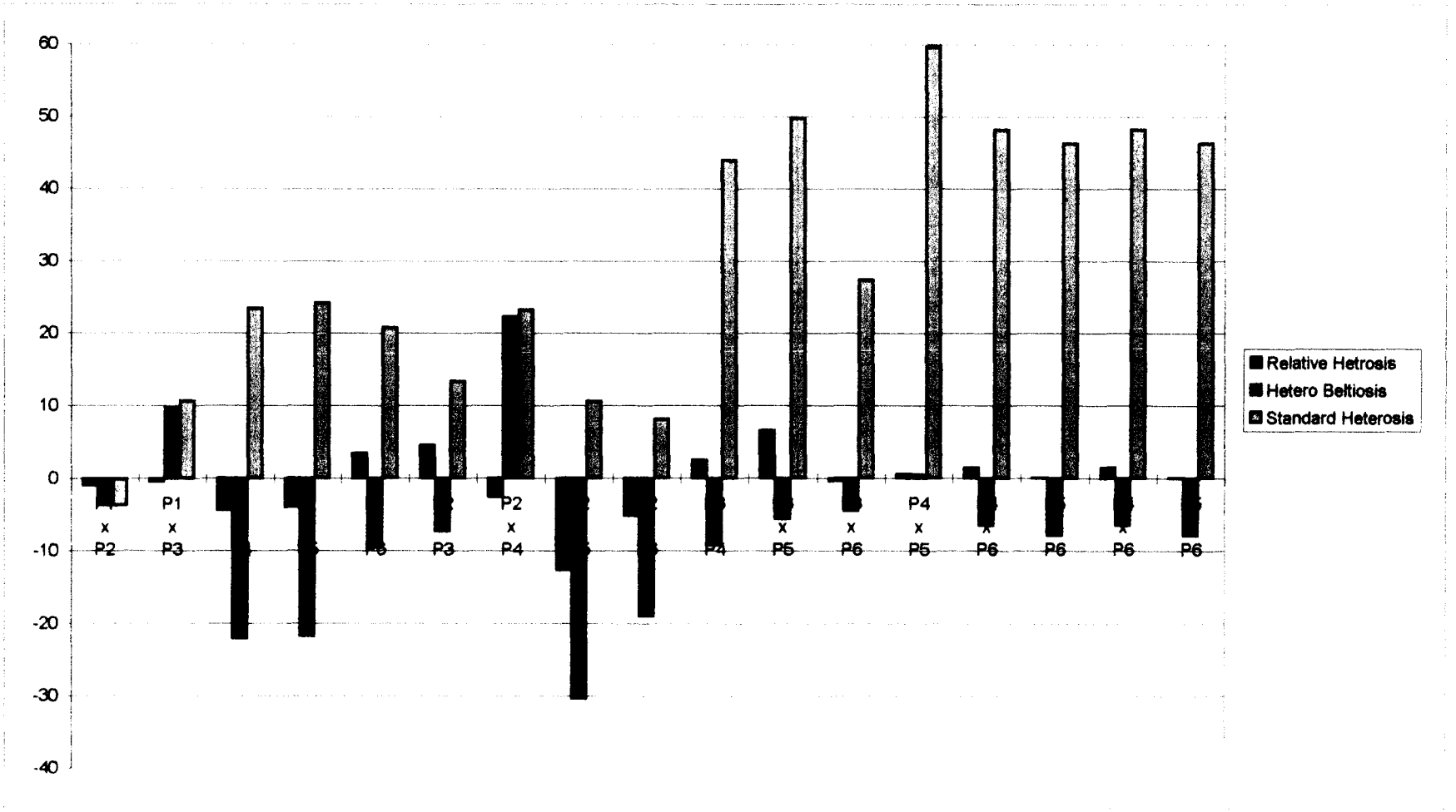


FIGURE - 25

Heterosis. Number of seeds per fruit



Relative heterosis, heterobeltiosis and standard heterosis were significant in the hybrids. Relative heterosis was significant and positive in all the hybrids except in Sakthi x LE 79-5. Four hybrids *viz*., Arka Alok x Arka Abha (3.10), LE 373 x PKM 1 (4.35), LE 79-5 x PKM 1 (5.18) and Arka Alok x PKM 1 (17.75) exhibited significant positive heterobeltiosis. Significant positive standard heterosis was exhibited by fourteen hybrids out of which Arka Alok x Arka Abha recorded the highest (92.05) and LE 79-5 x LE 373 recorded th lowest (10.23) percentage of standard heterosis. Five hybrids *viz*., LE 79-5 x PKM 1, LE 373 x PKM 1, Arka Alok x Arka Abha, Arka Alok x PKM 1 and Arka Abha x PKM 1 recorded significant positive relative heterosis, heterobeltiosis and standard heterosis.

NUMBER OF SEEDS PER FRUIT

The mean value of parents and hybrids and percentage of heterosis for number of seeds per fruit are given in the table 16.

Hybrids exhibited significant relative heterosis, heterobeltiosis and standard heterosis for this trait. Five hybrids, Arka Alok x PKM 1 (1.46), LE 373 x Arka Alok (2.44), Sakthi x PKM 1 (3.38), LE 79-5 x LE 373 (4.54) and LE 373 x Arka Abha (6.54) recorded significant positive relative heterosis. None of the hybrids recorded significant positive heterobeltiosis. Among the

fifteen hybrids fourteen hybrids exhibited significant positive standard heterosis and highest was recorded by Arka Alok x Arka Abha (59.61). The hybrid LE 373 x Arka Abha expressed maximum relative heterosis and Arka Alok x Arka Abha recorded maximum standard heterosis. Five hybrids *viz.*, Sakthi x Arka Alok. Sakthi x Arka Abha, LE 79-5 x Arka Alok. LE 79-5 x Arka Abha and LE 79-5 x PKM 1 recorded significant negative relative heterosis and heterobeltiosis.

PERICARP THICKNESS

The mean value of parents and hybrids and heterosis percentage of hybrids for pericarp thickness are given in table 17

The hybrids exhibited significant heterosis for pericarp thickness. Relative heterosis ranged from -14.29 to 26.53. but none of them recorded positive significant relative heterosis. Only one hybrid exhibited significant positive heterobeltiosis *viz.*, LE 79-5 x Arka Alok (26.53). Significant positive standard heterosis was exhibited by three hybrids *viz.*, Arka Alok x Arka Abha (19.89). Arka Abha x PKM 1 (23.43) and LE 373 x Arka Abha (30.79). For pericarp thickness LE 79-5 x Arka Alok recorded maximum significant heterobeltiosis and LE 373 x Arka Abha recorded maximum standard heterosis. The two hybrids. LE 79-5 x LE 373 and LE 79-5 x Arka Abha recorded significant negative heterobeltiosis.

TABLE - 17

Mean value of parents and hybrids and heterosis percentage for pericarp thickness.

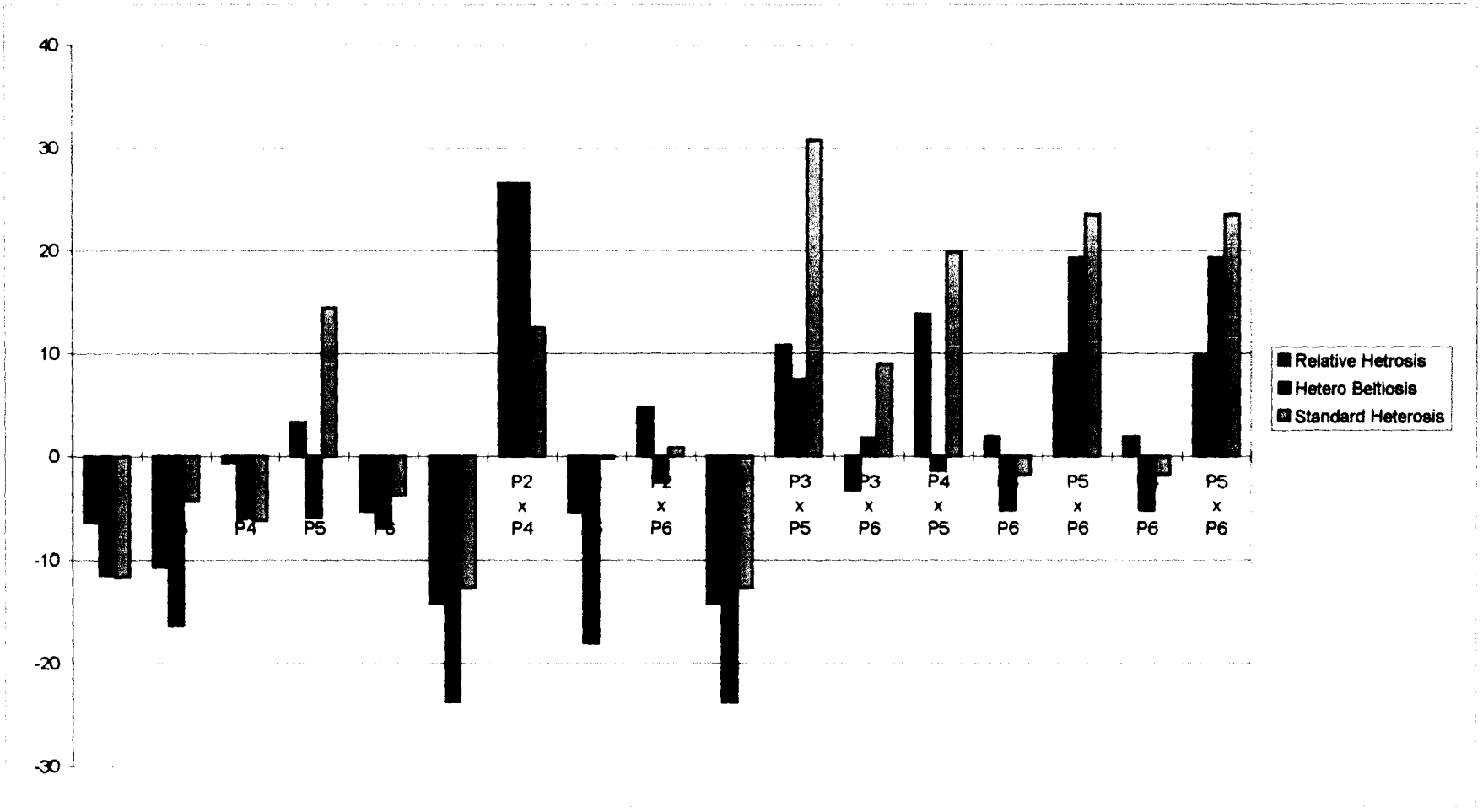
Parents/ hybrids	Pericarp thickness				
	Mean (m.m.)	MP Value	Heterosis (%)		
			RH	HB	SH
P1	3.67				
P2	3.27				
P3	4.20				
P4	3.27				
P5	4.47				
P6	3.80				
P1 x P2	3.24	3.47	-6.63	-11.72	-11.72
P1 x P3	3.51	3.94	-10.91	-16.43	-4.360
P1 x P4	3.44	3.47	-0.86	-6.27	-6.260
P1 x P5	4.20	4.07	3.19	-5.970	14.44
P1 x P6	3.53	3.74	-5.61	-7.020	-3.810
P2 x P3	3.20	3.74	-14.44	-23.81 *	-12.81
P2 x P4	4.13	3.27	26.29	26.53*	12.53
P2 x P5	3.66	4.07	-10.07	-18.13 *	-0.270
P2 x P6	3.70	3.54	4.52	-2.630	0.820
P3 x P4	3.20	3.74	-14.44	-23.84 *	-12.80
P3 x P5	4.80	4.34	10.59	7.460	30.79*
P3 x P6	3.87	4.00	-3.25	1.750	8.990
P4 x P5	4.40	3.87	13.69	-1.57	19.89*
P4 x P6	3.60	3.54	1.69	-5.260	-1.91 *
P5 x P6	4.53	4.14	9.42	1.34	23.53*
CD (0 05)			0.55	0.7	0.7

MP - Mid parent RH - Relative heterosis HB - Heterobeltiosis SH - Standard heterosis

* - Significant at 5% level

FIGURE - 26

Heterosis. Pericarp thickness



DISEASE AND PEST INCIDENCE

DISEASES

Observations were made on the incidence of diseases - mosaic fruit rot and bacterial wilt. There was no natural incidence of bacterial wilt. The percentage of mosaic infected plants and fruit rot infected fruits in the parents and hybrids are presented in the table 18.

a) Mosaic

In the parents the percentage of infected plants ranged from 0 in LE 79-5 to 20 in Arka Alok. In the hybrids, the range was from 0 to 12.4 percent. Maximum infection was recorded in Sakthi x PKM 1 (12.4%) among the hybrids. The hybrids Sakthi x LE 79-5, Sakthi x LE 373, Sakthi x Arka Alok, Sakthi x Arka Abha, LE 79-5 x LE 373 and LE 79-5 x Arka Abha were free from mosaic infection.

b) Fruit rot

The percentage of fruits infected by fruit rot in the two parents Arka Abha and PKM 1 were 10.56 and 20.71 percent respectively. The parents

TABLE - 18

Disease and Pest Incidence

Treatments	Fruit rot %	Mosaic %	Fruit borer %	Fruit crack %	Colour at Collar of fruit
P1	0.00	12.33	5.68	0.00	Red
P2	0.00	0.00	7.80	0.00	Red
P3	0.00	5.00	2.36	0.00	Red
P4	0.00	20.00	18.00	10.21	Yellowish red
P5	10.56	8.32	21.83	18.30	Yellowsih red
P6	20.71	14.56	15.00	15.50	Dark Green
P1 x P2	0.00	0.00	10.00	0.00	Red
P1 x P3	0.00	0.00	4.00	0.00	Red
P1 x P4	0.00	0.00	6.60	3.80	Red
P1 x P5	0.00	0.00	7.00	0.00	Light red
P1 x P6	0.00	12.40	2.28	12.50	Red
P2 x P3	0.00	0.00	3.50	0.00	Red
P2 x P4	0.00	6.00	5.50	10.80	Light red
P2 x P5	0.00	0.00	4.60	9.20	Red
P2 x P6	10.52	5.76	8.20	0.00	Red
P3 x P4	8.76	10.26	7.50	0.00	Red
P3 x P5	0.00	9.78	5.70	0.00	Red
P3 x P6	0.00	8.50	10.00	0.00	Red
P4 x P5	13.04	12.00	14.30	7.80	Yellowish Red
P4 x P6	0.00	1.25	3.25	3.30	Red
P5 x P6	23.00	10.50	10.30	5.90	Red

Sakthi, LE 79-5, LE 373 and Arka Alok were free from this disease. Among the 15 hybrids only four hybrids LE 79-5 x PKM1, LE 373 x Arka Alok, Arka Alok x Arka Abha and Arka Abha x PKM 1 showed this disease.

INSECT PEST

The major insect pest noticed was fruit borer. The percentage of fruits attacked by the fruit borer in the parents and hybrids are presented in table 20. All the parents recorded fruit borer attack among which the attack was maximum in Arka Abha (21.83%) and minimum in LE 373 (2.36%). Among the hybrids the maximum percentage of fruit borer attack was in Arka Alok x Arka Abha (14.3%) and minimum in Sakthi x PKM 1 (2.28%).

FRUIT CRACK

Fruit crack was noticed in three parents *viz.*, Arka Alok (10.21%), Arka Abha (18.30%) and PKM 1 (15.50%) and the remaining parents were free from fruit crack. Among the 15 hybrids seven hybrids were free from fruit crack. They were Sakthi x LE 79-5, Sakthi x LE 373, Sakthi x Arka Abha, LE 79-5 x LE 373, LE 79-5 x PKM 1, LE 373 x Arka Alok and LE 373 x Arka Abha. The highest percentage of fruit crack was recorded in Sakthi x PKM 1 (12.50%)

DISCUSSION

DISCUSSION

The success of crop improvement programme, aimed at the production of superior varieties, depends solely on the selection of suitable genotypes to be used as parents in the hybridization programme. Breeders have often used high *per se* performance as a criterion for selection of parents for attempting crosses. Combining ability analysis provides useful information on the nature of inheritance of quantitative characters and also helps in identifying superior parents and cross combinations likely to yield better progeny. The concept of combining ability was first proposed by Sprague and Tatum (1942). Combining ability analysis is aimed at getting informations about the general combining ability (g.c.a) of parents and specific combining ability (s.c.a) of hybrids. Combining ability is the ability of a biotype to transmit desirable performance to its progeny. General combining ability is the average performance of a strain in a series of crosses. Specific combining ability is used to designate those cases in which certain combinations do relatively better or worse than that would be expected on the basis of average performance of the lines involved

In almost all major crops, combining ability analysis has been used to estimate g.c.a. and s.c.a variances and effects and also to assess the nature

of gene action involved in the expression of various quantitative traits Higher magnitude of g.c.a. variances indicate the predominant role of additive gene action which is fixable and higher s.c.a variances indicate dominance deviation and epistatic effect.

The diallel mating system involved in the present study is an effective method of determining the combining ability of the parents which enables a rational choice of the parental material to be used in a heterosis breeding programme. This method also helps to study the nature of gene action governing the different characters based on which an appropriate breeding methodology can be adopted. In the present study, six parental lines and their 15 hybrids were subjected to diallel analysis employing Griffing's method 2 under Model 1 for studying combining ability and gene action.

Analysis of variance had shown that the treatments were significant for all the characters except for number of locules per fruit, suggesting that there were significant differences among the genotypes except for number of locules per fruit. So diallel analysis was carried out excluding the character number of locules per fruit and the results obtained are discussed below.

COMBINING ABILITY AND GENE ACTION

The analysis of variance revealed that the mean squares due to parents and hybrids were significant for all the thirteen characters analysed.

This indicated the importance of both g.c.a. and s.c.a. for these traits which in turn suggests the involvement of both additive and non-additive gene action in the inheritance of these characters. Hence, these characters are amenable to selection as well as hybridization.

PLANT HEIGHT

For plant height significant variance was recorded by parents and hybrids. So both g.c.a. and s.c.a. effects were significant for this character suggesting the involvement of both additive and non-additive gene action for the expression of this trait. But the ratio of additive to dominance variance was greater than unity. This revealed the predominant role of additive gene action. In agreement to this, additive gene action was reported by Singh and Singh (1980) and Ghosh and Symal (1994). Predominance of non-additive gene action was reported by Sonone et al. (1986) ande Brahma et al (1991) in tomato. However, the involvement of both additive and non-additive effects were also reported by Moya et al. (1986) and Ali et al. (1989) in tomato.

The estimates of combining ability revealed that among the parents LE 79-5 and LE 373 recorded significant positive g.c.a. effect and the other four parents recorded significant negative g.c.a. effects. Significant positive s.c.a.

effects were shown by nine hybrids, among which Arka Alok x PKM1 recorded the maximum s.c.a effect where both the parents had negative g.c.a. effects.

Observations on heterosis in the hybrids, well supported the results of combining ability analysis. Positive heterosis was recorded by fourteen hybrids out of fifteen. Significant positive heterosis over mid-parent was recorded by thirteen hybrids. Of these eleven hybrids recorded significant positive heterosis over the better-parent also. The hybrid Arka Alok x PKM1 which recorded significant s.c.a. effect showed maximum positive heterobeltiosis. Positive heterosis for this trait was reported earlier by Rema Bai (1975), Babu (1978), Ahmed et al. (1985), Brahma et al. (1991) and Dod et al. (1992).

NUMBER OF BRANCHES PER PLANT

For number of branches per plant, variances due to parents and hybrids were significant, suggesting the involvement of both additive and non-additive gene action. Here the g.c.a. effects of parents and s.c.a. effects of hybrids were significant. The ratio of additive to dominance variance was greater than unity and hence it indicates the predominance of additive gene action. Predominance of additive gene action for the above trait was reported by Gurdalbir Singh and Nandpuri (1974), Singh and Singh (1980), Lonkar

and Borikar (1988). Ghosh and Symal (1994) and Seeja (1995) in tomato which supports the present findings. But contrary to this, predominance of non-additive gene action was reported by Govindarasu et al. (1981) and Sidhu et al. (1981). Involvement of both additive and non-additive gene actions was reported for this trait by Ali et al. (1989).

Among the parents, Sakthi, LE 79-5 and LE 373 showed significant positive g.c.a. effects and Arka Alok, Arka Abha and PKM 1 showed significant negative g.c.a. effects. Only two hybrids *viz.*, Sakthi x LE 79-5 and Arka Alok x Arka Abha showed significant positive s.c.a. effect. In the first hybrid both the parents had significant positive g.c.a. effects and in the second hybrid both the parents had significant negative g.c.a. effects.

Significant positive heterosis over mid-parent was recorded by three hybrids *viz*., Sakthi x LE 79-5, Arka Alok x Arka Abha and Sakthi x Arka Abha, of which the first two recorded significant positive s.c.a effects. Rema Bai (1975) and Sidhu et al. (1981) also reported significant heterosis for this trait.

NUMBER OF LEAVES PER PLANT

Analysis of variance for number of leaves per plant showed significance for the parents and the hybrids. Hence, g.c.a. and s.c.a. effects were significant for this character, indicating that both additive and non-

additive genetic components were involved in the expression of this trait The ratio of additive to dominance variance was greater than one, suggesting the predominant role of additive gene action. Contrary to this predominance of non-additive gene action was reported earlier by Konstantinova et al. (1990).

Among the parents, only two exhibited significant positive g.c.a. effects and the maximum positive g.c.a. effect was exhibited by LE 373. Out of fifteen hybrids five exhibited significant positive s.c.a. effects and six exhibited significant negative s.c.a. effects. The maximum s.c.a. effect was expressed by Arka Alok x PKM1 where both the parents have negative g.c.a. effects. In the four hybrids Sakthi x LE 79-5, Sakthi x LE 373, LE 79-5 x Arka Abha and LE 373 x Arka Abha, one of the parents has negative and the other has positive g.c.a. effects.

Heterosis was significant in the hybrids. Significant positive heterosis was observed in thirteen hybrids over mid-parent and eleven hybrids over the better-parent. Maximum positive heterosis was recorded by the hybrid, Arka Alok x PKM 1 which showed high s.c.a. effect in the combining ability analysis.

SPREAD OF THE PLANT

The mean squares for both parents and hybrids were significant for spread of the plant. This indicated significant g.c.a. and s.c.a. effects. But

the ratio of additive to dominance variance was less than unity. This suggested the predominance of non-additive gene action for the expression of this trait. It is in agreement with the result of Chandrasekhar and Rao (1989) and Seeja (1995) in tomato.

The parents LE 79-5 and LE 373 showed significant positive g.c.a. effects and the other four parents showed significant negative g.c.a. effects. Significant positive s.c.a. effect was observed in nine hybrids and maximum s.c.a. effect was exhibited by LE 373 x Arka Abha which had parents with positive and negative g.c.a. effects.

The heterosis expressed in the hybrids for spread of the plant indicated that a very high degree of heterosis was manifested among the hybrids. All the fifteen hybrids recorded positive relative heterosis. Significant positive heterosis was recorded by all the fifteen hybrids over the mid-parent, thirteen hybrids over the better-parent and all the fifteen hybrids over the standard parent. The maximum heterosis was expressed by LE 373 x Arka Abha which recorded the highest s.c.a. effect in the combining ability analysis.

NUMBER OF DAYS FOR FIRST FLOWERING

Variance due to parents and hybrids were significant for period of harvest. This indicated that both additive and non-additive gene actions were

involved in the expression of this trait. The ratio of additive to dominance variance was less than unity indicating the predominant effect of non-additive genes.

In agreement to this non additive gene action was reported by Egiyan and Luk'yanenko (1976) Scossiroli et al. (1979). Natarajan (1992) and Perera and Liyanaarachchi (1993). The involvement of both additive and non-additive gene action was reported by Szwadiak and Kordus (1992)

Among the parents, Sakthi and LE 79-5 exhibited significant positive and negative g.c.a. effects. The highest negative s.c.a. effect was observed in the hybrid Sakthi x Arka Abha, where one parent is a negative general combiner and the other is a positive general combiner.

The predominance of s.c.a. variance was well reflected in the hybrids. Significant heterosis was recorded by the different hybrids. Maximum significant negative heterosis was exhibited by the hybrid Sakthi x Arka Abha which recorded maximum negative s.c.a. effect in the combining ability analysis. Similar results were reported by Singh and Singh (1993) Pujari and Kale (1994) and Suresh Kumar et al. (1995).

NUMBER OF DAYS FOR FIRST HARVEST

Significant mean sum of squares due to parents and hybrids were recorded for number of days for first harvest. This indicated significant g.c.a. and s.c.a. effects and the involvement of additive and non-additive genetic components in the expression of this trait. But the ratio of additive to dominance variance was found to be less than one, indicating the predominant role of non-additive gene action.

Among the parents only LE 79-5 exhibited negative g.c.a. effect. The highest negative s.c.a. effect was observed in the hybrid Sakthi x Arka Abha, where one parent is a positive general combiner and the other is a negative general combiner.

The predominance of s.c.a. variance was well reflected in the hybrids. Significant heterosis was recorded by the different hybrids. Significant negative heterosis, which is desirable for earliness was exhibited by the hybrid Sakthi x Arka Abha. Significant heterotic effects for number of days for first harvest was reported by Dod et al. (1992).

DURATION OF HARVEST

Variances due to parents and hybrids were significant for period of harvest. This indicated that both additive and non-additive gene actions were

involved in the expression of this trait. The involvement of both additive and non-additive gene action was reported earlier by Nandpuri et al. (1975) and Ali et al. (1989). However, this trait was found to be controlled predominantly by non-additive gene action since the additive to dominance variance ratio was less than one . Non-additive gene action for this character reported by Egiyan and Luk'yanenko (1979) and Singh and Singh (1980) support the present findings. But predominance of additive gene action was reported by Swamy and Mathai (1982) and Ghosh and Symal (1994).

Among the parents Arka Alok and PKM 1 exhibited significant negative g.c.a. effects. The highest negative s.c.a. effect was observed in the hybrid Arka Alok x Arka Abha, where both the parents were negative general combiners.

Significant negative relative heterosis and heterobeltiosis were exhibited by the different hybrids, but it was significantly negative and maximum in the hybrid Arka Alok x Arka Abha. Negative heterosis is preferable for period of harvest, since it gives earliness and compactness for harvest. Significant heterotic effects for early yield were reported by Zubeldia and Neuz (1974), Trinklein (1975) and Suresh Kumar et al. (1995). Moderate heterosis for earliness was also reported by Govindarasu et al. (1982).

SINGLE FRUIT WEIGHT

Variances due to parents and hybrids were significant for individual fruit weight. This showed that both additive and non-additive gene actions were involved in the inheritance of this trait. This is in confirmity with the results of Gurdalbir Singh and Nandpuri (1974). Moya et al. (1986), Ali et al. (1989) and Szwadiak and Kordus (1992). Predominance of additive gene action was reported by Dixit et al. (1980). Sonone et al. (1986) and Omara et al. (1988) for this trait. In the present study also predominance of additive gene action was indicated by the additive to dominance variance ratio since it exceeds unity

All the parents showed significant g.c.a. effect for single fruit weight. Maximum g.c.a. effect was exhibited by Arka Abha, but Sakthi showed significant negative g.c.a. effect. Eight hybrids exhibited significant s.c.a. effect. But significant positive s.c.a. effect was expressed by only five hybrids. Maximum s.c.a. effect was observed in Arka Alok x PKM 1 where both the parents were having significant positive g.c.a. effects. The hybrids Sakthi x PKM 1, LE 79-5 x Arka Abha, LE 373 x Arka Alok, and LE 373 x Arka Abha had parents with negative and positive general combiners.

Significant heterosis expressed in the hybrids for individual fruit weight supported the results of combining ability analysis. Eleven hybrids recorded

significant positive relative heterosis of which Arka Alok x PKM 1 and Arka Abha x PKM 1 recorded significant positive heterobeltiosis also. The hybrid Arka Alok x PKM 1 which had the highest s.c.a. effects recorded maximum positive heterosis for fruit weight. Similar findings were also reported for this trait by Ahmed et al. (1988).

NUMBER OF FRUITS PER PLANT

For number of fruits per plant the variance was significant for both parents and hybrids. Hence both g.c.a. and s.c.a. were significant. suggesting the involvement of both additive and non-additive gene action. Significance of both additive and non-additive gene effects were reported by Moya et al. (1986), Dhaliwal and Nandpuri (1988), Ali et al. (1989) Szwadiak and Kordus (1992) and Seeja (1995). Here the ratio of additive to dominance variance was found to be greater than one indicating the preponderance of additive gene action. This is in agreement with the findings of Singh and Singh (1980), Omara et al. (1988) and Sonone et al. (1986). But contrary to this Govindarasu et al. (1981) and Sidhu et al. (1981) reported predominant non-additive gene action for this trait.

Except PKM 1, all the parents recorded significant g.c.a. effect. Two parents Sakthi and LE-79-5 exhibited significant positive g.c.a. effect. Among

the hybrids significant s.c.a. effect was observed in eight hybrids, five with positive s.c.a. effect and three with negative s.c.a. effect. Significantly high s.c.a effect was observed in the hybrids LE 79-5 x LE 373, Sakthi x Arka Abha and Arka Abha x PKM1. Hybrids Sakthi x Arka Abha and LE 79-5 x LE 373 had parents with positive and negative g.c.a. effects while Arka Abha x PKM 1 had parents with negative and negative g.c.a. effects.

Out of fifteen hybrids heterosis was significantly positive in five hybrids over mid-parent *viz*., Sakthi x PKM 1, Sakthi x Arka Abha, LE 79-5 x LE 373 Arka Alok x PKM 1 and Arka Abha x PKM 1. Among these only Arka Abha x PKM 1 showed significant positive heterobeltiosis. The above hybrids recorded significant s.c.a. effect also in the combining ability analysis.

Pronounced heterosis for this trait was reported earlier by Sonone et al. (1981), Govindarasu et al. (1982), Brahma et al. (1991) and Dod et al. (1992). Heterobeltiosis was also reported by Ahmed et al. (1988).

FRUIT YIELD PER PLANT

Significance of g.c.a. and s.c.a. was revealed from the analysis of variance for fruit yield per plant: as the mean squares due to parents and hybrids were significant. This trait is therefore controlled by both additive and

non-additive gene actions. The ratio of additive to dominance variance was greater than unity indicating that this character is predominantly controlled by additive gene action. This is in accordance with the findings of Dholaria and Qadri (1983). Lonkar and Borikar (1988) and Omara et al. (1988). But predominance of non-additive gene effects were reported by Govindarasu et al. (1981), Sidhu et al. (1981) and Kryuchkov et al. (1992).

The g.c.a. effect was positively significant in two parents *viz*., Sakthi and PKM 1. Maximum positive s.c.a. effect was shown by Sakthi x Arka Abha obtained from parents with positive and negative g.c.a. effects. It was followed by LE 79-5 x LE 373, where both parents were having negative g.c.a. effects. The s.c.a. effect was significant and positive in five hybrids *viz*. Sakthi x Arka Abha, LE 79-5 x LE 373, Sakthi x PKM 1, Arka Abha x PKM 1 and Arka Alok x PKM 1. All these hybrids recorded significant positive relative heterosis.

Out of fifteen, twelve hybrids showed significant positive heterosis over mid-parent and eight hybrids over better-parent. The hybrid Arka Abha x PKM 1 exhibited high significant relative heterosis and heterobeltiosis. Earlier report by Avdeev (1974), Ahmed et al. (1988), Narcisco and Rosario (1988) and Mandal et al. (1989) indicated that there was significant positive heterobeltiosis expressed for this trait in tomato.

SIZE OF FRUITS

In the analysis of variance for size of fruits significant mean sum of squares were recorded for parents and hybrids. This indicated the importance of both g.c.a. and s.c.a. for this trait. The ratio of additive to dominance variance was greater than unity indicating that this character was predominantly under the control of additive gene action. Nandpuri and Tyagi (1976) Dudi et al. (1979). Singh and Singh (1980). Govindarasu et al. (1981) and Dholaria and Qadri (1983) reported predominance of additive gene action for this trait. But significance of both additive as well as non-additive gene action was reported by Nandpuri et al. (1975). Tarrega and Neuz (1983) and Moya et al. (1986).

Combining ability analysis revealed that all the parents showed significant g.c.a. effects. Arka Alok, Arka Abha and PKM1 exhibited significant positive g.c.a. effects whereas Sakthi, LE 79-5 and LE 373 exhibited significant negative g.c.a. effects. Maximum g.c.a effect was exhibited by Arka Alok. Nine hybrids showed significant positive s.c.a. effect and two hybrids showed significant negative g.c.a. effects. Maximum positive s.c.a. effect was shown by LE 79-5 x PKM 1, formed from parents which were having negative and positive g.c.a. effects respectively.

The heterosis observed in the hybrids also support the above findings. Out of the fifteen hybrids, fourteen hybrids recorded significant positive heterosis over mid-parent and standard parent and five hybrids exhibited significant positive heterosis over better-parent. The six hybrids viz. LE 79-5 x PKM, LE 79-5 x Arka Alok, Arka Alok x PKM 1, Sakthi x Arka Abha, Sakthi x Arka Alok, Sakthi x PKM 1 and LE 373 x Arka Abha which recorded significant s.c.a. effects showed significant positive relative heterosis. Maximum heterosis was recorded by the hybrid Arka Alok x PKM 1. Significant heterosis for size of fruits was reported earlier by Alvarez (1985) and Sonone et al. (1987).

NUMBER OF SEEDS PER FRUIT.

Analysis of variance for number of seeds per fruit showed significant variances for parents and hybrids. Hence g.c.a. and s.c.a. effects were significant for this character indicating that both additive and non additive genetic components were involved in the expression of this trait. Since the ratio of additive to dominance variance was greater than one, there was predominance of additive gene action. Arka Alok, Arka Abha and PKM 1 showed positive g.c.a. effects and Sakthi, LE 79-5 and LE 373 showed negative g.c.a. effects. The maximum significant positive g.c.a. effect was shown by the parent Arka Alok. Out of twelve hybrids, six exhibited

significant positive s.c.a. effects and the remaining six exhibited negative s.c.a. effects. The maximum significant positive s.c.a. effect was shown by the hybrid LE 373 x Arka Abha where the parents were having negative and positive g.c.a. effects

Significant positive heterosis was observed in five hybrids over mid-parent and none of the hybrids exhibited significant positive heterobeltiosis. Maximum relative heterosis was exhibited by LE 373 x Arka Abha, which had shown maximum s.c.a. effect in the combining ability analysis. The other four hybrids *viz.*, Arka Alok x PKM 1, LE 373 x Arka Alok, Sakthi x PKM 1 and LE 79-5 x PKM 1 which recorded significant s.c.a. effect showed significant positive relative heterosis also.

PERICARP THICKNESS

Variances due to both parents and hybrids were significant for pericarp thickness suggesting the importance of both additive and non-additive gene action for the expression of this trait. The ratio of additive to dominance variance was greater than one suggesting the predominant role of additive gene action. This finding was in agreement with the results of Nandpuri and Tyagi (1976), Patil and Patil (1988) and Ghosh and Symal (1994) in tomato. But the predominance of non-additive gene action was reported by Dixit et al. (1980), Bhutani (1981) and Sidhu et al. (1981).

The parent Arka Abha showed maximum positive g.c.a. effect and LE 79-5 showed significant negative g.c.a. effect. Significant positive s.c.a. effects were found in the hybrids LE 79-5 x Arka Alok and LE 373 x Arka Abha. In the first cross, the parents had negative and positive g.c.a. effects. In the second cross the parents were having positive g.c.a. effects.

The two hybrids LE 79-5 x Arka Alok and LE 373 x Arka Abha which recorded significant positive s.c.a. effect showed significant heterosis also. Only one hybrid exhibited significant heterosis over better parent and three hybrids exhibited significant positive standard heterosis. Maximum heterosis was recorded by the hybrid LE 79-5 x Arka Alok.

In general the specific combination of Arka Alok x PKM 1 showed significantly high s.c.a. as well as heterosis for the yield attributes such as fruit yield per plant, single fruit weight, size of fruit and vegetative characters such as plant height, number of leaves per plant and spread of the plant. Observations on pests and diseases showed that the above hybrid is free from fruit borer attack and disease like mosaic and fruit rot. It is red coloured and also free from fruit crack.

The specific combination Arka Abha x PKM 1 was also showing significantly high s.c.a. as well as heterosis for number of fruits per plant, fruit yield per plant, plant height, number of leaves per plant and spread of the plant.

The two hybrids Sakthi x Arka Alok and Sakthi x Arka Abha were showing high s.c.a. and heterosis for single fruit weight, number of fruits per plant and fruit size. For fruit yield per plant the above two combinations were showing significant heterosis.

LE 79-5 x LE 373 is a specific combination which showed high s.c.a. for fruit yield per plant. This combination is showing significant heterosis for number of fruits per plant and fruit yield per plant.

From the general combining ability analysis, it is evident that Sakthi and PKM 1 are good general combiners with respect to yield and yield attributes. With respect to different vegetative characters LE 79-5 and LE 373 are the good general combiners.

In the specific combining ability analysis of the fifteen hybrids, pronounced specific combining ability and significant heterosis were observed in the five hybrids *viz*., Arka Alok x PKM 1, Arka Abha x PKM 1,

Sakthi x Arka Alok. Sakthi x Arka Abha and LE 79-5 x LE 373: for the different yield attributes. Among these the hybrid Arka Alok x PKM 1 and Sakthi x Arka Abha are found to be free from diseases like mosaic and fruit rot and also free from the fruit borer attack.

The s.c.a. effects of the crosses revealed that the best cross combinations were between good x good, good x poor and poor x poor general combiners for most of the characters studied. But a critical examination of the performance of parents and crosses showed that crosses having highest s.c.a. effects for different characters involved parents with high x low, low x high, and low x low g.c.a. effects, of which high x low combinations were more frequent.

The crosses involving high x high parents could be of immense value for exercising single plant selection in advanced generations, since in such hybrids the high s.c.a. effects manifested were due to additive and additive x additive type of gene action which are fixable. The crosses which involved at least one good general combiner may be exploited for isolating desirable trangressive segregants in the F2 if the additive genetic system present in the good combiner and the complementary epistatic effects in the F1 acted in the same direction to maximise the desirable plant attributes (Singh and Singh, 1980)

In the crosses involving high x low combinations, genetic interactions might be of additive x dominance type and g.c.a. effect played an important role in the expression of positive and significant s.c.a. effects (Singh et al., 1987). However in hybrids, significant s.c.a. effects associated with low x low performers reflected non-additive type of gene effects, hence these hybrids could be exploited for heterosis breeding. Here the genetic interaction might be of dominance x dominance type.

Intermating amongst the selects in biparental fashion in the early generation is likely to break undesirable linkages and may result in rare desirable combinations.

Regarding gene action, most of the hybrids showed predominance of additive gene action except spread of the plant, number of days for first flowering, number of days for first harvest and period of harvest which showed predominance of non-additive type of gene action.

SUMMARY

taken for first flowering, number of days taken for first harvest, duration of harvest, single fruit weight, fruit size, number of fruits per plant, fruit yield per plant, pericarp thickness, locules per fruit, number of seeds per fruit, reaction to pests and diseases, colour at collar of fruits and fruit cracking. The salient inferences are presented below.

Analysis of variance indicated highly significant differences among the treatments (genotypes) for all the characters, except for number of locules per fruit. Both g.c.a. and s.c.a. variances were significant for all these characters indicating that these characters are governed by additive as well as non-additive gene action. Among these thirteen characters, number of days for first flowering, number of days for first harvest and duration of harvest showed predominance of non-additive gene action while the other showed predominance of additive gene action.

The general combining ability analysis showed that Sakthi and PKM 1 were good general combiners with respect to fruit yield and other yield attributes whereas LE 79-5 and LE 373 were good general combiners for the different vegetative characters, such as plant height, branches per plant and leaves per plant. These promising varieties can be used in recombination breeding programmes for better results.

Among the fifteen hybrids, the performance of five hybrids excel the others. They are Arka Alok x PKM 1, Arka Abha x PKM 1, Sakthi x Arka Alok, Sakthi x Arka Abha and LE 79-5 x LE 373. The hybrid Arka Alok x PKM 1 exhibited highly significant specific combining ability and heterosis for fruit yield, individual fruit weight, size of fruit and for vegetative characters such as plant height, number of leaves per plant and spread of the plant. This hybrid was free from fruit borer attack and diseases like mosaic and fruit rot. It's fruits were red coloured and was free from fruit crack. The hybrid Arka Abha x PKM 1 exhibited significantly high s.c.a. as well as heterosis for number of fruits per plant, fruit yield per plant, plant height, number of leaves per plant and spread of the plant. The combinations Sakthi x Arka Alok and Sakthi x Arka Abha showed significantly high s.c.a. and heterosis for individual fruit weight, number of fruits per plant and fruit size. These combinations also showed high heterosis for fruit yield per plant. LE 79-5 x LE 373 exhibited significantly high s.c.a. for fruit yield per plant and significant and positive heterosis for number of fruits per plant and fruit yield per plant.

The above promising hybrids can be directly popularised as hybrid varieties or can be carried forward to evolve high yielding pest and disease resistant varieties.

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* Original not seen

GENETIC MAKE UP OF YIELD AND YIELD ATTRIBUTES IN A SIX PARENT DIALLEL CROSS OF TOMATO (Lycopersicon esculentum Mill.)

BY
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ABSTRACT

An experiment in tomato (Lycopersicon esculentum Mill.) was carried out at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 1995-96, with the objective of estimating the combining ability of parents, and gene action involved in the inheritance of different yield attributes. The study was conducted in a diallel model, using three bacterial wilt resistant varieties and three popular varieties.

The three bacterial wilt resistant varieties were Sakthi, Arka Alok and Arka Abha. The three popular varieties were LE 79-5, LE 373 and PKM 1. These six parental varieties and fifteen hybrids were planted in the field in Randomised Block Design., with three replications. Observations recorded were plant height, number of branches per plant, spread of the plant, number of leaves per plant, number of days taken for first flowering, number of days taken for first harvest, duration of harvest, single fruit weight, fruit size, number of fruits per plant, fruit yield per plant, pericarp thickness, locules per fruit, number of seeds per fruit, reaction to pests and diseases, colour at collar of fruits and fruit cracking.

Analysis of variance revealed highly significant differences among the genotypes for all the characters except for number of locules per fruit. Both g.c.a. and s.c.a. were significant for all these characters. The additive to

dominance variance ratio indicated a preponderance for non-additive gene action in the characters such as spread of the plant, number of days for first flowering, number of days for first harvest and duration of harvest, and a preponderance for additive gene action in the remaining characters.

Combining analysis showed that Sakthi and PKM 1 were good general combiners with respect to fruit yield and other yield attributes whereas LE 79-5 and LE 373 were good general combiners for the different vegetative characters such as plant height, branches and leaves per plant. Among the fifteen hybrid combinations, significant s.c.a. and heterosis were observed in the hybrids such as Arka Alok x PKM 1, Arka Abha x PKM 1, Sakthi x Arka Alok, Sakthi x Arka Abha and LE 79-5 x LE 373. Among these hybrids Arka Alok x PKM 1 showed significance for fruit yield, individual fruit weight, size of fruit, plant height, leaves per plant spread of the plant and also showed resistance to mosaic, fruit rot and fruit borer. The hybrid Arka Abha x PKM 1 showed significance for fruits per plant, fruit yield per plant, plant height, leaves per plant and spread of the plant. The combinations Sakthi x Arka Alok and Sakthi x Arka Abha showed high s.c.a. and heterosis for fruit weight, fruits per plant and fruit size and also high heterosis for fruit yield per plant. LE 79-5 x LE 373 exhibited high s.c.a. for fruit yield per plant and heterosis for fruit number and fruit yield. Therefore, these hybrids can be utilized for further crop improvement programme.

BIOCHEMICAL AND BIOLOGICAL BASES OF RESISTANCE IN SOLANACEOUS VEGETABLES AGAINST BACTERIAL WILT INCITED BY *RALSTONIA SOLANACEARUM* (SMITH) YABUUCHI *ET AL.*

By

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ABSTRACT OF THE THESIS

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ABSTRACT

An investigation on biochemical, biological and nutritional bases of resistance in solanaceous vegetables against bacterial wilt incited by *Ralstonia solanacearum* (Smith) Yabuuchi *et al.*, has been attempted.

The pathogen *R. solanacearum* was isolated from respective hosts and characterised by various morpholcgical, cultural, biochemical and physiological tests upto biovar level.

The three isolates were cross inoculable, and were sensitive to Ambistryn and Streptocycline. Based on these studies the tomato and chilli isolates were identified as *Ralstonia solanacearum* race I biovar III and that from brinjal as *R. solanacearum* race I biovar V.

The study on toxigenic property of the bacterial isolates revealed that the toxic metabolites were not host specific.

Out of the 43 varieties / lines screened , 12 varieties / lines were selected, one each from resistant, moderately resistant, moderately susceptible and susceptible

categories. The varieties / lines selected were LE 79-5, BT-10, LE 470 and Pusa Ruby for tomato; Swetha, Composite-2, BB-7 and Pusa Purple Long for brinjal and Ujwala, Manjari, Jwalasakhi and Pusa Jwala for chilli.

The studies on biochemical, biological and nutritional factors in tomato, brinjal and chilli showed considerable variation between crops, between varieties/ lines, and between plant parts. However the root being the primary foci of infection by *R. solanacearum* the biochemical reactions in root is considered more important than other plant parts. Among the biochemical factors, the OD phenol and specific activity increased due to infection and the content was higher in the resistant genotype (LE 79-5) both under healthy and diseased condition in tomato. In brinjal, the polyphenol oxidase activity, specific activity and peroxidase activity increased due to infection and were higher in resistant genotype (Swetha) both under healthy and diseased condition. In chilli, total phenol and OD phenol, increased due to infection and were higher in resistant plants (Ujwala) under healthy and diseased conditions. The soluble sugar content and specific activity were also higher in resistant plants both under healthy and diseased condition even though a decrease was observed due to infection .

In tomato, the resistant genotype showed a higher content of OD phenol, polyphenol oxidase activity, specific activity and alkaloids under healthy condition; and total phenol, OD phenol, soluble protein, specific activity and peroxidase activity under diseased condition. In brinjal, the resistant genotype recorded higher content of total phenol, OD phenol, soluble sugars, amino acids, soluble protein, polyphenol oxidase activity, specific activity and peroxidase activity under healthy condition; and polyphenol oxidase activity, specific activity and peroxidase activity under diseased condition. In chilli, the resistant genotype recorded higher total phenol, OD phenol, soluble sugars and specific activity under healthy condition; and total phenol, OD phenol, soluble sugars, specific activity and peroxidase activity under diseased condition.

Among the biological factors, the total microflora (fungi and actinomycetes), Pseudomonads and parasitic nematodes increased due to infection in resistant genotype whereas beneficial microbes recorded a decrease in population in resistant genotype by infection.

In tomato the resistant genotype recorded higher nematode population under healthy condition and higher total microflora, virulent *Ralstonia* and avirulent *Pseudomonas* under diseased condition. In brinjal the

resistant genotype recorded higher population of fungi, avirulent *Pseudomonas*, mycorrhiza and saprophytic nematodes under healthy condition, and fungi, virulent *Ralstonia*, avirulent *Pseudomonas* and nematodes under diseased condition. In chilli, the resistant genotype recorded higher populations of avirulent *Pseudomonas*, mycorrhiza and nematodes under healthy condition and fungi, avirulent Pseudomonas and mycorrhiza under diseased condition.

Among the nutritional factors, in tomato the resistant genotype recorded higher content of potassium and calcium under healthy condition and iron, zinc and manganese under diseased condition. In brinjal the resistant genotype recorded higher content of nitrogen, calcium, magnesium and zinc under healthy condition; and potassium , magnesium, iron and zinc under diseased condition. In chilli, the resistant genotype recorded higher content of phosphorus, calcium and iron under healthy condition; and nitrogen, potassium magnesium and zinc under diseased condition.

Thus the study revealed that it was not possible to arrive at common bases for resistance to bacterial wilt in tomato, brinjal and chilli taken together. However it was possible to outline the important parameters that conditions resistance in individual crops.