HETEROSIS FOR YIELD AND RESISTANCE TO BACTERIAL WILT IN BRINJAL

By

JAMEELA THOMAS

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DECLARATION

I hereby declare that this thesis entitled "Heterosis for yield and resistance to bacterial wilt in brinjal" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title of any other University or Society.

Vellayani,
28-5-1987.

JAMEELA THOMAS

CERTIFICATE

Certified that this thesis entitled "Heterosis for yield and resistance to bacterial wilt in brinjal" is a record of research work done independently by Smt. Jameela Thomas under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

V. GOPINATHAN NAIR.
Chairman
Advisory Committee
Professor and Head
Department of Plant Breeding
College of Agriculture

Vellayani,

28-5-1987.

Approved by

Chairman:

Dr. V.Gopinathan Nair.

Members:

1. Dr. R.Gopimony

2. Sri. S.G.Sreekumar

3. Dr. S.Balakrishnan

External Examiner:

18.1.88

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JAMEELA THOMAS

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INTRODUCTION

Vegetables, being protective foods, constitute an important item of human diet. They include leafy vegetables, fruits and tubers. Among the fruits consumed as vegetables, those belonging to Solanaceae to which the common egg plant or brinjal (Solanum melongena L.) belongs are important.

Brinjal is a common vegetable grown all over India. It can be cultivated all the year round and enjoys a privileged position in homesteads as well as commercial gardens. Its unripe fruit can be cooked in a variety of ways and its nutritive value is comparable with that of other vegetables. It is also a source of Vitamin A, thiamine, riboflavin, nicotinic acid, Vitamin C and minerals like calcium, phosphorus and iron. Wild relatives of this vegetable has wide application in medicine also.

The production of vegetables in India is far below the national requirement. Hence research is now oriented to intensify cultivation by increasing the per hectare yields. In brinjal, selection played a major role in the earlier years. The wide range of variability prevalent in the crop facilitated the utilisation of hybrids in subsequent experiments. The present day trend is therefore to exploit hybrid vigour as this is one of the quickest and easiest ways of increasing production.

A constant threat to brinjal growers is the heavy incidence of bacterial wilt caused by Pseudomonas solanacearum E.F.Smith. The climatic condition of Kerala is highly conducive for wilt infection.

Hence the disease leads to increased yield losses which at times become total (Figure 1). Nonavailability of suitable control measures necessitated the screening of several cultivars to find out sources of resistance. The resistant varieties identified were low yielders and hence were economically not feasible. There is therefore an urgent need to combine disease resistance with high yield potential.

With this in view, Narayanan (1984) crossed three resistant varieties with three commercial types and the hybrids obtained were tested for disease resistance and yield attributes. A few promising hybrids were identified. The superiority of these hybrids needs confirmation. Hence the same six varieties are proposed to be crossed using the resistant varieties as ovule parents. The six varieties and nine hybrids will be evaluated under artificial conditions of wilt infection as well as in the field for resistance to bacterial wilt. The organism causing wilt in brinjal will be isolated and confirmed. The hybrids will be evaluated for yield and related characters also. The present study thus aims to identify promising hybrids of brinjal with high yield and fairly good resistance to bacterial wilt. Such hybrids can be recommended for wilt endemic areas where brinjal cultivation has been a total failure.

FIGURE-1. A WILT INFECTED BRINJAL PLOT

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Brinjal is a popular vegetable that is widely cultivated in India and other tropical and sub-tropical countries. Its position in the east is comparable with that of tomatoes in the west.

There is a lot of controversy regarding the origin of the egg plant. Vavilov (1931) indicated the centre of origin of *Solanum melongena* as the Indo Burma region while Filov (1940) and Coulter (1942) considered India to be the centre of origin. Bhaduri (1951) strongly supported the view of Vavilov. Omidiji (1976) suggested that *S. melongena* might have evolved through interspecific hybridisation.

Brinjal exhibits a lot of varietal variation with respect to flower type. Pal and Singh (1943) have classified the flowers of brinjal as long styled, short styled and pseudo short styled. The short styled flowers do not set fruit due to the failure of pollen to reach the stigma. Krishnamoorthy and Subramoniam (1953) included another category i.e. medium styled flowers and stated that both short styled and pseudo short styled flowers do not set fruit under natural conditions. There are several reports on anthesis and pollination studies in brinjal (Cariappa, 1961; Prasad and Prakash, 1968). Gopimony (1968) has reported that flower opening and anther dehiscence were simultaneous and vary between 7 and 10 A.M. under Vellayani conditions. The work done in brinjal and other solanaceous plants have been reviewed in the following sections with respect to heterosis and resistance to bacterial wilt.

A. HETEROSIS IN BRINJAL

Exhaustive studies have been made on heterosis in egg plant. These have been grouped as follows.

1. Combining ability and Heterosis

The oldest record of artificial hybridization in the egg plant dates back to Bailey and Munson (1891). The hybrids did not exhibit any heterosis but were intermediate between the parents. Bailey (1892) further reported that the hybrids were unfruitful. The first positive report of heterosis came from Munson (1892). Halstead (1901) reported that one of his hybrids had double the size of the parents and also yielded more. Odland and Noll (1948) obtained hybrids that outyielded their respective parents besides being earlier. They also observed that the highest yielding hybrids were the progeny of lowest yielding parents. Jasmin (1954) performed a wide cross and obtained a male sterile hybrid.

In the Philippines, Bayla (1918) crossed some local varieties and obtained hybrids that were much more vigorous, stronger and healthier than their respective parents. Capinpin and Alviar (1949) reported that their hybrids showed higher germination percentage, early flowering and fruit set, more number of fruits per plant and longer fruits.

In Japan, Nagai and Kida (1926) were the first to report heterosis in the egg plant. The hybrids were heterotic for total yield, number of fruits per plant, earliness in flowering and maturity, plant height, number of branches, number of spines on the pedicel and length of fruit. Kakizaki (1931) reported heterosis for seed weight, stem diameter, height, earliness of production, yield and vigour in growth. He also found that marked yield increase was obtained by crossing varieties of widely diverse types.

In Bulgaria, Daskaloff (1941) obtained higher yields in crosses between Bulgarian and imported varieties of egg plant.

Rao (1934) was the first Indian to undertake hybridization studies in brinjal. Pal and Singh (1946) reported heterosis for germination, plant height and spread, number of branches, earliness in flowering, fruits per plant and total yield. Venkataramani (1946) also obtained similar results.

Heterosis in weight of F_1 seeds, early germination, quick early growth, earliness in flowering and profuse flowering, greater height and spread, increased fruit set, increase in size, number and weight of fruit, improved quality, early yield, total yield and resistance to pests, diseases and drought were reported by many of the early workers (Mishra, 1961; Sambandam, 1962; Joshi and Dhawan, 1966; Tiwari, 1966; Viswanathan, 1967; Gopimony, 1968; Thakur _et al._, 1968 and Vijayagopal, 1969).

Oganesyan (1967) obtained higher yield in the progeny of intervarietal crosses done without prior emasculation than that of the progeny obtained with emasculation. Pollination at the bud coloration stage gave up to 97% hybrid seed without emasculation.

Dutt (1968) found that number of fruits per plant and length and weight of fruit contribute significantly to yield increase. Jyotishi and Hussain (1968) suggested the use of 2,4-D at 10 ppm for inducing male sterility in hybrid seed production. This treatment also increased fruit set.

Gopimony and Sreenivasan (1970) reported heterosis for number of leaves, branches, flowers and fruits per plant and length of tap root in a cross between Solanum melongena var. insanum and three cultivated brinjal varieties. Silvetti and Brunelli (1970) observed heterosis for yield per plant, fruit weight and uniform ripening.

In a cross between Kalyanpur type-2 and Pusa purple round, Peter and Singh (1974) reported heterosis for weight of fruits per plant. Oganesyan (1976) obtained fairly marked heterosis for yield when two high yielding varieties were crossed. He found that the more the parents differed in yield, the less marked was the degree of heterosis.

In hybrids obtained by crossing four varieties, Badr et al. (1977) found that Black beauty x Balady white long recorded maximum heterosis for early yield and total yield. The hybrids were intermediate between the parents for mean fruit weight and only two hybrids exceeded the better parent for number of fruits per plant. Mishra (1977) reported heterosis for days to flower, plant height, number and length of fruit and yield per plant. The cross Pusa purple cluster x T_3 was recommended for exploitation of hybrid vigour.

In a diallel analysis involving seven varieties, Singh et al. (1977) observed heterosis for plant height, days to flowering, length and width of fruit and yield per plant. The best combinations were Black beauty long x Pusa purple long and Black beauty long x Kalianpur T_2 long. Considerable inbreeding depression was noticed in the F_2 for all the traits measured.

Combining ability studies by Srivastava and Bajpai (1977) revealed that additive genetic variance was higher than non-additive genetic variance for number of days to flowering and plant height while the opposite was observed for number of branches per plant and plant spread. Except for number of days to flowering, GCA and SCA effects were significant for all characters. H-4 and S-605 had the highest negative GCA for number of days to flowering and H-4 and Pusa kranti were good general combiners for number of branches per plant. Crosses with high SCA effects were those whose parents had high GCA.

Singh et al. (1978 a) reported heterosis for height, number of primary branches and yield in a study of eight varieties and twenty hybrids. Number of fruits per plant and fruit length were found to give maximum contribution to yield and hybrid, Sel-5 x Purple cluster recorded the highest yield.

Egg plant hybrids from crosses between fifteen female lines and four male testers were studied by Singh et al. (1978 b). Heterosis for early flowering was shown by the hybrid T-4 x Vijai, for plant height by 5144 x BLK and for yield by T-4 x T-3. The parents T-1, T-3 and Pusa purple long proved to be good combiners for yield and earliness.

In a 9 x 9 diallel cross, Dharmegowda et al. (1979 a) observed that Muktakeshi recorded the highest yield per plant with significant GCA for yield and number of days to flower. Arka shirish had the densest fruit with high GCA. Arka kusumkar had the highest number of fruits per plant with significant GCA for that character, yield per plant, fruit density and number of seeds per fruit. S-529 was early maturing with lowest number of seeds. Dharmegowda et al. (1979 b) also recorded heterosis for days to flower, height, number of fruits per plant, yield per plant, fruit density and seeds per fruit.

Bhutani et al. (1980) studied six varieties and their hybrids in a diallel cross excluding reciprocals. Non-additive gene action was found to be more important for yield than additive gene action. Pusa purple long, Br-112 and Aushey gave high GCA for most characters. Crosses with high SCA value were Pusa purple long x R-34, Pusa kranti x Aushey, Br-112 x Sel-26 for yield, Pusa purple long x R-34 for fruit number and Pusa kranti x Br-112 for earliness. Some association was observed between performance of crosses and their SCA values.

In a study of four hybrids and their six parental varieties that differed in resistance to shoot and fruit borer and yield potential, Dhankhar et al. (1980) found that the hybrids Br-103 x White long and Br-112 x Aushey gave positive heterosis for marketable yield and tolerance. The susceptibility of the hybrid obtained by crossing two tolerant types (Pusa purple long and Aushey) indicated that more than one recessive gene controls tolerance.

Cheah et al. (1981) reported significant heterosis in the F_1 for canopy spread and total yield per plant. Studies on quantitative characters by Joarder et al. (1981) revealed that the cross Thal x Japani showed the highest degree of heterosis for yield per plant, fruit number per plant and weight and volume of fruit. Ram et al. (1981) studied eleven varieties and their crosses and observed that none of the crosses gave a higher yield than the best parent H-4.

While studying sixteen F_1 hybrids from twelve parental varieties, Salehuzzaman (1981) found that none of the hybrids was earlier than the earlier parent. Four hybrids exhibited heterosis for yield per plant and fruit weight, three of which were derived from crosses between varieties with many small fruits on the one hand and few large fruits on the other. In a diallel analysis of two varieties and four lines, Salimath (1981) obtained significant heterosis for ascorbic acid content in Malapur x line-3, Malapur x line 14 and line-14 x line-17 wherein Malapur x line-17 had the highest GCA values. Singh et al. (1981) studied crosses between fifteen lines and four testers and identified good general combiners for plant height, early flowering, length, width, weight and number of fruit.

An 8 x 8 diallel set excluding reciprocals was studied by Dixit *et al.* (1982) and the good specific combinations obtained were Pusa purple long x Aushey, Br-112 x R-34 and PH-4 x Aushey for total yield per plant, Pusa purple long x R-34 and Pusa kranti x Aushey for number of fruits per plant and PH-4 x Br-112 and Pusa kranti x S-16 for fruit weight. These could be exploited following pedigree or single seed descend procedure in segregating generations. Singh and Hazarika (1982) investigated the relationship between performance per se and GCA of parents and concluded that for some characters, selection of parents for inclusion in hybridization programmes may be based on their mean performance but for other characters, combining ability had to be determined.

While evaluating crosses between six lines and four testers, Balamohan *et al.* (1983) found that twenty two crosses showed heterosis for yield. SM-19 x SM-2 was the highest yielder and heterosis in this case was contributed by increase in number of branches, fruit number and length. Kandasamy *et al.* (1983) assessed forty five hybrids from a 10 x 10 half diallel and the better performers with respect to yield were Pusa purple long x Punjab bahar, Pusa purple long x S-373 and Annamalai x S-96.

Narayanan (1984) reported positive heterosis for yield, number of branches and plant height in a study of nine hybrids and their six parents. However, none of the hybrids was earlier than its early parent. The hybrid SMI-10 x Pusa purple long was the best yielder. The hybrids SM-6 x Pusa purple long and Pusa purple cluster x Pusa purple long were also good combiners for yield.

Fifteen egg plant hybrids derived by crossing five female lines with three male testers were studied by Patil and Shinde (1984). All the hybrids showed heterosis over the better parent which was associated with per se performance for all the characters except plant height. In fifty per cent of the crosses studied, heterosis in fruit yield was positively correlated with the heterosis in fruits per cluster and fruits per plant. Hence they have stressed the importance of the latter two characters while selecting parents in hybridization programmes aimed at yield improvement in brinjal.

2. Genetic studies on Heterosis

Much effort has been made to evolve an acceptable genetic explanation for heterosis in this crop. A lot of reports are available on the yield components which contribute to heterosis, though the earlier reports are on qualitative characters.

Tatebe (1943) reported that atleast three partially dominant genes govern fruit shape while Khan and Ramzan (1953) found that five pairs of genes govern this character. Capinpin *et al.* (1963) observed that the F_1 hybrid was intermediate between the parents in fruit shape.

Empig and Sumaong (1964) found that clusterness was partially dominant over solitary fruiting habit. Genetic studies conducted by Gotoh (1964) revealed that the minimum number of genes governing fruit shape, fruit weight and period from sowing to flowering were five, nine and four respectively.

In a study of crosses between egg plant varieties, Rao (1970) observed that elongated fruit was dominant over round fruit and clustered over non-clustered fruit. Both characters were found to be monogenically controlled.

Peter and Singh (1973), in a diallel analysis involving five varieties, concluded that the number of days to flowering and number of primary branches were controlled by over-dominant genes, weight of fruits per plant by dominant genes, plant height by additive gene action with some over-dominance and number of fruits per plant, number of flowers per inflorescence, number of long styled plus medium styled flowers, number of short styled plus pseudo short styled flowers, length and equatorial perimeter of fruit by additive genes.

Six varieties were evaluated in a diallel cross by Ramadas (1980). A preponderence of additive gene action was noted for fruit number, weight, length and girth. Partial dominance existed for these characters while over-dominance was evident for total yield. Reciprocal differences were reported in some of the F_1 hybrids. Good association was noted between performance per se and GCA effects.

Borikar *et al.* (1981) crossed four varieties in a diallel series and found that additive gene effect predominated for yield per plant, height of plant and number of branches per plant. Yield per plant was influenced by non-additive effects also. Heritability values were high for number of branches per plant and plant height while it was moderate for yield per plant.

F_2 segregation studies made by Cheah *et al.* (1981) revealed that late flowering was partially dominant over early with number of days to first flowering being controlled by non-additive genes. The number of loci controlling weight, shape, length and girth of fruit was estimated as eight, three, three and six respectively. Fruit weight in the F_1 was intermediate between that of the parents

Joarder *et al.* (1981) studied the inheritance of yield and yield components in egg plant. They reported that dominance effect was more important than additive effect for most of the characters. Duplicate epistasis was noted for all the characters studied. F_2 means showed high inbreeding depression. Salimath (1981) performed a diallel analysis for nine characters which showed that all the characters had high estimates of additive and non-additive variance components and high to moderately high narrow sense heritability estimates.

Salehuzzaman and Alam (1983) while analysing yield and its components found that additive gene effect was important in fruit weight while dominance and duplicate epistasis predominated for fruit number and yield.

In a diallel analysis involving eight parents, Dixit _et al._ (1984) indicated that both additive and non-additive gene actions were important for yield per plant, number of fruits per plant and height of plant. Additive gene effect predominated for length, circumference and weight of fruit. Partial dominance was noted for all the characters except yield per plant and plant height which were controlled by overdominanace and complete dominance respectively. Yield per plant, circumference and weight of fruit were mainly controlled by dominant alleles. Heritability values were high for all characters except plant height and yield per plant.

Studies on yield and five other characters by Singh and Singh (1981) revealed that yield was positively correlated with weight, number and length of fruit and negatively correlated with days to flowering, plant height and fruit girth. Fruit girth showed the maximum direct effect on yield per plant followed by fruit length and weight.

Sinha (1983) while analysing certain quantitative characters found that fruits per plant, fruit weight and fruit length : circumference ratio showed high genotypic coefficient of variation and heritability values. Yield was positively correlated with fruits per plant, plant height and number of branches at the phenotypic and genotypic levels and with fruit length : circumference ratio at the genotypic level.

Investigations on yield and five yield related characters by Chadha and Paul (1984) revealed that yield per plant was positively correlated with fruits per plant and height of plant, the former having the highest value for genotypic coefficient of variation. Heritability values were high for all the characters.

B. RESISTANCE TO BACTERIAL WILT

Bacterial wilt caused by *Pseudomonas solanacearum* E.F.Smith is one of the most destructive bacterial diseases of plants in the tropics and subtropics. The disease is a constant threat to the brinjal growers of Kerala. Unpublished reports from various district agricultural farms in Kerala reveal that the incidence of wilt is very high even in improved varieties like Banaras giant and Arka kusumkar. This disease is also serious in other states like Karnataka, West Bengal, Orissa, Maharashtra, Madhya Pradesh and Bihar (Rao, 1972; Anon., 1974). The average reduction in yield was estimated as 54.6 to 62.3% by Das and Chattopadhyay (1955) while Gowda et al. (1974) recorded an economic loss of about 40 to 50%.

1. Nature of the Disease

Bacterial wilt of solanaceous plants was first reported by Burrill (1890) but it was Smith (1896) who described it in solanaceous crops including brinjal. This disease was reported from Puerto Rico by Nolla (1931). The affected plants showed yellowing and withering of shoots and leaves accompanied by general wilting of the entire plant. The vascular bundles showed a brown discolouration. Davidson (1935) gave a more detailed account of the disease from Ceylon. Plants of all ages were affected by the disease and there was wilting of either the whole plant or any of the branches and ultimately the entire plant. The leaves which were still green, curled inwards at the margin. When the stem of the infected plants was cut across with a sharp knife, the conducting tissues were found to be discoloured and a greyish white or brown slime, which consisted of numerous bacteria, oozed out of the discoloured tissues.

The first detailed report of this disease in India came from Das and Chattopadhyay (1955). The symptoms were similar to those observed by Davidson (1935) but the young plants were not affected and the disease appeared only when the plants came to flower and began to bear fruit. Gowda et al. (1974) also reported that the flowering stage was most conducive for wilt infection.

Vaughan (1944) observed that though wilt infection in tomato could be initiated at soil temperatures as low as 13°C, wilt symptoms did not develop unless soil temperatures were higher than 21°C for several days. A constant supply of soil moisture is essential for growth and the most suitable pH range was between 6 and 8. Gilbert and Mohanakumaran (1969) found that resistant cultivars were not stable in their reaction to wilt infection at 31 to 33°C and plants died of the disease. Mew and Ho (1977) obtained similar results and recommended that tomato lines should be screened at soil temperatures of 30 to 32°C for the development of bacterial wilt resistant varieties.

Wallis and Truter (1978) studied the histopathology of tomato plants affected by bacterial wilt through electron microscopy. Their study indicated that initially only small diameter cells adjacent to large vessels were invaded, the vessels remaining bacterium free. Some of these cells were stimulated to form tyloses which bulged into the vessels. Bacteria migrated into the tyloses which ruptured 48 to 72 hours after inoculation liberating the organisms into the vessels. At this time plants began to show the first signs of wilting. Within the vessels, bacterial multiplication and spread were rapid and was accompanied by accumulation of large amounts of fine granular material identified as bacterial extra cellular polysaccharides which are considered as the major cause for the sudden wilting of plants.

Tests conducted by Nesmith and Jenkins (1984) in North Carolina soils indicated that suppressive soil factors (possibly of biological origin) exist in areas where Pseudomonas solanacearum does not persist from season to season.

Eleven economic plants belonging to five families were artificially and naturally inoculated with Pseudomonas solanacearum isolates from Abaca (Musa textilis) by Rillo (1982). He found that potato, castor, bean, tobacco, tomato, egg plant, diploid banana, abaca and heliconia were infected when artificially inoculated while under natural conditions only castor, bean, tomato and egg plant were infected. This study further implied that Pseudomonas solanacearum exists as a variable species with various pathogenic potential. More detailed studies were essential to deal with disease origin and spread, to know the role of weed host species in epiphytotic outbreakes and the effect of crop rotation and fallowing as control measures.

2. On the Pathogen

The bacterium has been reported to be gram negative short rods, motile by means of polar flagella (Hayward, 1964). Inoculation tests by Kelman (1954) showed that colony appearance of the pathogen on tetrazolium medium was related to pathogenicity. Cultures derived from butyrous red colonies were either weakly pathogenic or non-pathogenic whereas those from fluidal white colonies with pink centres were highly pathogenic.

In order to preserve the virulence of cultures, Kelman and Person (1961) stored the isolates of Pseudomonas solanacearum by placing 1 to 3 loopfuls in 5 ml sterile distilled water in test tubes.

Buddenhagen et al. (1962) reported that race 1 of Pseudomonas solanacearum isolated from many solanaceous plants like tobacco, tomato and brinjal was capable of cross infecting each other. In cross inoculation tests, Khan (1974) found that the two isolates affecting tomato and potato were cross inoculable while the brinjal isolate infected tomato but failed to infect potato.

Khan *et al.* (1979) concluded that the chilli isolate was only a distinct strain of the pathogen as it failed to infect potato or brinjal. Samuel (1980) observed that the ginger isolate caused wilting in tomato but the tomato isolate failed to infect ginger.

i) Strain differentiation

It was Das and Chattopadhyay (1955) who reported for the first time in India that the organism causing wilt in brinjal was *Pseudomonas solanacearum* var. *asiaticum*. They have given a detailed account on the characterization of the pathogen. Pathogenicity tests showed that the brinjal isolates were capable of producing wilt in tomato and potato. Robinson (1962) reported that brinjal plants in some parts of Africa were attacked by *Pseudomonas solanacearum* var. *asiaticum*.

Based on the capacity to oxidise three disaccharides (lactose, maltose and cellobiose) and three hexose alcohols (mannitol, sorbitol and dulcitol), Hayward (1964) classified a collection of 185 isolates of *Pseudomonas solanacearum* into four biotypes. Isolates of biotype-1 oxidised neither group, biotype-2 only disaccharides, biotype-3 both the groups and biotype-4 only the hexose alcohols. Biotype-2 appeared to have a restricted host range and it was obtained solely from two host plants, potato and tomato whereas the other biotypes were obtained from many families in addition to Solanaceae. Robinson (1964) also observed that brinjal plants in Kenya were severely damaged by group-3 of *Pseudomonas solanacearum*.

French and Sequeira (1970) collected 42 strains of *Pseudomonas solanacearum* from solanaceous and musaceous hosts in North and South America and compared them on the basis of size, shape, colouration and slime deposition in isolate colonies grown on a tetrazolium medium and melonin formation in a tyrosine medium. The results indicated similarity as well as differences between isolates from different regions in pathogenicity, colony characteristics and host range. All Peruvian Amazon basin isolates had identical pathogenic potential on various hosts and could be distinguished from Central American isolates on the basis of colony morphology.

Shekhawat *et al.* (1978) studied the distribution of bacterial wilt and races and biotypes of the pathogen in India and reported that the organism *Pseudomones solanacearum* E.F.Smith was endemic in India throughout the West Coast, Central and Deccan Plateau of Karnataka, Western Maharashtra and Madhya Pradesh, eastern plains of Assam, West Bengal, Orissa and Chotta Nagpur plateau on potato, tomato, brinjal, chilli and wild Datura, the incidence being 10 to 50 per cent. In the North Western, Eastern and Southern hills, it was endemic but affected only the potato. The disease was more widespread in heavy and acidic soils (pH 3.5 to 6.9) than in light and neutral (pH 6.5 to 7.5) to alkaline (pH 7.5 to 8.5) soils.

Tabei and Quimio (1978) selected 88 Philippine isolates of Pseudomonas solanacearum for strain differentiation. Eighty per cent of the isolates showed characteristics of biovar III although all the four biovars were present. Strains were classified into six phage types based on relative sensitivity to the three isolates of bacteriophage used. Cardinal temperatures for growth of the isolates were determined. It was found that with the exception of tomato isolates, the range of optimum temperature was quite narrow for isolates taken from the same host plant. In the egg plant isolate, it varied between 33 and 35°C. The temperatures did not vary whether it was from high or low altitudes.

Nayar (1982) studied two brinjal isolates of Pseudomonas solanacearum obtained from the campus of the Agricultural College, Vellayani and one isolate from Bangalore. Based on biochemical characteristics, pathogenicity tests and cross inoculation studies, the isolates have been identified as Pseudomonas solanacearum var. asiaticum (Smith) Stapp.

ii) Isolation technique

Kelman (1954) has standardised the technique for the isolation of Pseudomonas solanacearum from diseased plant material through culturing on TTC medium and incubating at 30°C for 48 hours. A new selective medium for the isolation and quantification of Pseudomonas solanacearum from the soil was developed by Nesmith and Jenkins (1979). The basal medium was derived by modification of the standard TTC medium and the final selective medium was prepared by adding antimicrobial compounds at the time of use.

Granada and Sequeira (1983) have developed a new medium (SM-1) with good plating efficiency and high selectivity for isolating the pathogen from artificial and naturally infected soils. It was prepared by adding crystal violet (50 µg/ml), thimerosal (5 µg), polymyxin B sulphate (100 µg), tyrothrysin (20 µg) chloromycetin (5 µg) to Kelman's TTC medium. Adding cycloheximide (50 µg) or chlorothalonil (80 µg) prevented fungal contamination. The bacteria was easily isolated from naturally infected soils using this medium.

3. Effect of Root-knot nematode on Bacterial wilt

In greenhouse tests on tomato, Temiz (1968) observed severe damage in the variety Ackerson by inoculation with Pseudomonas solanacearum even in the absence of Meloidogyne incognita and two other nematodes. In Floradel, infection was more severe in the presence of the nematodes while in S-12 it failed to develop without their action.

Jenkins (1974) studied the interaction between Pseudomonas solanacearum and Meloidogyne incognita on bacterial wilt incidence in egg plant and found that the nematodes had no apparent effect on wilt development. Reddy et al. (1979) concluded that root-knot nematodes were probably responsible for breaking bacterial wilt resistance in the variety Pusa purple cluster of brinjal by modifying the plant tissue for a better bacterial colonization.

Samuel (1980) reported that the inoculation of nematodes prior to bacteria increased the incidence of bacterial wilt of ginger. While testing the resistance of certain breeding lines of tomato to eight isolates of *Pseudomonas solanacearum* race-1, Goth *et al.* (1983 a) observed that resistance broke down when *Meloidogyne incognita* was added to the resistant lines inoculated with *Pseudomonas solanacearum*. Hence it was suggested that *Meloidogyne incognita* should be considered while breeding for wilt resistance.

4. Screening techniques

Winstead and Kelman (1952) suggested two inoculation techniques viz. by cutting the lateral roots with a scalpel on one side of the plant to a depth of 4 to 6 cm and pouring 10 ml of the standardised suspension over the injured roots and by 'stem puncturing' method in which an injury is made with a needle on the second leaf axil of a seedling two weeks after transplanting and putting a small piece of sterile cotton wool dipped in the bacterial culture over the injury. A technique of disease scoring was also developed by them. The symptom was graded as follows:

Score	Symptom
0	No symptom
1	One leaf partly wilted
2	Two or three leaves wilted
3	All except the top 2 or 3 leaves wilted
4	All leaves wilted
5	Complete death of the plant

The number of plants in each symptom category was multiplied by the corresponding score and the products added. The summation was converted to a disease index value by dividing by the total scores for the given number of plants and multiplied by 100.

To study the influence of plant age, inoculation technique and isolate source on bacterial wilt incidence in tomato and egg plant, Jenkins and Nesmith (1976) inoculated resistant 'Venus and Saturn' tomato and 'Kopek' egg plant and susceptible 'Manapal' tomato and 'Black beauty' egg plant with isolates of Pseudomonas solanacearum from the U.S.A. and India by root wounding and stem puncture. Manapal and Black beauty were more resistant to the American isolate than to the Indian isolate between four and six weeks of age. Saturn, Venus and Kopek were susceptible to the American isolate at 2 to 4 weeks of age but became resistant after 4 to 6 weeks. All cultivars were highly susceptible up to 10 weeks of age to the Indian isolate when stem inoculated. Venus, Saturn and Kopek were more resistant when root inoculated with the Indian than with the American isolate after 6 weeks. It was concluded that the Indian isolate was more virulent than the American isolate on all cultivars at all ages using both inoculation techniques. The resistant varieties are believed to survive bacterial wilt in the field better if transplanted when about 8 weeks old.

Forty three tomato lines were screened for resistance to wilt by Mew and Ho (1976). They observed that screening at the seedling stage did not agree with that at the flowering stage.

Varieties which survived a severe screening after natural infection were resistant, moderately resistant or susceptible when artificially inoculated.

Sitaramaiah and Sinha (1984) studied the effectiveness of different inoculation techniques on brinjal with *Pseudomonas solanacearum* - biotype-3. Wilt symptoms were first evident in plant inoculations by puncturing the stem through a drop of bacterial suspension placed in the axil of the second and third expended leaves below the stem tip. However disease development was less rapid in plant inoculation in a similar manner with bacterial slime taken directly from cultures. In both the above methods, symptoms could be observed on the third day after inoculation. The other methods used were less sensitive as the wilt symptoms could be noticed only on the sixth day of inoculation.

5. Genetics of Resistance

In an attempt to transfer wilt resistance from a wild variety *Solanum melongena* var. *insanum* to a cultivated variety Purple long dutta, Swaminathan and Sreenivasan (1971) found that the former carried a single dominant gene for resistance to wilt while the latter carried the recessive gene. The F_1s were resistant but segregation occurred in the BC_1 to Purple long dutta. Studies on intervarietal hybrids of brinjal by Vijayagopal and Sethumadhavan (1973) revealed that resistance to wilt was controlled by a single dominant gene.

Gopimony (1983) reported that resistance was monogenic and dominant. While investigating the nature of resistance to wilt in tomato Ferrer (1984) reported that resistance was polygenically controlled.

Graham and Yap (1976) studied the inheritance of resistance to wilt in tomato and observed that GCA was more important than SCA and that additive gene action was predominant.

6. Source of resistance and Breeding techniques

Non-availability of suitable chemical control measures necessitated screening of several cultivars to find out sources of resistance to wilt. Sreenivasan *et al.* (1969) identified a wild variety *Solanum melongena* var. *insanum* as resistant to bacterial wilt. It has been established as a potential gene source for breeding resistant varieties as it is highly cross compatible with cultivated varieties.

In another study, Gopimony and Sreenivasan (1970) crossed three cultivated varieties with the wild *insanum* variety and found that the F_1 hybrids inherited resistance to wilt from the wild parent. The egg plant varieties Long purple, Udipi, Improved muktakesh, Purple long and Pusa purple cluster, *Solanum torvum* and *Solanum xanthocarpum* were identified as resistant to *Pseudomonas solanacearum* by Khan (1974).

Ten varieties of brinjal were screened for resistance by Gowda *et al.* (1974) when Gulla and *Solanum torvum* were found to be resistant. Varieties, Improved muktakesh and Pusa purple round took delayed infection while Pusa purple long, SM-2 and Black beauty were infected earlier. Maximum infection was noted during flowering stage and wilting was sudden and not gradual in all varieties. The roots of the wilted plants were decayed. Virulent population of the pathogen was higher in the rhizosphere of wilting plants compared to non-wilting plants.

Of five foreign and 14 Indian varieties tested for resistance, Rao _et al_. (1976) found that Dingras multiple purple and Sinampiro (from Philippines) and Pusa purple cluster (from India) were resistant.

Gopimony and George (1979) reported that out of 56 varieties including two wild ones, only the small fruited form (_Solanum melongena_ var. _insanum_) proved completely resistant to wilt. The variety Pusa purple cluster which was reported to be resistant (Rao _et al_., 1976) was found to be susceptible under Vellayani conditions. Screening of egg plant varieties and related wild species by Mochizuki and Yamakawa (1979) revealed that Dingras multiple purple and Aubergine were fairly resistant. Among the wild forms, _Solanum toxicarium_ followed by _Solanum nigrum_ and _Solanum sisymbriifolium_ were found to be resistant.

Screening for wilt resistance was undertaken at the Kerala Agricultural University. Of the 29 lines and 2 species screened for resistance, SM-6 and Pusa purple cluster were found to possess remarkable resistance (Anon., 1980). SM-6 was found to be resistant under field conditions also (Anon., 1981). The line became accepted as a source of resistance in the All India Coordinated Vegetable Improvement Programme (Anon., 1982). In 1982-83, the line SM-6 was screened under artificial conditions against seven virulent isolates of Pseudomonas solanacearum belonging to race-1 and race-2. SM-6 proved resistant to 3 isolates viz. TEP-13, 1246408-1 and W-82 and tolerant to one viz. A-21 (Anon., 1983).

Goth et al. (1983 b) have implied that the line SM-6 was resistant to the Pseudomonas solanacearum isolates tried. A hybrid obtained by Hadalageri et al. (1983) from a cross between a highly tolerant variety West coast green and susceptible Pusa kranti was found to be highly resistant and commercially acceptable.

Twenty seven varieties of brinjal were evaluated for resistance to wilt under natural conditions in the field and in the greenhouse using artificial inoculation by Mak and Vijiarungam (1980). The percentage survival in the field was higher than that in the greenhouse and was correlated with it. Ten varieties were found to have survival rates of 70 per cent or more in the greenhouse of which four were high yielding.

Interspecific hybridization by Rao (1980) showed that the cross between Solanum melongena (Pusa purple long) and Solanum torvum was successful only when the former was the female parent. The F_1 hybrid inherited the resistance to wilt from Solanum torvum. Sitaramaiah et al. (1981) screened 22 cultivars in the field for three years and reported that Pusa purple round, Vijai hybrid, Banaras giant green and Pusa purple cluster were consistently highly resistant.

The F_1 seeds of the cross between Solanum melongena var. insanum and Purple giant (a cultivar from Nagercoil) were exposed to gamma irradiation by Gopimony (1983) to enhance the recombination of bacterial wilt resistance from the former and yield characters from the latter. Further selections up to the M_7 gave 11 promising mutants. The evolved varieties were inferior in fruit yield. Hence further improvement of these varieties through hybridization with high yielding susceptible varieties for the production of wilt resistant high yielding hybrids was suggested.

Narayanan (1984) screened 11 varieties of brinjal and found SM-6, SMI-10 and SMI-31-2 to be highly resistant. The variety Pusa purple cluster was found to be fairly resistant. Three resistant varieties (Pusa purple cluster, SM-6 and SMI-10) and three susceptible commercial varieties (Black beauty, Pusa purple long and Pusa purple round) were chosen for hybridization and nine cross combinations were made. The six parents and nine hybrids were screened artificially for wilt resistance using the sick soil, seedling dip and stem puncture methods. The hybrids were found to possess a high degree of resistance compared to the susceptible parents. Two promising hybrids that combined wilt resistance with high yield were SMI-10 x Pusa purple long and SM-6 x Pusa purple long.

Out of 34 lines of Solanum melongena and one each of Solanum indicum, Solanum macrocarpon, Solanum integrifolium and Solanum *sisymbriifolium* evaluated in the field by Sheela *et al*. (1984), seven *Solanum melongena* lines and *Solanum integrifolium* were found to be immune to wilt. An immune line SM-6-1 was selected through pureline selection. Further, the survival of grafts of susceptible tomato 'Pusa ruby' on *Solanum melongena* was 100 per cent in pots and 36 per cent in the field. This study indicated that resistant *Solanum melongena* lines could be used as root-stocks for susceptible tomatoes in infected soils.

Hebert (1985) tested nine solanum species for resistance to *Pseudomonas solanacearum* and *Meloidogyne incognita* in pot experiments in Guadeloupe. Resistance was most marked in some populations *Solanum aethiopicum*, *Solanum incanum*, *Solanum nigrum*, *Solanum torvum*, *S. viarum* and *Solanum warscewiczii*.

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiments were conducted at the Department of Plant Breeding, College of Agriculture, Vellayani, from 1984 to 1986.

A. MATERIALS

Three commercial varieties of brinjal (Solanum melongena L.) susceptible to wilt viz. Black beauty, Pusa purple long and Pusa purple round and three varieties resistant to wilt viz. Pusa purple cluster, SM-6 and SMI-10 were selected for the study (Figures 2 and 3). Seeds of the resistant varieties were collected from the Department while those of the commercial varieties were obtained from M/s. Sutton Seeds, Calcutta.

B. METHODS

The study comprised of the following:

1. Hybridisation of the three resistant varieties as ovule parents with each of the three susceptible varieties as pollen parent.

2. Evaluation of the six varieties and nine hybrids for resistance to bacterial wilt under conditions of artificial infection as well as under field conditions.

3. Confirmation of the causal organism for wilt through isolation and identification of the bacterium.

4. Estimation of heterosis in the hybrids for yield and other important characters for two seasons.

FIGURE 2. COMMERCIAL (SUSCEPTIBLE) VARIETIES

1. BLACK BEAUTY
2. PUSA PURPLE LONG
3. PUSA PURPLE ROUND

FIGURE 2.

FIGURE 3. RESISTANT VARIETIES

4. PUSA PURPLE CLUSTER

5. SM-6

6. SMI-10

FIGURE 3.

1. Hybridisation

The six varieties were raised in pots with 10 plants in each variety for crossing. Nine cross combinations were made between the three resistant varieties as ovule parents and each of the three commercial varieties as pollen parent. Selfed seeds of each variety were also collected.

The first bold flower in the cyme was long styled and invariably sets fruit. Such flowers only were selected for hybridisation. However, in the variety Pusa purple cluster, most of the flowers in the cyme were long styled and were hence utilised.

Mature flower buds which would open the next day were selected in the evening. The corolla was forced open by gently pressing at its tip. Using a pair of fine forceps, the anthers were pulled out one by one without crushing. The emasculated flower buds were then covered with butter paper covers.

Under Vellayani conditions, flower opening and anther dehiscence were found to be simultaneously occurring between 7 and 10 A.M. (Gopimony, 1968). Hence pollination was done from 8 A.M. onwards when the pollen became powdery in nature and was not too sticky. Using a pointed needle, a longitudinal slit was made along the anther and pollen were scooped out. The powdery mass was applied on the receptive stigma of the emasculated flower. These flowers were again covered and labelled and the covers were retained for three days.

Selfing was comparatively easy as the flowers are bisexual. Mature flower buds that would open the next day were covered with butter paper covers in the evening. Assisted pollination was done the next day using pollen from the same flower to ensure fruit set. The flowers were again protected and suitably tagged.

Fruits mature within 40 to 45 days of pollination. Maturity of the fruits for harvesting was indicated by the change of colour to yellow from the stalk end downwards. They were harvested when about 1/4th of the fruit turned yellow (Singh and Sidhu, 1985).

The harvested fruits were gently beaten with a stick for softening. They were then cut into pieces and put in water. The seeds were then separated out, cleaned and dried in the shade for three hours. They were stored in properly labelled covers for two weeks to overcome the dormancy period.

2. Evaluation of the varieties and hybrids for resistance to bacterial wilt

The six varieties and nine hybrids were raised in polythene bags and evaluated for resistance to bacterial wilt by artificial inoculation. The testing was conducted with twenty plants per variety or hybrid in two replications. Artificial inoculation with the bacterial wilt pathogen, *Pseudomonas solanacearum*, was done by three methods.

(i) Using sick soil: The seedlings were planted in polythene bags filled with wilt sick soil collected from the root zone of freshly wilted brinjal plants.

(ii) By seedling dip: The seedlings, before planting, were washed free of soil and the roots dipped in a suspension of bacterial ooze obtained by dipping the cut ends of the stems of freshly wilted plants in distilled water for one hour (Gopimony and George, 1979). The wilted plants were counted at weekly intervals.

(iii) By stem puncture: The surviving seedlings at four weeks were subjected to stem puncture and inoculation. An incision was made in the axil of the third leaf from the tip using a pointed needle. Cotton wool dipped in fresh bacterial ooze was applied over the wound (Winstead and Kelman, 1952). The wilt count was continued for another four weeks. The number of plants out of twenty which wilted till the end of the eighth week from transplanting in each variety or hybrid was recorded and the percentage of wilting was estimated.

Under field conditions, the number of plants wilted in each variety or hybrid per replication was counted on the final day of harvest and the percentage wilting was worked out in both the seasons, viz. February to June, 1985 and November 1985 to March 1986.

3. <u>Confirmation of the causal organism for wilt through isolation and identification of the bacterium</u>

The bacterial pathogen causing wilt in brinjal was isolated from wilted plants and tested for its pathogenicity. The cultural and physiological characteristics of the bacterial isolate were studied.

Brinjal plants with initial symptoms of wilt were collected from a field where the disease destroyed a major portion of the plants. They were subjected to 'ooze test' to determine the presence of bacteria. The plant parts giving profuse bacterial ooze were selected, cut into small bits and surface sterilized using 0.1% mercuric chloride solution. They were then washed in three changes of sterile distilled water. The bits were then placed on a sterilized glass slide and crushed after adding a drop of sterile distilled water to obtain a bacterial suspension.

Peptone casamino acid (PCA) medium (Harrigan and McCance, 1966) was prepared and 100 ml portions poured in 250 ml conical flasks and sterilized by autoclaving at 15 lb/sq in. for twenty minutes. One per cent solution of 2, 3, 5 triphenyl tetrazolium chloride (TTC) was prepared in distilled water, sterilized by autoclaving for 8 minutes and stored in the dark. 0.5 ml of this solution was transferred aseptically to the 100 ml of the melted and cooled PCA medium in each conical flask using a sterilized pipette to give a TTC medium with final concentration of 0.005%. This liquid medium was poured at the rate of about 15 ml in sterilised petri dishes.

A loopful of the bacterial suspension was streaked on petri dishes containing the TTC medium and incubated at $30 \pm 2^{\circ}C$ for 24 to 48 hours. Irregularly round, fluidal white colonies with light pink centres, which characterise virulent colonies of Pseudomonas solanacearum, were selected and purified by several transfers on the same medium (Kelman, 1954).

The isolated culture was maintained as stock suspension, by placing 1 to 3 loopful of bacteria from the pure isolate, in test tubes containing 5 ml of sterile distilled water (Kelman and Person, 1961). The cultures were tested periodically for virulence and purity by streaking on TTC medium.

The bacterial isolate was tested for its pathogenicity by using 48 hour old growth on PCA slants. A suspension was made using sterile distilled water. Young seedlings of Pusa purple long were uprooted and their roots were washed in water. They were then dipped in the bacterial suspension for four hours and planted in sterilized soil.

The cultural and physiological characters of the bacterial isolate were studied following the procedures described in 'Laboratory Methods in Microbiology' (Harrigan and McCance, 1966) and 'Manual of Microbiological Methods' (Anon., 1957).

i) <u>Cultural characters</u>

a) Morphology: Morphology of the isolate was studied using 24 and 48 hour old cultures grown on PCA medium. A loopful of the dilute suspension of the bacterial isolate was streaked over PCA medium in petri dishes. Growth charecteristics were studied after 24 and 48 hours of incubation.

b) Motility: The bacterial culture was stab inoculated on nutrient agar medium (Harrigan and McCance, 1966) in a test tube using a straight needle and observed the following day.

e) Pigment: Production of water insoluble pigment was tested on Yeast Glucose Chalk Agar medium (Harrigan and McCance, 1966). 48 hour old growth of the isolate was tested for pigment production.

ii) Physiological characters

a) Hydrolysis of starch: Ability of the bacterial isolate to hydrolyse starch was studied using nutrient agar containing 0.2% soluble starch (Harrigan and McCance, 1966). The isolate was spot inoculated on the medium in petri dishes. After four days of incubation, starch hydrolysis was tested by flooding the agar surface with Gram's iodine.

b) Catalase test: Hydrogen peroxide was poured over 3 day old bacterial culture and effervescence if any was noted.

c) Production of levan: Levan production was tested on Peptone beef extract medium containing 5% sucrose (Harrigan and McCance, 1966). Dilute suspension of the isolate was streaked over the medium and observed after 48 hours.

d) Utilization of carbon sources: The Hugh and Leifson medium (Harrigan and McCance, 1966) was used as the basal medium. One per cent glucose, fructose, lactose, sucrose and arabinose were added to the above medium and dispersed in tubes to a depth of 4 cm and sterilized by tyndallization. They were inoculated by stabbing with a straight inoculation needle charged with bacterial growth. In one set of tubes, the medium was sealed with 1cm layer of sterile liquid paraffin. The tubes were incubated and observations recorded.

4. Estimation of heterosis in the hybrids

The six varieties and nine hybrids evaluated are listed below. The hybrids are presented in Figures 4 to 6.

Black beauty (BB)
Pusa purple long (PPL)
Pusa purple round (PPR)
Pusa purple cluster (PPC)
SM-6
SMI-10
Pusa purple cluster x Black beauty
Pusa purple cluster x Pusa purple long
Pusa purple cluster x Pusa purple round
SM-6 x Black beauty
SM-6 x Pusa purple long
SM-6 x Pusa purple round
SMI-10 x Black beauty
SMI-10 x Pusa purple long
SMI-10 x Pusa purple round

They were evaluated in field trials employing RBD with three replications in two seasons, viz. February to June, 1985 and November 1985 to March 1986. There were 21 plants per variety or hybrid in each replication.

Good seeds of each variety and hybrid were soaked in water for two hours. They were sown in pots filled with standard potting mixture, covered with a layer of sand and watered daily. The seeds

FIGURE 4. HYBRIDS WITH PPC AS OVULE PARENT

7. PPC x BB

8. PPC x PPL

9. PPC x PPR

FIGURE 4.

FIGURE 5. HYBRIDS WITH SM-6 AS OVULE PARENT

10. SM-6 x BB

11. SM-6 x PPL

12. SM-6 x PPR

FIGURE 5.

FIGURE 6. HYBRIDS WITH SMI-10 AS OVULE PARENT

13. SMI-10 x BB

14. SMI-10 x PPL

15. SMI-10 x PPR

FIGURE 6.

germinated in one week's time. Thirty to forty days old seedlings were used for transplanting. Healthy, vigorous seedlings of uniform growth were selected and transplanted.

Small pits of uniform size were taken in the main field at a spacing of 75 x 75 cm. Farm yard manure was applied in the pit and stirred well before transplanting at one seedling per pit. The management practices were followed as per the Package of Practices Recommendations of the Kerala Agricultural University (Anon., 1986).

From each variety or hybrid in a replication, five plants were selected at random and labelled. In plots with less than five surviving plants, all the plants were selected. The observations (i) to (vii) below were recorded on these selected plants.

i) Days to first flowering: The day of first flower opening was recorded in each plant and the number of days from transplanting to this date was computed.

ii) Height of plants: The height of each plant was measured from the ground level to the top most bud on the day of final harvest.

iii) Number of branches: The number of primary branches were counted and recorded on the day of final harvest.

iv) Days to final harvest: The number of days from transplanting to the last harvest in each plant was computed and recorded.

v) Number of fruits per plant: The number of fruits from each plant was recorded at each harvest and the total number of fruits obtained till the last harvest was computed.

vi) Weight of fruits per plant (at three months): The weight of fruits from each plant up to three months after transplanting was totalled.

vii) Weight of fruits per plant (final): The total weight of fruits harvested from each plant till the last harvest was calculated.

viii) Weight of fruit: Five fruits from each variety or hybrid in each replication were selected at random from the bulk of fruits harvested at a time and their weights recorded.

ix) Volume of fruit: The volume of the above five fruits was determined by the water displacement method. The water displaced was collected in a measuring cylinder and the volume read.

x) Density of fruit: The weight and volume recorded above were used to compute the density of fruit.

xi) Fruit and shoot borer incidence: The number of plants in each plot affected by shoot borer was recorded at a particular period and the percentage of infected plants worked out.

5. Statistical Analysis

The data collected from the two field trials were tabulated and subjected to statistical analysis. The analysis of variance in respect of various characters was done for the first trial data while analysis of covariance with 0 and 1 as covariates was done for the second evaluation trial since the data collected was inadequate due to damage caused by heavy incidence of wilt (Federer, 1967).

The three estimates of heterosis viz. relative heterosis, heterobeltiosis and standard heterosis were made for all the hybrids and characters as follows:

i) Relative heterosis $= \dfrac{(F_1 - \text{Mid parent})}{\text{Mid parent}} \times 100$

ii) Heterobeltiosis $= \dfrac{(F_1 - \text{Better parent})}{\text{Better parent}} \times 100$

iii) Standard heterosis $= \dfrac{(F_1 - \text{Standard variety})}{\text{Standard variety}} \times 100$

The variety Pusa purple cluster was taken as the standard variety.

The critical differences (CD) were computed as follows:

i) C.D. I (for testing the significance over the mid parental value)

$$\text{C.D. I } (0.05) = t_{e(0.05)} \sqrt{\frac{3MS_e}{2r}}$$

ii) C.D. II (for testing the significance over the better parent and the standard variety)

$$\text{C.D. II } (0.05) = t_{e(0.05)} \sqrt{\frac{2MS_e}{r}}$$

where, C.D. (0.05) = Critical difference value at 0.05 level of probability.

$t_{e(0.05)}$ = Critical value of 't' corresponding to the error degrees of freedom at 0.05 level.

MS_e = Mean square for error,

and r = Number of replications.

RESULTS

RESULTS

The six varieties and nine hybrids were evaluated for bacterial wilt resistance by artificial inoculation as well as under field conditions. Their reaction to fruit and shoot borer were also studied. The bacterium causing wilt was isolated and identified. The data obtained from the two trials involving the six varieties and nine hybrids were subjected to analysis of variance (first trial) and analysis of co-variance (second trial). The three estimates of heterosis viz., relative heterosis, heterobeltiosis and standard heterosis pertaining to the characters studied were also computed. The results on the various aspects are presented below.

A. Reaction to wilt disease and pests

1. Wilt infection

The percentage of wilting in the varieties and hybrids under artificial inoculation and in the field are presented in Table 1. At the end of four weeks in seedling screening, the susceptible varieties showed complete wilting. At the end of eight weeks, even the resistant varieties showed high percentages of wilting (70 to 95%). All the hybrids were found to be susceptible.

The field scoring showed that wilting ranged from 1 to 43 per cent with maximum wilting in the variety Pusa purple long.

Table 1. Percentages of wilting in the varieties and hybrids

Sl. No.	Varieties/hybrids	Seedling screening		In the field at harvest
		After 4 weeks	After 8 weeks	First trial
1.	BB	95	100	5
2.	PPL	100	100	43
3.	PPR	100	100	19
4.	PFC	75	80	3
5.	SM-6	30	70	3
6.	SMI-10	70	95	1
7.	PFC x BB	100	100	1
8.	PFC x PPL	90	95	10
9.	PFC x PPR	90	95	1
10.	SM-6 x BB	90	95	3
11.	SM-6 x PPL	85	100	21
12.	SM-6 x PPR	85	90	6
13.	SMI-10 x BB	85	100	1
14.	SMI-10 x PPL	95	100	6
15.	SMI-10 x PPR	70	90	5

In the hybrids, maximum wilting of 21% was seen in the hybrid SM-6 x PPL followed by PPC x PPL (10%). The hybrids involving Black beauty as the pollen parent were found to be more resistant and those with Pusa purple long as pollen parent were less resistant.

2. Fruit and Shoot borer infestation

The percentage infestation in the varieties and hybrids are presented in Table 2. It was found that the variety PPL possess field tolerance. This was also true in the hybrids involving this variety as the pollen parent.

B. Isolation and identification of the bacterium causing wilt

The bacterium from wilted plants was isolated on triphenyl tetrazolium chloride (TTC) medium. After 24 hours of incubation, white, fluidal colonies with light pink centre were noticed. The cultural and physiological characters of the bacterium were studied.

1. Cultural characters

i) Morphology: Twenty four hour old cultures on PCA medium gave white, slimy colonies with pink centre. After 48 hours the entire colony turned pinkish.

ii) Motility: Tests on nutrient agar indicated motility as revealed by a diffused zone of growth spreading from the line of inoculation.

Table 2. Percentage infestation to fruit and shoot borer in the varieties and hybrids

Sl. No.	Varieties/hybrids	First trial
1.	* BB	10
2.	PPL	0
3.	PPR	6
4.	PPC	3
5.	SM-6	6
6.	SMI-10	6
7.	PPC x BB	5
8.	PPC x PPL	0
9.	PPC x PPR	8
10.	SM-6 x BB	5
11.	SM-6 x PPL	0
12.	SM-6 x PPR	3
13.	SMI-10 x BB	8
14.	SMI-10 x PPL	0
15.	SMI-10 x PPR	6

iii) Pigment: The bacterial isolate failed to produce any pigment on Yeast Glucose Chalk Agar medium.

2. Physiological characters

i) Starch hydrolysis: On flooding the plates with iodine, the region around the colonies turned blue indicating negative starch hydrolysis.

ii) Catalase test: This test gave positive results as shown by the effervescence caused by the liberation of free oxygen as gas bubbles.

iii) Production of levan: Presence of large, white, domed and mucoid colonies on Peptone beef extract medium indicated the production of levan.

iv) Utilization of carbon sources: In all the tubes there was a change of colour from purple to yellow indicating positive utilization.

C. Comparison of varieties and hybrids

The analysis of variance (first trial) and analysis of co-variance (second trial) done separately for the ten characters in the two evaluation trials revealed that the six varieties and their nine hybrids differed significantly in respect of all the characters except number of branches in both the trials and weight of fruits per plant at three months in the second trial. The mean values of the varieties and hybrids in respect of the ten characters studied in the two trials are presented in Tables 3 and 4.

Table 3. Mean values of the varieties and hybrids in the first season (February - June)

Varieties/ hybrids	Days to first flowering	Height of plants (cm)	Number of branches	Days to final harvest	Number of fruits per plant	Weight of fruit (g)	Volume of fruit (ml)	Density of fruit (g/ml)	Weight of fruits per plant at 3 months (g)	Weight of fruits per plant (final) (g)
BB	48	100	6.7	92	3.9	94	121	0.78	150	258
PPL	40	63	7.2	114	10.5	81	101	0.80	118	466
PPR	42	80	7.9	111	6.0	125	159	0.79	219	428
PPC	46	100	6.8	123	27.3	51	46	1.10	176	625
SM-6	39	91	7.8	124	27.5	72	97	0.74	418	1008
SMI-10	42	100	6.9	120	18.1	108	172	0.63	398	886
PPC x BB	37	112	7.3	124	22.1	130	178	0.74	445	1176
PPC x PPL	36	99	7.9	123	31.5	93	118	0.79	559	1313
PPC x PPR	38	106	7.3	123	19.1	144	181	0.79	361	1134
SM-6 x BB	37	105	7.8	121	15.2	147	279	0.57	486	1093
SM-6 x PPL	37	100	8.6	122	23.2	95	148	0.64	547	1400
SM-6 x PPR	38	124	7.9	124	20.9	121	146	0.82	554	1201
SMI-10 x BB	40	107	7.7	122	22.1	172	234	0.73	640	1498
SMI-10 x PPL	35	104	7.6	124	36.9	114	161	0.71	668	1534
SMI-10 x PPR	39	106	8.5	123	21.5	149	201	0.74	593	1370
C.D. at P = 0.05	4.4	18.3	1.27	8.7	6.34	35.7	68.3	0.133	140.0	362.7

Table 4. Mean values of the varieties and hybrids in the second season (November – March)

Varieties/ hybrids	Days to first flowering	Height of plants (cm)	Number of branches	Days to final harvest	Number of fruits per plant	Weight of fruit (g)	Volume of fruit (ml)	Density of fruit (g/ml)	Weight of fruits per plant at 3 months (g)	Weight of fruits per plant (final) (g)
BB	47	57	3.8	84	2.2	47	72	0.64	76	100
PPL	32	54	4.8	59	2.0	51	69	0.73	93	105
PPR	35	58	3.9	81	4.0	71	85	0.82	169	210
PPC	42	89	3.5	123	29.9	42	64	0.66	411	782
SM-6	37	79	3.4	112	8.6	45	71	0.62	226	335
SMI-10	42	83	4.7	115	13.7	68	98	0.68	315	643
PPC x BB	36	69	4.3	112	10.8	79	104	0.75	344	640
PPC x PPL	35	58	4.4	89	7.1	47	75	0.62	145	206
PPC x PPR	38	79	5.1	119	16.8	103	144	0.70	415	1041
SM-6 x BB	34	83	4.3	105	5.7	78	113	0.67	181	319
SM-6 x PPL	36	60	3.8	64	2.8	60	96	0.61	147	170
SM-6 x PPR	39	82	4.9	115	9.6	68	97	0.69	142	481
SMI-10 x BB	39	73	4.4	99	6.4	58	84	0.67	160	329
SMI-10 x PPL	31	58	4.1	79	4.5	66	100	0.64	230	276
SMI-10 x PPR	34	80	4.3	107	9.3	70	104	0.66	419	666
C.D. at P = 0.05	2.8	11.2	1.06	25.5	10.00	23.4	33.8	0.063	293.0	528.6

The fruit characters of the varieties and hybrids are furnished in Figures 7 to 10.

1. <u>Days to first flowering</u>

Significant differences were noted among the varieties and hybrids with respect to this character in both the trials. The days to flowering ranged from 35 to 48 and 31 to 47 in the first and second trials respectively. This character was found to be stable over the two seasons for most of the varieties and hybrids. SMI-10 x PPL was found to be the shortest and Black beauty the longest in duration in both the trials. In the first trial, the hybrid SMI-10 x PPL was the shortest in duration followed by PPC x PPL, SM-6 x PPL, SM-6 x BB and PPC x BB. The variety with longest duration was Black beauty preceded by Pusa purple cluster. In the second trial, the hybrid SMI-10 x PPL was followed by Pusa purple long and the variety with longest duration Black beauty was preceded by Pusa purple cluster and SMI-10.

2. <u>Height of Plants</u>

The treatment means differed significantly in both the trials. The mean values ranged from 63 to 124 and 54 to 89 in the two trials respectively. The shortest variety was Pusa purple long in both the trials. Plant height was highly unstable over the two seasons and the plants were found to attain greater height during the first season than in the second. The hybrid, SM-6 x PPR recorded the maximum height in the first trial followed by PPC x BB and SMI-10 x BB. The shortest variety Pusa purple long was preceded by Pusa purple round. In the second trial, Pusa purple

FIGURE 7. (a) FRUITS OF SIX VARIETIES

(b) FRUITS OF NINE HYBRIDS

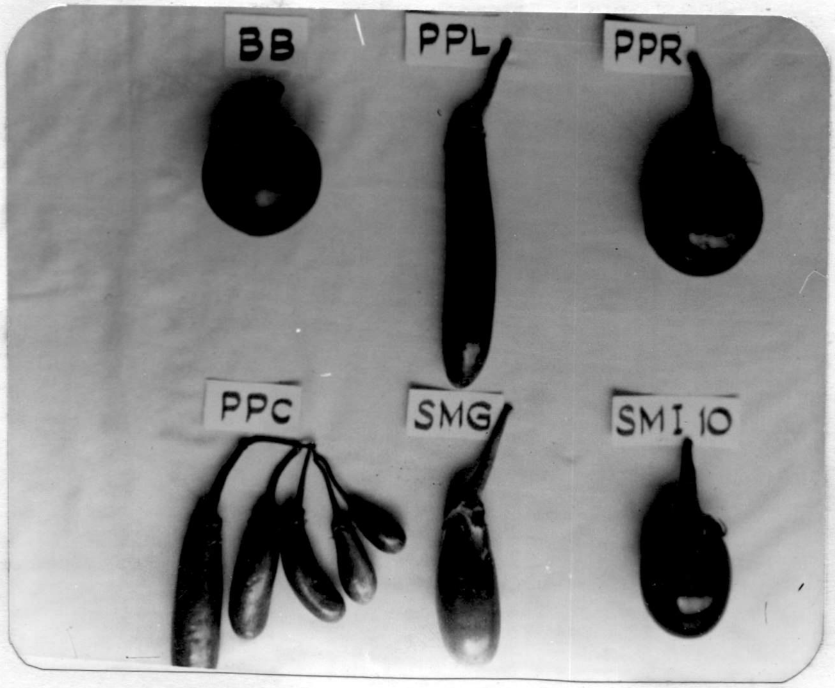


FIGURE 7(a).

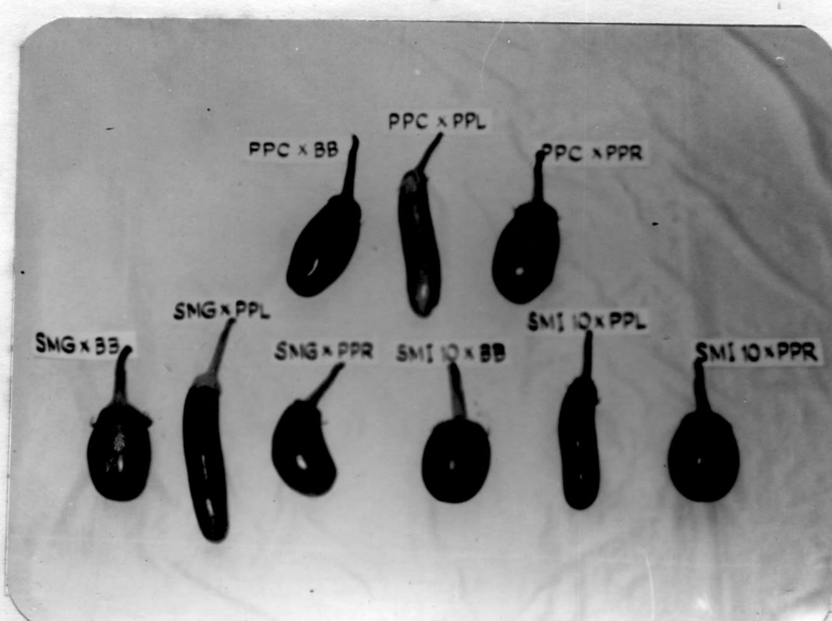
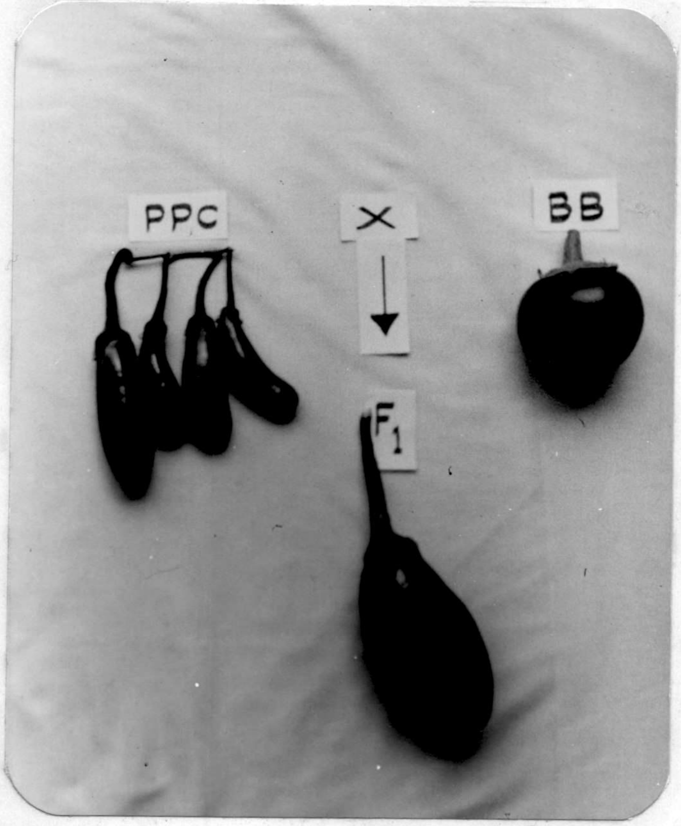
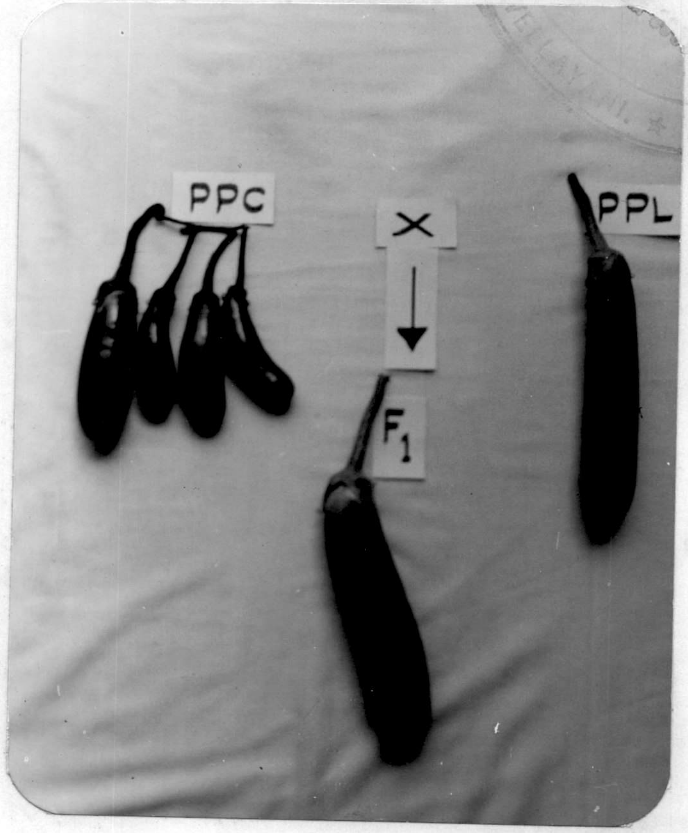


FIGURE 7(b)

FIGURE 8. FRUITS OF VARIETIES AND HYBRIDS WITH PFC AS OVULE PARENT





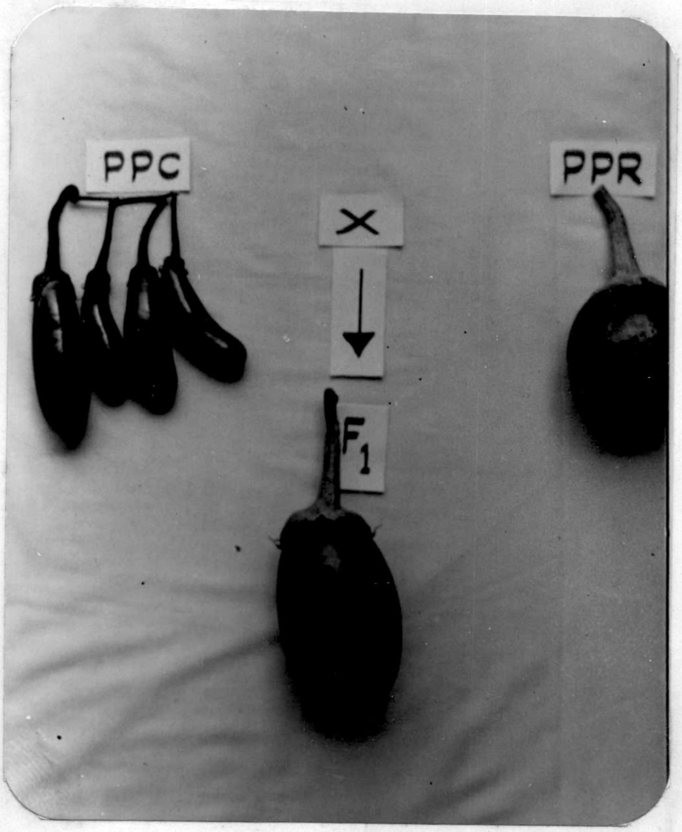
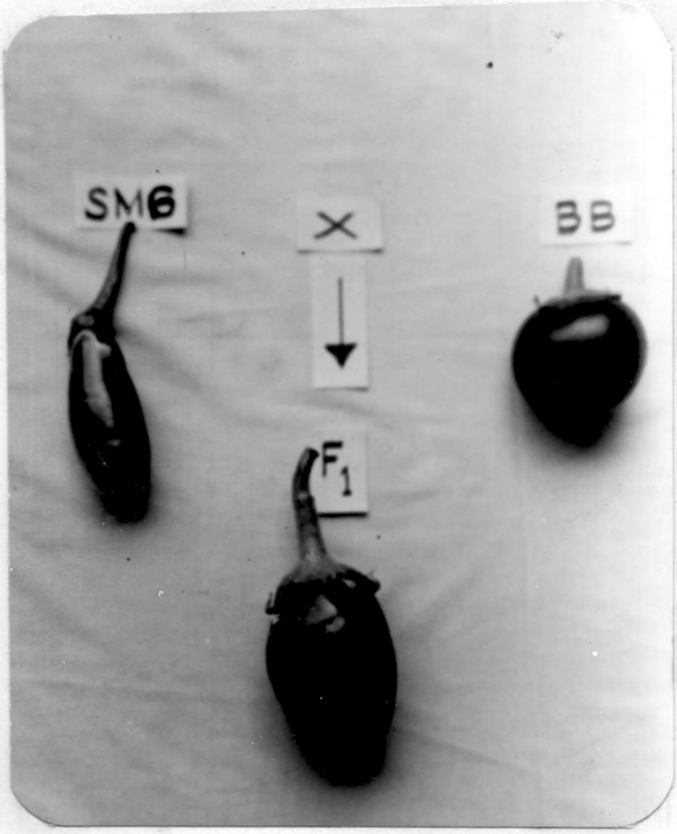
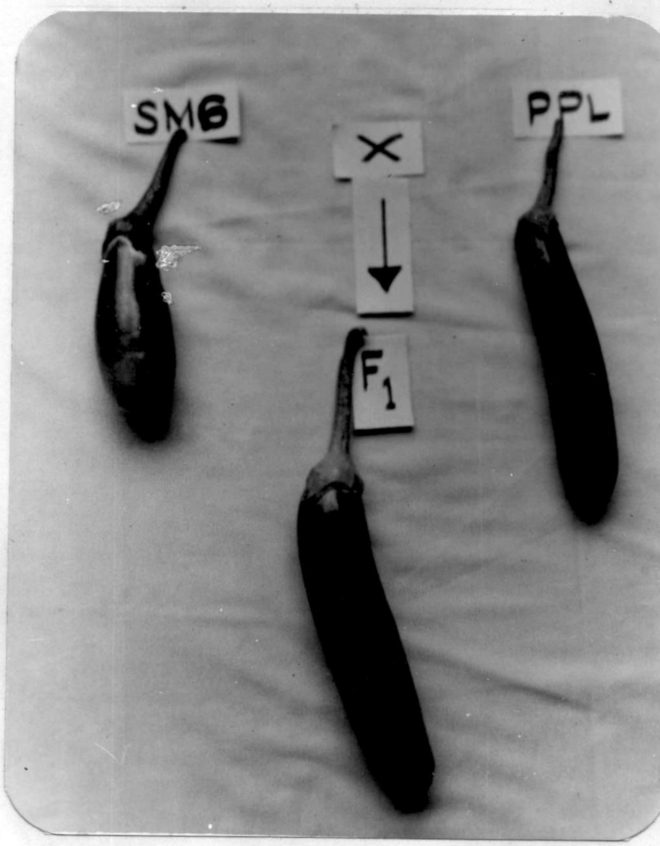


FIGURE 8.

FIGURE 9. FRUITS OF VARIETIES AND HYBRIDS WITH SM-6 AS OVULE PARENT





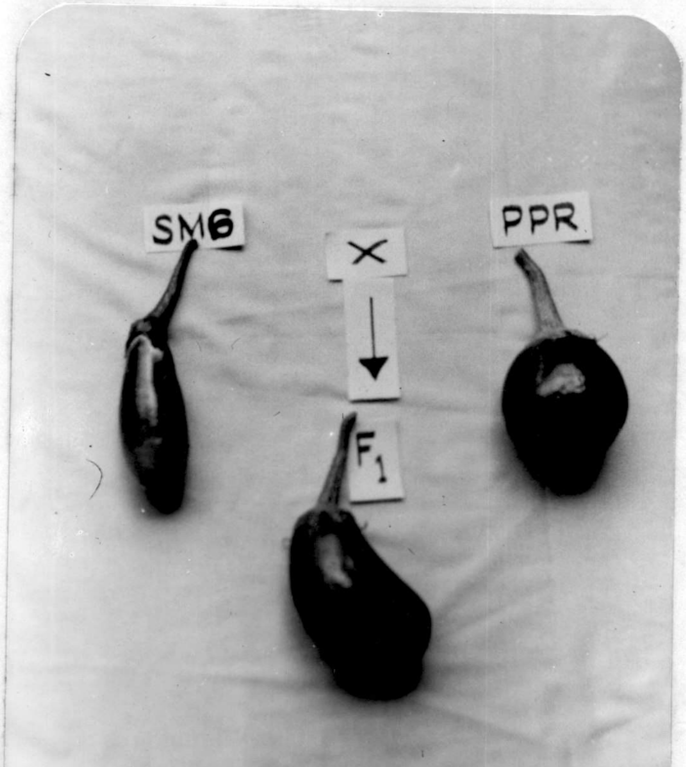


FIGURE 9.

FIGURE 10. FRUITS OF VARIETIES AND HYBRIDS WITH SMI-10 AS OVULE PARENT

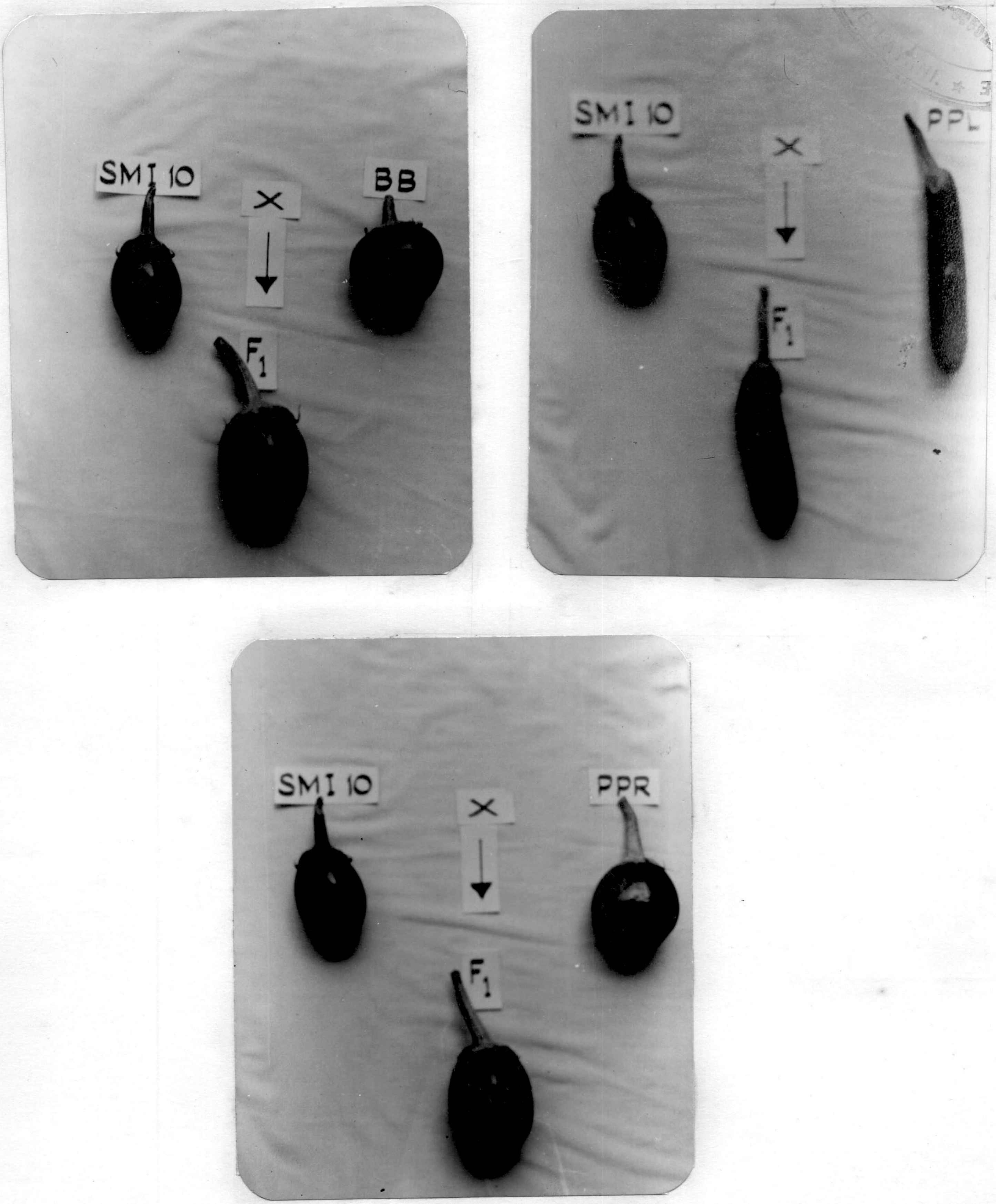


FIGURE 10.

cluster was found to exhibit maximum height followed by SM-6 x BB and SMI-10. The shortest variety was Pusa purple long which was preceded by Black beauty.

3. Number of branches

The analysis of variance indicated that the varieties and hybrids did not differ significantly for this character in both the trials. The mean values ranged from 6.7 to 8.6 and 3.4 to 5.1 in the first and second trials respectively. This character proved to be highly unstable over the two seasons with greater tendency for branching during the first season.

4. Days to final harvest

The varieties and hybrids differed significantly with respect to this character. The hybrid SMI-10 x PPL recorded the maximum number of days to final harvest in the first trial followed by PPC x BB. The shortest fruiting phase was recorded by Black beauty. In the second trial, Pusa purple cluster recorded the longest fruiting period followed by PPC x PPR while Pusa purple long took the minimum number of days to reach final harvest. The mean values in the two trials revealed that the days taken to final harvest varied with season with a longer bearing period during the first season (February to June).

5. Number of fruits per plant

Significant differences existed among the varieties and hybrids in both the evaluations for number of fruits per plant.

In the first trial, SMI-10 x PPL performed best followed by PPC x PPL while Black beauty produced the lowest number of fruits per plant preceded by Pusa purple round. Pusa purple cluster ranked first in the second trial with PPC x PPR coming next to it. Pusa purple long proved to be the most inferior variety which succeeded Black beauty. This character was highly unstable across seasons as indicated by the differences in varietal means. More number of fruits per plant were obtained during the first season in all the varieties and hybrids.

6. Weight of fruit

This character was found to very significantly among the varieties and hybrids in both the evaluations. Fruit weight ranged from 51 to 172 g and from 42 to 103 g in the two trials respectively. In both the trials, fruit weight was the lowest in Pusa purple cluster followed by SM-6. The hybrid SMI-10 x BB which showed the highest fruit weight in the first trial was followed by SMI-10 x PPR and SM-6 x BB. In the second trial, PPC x PPR ranked first followed by PPC x BB. The fruit weight was higher during the first season in all the varieties and hybrids. This indicated unstability of the character with season.

7. Volume of fruit

Significant differences were noted among the varieties and hybrids for fruit volume in both the trials. This character also proved unstable with differences in mean values in the first and the second trials, in all varieties and hybrids. In the first trial, SM-6 x BB was found to rank first followed by SMI-10 x BB whereas in the second trial, PPC x PPR came first followed by SM-6 x BB. In both the trials, Pusa purple cluster gave the lowest volume indicative of small fruits.

8. Density of fruit

This character also differed significantly in the varieties and hybrids in both the trials. The mean values varied from 0.57 to 1.10 and from 0.61 to 0.82 in the first and second evaluations respectively. The variety Pusa purple cluster possessed maximum density in the first trial followed by SM-6 x PPR whereas the hybrid SM-6 x BB gave the lowest value preceded by SMI-10. In the second trial Pusa purple round ranked the first. Then came PPC x BB. SM-6 x PPL proved most inferior. Fruit density was also found to vary from season to season.

9. Weight of fruits per plant at three months

The varieties and hybrids differed significantly only in the first evaluation where the means ranged between 118 and 668 g. The hybrid SMI-10 x PPL gave the maximum fruit yield followed by SMI-10 x BB and SMI-10 x PPR. Pusa purple long gave the minimum fruit yield followed by Black beauty and Pusa purple cluster. This character was also unstable over the seasons with a higher mean during the first season.

10. Weight of fruits per plant (final)

Fruit weight varied significantly among the varieties and hybrids in both the trials. The means ranged from 258 to 1534 g in the first trial and from 100 to 1041 g in the second trial. SMI-10 x PPL ranked topmost in the first evaluation followed by SMI-10 x BB and SM-6 x PPL. In the second trial, PPC x PPR came first with Pusa purple cluster and SMI-10 x PPR close behind. In both the evaluations, Black beauty recorded minimum value. Better expression for fruit weight per plant was shown by most of the varieties and all the hybrids during the first season.

D. Heterosis

The mean values of the six varieties and nine hybrids and the three estimates of heterosis namely, relative heterosis, heterobeltiosis and standard heterosis based on the pooled means for the two trials are presented.

1. Days to first flowering

The mean number of days to first flowering of the varieties and hybrids in the two trials, their pooled means and the estimates of heterosis are given in Table 5. The heterosis values are graphically presented in Figure 11. Negative relative heterosis was exhibited by all the hybrids except SM-6 x PPL and SM-6 x PPR. The hybrid PPC x BB gave the maximum negative heterosis. Heterobeltiosis was also negative in hybrids except PPC x PPL, SM-6 x PPL and SM-6 x PPR, the maximum negative value

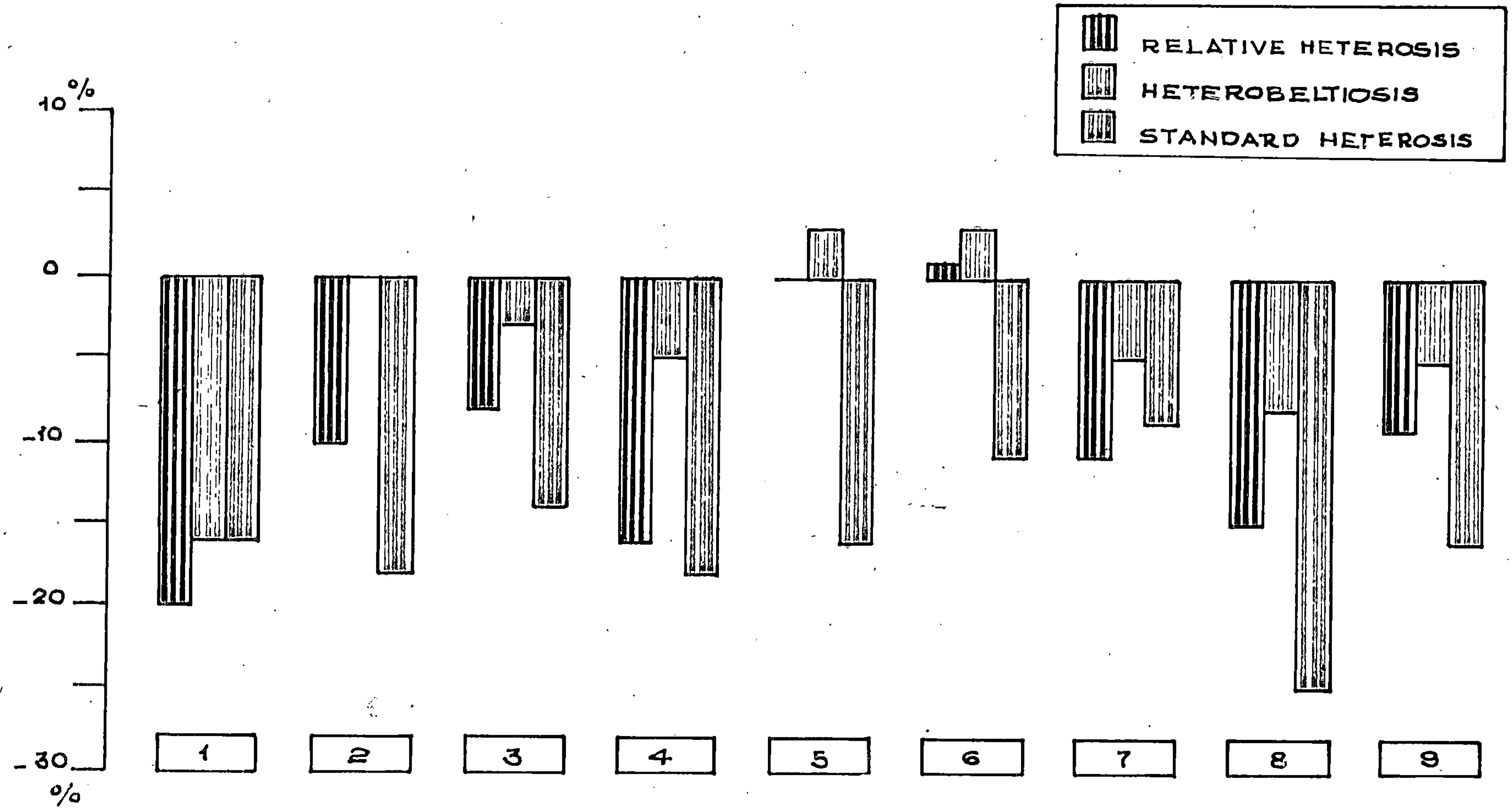
Table 5. Heterosis (percentage) for days to first flowering

Varieties/ hybrids	Mean			Relative heterosis	Hetero-beltiosis	Standard heterosis
	First trial	Second trial	Pooled			
BB	48	47	48	-	-	-
PPL	40	32	36	-	-	-
PPR	42	35	39	-	-	-
PPC	46	42	44	-	-	-
SM-6	39	37	38	-	-	-
SMI-10	42	42	42	-	-	-
PPC x BB	37	36	37	-19.6	-15.9	-15.9
PPC x PPL	36	35	36	-10.0	0.0	-18.2
PPC x PPR	38	38	38	-8.4	-2.6	-13.6
SM-6 x BB	37	34	36	-16.3	-5.3	-18.2
SM-6 x PPL	37	36	37	0.0	2.8	-15.9
SM-6 x PPR	38	39	39	1.3	2.6	-11.4
SMI-10 x BB	40	39	40	-11.1	-4.8	-9.1
SMI-10 x PPL	35	31	33	-15.4	-8.3	-25.0
SMI-10 x PPR	39	34	37	-8.6	-5.1	-15.9

FIGURE 11. HETEROSIS FOR DAYS TO FIRST FLOWERING

1. PPC x BB	4. SM-6 x BB	7. SMI-10 x BB
2. PPC x PPL	5. SM-6 x PPL	8. SMI-10 x PPL
3. PPC x PPR	6. SM-6 x PPR	9. SMI-10 x PPR

FIGURE 11. HETEROSIS FOR DAYS TO FIRST FLOWERING



given by PPC x BB. Standard heterosis was negative in all the hybrids indicating that all of them were earlier than the standard variety, Pusa purple cluster. The hybrid SMI-10 x PPL seems to be the best in respect of earliness.

2. Height of plants

Table 6 shows the mean height of the varieties and hybrids and the three estimates of heterosis. Figure 12 illustrates the different heterosis estimates. All the hybrids showed positive relative heterosis and SM-6 x PPR gave the maximum height. The minimum height was shown by PPC x PPL. Concerning heterobeltiosis, positive results were given by SM-6 x BB, SM-6 x PPR and SMI-10 x PPR. All the hybrids showed negative heterosis over the standard variety except SM-6 x PPR. This hybrid seems to be the best in respect of plant height.

3. Number of branches

The mean values of the varieties and hybrids and the heterosis values for this character are presented in Table 7. Graphical illustration of the heterosis values is made in Figure 13. Relative heterosis ranged from 0 to 10.9%. Some of the good hybrids were SM-6 x BB, PPC x PPL, PPC x PPR and SM-6 x PPR. Heterobeltiosis was positive in all except one hybrid and was marked in the hybrids PPC x BB, SM-6 x BB, SM-6 x PPR and SMI-10 x PPR. It was negative for the hybrid SMI-10 x PPL. When compared to the standard variety Pusa purple cluster, heterosis was marked

Table 6. Heterosis (percentage) for height of plants

Varieties/ hybrids	Mean (cm)			Relative heterosis	Hetero-beltiosis	Standard heterosis
	First trial	Second trial	Pooled			
BB	100	57	79	-	-	-
PPL	63	54	59	-	-	-
PPR	80	58	69	-	-	-
PPC	100	89	95	-	-	-
SM-6	91	79	85	-	-	-
SMI-10	100	83	92	-	-	-
PPC x BB	112	69	91	4.6	-4.2	-4.2
PPC x PPL	99	58	79	2.6	-16.8	-16.8
PPC x PPR	106	79	93	13.4	-2.1	-2.1
SM-6 x BB	105	83	94	14.6	10.6	-1.1
SM-6 x PPL	100	60	80	11.1	-5.9	-15.8
SM-6 x PPR	124	82	103	33.8	21.2	8.4
SMI-10 x BB	107	73	90	5.3	-2.2	-5.3
SMI-10 x PPL	104	58	81	7.3	-12.0	-14.7
SMI-10 x PPR	106	80	93	15.5	1.1	-2.1

FIGURE 12. HETEROSIS FOR HEIGHT OF PLANTS

1. PPC x BB	4. SM-6 x BB	7. SMI-10 x BB
2. PPC x PPL	5. SM-6 x PPL	8. SMI-10 x PPL
3. PPC x PPR	6. SM-6 x PPR	9. SMI-10 x PPR

FIGURE 12. HETEROSIS FOR HEIGHT OF PLANTS

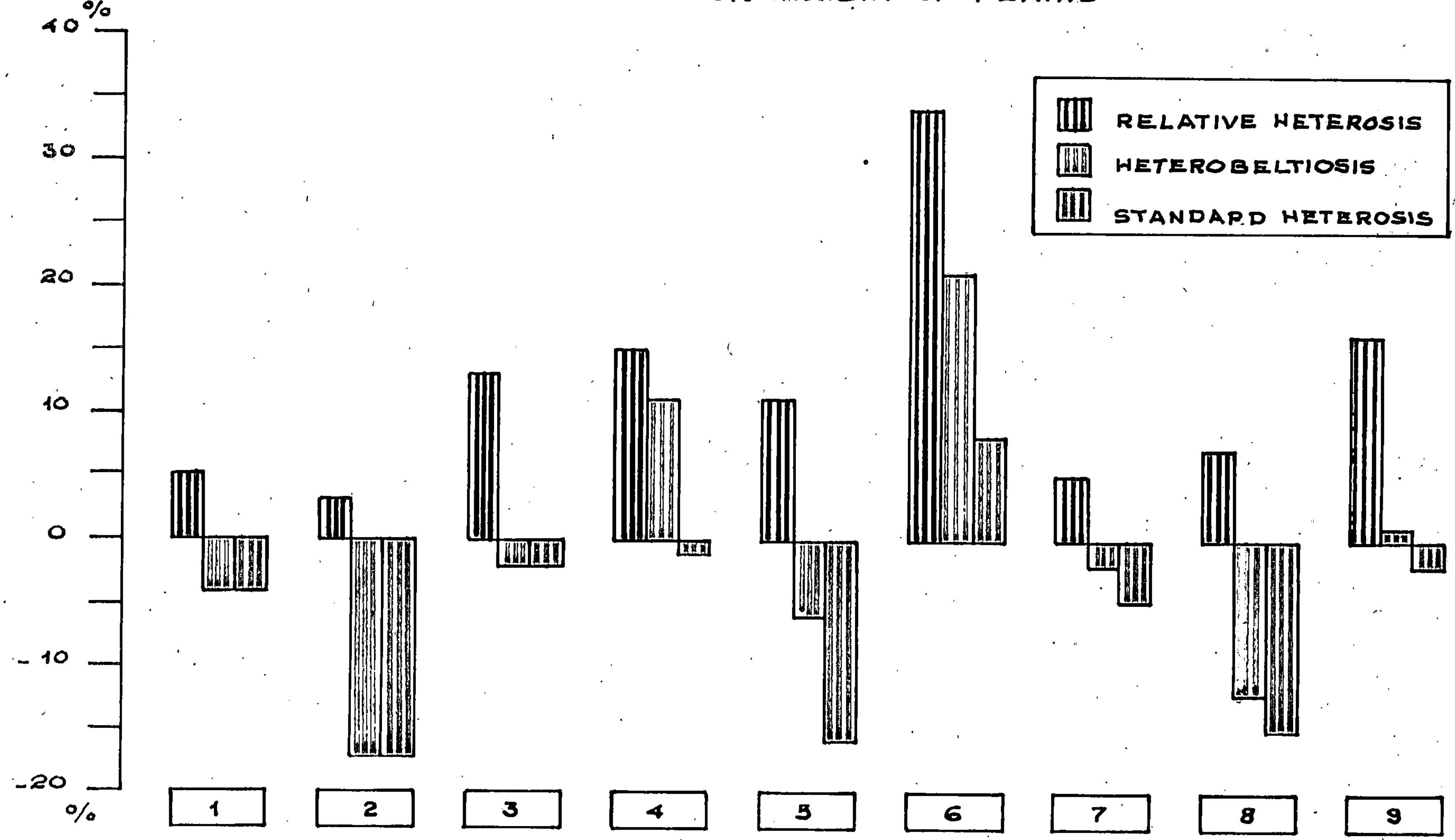


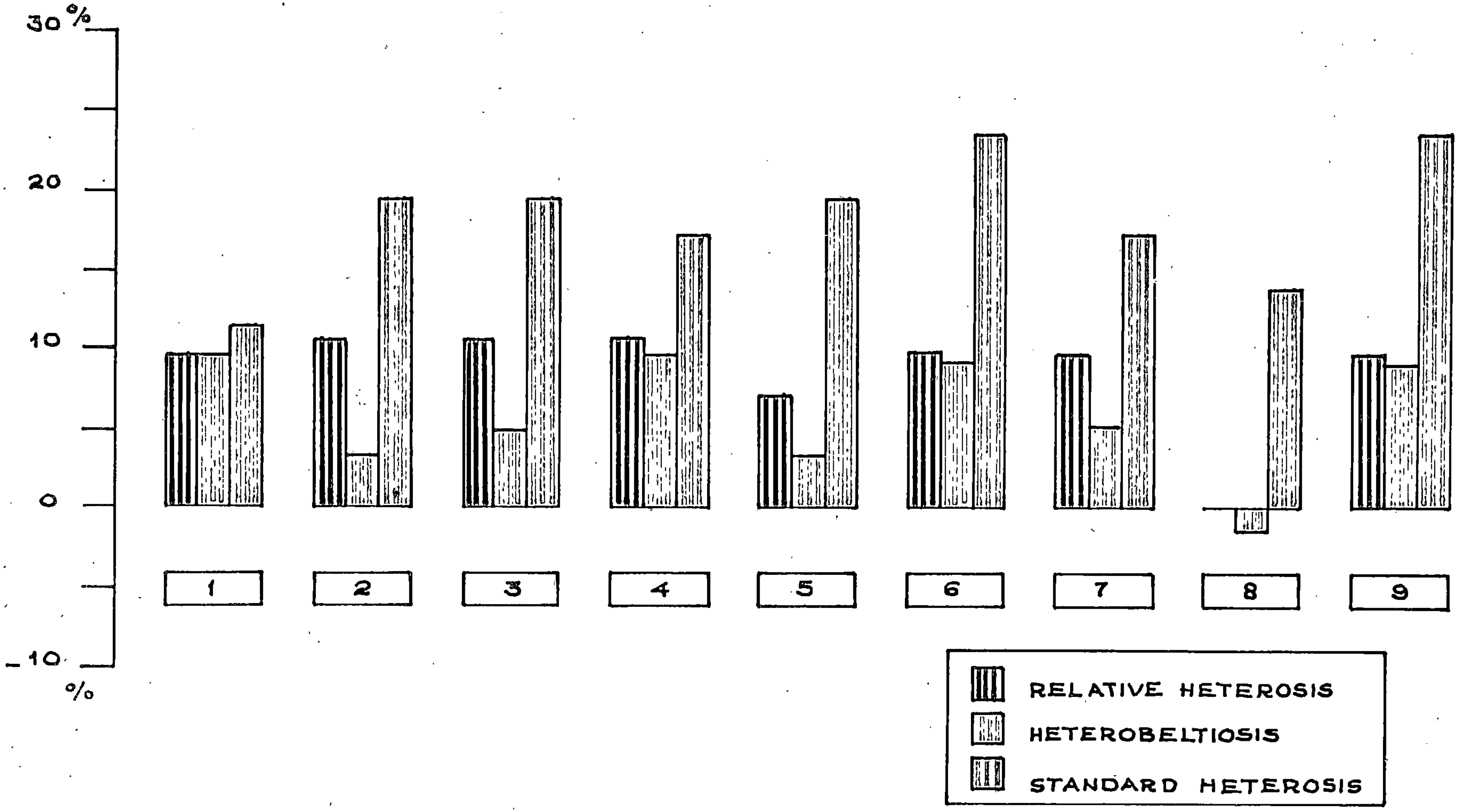
Table 7. Heterosis (percentage) for number of branches

Varieties/ hybrids	Mean			Relative heterosis	Hetero-beltiosis	Standard heterosis
	First trial	Second trial	Pooled			
BB	6.7	3.8	5.3	-	-	-
PPL	7.2	4.8	6.0	-	-	-
PPR	7.9	3.9	5.9	-	-	-
PPC	6.8	3.5	5.2	-	-	-
SM-6	7.8	3.4	5.6	-	-	-
SMI-10	6.9	4.7	5.8	-	-	-
PPC x BB	7.3	4.3	5.8	9.4	9.4	11.5
PPC x PPL	7.9	4.4	6.2	10.7	3.3	19.2
PPC x PPR	7.3	5.1	6.2	10.7	5.1	19.2
SM-6 x BB	7.8	4.3	6.1	10.9	8.9	17.3
SM-6 x PPL	8.6	3.8	6.2	6.9	3.3	19.2
SM-6 x PPR	7.9	4.9	6.4	10.3	8.5	23.1
SMI-10 x BB	7.7	4.4	6.1	8.9	5.2	17.3
SMI-10 x PPL	7.6	4.1	5.9	0.0	-1.7	13.5
SMI-10 x PPR	8.5	4.3	6.4	9.4	8.5	23.1

FIGURE 13. HETEROSIS FOR NUMBER OF BRANCHES

1. PPC x BB
2. PPC x PPL
3. PPC x PPR
4. SM-6 x BB
5. SM-6 x PPL
6. SM-6 x PPR
7. SMI-10 x BB
8. SMI-10 x PPL
9. SMI-10 x PPR

FIGURE 13. HETEROSIS FOR NUMBER OF BRANCHES



in the hybrids SM-6 x PPR and SMI-10 x PPR. SM-6 x PPR was found to be the best hybrid for number of branches.

4. <u>Days to final harvest</u>

Table 8 represents the mean values and the three heterosis estimates for this character. Figure 14 shows the heterosis estimates graphically. Relative heterosis was positive for all hybrids except SM-6 x PPL and SMI-10 x PPL. PPC x BB showed maximum heterosis followed by SM-6 x PPR. In comparison with the better parent, positive heterosis was exhibited only by SM-6 x PPR. None of the hybrids gave positive heterosis over the standard variety but PPC x PPR and SM-6 x PPR proved comparatively better. SM-6 x PPR was identified as the best performer for days to final harvest.

5. <u>Number of fruits per plant</u>

The mean values of the six varieties and nine hybrids and the three estimates of heterosis are presented in Table 9. The heterosis values are presented graphically in Figure 15. All the hybrids revealed positive heterosis in comparison with the mid-parent except SM-6 x BB. SMI-10 x PPL was the top ranker. Heterobeltiosis was negative in all the hybrids except SMI-10 x PPL which proved its marked superiority. Standard heterosis was negative in all the hybrids with the least value in SMI-10 x PPL. Thus the hybrid SMI-10 x PPL proved most heterotic for number of fruits per plant.

Table 8. Heterosis (percentage) for days to final harvest

Varieties/ hybrids	Mean			Relative heterosis	Hetero-beltiosis	Standard heterosis
	First trial	Second trial	Pooled			
BB	91.5	83.9	87.7	-	-	-
PPL	113.8	59.4	86.6	-	-	-
PPR	111.3	80.9	96.1	-	-	-
PPC	122.8	123.0	122.9	-	-	-
SM-6	123.7	112.3	118.0	-	-	-
SMI-10	119.9	115.1	117.5	-	-	-
PPC x BB	124.2	111.8	118.0	12.1	-4.0	-4.0
PPC x PPL	123.3	88.5	105.9	1.1	-13.8	-13.8
PPC x PPR	122.8	118.7	120.8	10.3	-1.7	-1.7
SM-6 x BB	121.4	104.6	113.0	9.8	-4.2	-8.1
SM-6 x PPL	122.3	63.8	93.1	-9.0	-21.1	-24.3
SM-6 x PPR	123.7	114.6	119.2	11.3	1.0	-3.0
SMI-10 x BB	122.3	99.2	110.8	8.0	-5.7	-9.9
SMI-10 x PPL	124.2	79.0	101.6	-0.5	-13.5	-17.3
SMI-10 x PPR	122.5	106.9	114.7	7.4	-2.4	-6.7

FIGURE 14. HETEROSIS FOR DAYS TO FINAL HARVEST

1. PPC x BB	4. SM-6 x BB	7. SMI-10 x BB
2. PPC x PPL	5. SM-6 x PPL	8. SMI-10 x PPL
3. PPC x PPR	6. SM-6 x PPR	9. SMI-10 x PPR

FIGURE 14. HETEROSIS FOR DAYS TO FINAL HARVEST

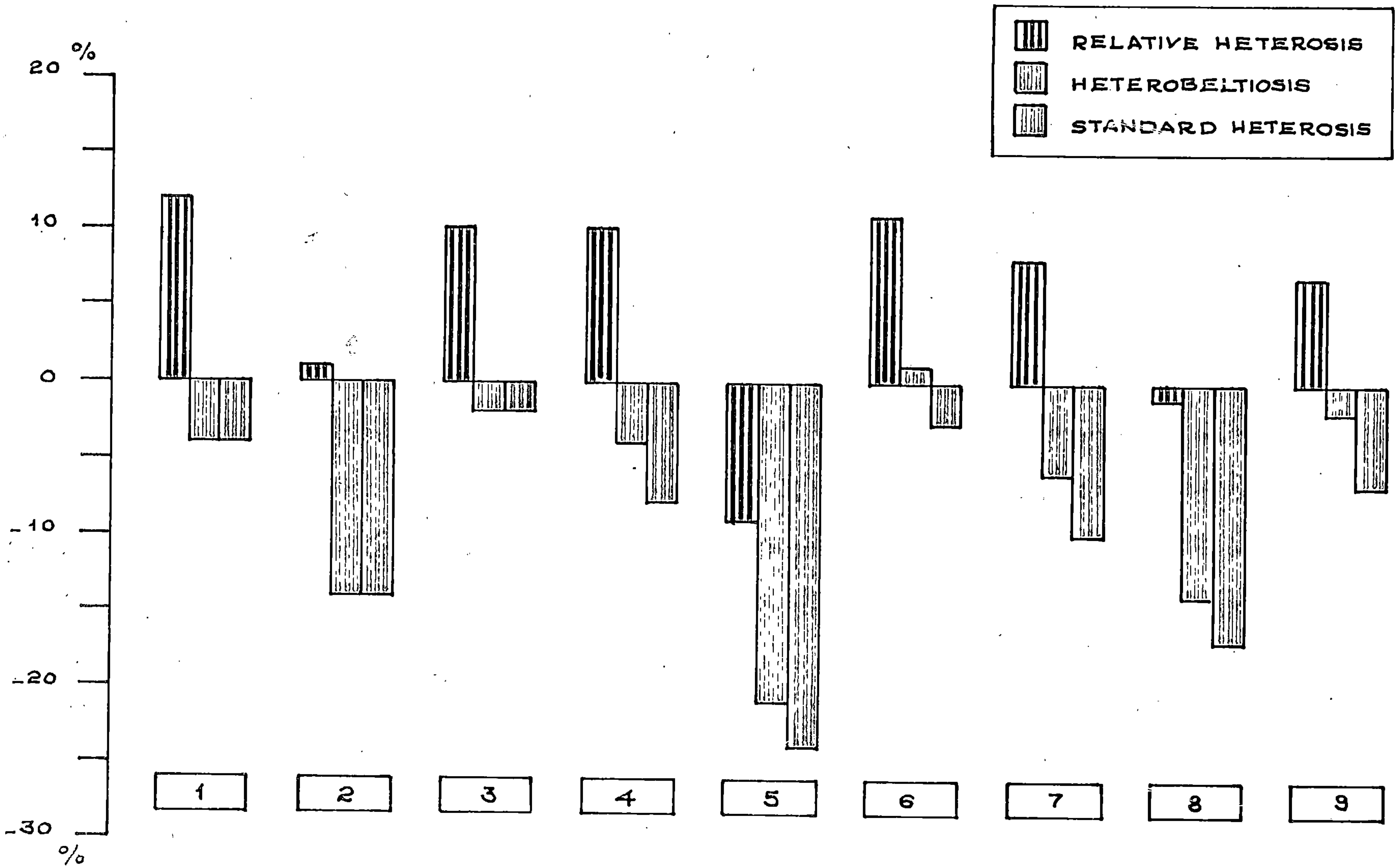


Table 9. Heterosis (percentage) for number of fruits per plant

Varieties/ hybrids	Mean			Relative heterosis	Hetero-beltiosis	Standard heterosis
	First trial	Second trial	Pooled			
BB	3.87	2.23	3.05	-	-	-
PPL	10.53	2.00	6.27	-	-	-
PPR	6.00	3.99	5.00	-	-	-
PPC	27.27	29.94	28.61	-	-	-
SM-6	27.53	8.60	18.07	-	-	-
SMI-10	18.07	13.67	15.87	-	-	-
PPC x BB	22.13	10.80	16.47	4.0	-42.4	-42.4
PPC x PPL	31.53	7.07	19.30	10.7	-32.5	-32.5
PPC x PPR	19.13	16.80	17.97	6.9	-37.2	-37.2
SM-6 x BB	15.20	5.74	10.47	-0.9	-42.1	-63.4
SM-6 x PPL	23.20	2.80	13.00	6.8	-28.1	-54.6
SM-6 x PPR	20.93	9.60	15.27	32.3	-15.5	-46.6
SMI-10 x BB	22.13	6.43	14.28	51.0	-10.0	-50.1
SMI-10 x PPL	36.87	4.50	20.69	86.9	30.4	-27.7
SMI-10 x PPR	21.47	9.27	15.37	47.2	-3.2	-46.3

FIGURE 15. HETEROSIS FOR NUMBER OF FRUITS PER PLANT

1. PPC x BB
2. PPC x PPL
3. PPC x PPR
4. SM-6 x BB
5. SM-6 x PPL
6. SM-6 x PPR
7. SMI-10 x BB
8. SMI-10 x PPL
9. SMI-10 x PPR

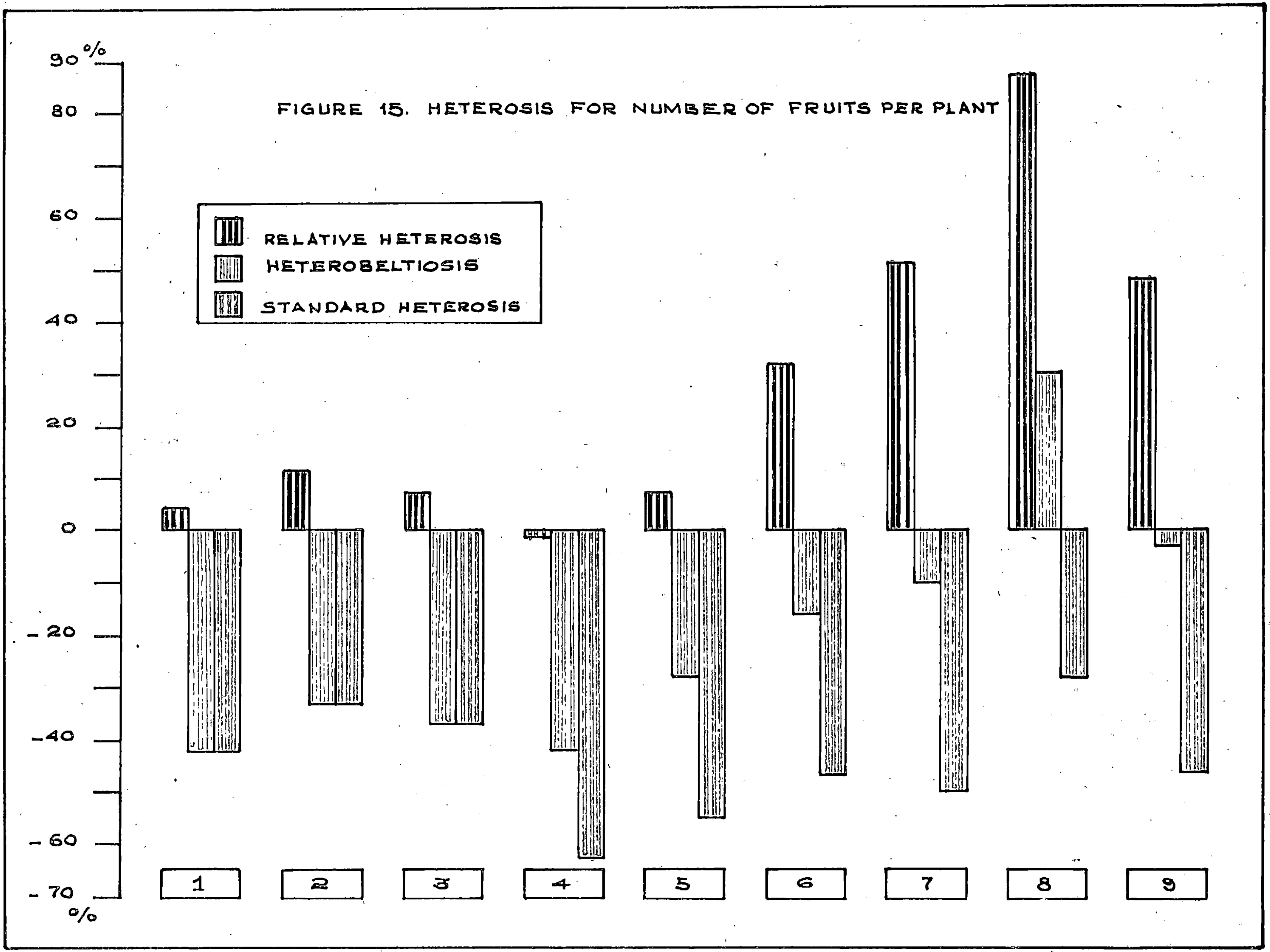


FIGURE 15. HETEROSIS FOR NUMBER OF FRUITS PER PLANT
RELATIVE HETEROSIS
HETEROBELTIOSIS
STANDARD HETEROSIS
90 %
80
60
40
20
0
- 20
-40
- 60
- 70 %
1
2
3
4
5
6
7
8
9

6. Weight of fruit

Table 10 represents the computations of the three estimates of heterosis for fruit weight. A graphical picture of heterosis is presented in Figure 16. Positive relative heterosis was noted in all the cases, the better hybrids being PPC x BB, SM-6 x BB and PPC x PPR. SMI-10 x PPL had the lowest value. Heterobeltiosis was negative in the case of SM-6 x PPR, while maximum positive value was given by SM-6 x BB followed by PPC x BB. Standard heterosis was markedly high in all the hybrids, the best being PPC x PPR followed by SMI-10 x BB and SM-6 x BB.

7. Volume of fruit

Table 11 indicates the mean values of the varieties and hybrids and the three heterosis estimates. Figure 17 gives an illustration of the heterosis values. All the hybrids manifested positive relative heterosis with SM-6 x BB as the best followed by PPC x BB. When compared to the better parent, only one hybrid SMI-10 x PPL gave negative heterosis. Maximum heterosis was recorded by SM-6 x BB. Marked standard heterosis was also shown by all hybrids, the top rankers being SM-6 x BB and PPC x PPR. SM-6 x BB gave maximum heterosis in all the three estimates and proved most superior.

8. Weight of fruits per plant at three months

The computations of relative heterosis, heterobeltiosis and standard heterosis for this character are provided in Table 12.

Table 10. Heterosis (percentage) for weight of fruit

Varieties/ hybrids	Mean (g)			Relative heterosis	Hetero-beltiosis	Standard heterosis
	First trial	Second trial	Pooled			
BB	94	47	71	-	-	-
PPL	81	51	66	-	-	-
PPR	125	71	98	-	-	-
PPC	51	42	47	-	-	-
SM-6	72	45	59	-	-	-
SMI-10	108	68	88	-	-	-
PPC x BB	130	79	105	78.0	47.9	123.4
PPC x PPL	93	47	70	23.9	6.1	48.9
PPC x PPR	144	103	124	71.0	26.5	163.8
SM-6 x BB	147	78	113	73.9	59.2	140.4
SM-6 x PPL	95	60	78	24.8	18.2	66.0
SM-6 x PPR	121	68	95	21.0	-3.1	102.1
SMI-10 x BB	172	58	115	44.7	30.7	144.7
SMI-10 x PPL	114	66	90	16.9	2.3	91.5
SMI-10 x PPR	149	70	110	18.3	12.3	134.0

FIGURE 16. HETEROSIS FOR WEIGHT OF FRUIT

1. PFC x BB	4. SM-6 x BB	7. SMI-10 x BB
2. PFC x PPL	5. SM-6 x PPL	8. SMI-10 x PPL
3. PFC x PPR	6. SM-6 x PPR	9. SMI-10 x PPR

FIGURE 16. HETEROSIS FOR WEIGHT OF FRUIT

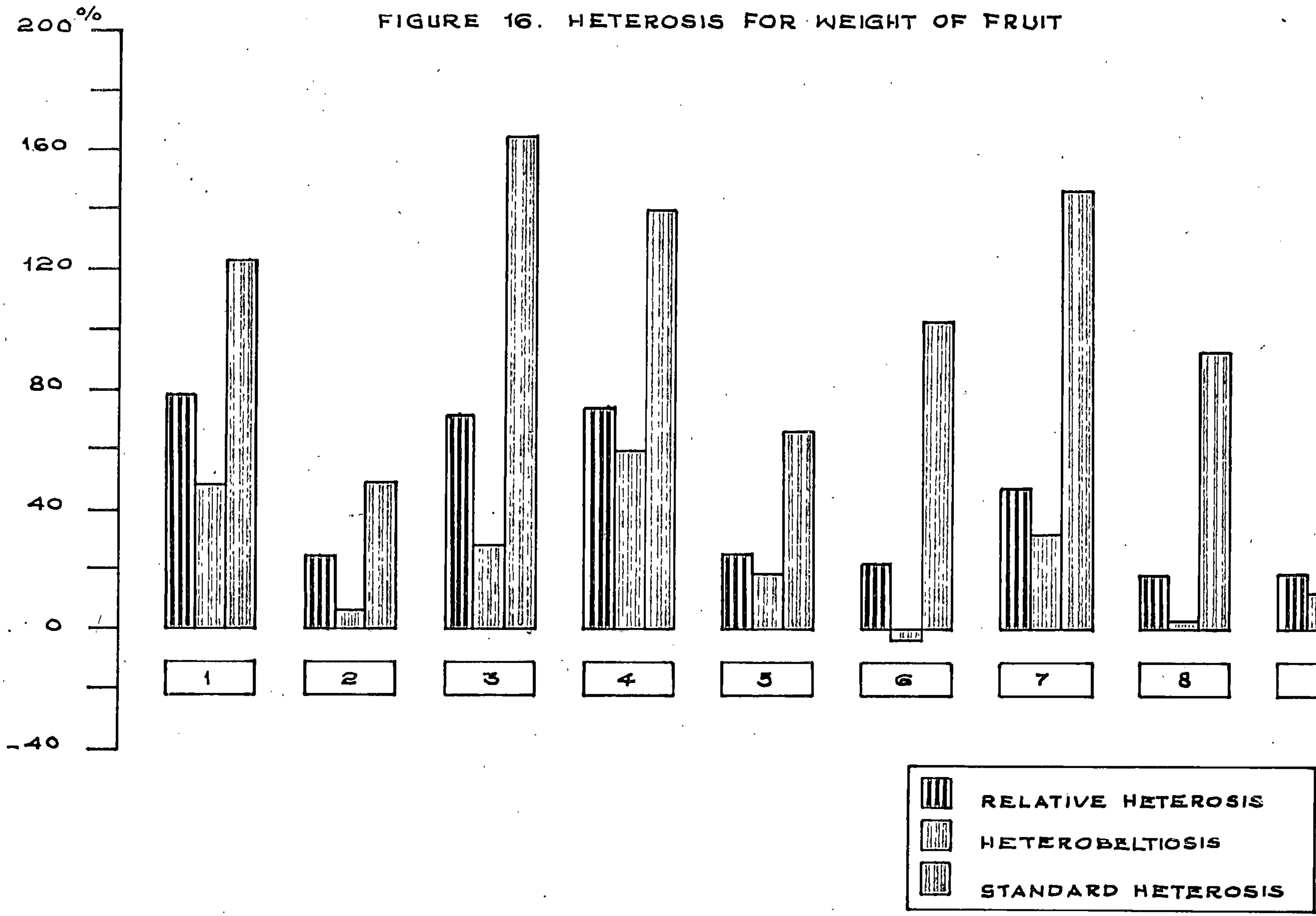


Table 11. Heterosis (percentage) for volume of fruit

Varieties/ hybrids	Mean (ml) First trial	Second trial	Pooled	Relative heterosis	Hetero-beltiosis	Standard heterosis
BB	121	72	97	-	-	-
PPL	101	69	85	-	-	-
PPR	159	85	122	-	-	-
PPC	46	64	55	-	-	-
SM-6	97	71	84	-	-	-
SMI-10	172	98	135	-	-	-
PPC x BB	178	104	141	85.5	45.4	156.4
PPC x PPL	118	75	97	38.6	14.1	76.4
PPC x PPR	181	144	163	84.2	33.6	196.4
SM-6 x BB	279	113	196	116.6	102.1	256.4
SM-6 x PPL	148	96	122	44.4	43.5	121.8
SM-6 x PPR	146	97	122	18.5	0.0	121.8
SMI-10 x BB	234	84	159	37.1	17.8	189.1
SMI-10 x PPL	161	100	131	19.1	-3.0	138.2
SMI-10 x PPR	201	104	153	19.1	13.3	178.2

FIGURE 17. HETEROSIS FOR VOLUME OF FRUIT

1. PPC x BB
2. PPC x PPL
3. PPC x PPR
4. SM-6 x BB
5. SM-6 x PPL
6. SM-6 x PPR
7. SMI-10 x BB
8. SMI-10 x PPL
9. SMI-10 x PPR

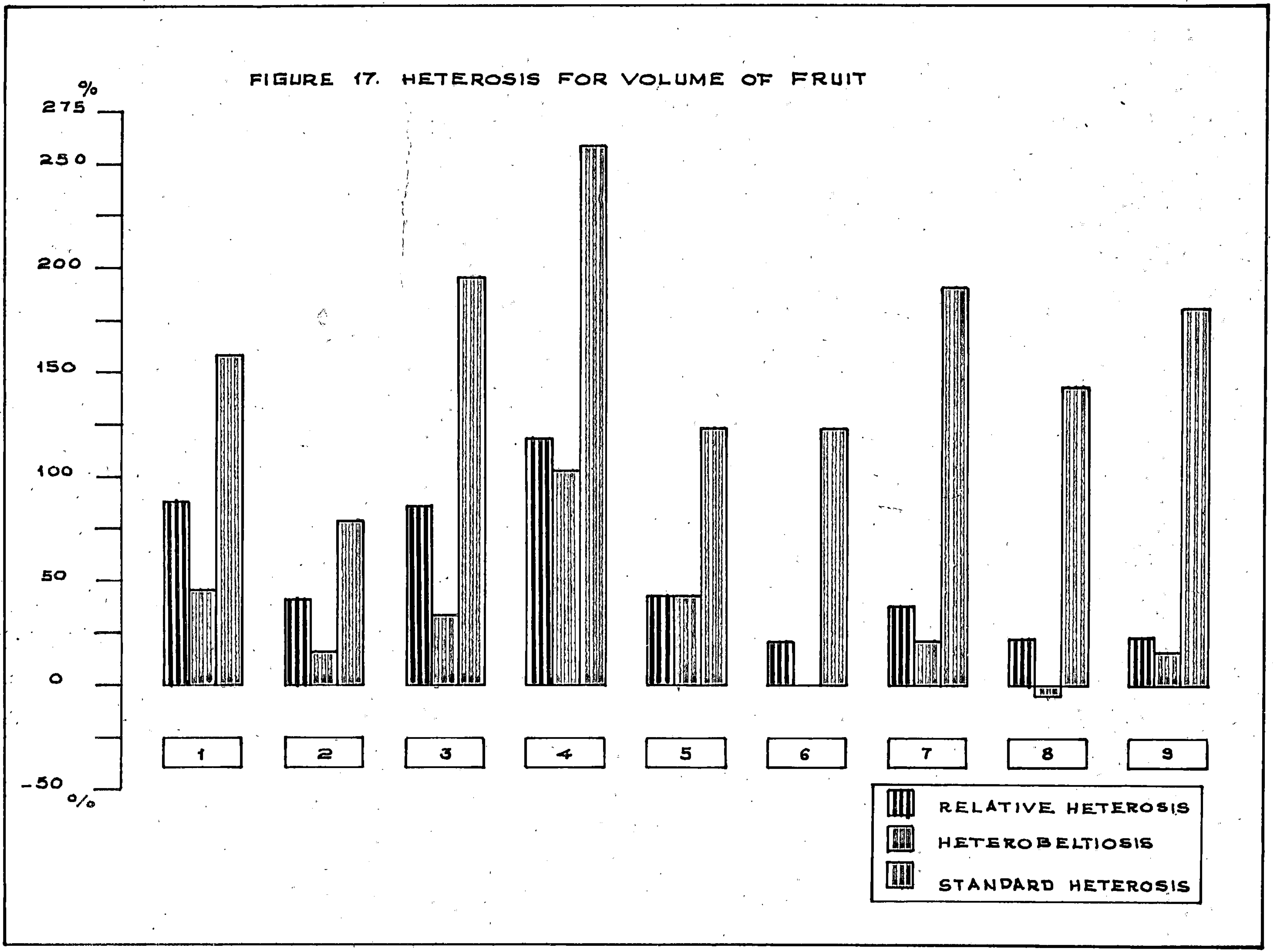


FIGURE 17. HETEROSIS FOR VOLUME OF FRUIT
%
275
250
200
150
100
50
0
-50
%
1
2
3
4
5
6
7
8
9
RELATIVE HETEROSIS
HETEROBELTIOSIS
STANDARD HETEROSIS

Table 12. Heterosis (percentage) for weight of fruits per plant at three months

Varieties/ hybrids	Mean (g)			Relative heterosis	Hetero- beltiosis	Standard heterosis
	First trial	Second trial	Pooled			
BB	150	76	113	-	-	-
PPL	118	93	106	-	-	-
PPR	219	169	194	-	-	-
PPC	176	411	294	-	-	-
SM-6	418	226	322	-	-	-
SMI-10	398	315	357	-	-	-
PPC x BB	445	344	395	94.1	34.4	34.4
PPC x PPL	559	145	352	76.0	19.7	19.7
PPC x PPR	361	415	388	59.0	32.0	32.0
SM-6 x BB	486	181	334	53.6	3.7	13.6
SM-6 x PPL	547	147	347	62.2	7.8	18.0
SM-6 x PPR	554	142	348	34.9	8.1	18.4
SMI-10 x BB	640	160	400	70.2	12.1	36.1
SMI-10 x PPL	668	230	449	94.0	25.8	52.7
SMI-10 x PPR	593	419	506	83.7	41.7	72.1

They are graphically presented in Figure 18. Relative heterosis was positive in all the hybrids with marked values in PPC x BB, SMI-10 x PPL and SMI-10 x PPR. Heterobeltiosis was also positive in all the hybrids with SMI-10 x PPR ranking first. When compared to the standard variety, SMI-10 x PPR proved most superior and this hybrid can be said to be the best hybrid with respect to this character.

9. <u>Weight of fruits per plant (final)</u>

Table 13 depicts the mean weight of fruits per plant and the three estimates of heterosis. Figure 19 provides a graphical illustration of the heterosis values. Positive relative heterosis was exhibited by all the hybrids. However, PPC x BB, SMI-10 x BB and SMI-10 x PPR were superior. Heterobeltiosis and standard heterosis were also positive for all hybrids except PPC x PPR with the hybrid SMI-10 x PPR ranking first in both the cases. The hybrid, SMI-10 x PPR can be classed as the best hybrid for weight of fruits per plant.

Among the three resistant varieties, Pusa purple cluster is recommended for wilt endemic areas, taking advantage of its resistance in spite of the low yield and inferior fruit quality. As such the desirability of the hybrids as commercial types has to be decided based on their performance in relation to Pusa purple cluster. Standard heterosis in all the hybrids in respect of the nine characters in relation to Pusa purple cluster are presented

FIGURE 18. HETEROSIS FOR WEIGHT OF FRUITS PER PLANT AT THREE MONTHS

1. PFC x BB
2. PFC x PPL
3. PFC x PPR
4. SM-6 x BB
5. SM-6 x PPL
6. SM-6 x PPR
7. SMI-10 x BB
8. SMI-10 x PPL
9. SMI-10 x PPR

FIGURE 18. HETEROSIS FOR WEIGHT OF FRUITS PER PLANT AT THREE MONTHS

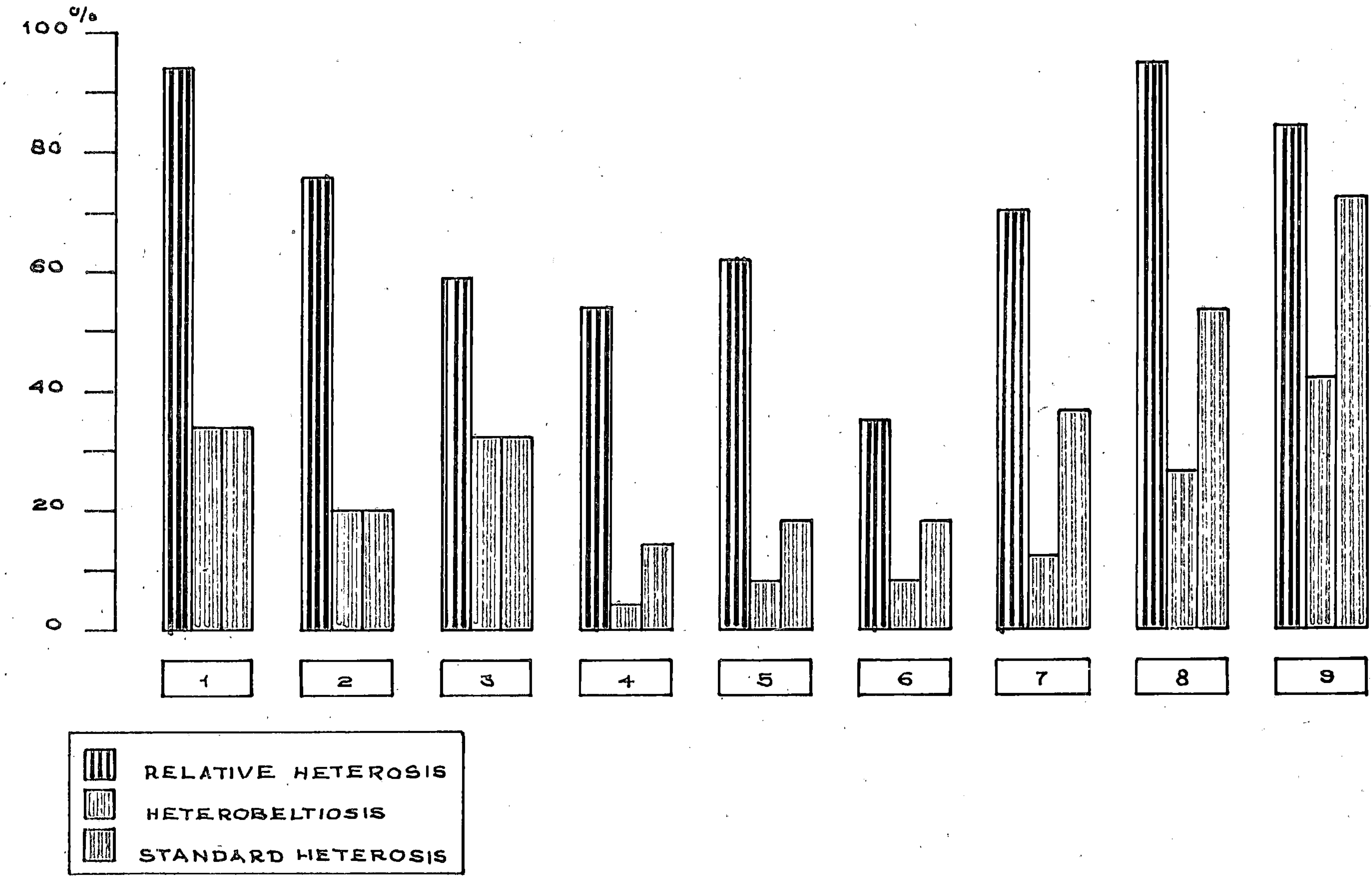


Table 13. Heterosis (percentage) for weight of fruits per plant (final)

Varieties/ hybrids	Mean (g) First trial	Mean (g) Second trial	Mean (g) Pooled	Relative heterosis	Hetero-beltiosis	Standard heterosis
BB	258	100	179	-	-	-
PPL	466	105	286	-	-	-
PPR	428	210	319	-	-	-
PPC	625	782	704	-	-	-
SM-6	1008	335	672	-	-	-
SMI-10	886	643	765	-	-	-
PPC x BB	1176	640	908	105.7	29.0	29.0
PPC x PPL	1313	206	760	53.5	8.0	8.0
PPC x PPR	1134	104	619	21.0	-12.1	-12.1
SM-6 x BB	1093	319	706	65.9	5.1	0.0
SM-6 x PPL	1400	170	785	63.9	16.8	11.5
SM-6 x PPR	1201	481	841	69.7	25.2	19.5
SMI-10 x BB	1498	329	914	93.6	19.5	29.8
SMI-10 x PPL	1534	276	905	72.2	18.3	28.6
SMI-10 x PPR	1370	666	1018	87.8	33.1	44.6

FIGURE 19. HETEROSIS FOR WEIGHT OF FRUITS PER PLANT (FINAL)

1. PPC x BB
2. PPC x PPL
3. PPC x PPR
4. SM-6 x BB
5. SM-6 x PPL
6. SM-6 x PPR
7. SMI-10 x BB
8. SMI-10 x PPL
9. SMI-10 x PPR

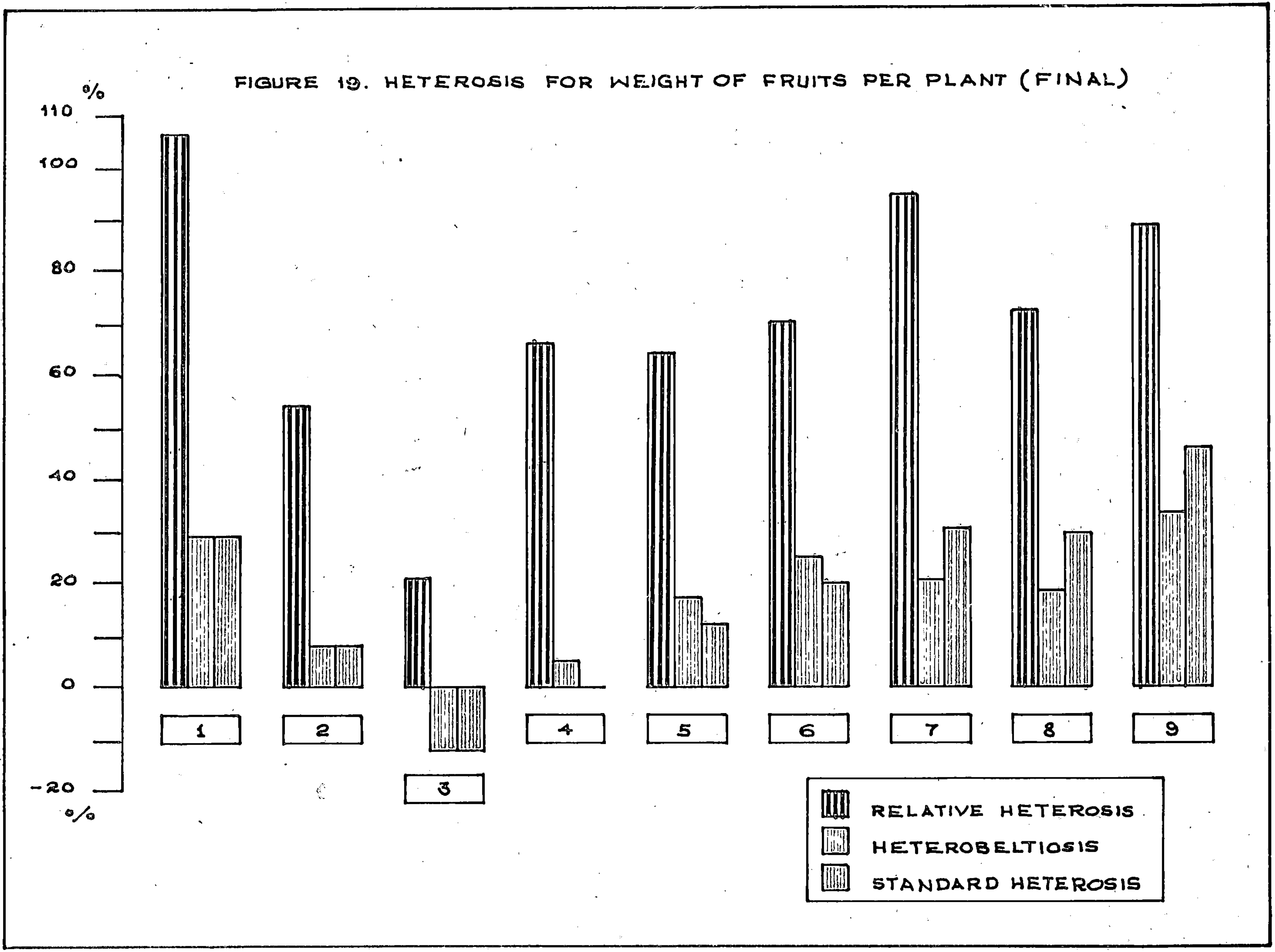


FIGURE 19. HETEROSIS FOR WEIGHT OF FRUITS PER PLANT (FINAL)
%
110
100
80
60
40
20
0
-20
%
1
2
3
4
5
6
7
8
9
RELATIVE HETEROSIS
HETEROBELTIOSIS
STANDARD HETEROSIS

in Table 14. All the hybrids were better than the standard for weight of fruit per plant at three months, with SMI-10 x PPR and SMI-10 x PPL giving substantially high yields. In respect of weight of fruits per plant (final) all the hybrids except PPC x PPR were superior to the standard with SMI-10 x PPR registering the maximum increase. As such these two hybrids are expected to have acceptance as commercial types in wilt endemic areas.

Table 14. Standard heterosis in the hybrids for the nine characters studied

Hybrids	Days to first flowering	Height of plants	Number of branches	Days to final harvest	Number of fruits per plant	Weight of fruit	Volume of fruit	Weight of fruit per plant at three months	Weight of fruit per plant (final)
PPC x BB	-15.9	-4.2	11.5	-4.0	-42.4	123.4	156.4	34.4	29.0
PPC x PPL	-18.2	-16.8	19.2	-13.8	-32.5	48.9	76.4	19.7	8.0
PPC x PPR	-13.6	-2.1	19.2	-1.7	-37.2	163.8	196.4	32.0	-12.1
SM-6 x BB	-18.2	-1.1	17.3	-8.1	-63.4	140.4	256.4	13.6	0.3
SM-6 x PPL	-15.9	-15.8	19.2	-24.3	-54.6	66.0	121.8	18.0	11.5
SM-6 x PPR	-11.4	8.4	23.1	-3.0	-46.6	102.1	121.8	18.4	19.5
SMI-10 x BB	-9.1	-5.3	17.3	-9.9	-50.1	144.7	189.1	36.1	29.8
SMI-10 x PPL	-25.0	-14.7	13.5	-17.3	-27.7	91.5	138.2	52.7	28.6
SMI-10 x PPR	-15.9	-2.1	23.1	-6.7	-46.3	134.0	178.2	72.1	44.6

DISCUSSION

DISCUSSION

Brinjal is one of the most popular vegetable crops under large scale cultivation in India. Several varieties of this vegetable are available, with each region having its own preferences for certain types. A wide range of variation is thus available for utilisation in genetic improvement programmes. However, crop improvement in brinjal has not been quite exhaustive as in other solanaceous vegetables such as tomato and chilli.

Hybrid vigour in brinjal has been investigated by many workers and heterosis for most of the economic characters has been established (Pal and Singh, 1946; Mishra, 1961; Tiwari, 1966; Gopimony, 1968; Peter and Singh, 1974; Badr et al., 1977; Bhutani et al., 1980 and Patil and Shinde, 1984). The ease of producing crossed seeds through hand pollination has enabled the exploitation of heterosis in brinjal for commercial purposes.

One of the major constraints in the commercial cultivation of brinjal in the tropical and subtropical regions of the world is the heavy incidence of bacterial wilt. The disease flares up all on a sudden and sometimes the entire crop is lost. The yield reduction has been estimated to be as high as 62% by Das and Chattopadhyay (1955). In many instances, farmers have been forced to abandon the cultivation of brinjal due to bacterial wilt incidence. The crop is susceptible to the disease at all stages and the plants begin wilting suddenly while the leaves are still green (Davidson, 1935).

The use of resistant varieties is in fact the cheapest and the only effective means of combating the disease. Almost all the commercial varieties are susceptible to wilt and are not suited for cultivation in wilt endemic areas. Hence, there is an urgent need to develop superior varieties that combine high yield potential with bacterial wilt resistance. With this end in view, the present study was undertaken to evolve superior wilt resistant hybrids of brinjal for wilt prevalent areas.

Three commercial varieties and three resistant varieties were selected. Cross combinations between the commercial varieties alone were ruled out as the hybrids would not be resistant. Similarly crosses between the resistant varieties were also avoided because this would not give high yielding progeny. Thus, nine combinations between the three resistant and three commercial varieties were studied. The resistant varieties were used as the ovule parents to ensure the production of hybrid seeds without the mother plants wilting off. The six varieties and nine hybrids were subjected to detailed investigations on resistance and productivity, the results of which are discussed in the following pages.

Reaction to bacterial wilt

The bacterial colonies obtained in the present study on Peptone Casamino Acid and Tetrazolium Chloride media were similar in morphology to those obtained by Das and Chattopadhyay (1955). The bacterial isolates showed motility as reported by Hayward

(1964). They failed to produce any pigmentation on Yeast Glucose Chalk Agar medium. Similar results were reported by Nayar (1982).

The physiological tests conducted on the pathogen revealed that starch hydrolysis was negative in the isolates. This is in agreement with the findings of Hayward (1964) but contradicts those of Das and Chattopadhyay (1955) and Nayar (1982). However, the catalase positive reaction, levan production and utilisation of carbon sources noted in the present investigation were similar to the observations of Nayar (1982). Based on these findings, the bacterial isolate in the present investigation was characterised and identified as Pseudomonas solanacearum.

The six varieties and nine hybrids were evaluated for resistance to wilt under conditions of artificial infection. At the end of four weeks of screening, the commercial varieties (Black beauty, Pusa purple long and Pusa purple round) showed complete wilting indicating high susceptibility. This study has thus confirmed the high susceptibility of the variety Pusa purple long as reported by Gowda et al. (1974). Among the resistant varieties, Pusa purple cluster showed maximum wilting of 75%. Similar reports were made by Gopimony and George (1979) and Gopimony (1983). This variety was however reported to be resistant to wilt by Rao et al. (1976). The hybrids were also found to be highly susceptible eventhough they were reported to be fairly resistant by Narayanan (1984). Sitaramaiah et al. (1981) found

Pusa purple round to be consistently highly resistant. Verma and Singh (1983) have suggested Pusa purple round as a source of resistance to wilt. But the findings of Narayanan (1984) contradict the above results.

Field scoring for the disease revealed that the commercial varieties gave a wilting of 5 to 43% with maximum wilting in the variety, Pusa purple long. The resistant varieties and the hybrids showed fairly high resistance. Wilting was up to 6% in all the hybrids except SM-6 x PPL with 21% and PPC x PPL with 10%. The hybrids were therefore definitely superior in resistance and were almost on par with the resistant varieties. Narayanan (1984) also obtained similar results with the same hybrids. The hybrids involving Pusa purple long as pollen parent (except SMI-10 x PPL) were found to be least resistant.

Heterosis for yield and its attributes

Significant differences between the varieties and hybrids were noted for total weight of fruits per plant. The hybrids proved superior with a mean yield of 828 g. as against 488 g. in the varieties. Relative heterosis was marked in the hybrid PPC x BB while heterobeltiosis was notable in SMI-10 x PPR. The latter also proved to be superior to the standard variety, Pusa purple cluster. All the hybrids showed positive relative heterosis, heterobeltiosis and standard heterosis for yield per plant at three months indicating the superiority of the hybrids over the parents. The mean yield of the hybrids at three months was 391 g.

whereas it was only 231 g. in the varieties. The hybrid PPC x BB was superior with respect to the mid parental value while heterobeltiosis was marked in SMI-10 x PPR. The latter proved superior over the standard variety also. These results are in confirmity with the reports on heterosis for yield per plant in brinjal by Silvetti and Brunelli (1970), Peter and Singh (1974), Cheah et al. (1981) and Kandasamy et al. (1983).

The varieties and hybrids differed significantly for fruit number per plant also. The mean number of fruits in the varieties was 12.8 whereas it was 15.9 in the hybrids. The hybrid SMI-10 x PPL was superior over the mid parent value. When compared to the better parent also, this hybrid showed positive heterobeltiosis. None of the hybrids could excell the standard variety, Pusa purple cluster, which was the most prolific bearer. Heterosis for fruit number was reported by several early workers such Mishra (1977), Singh et al. (1978a), Salehuzzaman (1981), Balamohan et al. (1983) and Patil and Shinde (1984).

All the hybrids exhibited positive, relative and standard heterosis for weight of fruit. Heterobeltiosis was also positive in all but one hybrid (SM-6 x PPR). Heterosis for weight of fruit has been noted by Viswanathan (1973), Singh et al. (1981) and Dixit et al. (1982). The hybrids with a mean weight of 100 g. per fruit were generally superior to the varieties (71.5 g). Relative heterosis was significant in the hybrids PPC x BB and SM-6 x BB. The latter hybrid was also superior to the better parent, Black beauty, for weight of fruit. Standard heterosis was marked in the hybrids PPC x PPR, SMI-10 x BB and SM-6 x BB. The hybrid SM-6 x BB can be rated as the best hybrid for fruit weight. When Black beauty, which possessed heavy fruits, was used as the pollen parent, the hybrids generally gave fruits with increased weight.

Variation was observed in the case of fruit size also between the varieties and hybrids. The hybrids with a mean fruit volume of 143 ml were superior to the varieties (96 ml). In general, the hybrids possessed bigger fruits than Pusa purple cluster, the standard variety. The hybrids involving Black beauty as the pollen parent proved to be superior, the hybrid SM-6 x BB being the best for fruit volume. Relative heterosis was maximum in the hybrids SM-6 x BB and PPC x BB, the former proving superior over the better parent also. Standard heterosis was also markedly high in the hybrid SM-6 x BB. Heterosis for fruit volume was reported by Viswanathan (1973), Joarder et al. (1981) and Narayanan (1984).

Weight by volume ratio in brinjal indicates the softness or seediness of the fruit. Hence a low ratio will be consumers' preference for quality. A low value for fruit density indicates high flesh to seed ratio. The hybrids SM-6 x BB, SM-6 x PPL and PPC x PPL gave fruits with high flesh to seed ratio similar to the varieties SM-6, SMI-10 and Black beauty. When SM-6 was used as the ovule parent, the hybrids generally gave fruits of superior quality. High flesh to seed ratio in hybrids was also noted by Vijay and Nath (1976) and Dharmegowda et al. (1979b).

Height of plant is an indication of vegetative vigour. Marked heterosis especially in relation to the mid parent value, was shown by all the hybrids. In general, the hybrids (89 cm) exhibited greater height than the varieties (80 cm). Similar reports were made by Singh et al. (1977), Mishra (1977), Singh et al. (1981) and Dharmegowda et al. (1979b). The hybrid SM-6 x PPR showed maximum relative heterosis and heterobeltiosis for plant height. No other hybrid superceded the standard variety, Pusa purple cluster. When SM-6 was used as the ovule parent and Black beauty as the pollen parent independently, the hybrids generally showed increased plant height. Patil and Shinde (1984) also reported the superiority of Black beauty as parent variety for plant height.

The varieties and hybrids did not differ significantly for number of branches per plant in both the seasons. The mean number of branches in the varieties was 5.6 while that in the hybrids was 6.1. The hybrid SM-6 x PPR was found to be the best performer for this character. Heterosis over the mid parent was exhibited by SM-6 x BB, PPC x PPR and SM-6 x PPR while hetero-beltiosis was significant in the hybrids PPC x BB, SM-6 x BB, SM-6 x PPR and SMI-10 x PPR. When compared to the standard variety Pusa purple cluster, more number of branches was noted in SM-6 x PPR and SMI-10 x PPR. Superiority of hybrids for number of branches was reported by Gopimony and Sreenivasan (1970), Srivastava and Bajpai (1977), Singh et al. (1978 a) and Balamohan *et al*. (1983). When the varieties Black beauty and Pusa purple round were used as the pollen parents, the hybrids showed a tendency for greater branching.

Days to first flowering denotes the earliness or lateness of a variety. In the present study, most of the hybrids exhibited relative heterosis, heterobeltiosis and standard heterosis for earliness. The mean number of days taken to flower by the varieties was 41 whereas that in the hybrids was only 37. This clearly indicates the earliness of the hybrids. Similar reports were made by Vijay and Nath (1976), Singh *et al*. (1978 b) and Bhutani *et al*. (1980) while Salehuzzaman (1981) and Narayanan (1984) observed that the hybrids were not earlier than the early parent. The hybrid PPC x BB recorded maximum relative heterosis and heterobeltiosis for earliness. All the hybrids were found to be earlier than the standard variety, Pusa purple cluster, the maximum heterosis for earliness being shown by SMI-10 x PPL.

The days to final harvest reflects the yielding span of a variety. The mean number of days to final harvest was 105 in the varieties and 111 in the hybrids. This shows that the hybrids possessed a longer yielding span than the varieties. The hybrid PPC x BB recorded maximum heterosis over the mid parental value. No hybrid other than SM-6 x PPR proved heterotic over the better parent. None of the hybrids exceeded the yielding span of the standard variety, Pusa purple cluster. Mishra (1961) and Narayanan (1984) also reported heterosis for days to final harvest.

Hybrids involving SM-6 and SMI-10 as ovule parents were superior for yield per plant, number of fruits per plant and fruit characters such as weight, volume and density. SMI-10 x PPR produced maximum fruit yield per plant while SMI-10 x PPL proved superior for number of fruits per plant and earliness. The hybrid SM-6 x BB produced fruits with maximum weight and size. The flesh to seed ratio was also maximum in this hybrid. With respect to height and number of branches, the hybrid SM-6 x PPR proved superior. This hybrid also had a long fruiting span.

The present study was aimed at identifying high yielding hybrids possessing high field resistance to bacterial wilt. The field scoring showed that all the hybrids except SM-6 x PPL and PPC x PPL possessed fairly high resistance to bacterial wilt disease. Evaluation of the varieties and hybrids for wilt resistance and fruit yield revealed that the hybrids of commercial value are SMI-10 x PPR, SMI-10 x PPL, SM-6 x BB and SM-6 x PPR. Hence they appear to be of promise as commercial types. Since most of the commercial varieties available are susceptible to bacterial wilt and the resistant varieties are low yielders, the hybrids now identified are expected to go a long way in increasing the productivity of brinjal in bacterial wilt endemic areas.

SUMMARY

SUMMARY

Exploitation of genetic variability in brinjal (Solanum melongena L.) has resulted in a number of improved varieties. But a major constraint is the susceptibility of these varieties to the bacterial wilt disease caused by Pseudomonas solanacearum E.F.Smith. This disease has become a nightmare for brinjal cultivators due to the lack of effective control measures. Breeding for disease resistance seems to be the only remedy to this dreaded disease.

With this in view, a programme for developing resistant hybrids was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani, from 1984 to 1986. Three varieties of brinjal resistant to bacterial wilt (Pusa purple cluster, SM-6 and SMI-10) and three commercial but susceptible varieties (Black beauty, Pusa purple long and Pusa purple round) were crossed in all possible combinations with the resistant varieties as ovule parents. The six varieties and nine hybrids were evaluated for resistance to bacterial wilt under artificial infection as well as in the field. The bacterium causing wilt in brinjal was isolated from wilted plants. The cultural and physiological characters of the isolate were studied and the organism was identified.

Artificial wilt inoculation was made by three methods viz. planting seedlings in sick soil, dipping seedlings in a bacterial suspension before planting and inoculating the four weeks old seedlings with bacterial ooze.

The six varieties and nine hybrids were evaluated for yield and related characters in field trials conducted in two seasons (February to June 1985 and November 1985 to March 1986). The characters studied include, days to first flowering, height of plants, number of branches, days to final harvest, number of fruits per plant, weight of fruit, volume of fruit, density of fruit, weight of fruits per plant at three months and final weight of fruits per plant. The data obtained were tabulated and subjected to statistical analysis. The three estimates viz. relative heterosis, heterobeltiosis and standard heterosis were made in the hybrids for all the characters studied.

The bacterial colony was isolated from wilted plants on Peptone Casamino Acid and Triphenyl Tetrazolium Chloride media. Their cultural and physiological characters were studied. Based on these characteristics, the bacterium in this study was identified as Pseudomonas solanacearum.

The artificial screening trial revealed that the susceptible varieties showed complete wilting. Among the resistant varieties, Pusa purple cluster showed a maximum of 75% wilting. This variety reported to be resistant at Hessarghatta, was thus found to be susceptible under Vellayani conditions. The hybrids were also found to be fairly susceptible.

The field trial showed that the resistant varieties were truly resistant to wilt. The hybrids also proved highly resistant with wilting up to 6% except in PPC x PPL and SM-6 x PPL with 10% and 21% respectively.

Evaluation of the varieties and hybrids for yield and its components revealed that the hybrids involving SM-6 and SMI-10 as ovule parents were superior for yield per plant at three months and at final harvest, number of fruits per plant and fruit characters (weight, volume and density). SMI-10 x PPR gave maximum yield per plant while SMI-10 x PPL proved superior for number of fruits per plant and earliness. The hybrid SM-6 x BB produced fruits with maximum weight and size. The flesh to seed ratio was also maximum in this hybrid. SM-6 x PPR proved the best hybrid for height, number of branches and fruiting span.

A few superior hybrids identified in the present study are SMI-10 x PPR, SMI-10 x PPL, SM-6 x BB and SM-6 x PPR. These hybrids were found to possess fairly high resistance to bacterial wilt infection under field conditions. The study also revealed the superiority of these hybrids with respect to yield and related characters. These hybrids can hence be recommended for commercial cultivation for increasing the yield potential in brinjal especially in wilt endemic areas.

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(* Original not seen)

HETEROSIS FOR YIELD AND RESISTANCE TO BACTERIAL WILT IN BRINJAL

By

JAMEELA THOMAS

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Kerala Agricultural University

Department of Plant Breeding
COLLEGE OF AGRICULTURE
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ABSTRACT

Bacterial wilt of brinjal (*Solanum melongena* L.) caused by *Pseudomonas solanacearum* E.F.Smith is a serious threat to brinjal cultivation all over India. Most of the commercial varieties are highly susceptible to this disease and hence unsuitable for cultivation in wilt endemic areas. Farmers in many places have been forced to abandon cultivation due to heavy incidence of bacterial wilt. Since breeding for resistant varieties is the only answer to this problem, there is an urgent need to evolve high yielding varieties possessing fairly good resistance against wilt.

Nine cross combinations were made between three resistant varieties (Pusa purple cluster, SM-6 and SMI-10) as ovule parents and each of three commercial but susceptible varieties (Black beauty, Pusa purple long and Pusa purple round) as pollen parent, with a view to combine the wilt resistance of the former and high yield potential of the latter.

The bacterial pathogen causing wilt in brinjal was isolated. Based on the cultural and physiological characters it was identified as *Pseudomonas solanacearum*.

The varieties and hybrids were evaluated for wilt resistance under artificial infection and field conditions. Artificial wilt infection was created by sick soil, seedling dip and stem inoculation methods. In the field, all the hybrids except PPC x PPL and SM-6 x PPL, exhibited very high resistance.

Evaluation for yield and yield contributing characters revealed that the hybrid SMI-10 x PPR is superior for yield per plant while SMI-10 x PPL showed maximum heterosis for number of fruits per plant and earliness. The hybrid SM-6 x BB produced fruits of superior quality, while SM-6 x PPR proved superior for plant height, number of branches and days to final harvest. These hybrids possessing high yield potential as well as wilt resistance can be recommended for cultivation in bacterial wilt endemic areas for increasing the productivity of brinjal.