HETEROSIS AND GENETIC ANALYSIS INVOLVING ISOGENIC LINES IN BRINJAL RESISTANT TO BACTERIAL WILT

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Heterosis and genetic analysis involving isogenic lines in brinjal resistant to bacterial wilt" 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 my degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
24-5-1989.

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CERTIFICATE

Certified that this thesis entitled "Heterosis and genetic analysis involving isogenic lines in brinjal resistant to bacterial wilt" is a record of research work done independently by Mrs. Geetha P.T. 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.

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Vellanikkara,
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To my parents

CERTIFICATE

We, the undersigned members of the advisory committee of Mrs. Geetha P.T., a candidate for the degree of Master of Science in Horticulture agree that the thesis entitled "Heterosis and genetic analysis involving isogenic lines in brinjal resistant to bacterial wilt" may be submitted by Mrs. Geetha P.T., in partial fulfilment of the requirement for the degree.

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- -1989.

GEETHA P.T.

To my parents

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Introduction

INTRODUCTION

Brinjal (*Solanum melongena* L.) is one of the most common vegetables grown in India and abroad. The average productivity of brinjal is 20-25 t/ha in India. (Som and Maity, 1986). Reasons for this low productivity include non availability of high yielding varieties, inadequate use of fertilizers and incidence of serious pests and diseases affecting the crop. Productivity of F_1 hybrids are very high compared to the productivity of varieties. F_1 hybrids like Suphal from Indo American Hybrid Seeds, Bangalore and Arka Navneeth from IIHR, Bangalore yield 62 t/ha and 68-72 t/ha respectively. Users of F_1 hybrid seeds are likely to increase in coming years. Exploitation of hybrid vigour in brinjal is economical as each fruit contains a larger number of seeds compared to other vegetables.

One of the serious problems limiting brinjal cultivation is the occurance of bacterial wilt caused by *Pseudomonas solanacearum* E.F. Smith. It is particularly serious in acidic soils of Kerala. Gopimony and George (1979) reported that in various District Agricultural Farms in Kerala, the percentage of wilt in certain improved varieties like Arka Kusumkar and Banaras Giant are as high as 100% where as in local varieties this varies from 6% to 20%. SM 6, a brinjal line from Kerala Agricultural University showed considerable degree of tolerance to bacterial wilt. Studies conducted at the Department of Olericulture, Kerala Agricultural University, Vellanikkara indicated presence of transgressive segregant(s) within SM 6 which were grouped into eleven distinct types. Of these lines SM 6-2, SM 6-6 and SM 6-7 were resistant to bacterial wilt but late to bear and were of relatively low productivity. The present work is intended to improve further the above three lines for earliness and yield, keeping resistance to bacterial wilt intact through heterosis breeding.

The specific objectives of the study were,

1. to estimate heterosis in brinjal F_1 hybrids involving isogenic lines resistant to bacterial wilt.

2. to estimate quality characters in the isogenic lines and F_1 hybrids

3. to work out biochemical bases of resistance to bacterial wilt in the isogenic lines.

Review of Literature

REVIEW OF LITERATURE

A. Heterosis in brinjal

The first recorded report on artificial hybridisation in brinjal is of Bailey and Munson (1891) in the U.S.A. The first positive report on heterosis in brinjal comes from Halsted (1901). Subsequently Odland and Noll (1948) confirmed yield increase in hybrids. The range of increased yields of hybrids over the mean of respective parents varied from 11% to 153%. The highest yielding hybrid outyielded the highest yielding parent by 43.23 t/ha. The hybrid New Hampshire x florida High Bush yielded 153% more than the mean yield of parents.

In Philippines, Bayla (1918) hybridised a few local varieties and observed that the hybrids were more vigorous, stronger and healthier than the respective parents. Capinpin and Alviar (1949) reported that hybrid seeds had higher germination percentage, the hybrids were superior to the parental lines in early flowering and setting of fruit, fruits/plant, length of fruits (in crosses between long fruited types), mean equatorial diameter of fruits and in mean fruit weight.

In Japan, Nagai and Kida (1926) reported heterosis for total yield, fruits/plant, earliness of blossoming earliness of maturity, plant height, number of branches, number of spines on the pedicel and fruit length; no heterosis was found with regard to leaf length and breadth. Kakizaki (1938) observed hybrid vigour for seed weight, stem diameter, plant height and earliness of production.

In India, Rao (1934) made the first report on hybridisation among brinjal varieties. Venkataramani (1946) reported F_1 heterosis for germination percentage, yield, earliness of flowering and maturity, plant height, well branched and spreading habit, soft fruits with attractive shape and colour. Pal and Singh (1946) reported heterosis for seed germination, height, spread, height x spread value, number of branches, early flowering, fruits/plant, fruit size and yield.

Goto (1952) observed marked increase in total yield exhibited by F_1 hybrids among Japanese varieties. Mishra (1961, 1962 and 1966) observed heterosis for pollen grain size, height and spread of the plant, number of branches, fruit dimensions, vitamin C content, sugar content and total soluble solid content. The scientific reports of Indian Agricultural Research Institute (1963) revealed that all F_1 hybrids having Pusa Purple Long as the female parent and particularly Pusa Purple Long x Hyderpur performed well. Sambandam (1962), Raman (1964), Tiwari (1966) and Choudhury and Kalda (1968) reported that the hybrids were superior to parental lines for many of the characters studied.

Quagliotti (1962) based on a review of literature, listed out 18 characters in which F_1 heterosis was observed. Biswas (1964) noted heterosis for vegetative growth, yield and related characters in ten single crosses among five varieties. Frydrych (1964) observed that the best of hybrids, Delikotes x Bulgarskij, yielded 310.17 g of fruits/plant, the yield from Delikotes being 88.55 g and that from Bulgarskij 21.81 g. Choudhury and Kalda (1968) reported that the hybrids were superior to parental lines in many characters studied. Thakur *et al.* (1968) reported that the F_1 hybrids showed heterosis for plant height, plant spread, number of branches, fruits/plant and total yield/plant.

Dutt (1970) reported that the F_1s, Green Long x Pusa Purple Long and Pusa Purple Long x Cluster White performed well. Silvetti and Brunelli (1970) conducted a diallel among a few brinjal varieties and observed heterosis for yield/plant, fruit weight and uniform ripening. Gopimony and Sreenivasan (1970) reported that the crosses between brinjal cultivars and wild *Solanum melongena* var. *insanum* showed a high degree of heterosis for branches/plant, flower and fruit numbers and longer tap root than cultivated varieties. They also reported that the hybrids had higher content of day matter, starch, protein and alkaloid than parents. Oganesyan (1971) reported heterosis for earliness in first generation brinjal hybrids. Peter (1971) reported heterosis for days to flower, plant height, primary branches and average fruit weight. Scossiroli *et al.* (1972) observed heterosis for yield/plant. Mital *et al.* (1972) reported heterosis to the extent of 92.5% and 90.21% over mid and better parents respectively for yield/plant in Black Beauty Long x Pusa Purple Long. They also reported heterosis for fruit weight and frui shape index. Lal *et.al.* (1973) reported heterosis for yield ranging from 62.84% to 112.37%. Viswanathan (1973) studied heterosis in brinjal and reported heterosis for plant height, number of fruits, fruit weight, Length and diameter of fruits and time of flowering. Mishra and Choudhury (1975) reported that heterosis for yield in Wynad Giant x Hyderpur was 160.71% and 163.82% over better and mid parents respectively. Hani *et al.* (1977) reported that the F_1 hybrid Black Beauty x Balady White Long showed relative heterosis for early and total yield. Singh *et al.* (1977) studied a 7 x 7 diallel excluding reciprocals. Heterobeltiosis was observed for plant height, days to flower, fruit length and yield/ plant. Vijay and Nath (1978) measured five characters associated with yield in parents and F_1s of a 6 x 6 diallel set. Heterobeltiosis was observed for fruit yield and days to flower, relative heterosis was observed for fruit yield, number of fruits, fruit weight and fruit size. Dharmegowda *et al.*(1979) conducted a 9 x 9 diallel. The 72 F_1 hybrids along with nine parents were evaluated for yield/plant, days to flower, plant height, seeds/plant and fruits/plant. The highest heterosis in respect of fruits/plant was 105.21% in S 529 x Pusa Purple Cluster and with regard to yield/plant the highest heterosis was to the extent of 94.64% in Pusa Purple Cluster x Arka Kusumkar. Hristakes (1979) reported that the F_1 hybrids Black Mammoth, Goliath and Zenith proved more superior for yield, earliness and keeping quality than parental lines. Baksh (1979) observed heterosis for plant height, number of branches, flowers and fruits and resistance to drought.

Dhankar *et al.* (1980) studied four hybrids and six parental lines. Heterosis for marketable yield was observed in BR 103 x White Long and BR 112 x Aushey. Bhutani *et. al.* (1980) studied heterosis and combining ability in brinjal and reported heterosis in Pusa Purple Long x R-34, Pusa Purple Long x BR 112, Pusa Kranti x Aushey and BR 112 x Selection 26 for yield. Singh (1980) observed heterosis for earliness and plant height. Joarder *et al.* (1981) reported that the F_1 Thal x Japani showed heterosis for yield, fruit weight, fruit volume and fruits/plant. Salehuzzaman (1981) studied 16 F_1 hybrids and reported heterobeltiosis for fruit yield/plant and relative heterosis for fruit weight in four of the 12 crosses. Salimath (1981) reported heterosis for ascorbic acid content. Ram *et al.* (1981) reported that none out of the 11 crosses they studied yielded better than the best parent. Chadha and Sidhu (1982) studied 22 F_1 hybrids along with their parents. Heterobeltiosis ranged from 0.32% for fruit weight to 177.37% for fruit breadth. Dixit *et al.*

(1982) reported that significant heterosis was exhibited by PH 4 x BR 112 for fruit weight. Singh *et al.* (1982) observed that the F_1 Pusa Purple Long x 5317 exhibited heterosis for yield to the extent of 140.19%. Kandaswamy *et al.* (1983) studied 45 F_1 hybrids of brinjal in a 10 x 10 diallel to find out heterosis and combining ability for days to fruit set, fruits/plant, fruit size index, and early yield. Heterosis was observed for all characters except days to first fruit set. Balamohan *et al.* (1983) studied yield/plant and seven related characters in nine crosses involving three local and three improved varieties. Bantivare x Muktakeshi showed relatively a low level of heterosis for yield but had the best *per se* performance of the F_1s. Patil and Shinde (1984) studied the hybrids derived from five female lines and three male lines. They reported that the heterosis for fruit yield was associated with heterosis for fruits/cluster and fruits/plant. Studies conducted at Kerala Agricultural University revealed marked vigour for number of primary branches and plant height (KAU, 1984-1985) Sanguineti *et al.* (1985) studied heterosis and combining ability in brinjal and reported that the fruit yield of the hybrids among seven purple fruited varieties was 38.1% higher than parental mean. Nualsri *et al.* (1986) studied inheritance of a few economically important characters in four cultivars of brinjal. Significant relative heterosis and heterobeltiosis were observed in many of the crosses for fruits/plant and fruit yield/plant. Dixit and Gautam (1987) observed heterosis in brinjal for yield/plant, number of fruits and fruit weight in studies with 30 F_1 hybrids and their parents. They also observed high heterosis in low x low and high x low yielding parental crosses. Gangappa (1986) reported a high degree of heterosis for fruit yield and fruits/plant in West Coast Green Round x Pusa Kranti. Gopinath *et al.* (1987) reported that there was highly significant positive heterosis for locules/fruit. Gopinath (1987) studied characters of agronomic importance in brinjal and reported that there was significant and positive heterosis for fruits/plant, fruit yield/plant, length and breadth of fruit, plant height at first and peak flowering, number of stomata and dry matter content of stems and roots. Seethapathy (1987) reported that the cross SM 87 x Co.1 exhibited heterosis of 129%, 118.05% and 10.01% over mid, better and the best parent respectively for yield. Singh and Mital (1988) reported that days to flower, plant height, branches/plant and yield/plant were controlled mainly by non additive gene action and therefore, heterosis breeding may be adopted for high yield in brinjal at commercial scale.

B. Genetic variability, heritability and genetic advance in brinjal

Goto (1953) calculated heritability for various characters in brinjal. Fruit shape, fruit weight, earliness, fruit yield and fruits/plant had heritability values of 89.3%, 88.8%, 69.6%, 10.0% and 4.1% respectively. Flowers/ bunch had a heritability of 80%. The heritability for flowering period, fruit shape and fruit weight were 65-78%, 60-75% and 40-60% respectively. Dhesi *et al.* (1964) reported that the heritability values for yield were low. The heritabilities obtained for fruit weight varied from 44.4% to 76.2% and for fruit length from 50.8% to 82.5%. Mital *et al.* (1972) reported that yield was governed by non fixable component of genetic variance and had the lowest heritability. High heritability estimates were observed for days to flower, fruit weight and fruit shape. Hiremath and Rao (1974) reported that fruits/plant, seed weight/fruit and rind thickness had high heritability and high genetic advance. Singh *et al.* (1974) studied genetic variability, heritability and genetic advance in brinjal. High value of genetic variability was observed for fruit weight, whereas fruit length and yield/plant and high genetic co-efficient of variation. High genetic advance was observed for fruit weight, fruit length, yield/plant and fruit girth. High heritability values and high values of genetic advance were observed for yield/plant, fruits/plant and average fruit weight by Mishra and Roy (1976). Gill *et al.* (1976) evaluated parents, F_1, F_2 and back cross generations of a half diallel cross. Low heritability was observed for branches/ plant. Bhutani *et al.* (1977) studied 17 varieties of diverse origin in brinjal. Marketable fruits/plant and total fruits/ plant both had high genetic coefficient of variation and high estimates of heritability and genetic advance. Dharmegowda *et al.* (1979) estimated narrow sense heritability for fruits/plant as 63.48% and for seeds/fruit as 67.48%. Singh and Khanna (1978) reported that the narrow sense heritability was high for plant height, branches/plant and fruit yield/plant. Sidhu *et al.* (1980) reported that the heritability value ranged from 20.90% for yield to 98.8% for fruit length. Salehuzzaman and Joarder (1980) observed that fruit weight, fruit volume, and fruits/plant had high genetic coefficient of variation accompanied by high heritability and genetic gain. Joarder *et al.* (1981) studied P_1, P_2, F_1, F_2, BC_1 and BC_2 of five single crosses grown in two locations. Heritability and genetic gain were high for fruit number and yield. Salimath (1981) reported high to moderately high heritability in narrow sense for yield and its components in brinjal.

Borikar *et al.* (1981) observed that the heritability was moderate for yield/plant but high for plant height and branches/plant. Singh and Singh (1981) studied seven varieties and their F_1 and F_2 in a diallel cross. High values of genotypic coefficient of variation was observed for fruit girth. High heritability and genetic advance were observed for plant height and fruit length. Salehuzzaman and Alam (1983) reported high heritability in narrow sense for fruit number. Chadha and Paul (1984) investigated genetic variability in brinjal and observed the highest genetic coefficient of variation for fruits/plant. Expected genetic advance was high for yield/plant and fruits/plant. Dixit *et al.* (1984) observed that the heritability values for plant height and yield/plant were less than 50%. Gopimony *et al.* (1984) investigated genetic variability in brinjal germplasm. Phenotypic coefficient of variation ranged from 12.5% to 98.85%, genotypic coefficient of variation from 10.63% to 18.20%, heritability from 38.7% to 99.12% and genetic advance from 18.5% to 201.38%. Singh and Singh (1985) reported that heritability was high for fruit length, girth, shape index and fruits/plant. Gopinath *et al.* (1987) observed that seeds/locule had higher genotypic and phenotypic variances compared to locules/fruit.

C. **Correlation and path analysis in brinjal**

Correlation studies are important in planning the most suitable selection programme. Odland and Noll (1948) recorded positive correlation between early yield and total yield in both parents and hybrids. Biswas (1964) listed a set of correlated pairs of characters in brinjal. Komochi (1966) reported that days to flower was positively correlated with number of leaves present before flowering and leaf size, and negatively correlated with total yield. The earliness in brinjal is positively correlated with plant vigour. Baha-Eldin *et al.* (1968) revealed that short plant and early flowering habit are positively correlated with high yield, more fruits and long fruit shape. There was negative correlation between plant height and fruit number and yield/plant. Sambandam and

Muthiah (1969) observed a relationship between pleumery of stigma and large fruit size. Peter (1971) observed that there was perfect negative correlation between long plus medium styled flowers and short plus pseudo styled flowers. A significant positive correlation existed between flowers/inflorescence and fruits/plant. Srivastava and Sachan (1974) conducted correlation and path analysis studies in brinjal and observed that yield/ plant had a significant positive correlation with fruits/ plant and a negative correlation with weight of 10 fruits. Path coefficient analysis revealed that fruits/plant had maximum positive direct effect on yield. Hiremath and Rao (1974) observed that yield/plant had high significant positive correlation with fruits/plant where as it had a negative correlation with fruit weight and fruit girth. There was positive correlation among fruit weight, seed weight and fruit girth. Singh and Khanna (1978) conducted correlation studies in brinjal. Plant height was negatively correlated with fruit number and yield at phenotypic and genotypic levels. A significant positive correlation between plant spread and number of branches and between fruit number and yield was observed. singh and Singh (1981) conducted the correlation and path analysis studies in brinjal. Yield was positively correlated with length, weight and number of fruits and negatively correlated with days to flower, plant height and fruit girth but fruit girth had the greatest direct effect on yield/plant followed by fruit length and fruit weight. Sinha (1983) investigated direct and indirect effects of seven yield components on yield through path coefficient analysis. Yield was positively correlated with fruits/plant, plant height and branches/plant at phenotypic and genotypic levels. Path analysis also indicated that fruits/plant and fruit length and circumference ratio had maximum direct effect on yield. Chadha and Paul (1984) observed that yield was positively correlated with fruits/plant and plant height. Nualsri *et al.* (1986) also reported that the yield/plant was correlated with fruits/plant.

D. Bacterial wilt resistance in brinjal

Bacterial wilt caused by *Pseudomonas solanacearum* E.F. Smith is a serious disease affecting solanaceous vegetables (Kelman, 1953). It occurs commonly in warmer parts of USA, Philippines, Indonesia, Sri Lanka and India causing considerable damage to crops. The disease assumes serious proposition in parts of Karnataka, Kerala, Orissa, Maharashtra, Madhya Pradesh, Bihar and in West Bengal (Rao, 1972; Anonymous, 1974). Gangopadhyay (1984) reported a maximum yield loss upto 62.5%. Gopimony and George (1979) reported that in various districts and agricultural farms in Kerala, the percentage of wilt in certain improved varieties like Arka Kusumkar and Banaras Giant are as high as 100% where as in local varieties this varies from 6% to 20%. Varieties resistant to bacterial wilt have been reported by workers as early as in 1935. The origin of the disease is lost in antiquity.

1. **Races and strains of pathogen**

Okabe and Goto (1961) conducted detailed studies on the strains of *Pseudomonas solanacearum.* They found that the isolates obtained from various solanaceous hosts in Japan could be seperated into 40 groups based on biochemical properties, serological reactions and sensitivity of virulent phages. In general *in vitro* determined groups were not the same as groups designated as pathotypes after evaluation of pathogenicity based on artificial inoculations using a series of differential hosts like tomato, tobacco and brinjal. Hayward (1964) also described *Pseudomonas solanacearum* as a complex species consisting of several races differing in host range and pathogenicity. Buddenhagen *et al.,* (1966) studied the comparative carbohydrate metabolism in different pathogenic strains of *Pseudomonas solanacearum.* The three strains used in the study were 'T' strain of Race 1 and 'B' and SER of Race 2. 'T' strain was different from the other two strains. The two strains of Race 2 were similar metabolitically. Morton *et al.* (1966) investigated serological relationship of Races 1, 2 and 3 of *Pseudomonas solanacearum* and observed that Races 2 and 3 have more agglutinins in common than either has with Race 1. Keshwal and Joshi (1976) studied occurance of different strains/

races of *Pseudomonas solanacearum* on different hosts. Ten isolates were put into test. It was found that the isolate A12/74 was equally infective on all solanaceous hosts but not on Ageratum, where the isolate G5/73 could infect this host but not solanaceous hosts except tomato and brinjal. T24/69 was the most infective isolate. In an attempt to study variation in *Pseudomouas solanacearum*, Rath and Reddy (1977) used 10 selected isolates from wilted tomato plants and the prepared culture was inoculated on tomato, chillies and potato. There was not much difference between the isolates on tomato while none of the ioslates were found pathogenic on potato and chillies. Though morphologically alike the isolates exhibited variations in respect of biochemical characters like gelatin liquifaction and action on litmus.

2. Factors affecting wilt incidence

Resistance and susceptibility to disease are conditions with defined metabolic, environmental and genetic conditions. Kuc (1968) opined that disease resistance is not an absolute or static condition and depends on many factors. Expression of the biochemical potential, determined by the genetic component of the organism is influenced by a multitude of factors including nutrition, growth regulators, temperature, moisture, day length, stage of development and nature of the tissue. Bell (1981) stated that factors which influence resistance, include intensity, duration, light quality, moisture levels, nutrient levels and agricultural and industrial chemicals. Long photoperiods generally result in higher levels of resistance (Bell, 1981). He further indicated that increasing the concentration of pottassium and calcium increases most often the resistance while nitrogen decreases resistance. Increased resistance in resistant lines was apparently associated with age rather than plant size (Winstead and Kelman, 1952). Bell (1981) reported that each plant part changes in its level of resistance with age. Resistant levels in stem and root generally increase rapidly during the first two weeks of seedling or when new shoot grows, and slowly thereafter. Levels of resistance in leaves and fruits frequently decline with age. Infection may occur at soil temperatures as low as 12.88 °C but symptoms of wilt do not ordinarily became apparent at 12.8°C to 15.6°C (Vaughan, 1944). Gallegly and Walker (1949) reported that high moisture levels in soils affected the disease by favouring survival of bacteria in soil and there by increasing capacity for infection. Kelman (1953) observed that high soil moisture levels usually favour development of bacterial wilt. But Chupp and Sherf (1960) reported that the infection can occur in dry soil and disease becomes serious in red laterite soils. Kelman and Cowling (1965) reported high wilt incidence at a pH of 3.5. Goth *et al.* (1983) observed that bacterial wilt resistance was broken down when root knot nematode larvae were added at the rate of 100/10 cm pot at the time of inoculation with bacterial isolates.

3. Biochemical bases of resistance

Resistant varieties possess physical and biochemical barriers which inhibit entry of pathogen to host cells. Mahadevan (1973) opined that resistance against parasitic microorganisms like bacteria, fungi and virus is not due to structural barriers like thick epidermis, leaf hairs, thick cuticle, sugar content, osmotic pressure, pH and other factors, chemical toxicants like prohibitins and phytoalexins are important in the defense reaction. The principal antimicróbial substance synthesised by phanerogams are alkaloids, glycosides, sulphur compounds, unsaturated lactones, fatty acids, phenols, quinones and their derivatives and essential oils. The chemical compounds which inhibit the pathogen are classified as preinfectional inhibitors (Russel, 1978). Preinfectional inhibitors in the plant are mainly catechol, procatechuic acids, terpenes, phenols, flavanoids and tomatine (Stoessl, 1969; and Roddick, 1974). Mahadevan (1973) defined prohibitins as preformed inhibitory compounds which confer some degree of protection to host plants against microorganism. These prohibitins are particularly effective at the point of entry and are primarily active during entry and penetration of the microorganism. The quantity of prohibitins in a host may largely determine the resistance of tissue to parasities; more prohibitins mean more resistance and vice-versa. Parasites may differ in their sensitivity to prohibitins. Solanine and tomatine are prohibitins occuring in *Lycopersicon esculentum* (Irwing, 1947; and Allison, 1952). Mullar (1959) and Cruickshank (1963) stated that a host may have two kinds of defense factors, prohibitins and phytoalexins. Prohibitins are active biochemical barriers against infection (Mahadevan, 1970). Disease results if both are overpowered by parasites.

Specific resistance is conferred by a compound or compounds extremely toxic to a small group of specialised pathogens of herbivores (Levin, 1976) and each compound is present only in a few species. Such compounds are sinigrine, gossypol, juglone, phorizidin; α-tomatine and solanine. General resistance is rendered by the presence of a compound or compounds which deter, repel or weekly toxic to most microorganisms and/or herbivores; such compounds include chlorogenic acid, coumarin, eugenol, α-pinene, quercetin, tannin, thymol and vanillin. Kuc (1964) reported that in some instances, inhibition of microorganism may result from the cumulative effect of two or more compounds. It was further reported that in some instances, inhibition of a microorganism may result from the cumulative effect of two or more compounds. It was further reported that non diffusible substances like tomatine, phenols etc. have a key role in the defence mechanism (Thypliyal and Nene, 1967).

Gallegly and Walker (1949) observed that resistant factors in host plants are associated with light dependent processes. Akai and Kuneida (1955) suggested a resistance mechanism based on presence of a few inhibitory substance in the leaves of brinjal varieties. Qualitative differences in phenolic compounds between resistant and susceptible brinjal varieties were also observed. Maine (1958) observed that resistant varieties became susceptible when reducing agents were applied. Maine and Kelman (1961) observed that polyphenol oxidase activity was much greater in infected than in healthy stem tissues. Hence they suggested that polyphenol oxidase activity may be involved directly or indirectly in resistance of host plants to pathogenic microorganisms including *Pseudomonas*. Gopimony and Sreenivasan (1970) observed a significant increase in dry matter content, starch, protein and total alkaloids in resistant brinjal hybrids. Mukherjee and Mukhopadhyay (1982) noticed that the root exudates of the brinjal variety Pusa Purple Cluster showed a very little enhancement of the bacterial population while that of the susceptible varieties greatly enhanced the population of bacterium. Sitaramaih *et al.* (1985) reported that there is no correlation between total phenol concentration of roots and disease reaction in the case of *Pseudomonas solanacearum*. Gangappa (1986) observed a negative association between percentage of wilt incidence and total phenol content in the roots.

4. **Inheritance of resistance**

Kelman (1953) reported that resistance to *Pseudomonas solanacearum* in groundnut, tobacco and brinjal had all the appearance of being horizontal. Suzuki *et al.* (1964) suggested that the bacterial wilt resistance exhibited in brinjal varieties Taiwan Naga and OTBI was hereditary and should be a quantitative character controlled by a number of genes. Swaminathan and Sreenivasan (1971) reported that resistance to bacterial wilt was monogenically controlled and was transmitted to the F_1 and back cross progenies completely. The donor parent *Solanum melongena* var. *insanum* carried the dominant gene for resistance. The F_1 hybrids were resistant since it had the dominant gene for resistance. Akiba *et al.* (1972) reported that resistance to *Pseudomonas solanacearum* is controlled by a pair of dominant genes. Graham and Yap (1976) conducted a variance component analysis of P_1, P_2, F_1, F_2, BC_1 and BC_2 generations of a cross between resistant and susceptible cultivars. A heritability (narrow sense) estimate of 42% and heritability (broad sense) estimate of 53% with a degree of dominance of 75% were observed. Gangappa (1986) reported that bacterial wilt resistance was inherited as a dominant factor in West Coast Green Round x Pusa Kranti.

5. Bacterial wilt resistant brinjal hybrids

Daly (1970) studied tolerance of hybrids obtained from a cross between SM 164 (tolerant) and the susceptible local varieties, Florida Market and Violete de Berbentane. F_1, F_2 and back crosses had a higher proportion of tolerant plants. Madalagiri et al. (1983) reported that the hybrid West Coast Green Round x Pusa Kranti is highly resistant. Heterosis for yield and resistance to bacterial wilt were shown by SM 10 x Pusa Purple Long and SM 6 x Pusa Purple Cluster, (KAU 1984-1985). High degree of heterosis for resistance to bacterial wilt was reported by Gangappa (1986) in West Coast Green Round x Pusa Kranti.

E. Quality characters in parental lines and F_1 hybrids of brinjal

Although not a rich source of Vitamin B_2, brinjal contains a higher percentage of Vitamins than many other Vegetables. Stanco *et al.* (1970) reported that brinjal when compared to other vegetables is considered as a poor source of Vitamin C. Gnanakumari and Satyanarayana (1971) studied the effect of NPK fertilizers at different levels on composition of brinjal and reported the

Vitamin C content in the fruits as 50 mg/100 g when 280 kg each of NPK were applied. Vitamin C content of the fruits varies according to varieties. Values as high as 24.2 mg/ 100 g have been reported but usually lies between 4 to 12 mg/ 100 g (CSIR, 1972). Brinjals with dark purple skin contains more Vitamin C than those with white skin. Singh *et al.* (1974) reported that Vitamin C content of brinjal fruits ranges from 11.87 to 18.45 mg/100 g. Ramaswamy and Rege (1975) observed 3.5 mg/100 g of Vitamin C in black roundish variety of brinjal. Gutierrez *et al.* (1976) studied effect of spacing on ascorbic acid content and reported the highest 10.6 mg/ 100 g and the lowest 5.6 mg/ 100 g in fruits when the plant population were 31,746 and 20,408 plants/ha respectively. Narayanaswamy and Sulladmath (1980) noticed an increase in ascrobic acid content with advance in fruit maturity and a maximum of 18.2 to 18.6 mg/100 g after 19th day of fruit set. Reports from Horticultural Research Station, Periyakulam (1984) showed Vitamin C content in PKM-1 variety of brinjal as 10 to 12 mg/100 g. Kalra *et al.* (1988) analysed brinjal fruits for Vitamin C and reported 4.3 to 28 mg/100 g of fruit.

Jaiswal *et al.* (1974) reported range of variability for iron content in round and oblong type of brinjal fruits from 0.59 mg to 0.80 mg/100 g and in long types from 0.69 to 1.22 mg/100 g. They also reported that the long type fruits were distinctly richer in iron content than round or oblong type. Singh *et al.* (1974) reported a range of 0.78 to 1.00mg/ 100 g of iron in brinjal.

Gnanakumari and Satyanarayana (1971) estimated 365 IU of Vitamin A/100 g of brinjal fruit. Brinjal fruits contain 124 IU of Vitamin A (CSIR, 1972). Ramaswamy and Rege (1975) reported that β-carotene of brinjal fruits varies from 430 to 630 μg/100 g of fruit.

The brinjal line SM6 is reported resistant to bacterial wilt. This line was segregating for fruit colour, shape and presence/absence of prickles. Twenty five lines were selected from this segregating population by mass, pure line, single plant and single seed descend method of selection. The lines SM 6-6, SM 6-7 and SM 6-2 were promising. But these lines were late to bear and comparatively low yielding. Heterosis breeding would be appropriate to develop earliness and to induce higher yield. If earliness and high yield could be induced in these three (SM 6-6, SM 6-7 and SM 6-2) wilt resistant lines, it will be of much use to farmers for cultivation in wilt prone areas. Heterosis breeding was hence taken as one of the objectives of the present study.

Materials and Methods

MATERIALS AND METHODS

The present studies were initiated during May 1988 and the evaluation trial was conducted during October 1988 - March 1989 in the vegetable research plots of department of Olericulture, Kerala Agricultural University, Vellanikkara. This area is located at an altitude of 23 m above MSL and is between 10° 32" N and 76° 16" E longitude. It enjoys a warm humid tropical climate. Weather parameters like maximum temperature, minimum temperature, humidity and rainfall during the experimental period are given in Annexure-I. The average monthly temperature ranged from 21.2°C to 36.3°C, humidity from 45% to 78% and rainfall from 0 to 116.6 mm.

Experimental materials

The materials comprised of a set of nine lines of brinjal. Three of the above lines SM 6-2, SM 6-6 and SM 6-7 (Surya) were derived from SM6, a highly segregating line reported resistant to bacterial wilt (Gopalakrishnan and Gopalakrishnan, 1985). These three lines were evolved through pure line and single plant methods of selection practised continuously for eight generations (Sheela, 1982; Sankar, 1984; Jessykutty, 1985; Ushamani, 1987). The other lines are Pusa Purple Cluster, Pant Samrat, SM-132, Arka Kusumkar, Pant Rituraj and Arka Navneeth. Resistance/ susceptibility of the selected lines to bacterial wilt was assessed by growing in wilt sick soil and looking for plants unaffected and healthy. Source and distinct morphological characters of the lines are given in Table 1.

Experimental method

Development of F_1 hybrids

Hybridisation was done during July - September 1988. The selected lines were grown in rows with a spacing of 75 cm between plants and 100 cm between rows. Long and medium styled flowers were selected for crossing purpose. Emasculation of flower buds were carried out and covered with paper bags. The flower buds from male parents were similarly protected to avoid contamination by foreign pollen-grains. Pollination was performed in the very next day of emasculation. Pollinated flowers were covered and labelled. The following F_1s were generated.

1. SM 6-2 x Pusa Purple Cluster.
2. SM 6-2 x Pant Samrat
3. SM 6-6 x Arka Kusumkar
4. SM 6-6 x SM-132
5. SM 6-7 x Pant Rituraj
6. SM 6-7 x Arka Navneeth

Experimental design

The seedlings were transplanted in a randomized block with four replications after 45th day of sowing.

Table 1. Source, pedigree and distinct morphological characters of 9 lines of brinjal

Name of the line	Source	Pedigree	Prickly/ non-prickly	Flower colour	Fruit shape	Fruit colour	Clustered/ Solitary	Resistance/ sisceptibi-lity to bacterial wilt
SM 6-6	KAU, Vellanikkara	Pure line selection from SM 6	Non prickly	Purple	Long	White	Clustered	Resistant
Arka Kusumkar	I.I.H.R. Bangalore	Local colle-ction (IIHR 193) from Karnataka	Non prickly	White	Long	White	Clustered	Susceptible
SM-132	K.A.U.	Local colle-ction from Palai	Prickly	Purple	Long	White	Solitary	Resistant
SM 6-7 (Surya)	K.A.U.	Single plant selection from SM 6	Non prickly	Purple	Oval	Purple	Solitary	Resistant
Pant Rituraj	GBPAUT Pant Nagar	Derivative of T_3 x PPC	Non prickly	Purple	Round	Purple	Solitary	Susceptible
Arka Navneeth (F_1)	I.I.H.R.	IIHR 22-1 x Supreme	Non prickly	Purple	Oval	Purple	Solitary	Susceptible
SM 6-2	K.A.U.	Single plant selection from SM 6	Non prickly	Purple	Long	Purple	Solitary	Resistant
Pusa Purple Cluster	I.A.R.I. New Delhi	Selection from Nurki	Non prickly	Purple	Long	Purple	Clustered	Resistant
Pant Samrat	GBPAUT Pant Nagar	Local colle-ction from Pantnagar	Non prickly	Purple	Long	Purple	Clustered	Resistant

Number of treatments - 15

T_1 - SM 6-6

T_2 - Arka Kusumkar

T_3 - SM-132

T_4 - SM 6-6 x Arka Kusumkar

T_5 - SM 6-6 x SM-132

T_6 - SM 6-7

T_7 - Pant Rituraj

T_8 - Arka Navneeth

T_9 - SM 6-7 x Pant Rituraj

T_{10} - SM 6-7 x Arka Navneeth

T_{11} - SM 6-2

T_{12} - Pusa Purple Cluster

T_{13} - Pant Samrat

T_{14} - SM 6-2 x Pusa Purple Cluster

T_{15} - SM 6-2 x Pant Samrat

Number of plants/replication - 16

Size of plot - 2.5 x 3 m

Spacing - 75 x 60 cm

Farm yard manure (20t/ha) was applied basally. Chemical fertilizers were applied at the rate of 120:60:60 kg/ha of N, P_2O_5 and K_2O respectively. Full P_2O_5, 1/2 N and 1/2 K_2O were applied basally, 1/4 N and 1/2 K_2O were applied 20-25 days after first fertilizer application. 1/4th N was applied one month after ist application. Plots were irrigated twice a week. The quantitative characters observed were plant height, primary branches/plant, days to first fruit set, percentage of productive flowers, average fruit weight, average fruit volume, fruits/plant/harvest, total fruits/plant and total yield/plant. Index to earliness was estimated using the formula.

Index to earliness $$IE = \frac{a_1 + a_2 + a_3 \ldots\ldots\ldots a_n}{c_1 + c_2 + c_3 \ldots\ldots\ldots c_n}$$

where,

a_i - yield of variety/hybrid on i^{th} day

c_i - yield of control (SM6-6) on i^{th}day

n - 3 (number of harvests)

Statistical analysis

One set of parents and F_1s were grown in a wilt sick plot in a randomised block design with 4 replications and another set in pots under wilt free condition in a completely randomised design

Set-I in a randomized block design

(a) Analysis of variance

Data recorded were analysed character wise as described by Ostle (1966).

$$Y_{ij} = \mu + t_i + b_j + e_{ij}$$

Y_{ij} = performance of i^{th} variety in j^{th} block

μ = General mean

t_i = True effect of i^{th} variety

bj = True effect of j^{th} block

eij = Random error

(b) **Estimation of variability**

Variability for quantitative characters were estimated as suggested by Burton (1952).

(i) Genotypic coefficient of variation (gcv) =

$$\frac{\text{Genotypic standard deviation}}{\text{Mean of the character}} \times 100$$

(ii) Phenotypic coefficient of variation (pcv) =

$$\frac{\text{Phenotypic standard deviation}}{\text{Mean of the character}} \times 100$$

(iii) Standard error of mean =

$$\frac{\text{Environmental standard deviation}}{\sqrt{\text{Replications}}} \times 100$$

(iv) Coefficient of variation = $\frac{\text{Standard deviation}}{\text{Mean of the character}} \times 100$

(v) Genotypic variance =

$$\frac{\text{Mean square due to genotypes} - \text{mean square due to error}}{\text{Number of replications}}$$

(vi) Phenotypic variance = Genotypic variance + Error variance

(vii) Error variance = Mean square due to error

(viii) Heritability in the broad sense

$$h^2(b) = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}}$$

(ix) Expected genetic advance at 5 per cent intensity of selection was calculated using the formula of Johnson *et al.* (1955).

$$GA = h^2 \times \sigma p \times i$$

where h^2 = heritability

σp = phenotypic standard deviation

i = coefficient of intensity of selection (2.06 at $p = 0.05$)

(x) $$\text{Genetic advance (\%)} = \frac{\text{Genetic advance}}{\text{Mean of the character}} \times 100$$

c) (i) **Estimation of genetic divergence and distance**

The genetic distances existing in parental genotypes were measured by Mahalanobis D^2 Statistics (Murthy and Arunachalam, 1967).

The genetic distance was calculated considering the following characters.

1. Plant height
2. Primary branches/plant
3. Days to first fruitset
4. Percentage of productive flowers
5. Average fruit weight
6. Average fruit volume
7. Fruits/plant/harvest
8. Total fruits/plant
9. Total yield/plant

The method suggested by Mahalanobis (1928) was used to estimate the D^2 between the nine varieties.

$$D^2 = b_1 d_1 + b_2 d_3 + b_3 d_3 \ldots\ldots\ldots\ldots b_9 d_9$$

Here the b_1 values were to be estimated such that ratio of variance between population to variance within population was maximised. In terms of variance and covariances, the D^2 value between genotypes 1 and 2 was obtained as follows:

$$_pD^2 = \sum_{i=1}^{p}\sum_{j=1} W^{ij} (X_i^{-1} - X_i^{-2}) (X_j^{-1} - X_j^{-2})$$

Where W^{ij} used is the i, j^{th} element of the inverse of estimated within variance - covariance matrix and x_1 is the observation on i^{th} character for j^{th} genotype. The square root of D^2 was calculated to obtain genetic distance between two genotypes.

d) **Estimation of heterosis**

Heterosis over better parent (heterobeltiosis), mid parent (relative heterosis) and standard variety (standard heterosis) were calculated (Briggle, 1963; Hayes *et al.* (1965)

The formula used were

Heterobeltiosis $= \dfrac{\overline{F}_1 - \overline{BP}}{\overline{BP}} \times 100$

Relative heterosis $= \dfrac{\overline{F}_1 - \overline{MP}}{\overline{MP}} \times 100$

Standard heterosis $= \dfrac{\overline{F}_1 - \overline{SV}}{\overline{SV}} \times 100$

Where

$\overline{F_1}$, $\overline{BP}$, $\overline{MP}$ and $\overline{SV}$ were the mean performance of F_1 hybrid, better parent, mid parent and standard variety respectively. The respective standard errors were also calculated.

The standard error of the difference between means for heterobeltiosis and standard heterosis was estimated using the formula.

$$SE = \sqrt{\frac{2\ \sigma_e^2}{r}}$$

σ_e = error mean square

r = number of replications

The standard error of the difference between means for relative heterosis was estimated using the formula

$$SE = \sqrt{3/2\ \frac{\sigma_e^2}{r}}$$

e) **Estimation of correlation**

Correlation between yield and its components were calculated at genotypic and phenotypic levels as given by Searle (1961).

a. Genotypic correlation between characters x and y

$$r_{xy}\ (g) = \frac{Cov\ xy^{(g)}}{\left(Var.\ x^{(g)}\ Var\ y^{(g)}\right)^{1/2}}$$

b. Phenotypic correlation between characters x and y

$$r_{xy}^{(p)} = \frac{\text{Cov } xy^{(p)}}{\left(\text{Var } x^{(p)} \text{ Var } y^{(p)}\right)^{1/2}}$$

Where Cov $xy^{(g)}$, Cov $xy^{(p)}$, denote genotypic and phenotypic covariance respectively between characters x and y. Var $x^{(g)}$ and Var $x^{(p)}$ denote genotypic and phenotypic variances for character 'x' and Var $y^{(g)}$ and Var $y^{(p)}$ denote genotypic and phenotypic variances respectively for character 'y'.

f) **Path coefficient analysis**

Fruit yield was considered as the effect factor in a closed system of "cause and effect" variables, the causual variables being plant height, primary branches/plant, days to first fruit set, percentage of productive flowers, average fruit weight, average fruit volume and fruits/plant.

The estimates of direct and indirect effects in such a closed system of variables were calculated by the path coefficient analysis as suggested by Dewey and Lu (1959). The folowing set of simultaneous equations were formed and solved for estimating the various direct and indirect effects.

$$r_{1y} = p_{1y} + r_{12}p_{2y} + r_{13}p_{3y} + r_{14}p_{4y} \ldots\ldots + r_{ik}p_{ky}$$

$$r_{2y} = p_{2y} + r_{21}p_{1y} + r_{23}p_{3y} + r_{24}p_{4y} \ldots\ldots + r_{2k}p_{ky}$$

$$r_{3y} = p_{3y} + r_{31}p_{1y} + r_{32}p_{2y} + r_{34}p_{4y} \ldots\ldots + r_{3k}p_{ky}$$

$$r_{4y} = p_{4y} + r_{41}p_{1y} + r_{42}p_{2y} + r_{43}p_{3y} \ldots\ldots + r_{4k}p_{ky}$$

$$\vdots$$

$$r_{ky} = p_{ky} + r_{k1}p_{1y} + rk_{2}p_{2y} + r_{k3}p_{3y} \ldots\ldots + r_{k(k-1)}\ {}_{(k-1)y}$$

where r_{iy} to r_{ky} denote coefficient of correlation between independent characters 1 to k and dependent character y. r_{12} to $r_{k(k-1)}$ denote coefficient of correlation between all possible combinations of independent characters; and p_{1y} to p_{ky} denote direct effects of characters 1 to k on character y. The above equations can be written in a matrix form as shown as

A	B						C
r_{iy}	1	r_{12}	r_{13}	r_{14}	......	r_{1k}	p_{1y}
r_{2y}	r_{21}	1	r_{23}	r_{24}	......	r_{2k}	p_{2y}
r_{34}	r_{31}	r_{32}	1	r_{34}	......	r_{3k}	p_{3y}
r_{4y}	r_{41}	r_{42}	r_{43}	1	......	r_{4k}	p_{4y}
$\vdots$						$\vdots$	$\vdots$
r_{ky}	r_{ki}					1	p_{ky}

The path coefficients were obtained by replacing the corresponding elements in A and B matrices by correlation coefficients.

Residual factor (p_{xy}) which measures the contribution of rest of the characters not considered in the causal scheme was obtained as given below.

$$\text{Residual factor } (x) = p_{xy} = (1 - R^2)^{1/2}$$

$$\text{where} \quad R^2 = \sum_{i=1}^{k} p_{iy}^2 + 2 \sum_{i<j}^{k} p_{ij}\, p_{jy}\, r_{ij}$$

$$i \neq j$$

$$i < j$$

Set II in completely randomised design

Since a few parental lines are highly susceptible to bacterial wilt in field conditions and also resistance of hybrids were not known, all the parental lines and hybrids were grown in pots under disease free situation.

Analysis of variance

Data recorded were analysed character wise using the following model.

$Yi = \mu + ti + ei$ $\quad i = 1 \, . \, . \, . \, . \, . \, t$

Yi = Performance of i^{th} variety

μ = General mean

ti = True effect of i^{th} variety

ei = Random error

Evaluation for wilt resistance

The nine parental lines and six hybrids were evaluated for bacterial wilt resistance. Ooze test was done to confirm bacterial wilt. Observations were recorded on number of plants. The genotypes were scored according to Mew and Ho (1976).

R - Resistant 20% plants wilted
MR - Moderately resistant 20 - 40% plants wilted
MS - Moderately susceptible 40 - 60% plants wilted
S - Susceptible 60% plants wilted.

Biochemical bases of resistance to bacterial wilt

The parental lines and hybrids were analysed for the biochemical status in three stages; 30 days after sowing, 45 days after transplanting and 60 days after transplanting (fruit set stage). Healthy plants were uprooted and contents of phenol and O D phenol was analysed.

(a) **Total phenol**

Total phenol in roots of plants was estimated by modified Folin-Denis methods (Mahadevan and Sridhar, 1982).

(b) **Orthodihydric phenols (OD Phenol)**

The Arnow's method as described by Mahadevan and Sridhar (1982) was followed.

Quality characters in parental lines and hybrids

Vitamin-C

Vitamin-C in fruits at vegetable stage was estimated by visual titration method based on reduction of 2,6-dichlorophenol indolphenol (A.O.V.C., 1966).

Iron

Iron centent of fruits was determined colorimetrically (Jackson, 1958).

Carotene

Carotene content of fruits was determined as per A.O.A.C. (1960).

Results

RESULTS

Data recorded in the present study were analysed and results are presented under following heads:

A. Genetic variability, heritability and genetic advance in brinjal

B. Heterosis in brinjal and genetic distance between parental lines

C. Correlation and path analysis in brinjal

D. Evaluation for field resistance to bacterial wilt and biochemical bases of resistance

E. Quality characters in parental lines and F_1 hybrids

A. Genetic variability, heritability and genetic advance in brinjal

Analysis of variance indicated significant differences among lines for all characters studied. Evaluation in a completely randomized design under disease free condition also indicated significant difference among lines for all characters studied except plant height (Table 2 and Table 3)

The extent of variability for yield and its components in parental lines and F_1 hybrids were measured in terms of range, mean, coefficient of variation at genotypic, phenotypic and environmental levels (Table 4). The range in mean

Table 2. Analysis of variance for yield and its components in brinjal

Sources of variation	df	Mean squares								
		Plant height (cm)	Primary branches/ plant	Days to first fruit set	Percentage of productive flowers	Average fruit weight (g)	Average fruit volume (cm^3)	Fruits/ plant/ harvest	Total fruits/ plant	Total yield/ plant (g)
Replications	3	14.63	0.02	40.19	153.65	20.16	143.98	4.38	1.28	6033.66
Treatments	14	442.89**	4.29**	58.11**	250.38**	1416.38**	4719.45**	20.19**	261.73**	104711.93**
Error	42	33.24	0.24	4.83	22.67	22.67	170.21	2.01	2.79	2546.40

** p = 0.01

Table 3. Analysis of variance for yield and its components in brinjal (*)

Sources of variation	df	Mean squares								
		Plant height (cm)	Primary branches/ plant	Days to first fruit set	Percentage of productive flowers	Average fruit weight (g)	Average fruit volume (cm^3)	Fruits/ plant/ harvest	Total fruits/ plant	Total yield/ plant (g)
Treatments	14	94.99	4.25**	44.16**	149.48**	4903.36**	3387.63**	102.58**	64.93**	21328.18**
Error	30	48.93	1.57	12	10.44	195.23	182.40	1.82	2.04	1597.22

(*) Evaluated in a completely randomized design under disease free condition

** p = 0.01

Table 4. Range, mean, phenotypic (pcv), genotypic (gcv) and environment (ecv) coefficient of variation, heritability (h^2) and genetic advance for yield and its components in brinjal.

		Plant height (cm)	Primary branches/ plant	Days to first fruit set	Percentage of productive flowers	Average fruit weight (g)	Average fruit volume (cm^3)	Fruits/ Plant/ harvest	Total fruits/ plant	Total yield
Range	P	42.24-68.27	3.61-5.99	36.07-50.27	32.63-62.85	33.75-83.39	80.50-177.50	2.10-9.71	3.56-29.76	433.90-965.32
	F_1	51.69-79.51	4.74-7.47	40.61-47.47	32.55-40.88	57.78-96.25	113.29-223.75	3.49-7.30	6.25-19.95	632.96-932.81
Mean	P	55.99 ± 2.88	4.69 ± 0.33	44.00 ± 1.09	41.22 ± 2.38	53.56 ± 2.34	121.02 ± 6.52	4.73 ± 0.71	15.59 ± 1.18	737.72 ± 14.85
	F_1	67.30 ± 2.88	5.94 ± 0.33	43.22 ± 1.09	37.03 ± 2.38	74.83 ± 2.34	140.02 ± 6.52	5.29 ± 0.71	14.03 ± 1.18	838.15 ± 14.85
gcv		16.72	18.94	8.34	19.08	30.10	26.21	43.09	51.84	19.08
pcv		19.25	22.71	9.73	22.56	31.03	28.10	51.69	52.95	22.56
ecv		9.53	12.52	5.02	12.04	7.54	10.14	28.60	10.76	12.04
Heritability		0.75	0.83	0.74	0.72	0.94	0.13	0.83	0.96	0.84
Genetic advance		17.99	2.02	6.41	13.23	37.27	9.68	4.38	15.91	15.44
Genetic advance (% of mean)		29.73	38.82	14.64	33.46	60.08	7.52	88.36	102.51	39.04

for plant height was 42.24 cm in Arka Navneeth to 79.51 cm in SM 6-6 x SM-132; primary branches/plant 3.61 (Pant Rituraj) to 7.48 (SM 6-2 x Pant Samrat); days to first fruit set 36 days (SM 6-6) to 50 days (SM-132); percentage of productive flowers 32.55% (SM 6-2 x Pant Samrat) to 62.85% (Pusa Purple cluster); average fruit weight 33.75 g (Arka Kusumkar) to 96.25 g (SM 6-7 x Pant Rituraj), average fruit volume 80.50 cm^3 (Arka Kusumkar) to 223.75 cm^3 (SM 6-7 x Arka Navneeth); fruits/plant/harvest 2.10 (SM-132) to 9.71 (Pusa Puple Cluster); total fruits/plant 3.56 (Arka Navneeth) to 29.76 (SM 6-6) and total yield 433.90 g (SM 6-7) to 965.32 g (SM 6-6). The highest estimate of genotypic coefficient of variation (gcv) was observed for total fruits/plant (51.84) followed by fruits/plant/harvest (43.09) and average fruit weight (30.10). The genotypic coefficient of variation was the lowest for days to first fruit set (8.34). The contribution of genotype in total expression of character was maximum in fruits/plant, expression of character was maximum in fruits/plant (h^2 = 0.96) followed by average fruit weight (h^2 = 0.94). The expected genetic advance as per cent of mean was the highest for total fruits/plant (102.51) followed by fruits/plant/harvest. The phenotypic differences among the lines were mainly genetic as indicated by high heritability for fruits/plant (h^2 = 0.96), fruits/plant/harvest (h^2 = 0.94) and average fruit weight (h^2 = 0.94). Environmental factors influenced extent of variation for plant height, days to first fruit set, percentage of productive flowers and average fruit volume.

B. Heterosis in brinjal and genetic distance between parental lines

Genetic distance between parental lines calculated using Mahalanobis D^2 statistics is presented in Table 5. Maximum genetic distance was observed between SM 6-6 and Arka Kusumkar (D = 4.16) followed by SM 6-6 and SM-132 (D = 4.14). The genetic distance was minimum between SM 6-7 and Arka Navneeth (D = 3.42).

Heterosis over better parent, mid parent and SM 6-7 (Surya) were calculated in all the crosses. Mean performance of parents and F_1s and extent of heterosis over better parent, mid parent and over SM 6-7 are presented in Table 6. Mean, heterobeltiosis, relative heterosis and heterosis over SM 6-7 of lines evaluated in a completely randomised design under wilt free condition are presented in Table 7.

1. Plant height

Two F_1 hybrids were taller than their respective better parents. Five F_1 hybrids were taller than their mid parents and four F_1 hybrids were taller than SM 6-7. The estimate over better parent ranged from -7.83% in SM 6-6 x Arka Kusumkar to 17.21% in SM 6-6 x SM-132 and mid parent from -7.68% in SM 6-6 x Arka Kusumkar to 26.5% in SM 6-7 x Arka Navneeth. The estimate over SM 6-7 ranged from -0.08% in SM 6-6 x Arka Kusumkar to 44.51% in SM 6-6 x SM-132. The tallest hybrid SM 6-6 x SM-132 (79.51 cm) expressed 17.27% heterobeltiosis, 24.98% relative heterosis and 44.51%

Table 5. Genetic distance (D) between parents of F_1 hybrids

HYbrids	Genetic distance between parents
SM 6-6 x Arka Kusumkar	4.16
SM 6-6 x SM-132	4.14
SM 6-7 x Pant Rituraj	3.73
SM 6-7 x Arka Navneeth	3.42
SM 6-2 x Pusa Purple Cluster	3.85
SM 6-2 x Pant Samrat	3.99

Table 6. Continued

	Days to first fruit set				Percentage of productive flowers			
	Mean	% over BP	% over MP	% over SM 6-7	Mean	% over BP	% over MP	% over SM 6-7
Lines								
SM 6-6	36.07				36.07			
Arka Kusumkar	44.44				48.73			
SM-132	50.27				44.52			
SM 6-7	45.63				35.65			
Pant Rituraj	45.11				35.65			
Arka Navneeth	48.1				33.65			
SM 6-2	38.01				32.62			
Pusa Purple Cluster	42.94				68.85			
Pant Samrat	45.84				40.26			
Hybrids								
SM 6-6 x Arka Kusumkar	42.66	18.33**	6.04**	-6.47*	40.88	-16.12**	-4.70**	14.61**
SM 6-6 x SM-132	43.21	19.79**	0.09	-5.30*	36.31	-18.43**	-10.98**	1.85
SM 6-7 x Pant Rituraj	47.51	5.45*	4.72	4.12	38.36	7.60*	7.60**	7.60*
SM 6-7 x Arka Navneeth	44.31	-0.29	-6.06**	-2.89	33.22	-6.82*	-4.14	-6.82*
SM 6-2 x Pusa Purple Cluster	40.61	6.84**	0.35	-11.00**	40.87	-34.97**	-14.38**	14.64**
SM 6-2 x Pant Samrat	40.97	7.78**	-2.28	-10.21**	32.55	-19.15**	-10.68**	8.69*
Sem		1.55	1.34	1.55		3.37	2.92	3.37

Contd.

Table 6. Continued

	Average fruit weight				Average fruit volume			
	Mean (g)	% over BP	% over MP	% over SM 6-7	Mean (cm^3)	% over BP	% over MP	% over SM 6-7
Lines								
SM 6-6	43.00				90.00			
Arka Kusumkar	33.75				80.50			
SM-132	55.92				130.00			
SM 6-7	51.76				115.00			
Pant Rituraj	66.31				135.75			
Arka Navneeth	83.38				177.50			
SM 6-2	64.38				138.29			
Pusa Purple Cluster	42.41				120.69			
Pant Samrat	41.79				103.44			
Hybrids								
SM 6-6 x Arka Kusumkar	57.38	33.43**	49.49**	10.83**	126.67	40.73**	48.57**	10.11
SM 6-6 x SM-132	64.25	16.99**	31.23**	24.12**	125.82	-3.22	14.38	9.40
SM 6-7 x Pant Rituraj	96.25	45.15**	63.05**	85.94**	124.17	-7.17	-0.17	7.97
SM 6-7 x Arka Navneeth	95.07	14.02**	40.70**	83.66**	223.75	26.06**	52.99**	94.56**
SM 6-2 x Pusa Purple Cluster	69.63	8.15*	30.42**	35.52**	127.51	-7.79	-1.53	10.86
SM 6-2 x Pant Samrat	66.40	3.14	25.07**	28.28**	113.29	-18.09	-6.26	-1.48
Sem		3.31	2.86	3.31		9.23	7.99	9.23

Contd.

Table 6. Continued

	Fruits/plant/harvest				Total fruits/plant			
	Mean	% over BP	% over MP	% over SM 6-7	Mean	% over BP	% over MP	% over SM 6-7
Lines								
SM 6-6	6.10				29.76			
Arka Kusumkar	3.86				20.61			
SM-132	2.10				10.12			
SM 6-7	3.54				11.50			
Pant Rituraj	2.30				5.25			
Arka Navneeth	2.80				3.56			
SM 6-2	3.86				12.81			
Pusa Purple Cluster	9.71				28.48			
Pant Samrat	8.28				18.25			
Hybrids								
SM 6-6 x Arka Kusumkar	4.72	-22.74**	5.32*	33.33**	13.75	-53.80**	-45.41**	19.56**
SM 6-6 x SM-132	5.19	-15.04**	26.46**	46.33**	18.65	-37.33**	-6.47**	62.17**
SM 6-7 x Pant Rituraj	4.28	19.05**	36.63**	19.21**	6.25	-45.65**	-25.42**	-45.65**
SM 6-7 x Arka Navneeth	4.50	9.04**	21.76**	9.03**	6.38	-44.52**	-10.00**	44.52**
SM 6-2 x Pusa Purple Cluster	6.76	-30.33**	-0.35	90.96**	19.18	-32.65**	-7.12**	66.78**
SM 6-2 x Pant Samrat	7.30	-11.86**	20.23**	105.93**	19.95	9.32**	28.46**	73.48**
Sem		1.00	0.87	1.00		1.18	1.02	1.18

Contd.

Total 6. Continued

	Total yield/plant			
	Mean	% over BP	% over MP	% over SM 6-7
Lines				
SM 6-6	965.32			
Arka Kusumkar	839.22			
SM-132	831.80			
SM 6-7	510.43			
Pant Rituraj	610.30			
Arka Navneeth	715.36			
SM 6-2	433.90			
Pusa Purple Cluster	851.31			
Pant Samrat	881.80			
Hybrids				
SM 6-6 x Arka Kusumkar	632.90	-34.43	29.85	24.00
SM 6-6 x SM-132	891.61	-7.64	-0.77	74.67*
SM 6-7 x Pant Rituraj	932.81	52.84	66.46**	82.74*
SM 6-7 x Arka Navneeth	776.56	8.55	26.70	52.14
SM 6-2 x Pusa Purple Cluster	904.06	6.16	40.69	77.11*
SM 6-2 x Pant Samrat	890.90	1.03	35.42	74.54*
Sem		35.68	30.90	35.68

Table 7. Mean performance of parental lines and F_1 hybrids of brinjal and extent of heterosis in a disease free condition

	Plant height				Primary branches/plant			
	Mean	% over BP	% over MP	% over SM 6-7	Mean	% over BP	% over MP	% over SM 6-7
Lines								
SM 6-6	53.00				3.00			
Arka Kusumkar	63.33				4.66			
SM-132	68.46				5.33			
SM 6-7	48.70				5.00			
Pant Rituraj	56.20				6.67			
Arka Navneeth	68.16				2.33			
SM 6-2	54.77				4.33			
Pusa Purple Cluster	55.83				4.33			
Pant Samrat	62.83				4.33			
Hybrids								
SM 6-6 x Arka Kusumkar	57.63	-9.00	-0.93	18.34**	3.66	-21.46**	-4.44**	-26.80**
SM 6-6 x SM-132	64.49	-5.79	6.19	32.42**	4.67	-12.38**	12.26**	-6.60**
SM 6-7 x Pant Rituraj	54.66	-2.74	4.21	12.24*	2.00	-70.01**	-65.75**	-60.00**
SM 6-7 x Arka Navneeth	61.00	-10.50	4.39	25.26**	5.33	6.60**	45.23**	6,60**
SM 6-2 x Pusa Purple Cluster	60.10	7.76	8.68	23.41**	4.00	0	0	-13.40**
SM 6-2 x Pant Samrat	61.10	1.59	9.00*	25.46**	4.33	-7.62**	-7.63**	-20.00**
Sem		5.70	4.04	5.70		1.02	0.89	1.02

Contd.

Table 7. Continued

	Days to first fruit set				Percentage of productive flowers			
	Mean	% over BP	% over MP	% over SM 6-7	Mean	% over BP	% over MP	% over SM 6-7
Lines								
SM 6-6	38.00				36.16			
Arka Kusumkar	42.33				50.00			
SM-132	44.33				42.40			
SM 6-7	48.67				34.75			
Pant Rituraj	41.67				33.66			
Arka Navneeth	50.00				36.73			
SM 6-2	37.00				31.94			
Pusa Purple Cluster	42.33				58.50			
Pant Samrat	46.00				42.17			
HYbrids								
SM 6-6 x Arka Kusumkar	41.67	9.66**	3.74	-14.38**	39.07	-21.86**	-9.31	12.43**
SM 6-6 x SM-132	40.00	5.26	-2.84	-17.81**	39.07	-7.85**	0.53	12.43**
SM 6-7 x Pant Rituraj	47.00	5.33	4.05	-3.43	36.00	3.59	5.23	5.33
SM 6-7 x Arka Navneeth	43.33	-3.43	4.74	-3.43	33.17	-9.69**	-7.19	-4.55
SM 6-2 x Pusa Purple Cluster	46.00	24.32**	14.50**	5.49	40.50	-30.77**	-10.44	16.55**
SM 6-2 x Pant Samrat	39.33	-7.09*	-8.17**	-19.19**	33.17	-21.34**	-10.50	-4.55
Sem		2.83	2.45	2.83		2.64	2.28	2.64

Contd.

Table 7. Continued

	Average fruit weight				Average fruit volume			
	Mean	% over BP	% over MP	% over SM 6-7	Mean	% over BP	% over MP	% over SM 6-7
Lines								
SM 6-6	32.33				88.33			
Arka Kusumkar	27.66				79.67			
SM-132	40.33				113.33			
SM 6-7	39.67				101.00			
Pant Rituraj	49.60				126.67			
Arka Navneeth	150.00				183.33			
SM 6-2	38.00				120.00			
Pusa Purple Cluster	26.67				96.66			
Pant Samrat	29.66				110.00			
HYbrids								
SM 6-6 x Arka Kusumkar	38.33	18.56	27.77*	-3.38	120.00	35.85**	42.86**	18.81
SM 6-6 x SM-132	46.00	-100.00**	26.62*	15.96	133.33	17.65	32.23**	32.01**
SM 6-7 x Pant Rituraj	55.66	12.08	24.60*	40.31	116.67**	-7.89	2.49	15.51
SM 6-7 x Arka Navneeth	163.67	9.11	72.58**	72.58**	210.00	14.55	47.72**	107.92**
SM 6-2 x Pusa Purple Cluster	35.67	-6.13	10.31	-10.08	128.33	6.94	18.46	27.06*
SM 6-2 x Pant Samrat	56.67	49.13**	67.51**	42.85**	130.00	8.33	12.55	28.71*
Sem		11.40	9.88	11.40		11.03	9.55	11.03

Table 7. Continued

	Fruits/plant/harvest				Total fruits/plant			
	Mean	% over BP	% over MP	% over SM 6-7	Mean	% over BP	% over MP	% over SM 6-7
Lines								
SM 6-6	6.00				18.00			
Arka Kusumkar	4.33				14.00			
SM-132	1.67				5.00			
SM 6-7	2.33				6.00			
Pant Rituraj	1.67				4.33			
Arka Navneeth	1.67				2.00			
SM 6-2	5.00				7.00			
Pusa Purple Cluster	5.33				14.00			
Pant Samrat	4.00				9.00			
Hybrids								
SM 6-7 x Arka Kusumkar	5.00	16.67**	-3.19**	114.59**	11.67	-53.80**	-45.41**	19.56**
SM 6-6 x SM-132	5.00	-16.67**	30.38**	114.59**	9.67	-37.33**	-6.47**	62.17**
SM 6-7 x Pant Rituraj	1.33	-42.92**	-33.50**	42.92**	5.67	-45.65**	-25.42**	-45.65**
SM 6-7 x Arka Navneeth	3.00	28.76**	50.00**	28.76**	5.33	-44.52**	-10.00**	-44.52**
SM 6-2 x Pusa Purple Cluster	3.00	-43.71**	-41.92**	114.59**	14.00	-32.65**	-7.12**	66.78**
SM 6-2 x Pant Samrat	3.00	-40.00**	-33.33**	28.75**	13.00	9.32**	28.46**	73.48**
Sem		1.10	0.95	1.10		1.17	1.01	1.17

Contd.

Table 7. Continued

	Total yield/plant			
	Mean	% over BP	% over MP	% over SM 6-7
Lines				
SM 6-6	596.67			
Arka Kusumkar	365.00			
SM-132	270.00			
SM 6-7	536.67			
Pant Rituraj	383.33			
Arka Navneeth	296.67			
SM 6-2	386.67			
Pusa Purple Cluster	430.00			
Pant Samrat	360.00			
Hybrids				
SM 6-6 x Arka Kusumkar	420.00	-29.61	-12.65	-21.74
SM 6-6 x SM-132	440.00	-26.26	1.54	-18.01
SM 6-7 x Pant Rituraj	413.00	-22.98	-10.15	-22.99
SM 6-7 x Arka Navneeth	460.00	-14.27	10.40	-14.27
SM 6-2 x Pusa Purple Cluster	440.00	2.33	7.75	-18.01
SM 6-2 x Pant Samrat	493.33	27.58	32.14	-8.08

heterosis over SM 6-7. Under disease free condition SM 6-2 x Pusa Purple Cluster expressed 7.76% heterobeltiosis, 8.68% relative heterosis and 23.41% heterosis over SM 6-7. All the hybrids expressed significant positive heterosis over SM 6-7.

2. Primary branches/plant

SM 6-2 x Pant Samrat had the maximum primary branches/ plant (7.48); which was 24.87% more than the better parent, 41.66% over mid parent and 64.63% over SM 6-7. Heterobeltiosis ranged from 3.95% in SM 6-7 x Pant Rituraj to 26.08% in SM 6-6 x Arka Kusumkar. Maximum relative heterosis was observed in SM 6-2 x Pant Samrat (41.66%) and minimum in SM 6-6 x SM-132 (12.24%). All the hybrids expressed significant positive heterosis over better parental value, mid parental value and over SM 6-7. In disease free condition maximum heterobeltiosis (6.60%) and relative heterosis (45.23%) were observed in SM 6-7 x Arka Navneeth (5.33). Maximum number of primary branches were observed in SM 6-6 x SM-132 (4.67) which was 12.26% more than the mid parent.

3. Days to first fruit set

One hybrid was earlier than respective mid parent and five were earlier than SM 6-7. SM 6-7 x Arka Navneeth produced first fruit 44 days after transplanting, expressing a relative heterosis of -6.06%. The F_1 hybrid SM 6-2 x Pant Samrat expressed heterosis over SM 6-7 for days to first fruit set. Under disease free condition SM 6-2 x Pant Samrat was the earliest.

4. Percentage of productive flowers

Out of 6 F_1 hybrids only one produced more number of productive flowers than better parents. The estimate over better parent varied from -34.97% (SM 6-2 x Pusa Purple Cluster) to 7.60% (SM 6-7 x Pant Rituraj). Significant positive relative heterosis was also shown by SM 6-2 x Pusa Purple Cluster (7.60%). Estimate over SM 6-7 varied from -6.82% in SM 6-7 x Arka Navneeth to 14.61% in SM 6-2 x Pant Samrat. Under wilt free condition maximum percentage of productive flowers were observed in SM 6-2 x Pusa Purple Cluster (40.50%) which was 16.55% more than SM 6-7.

5. Average fruit weight

All the 6 F_1 hybrids expressed significant positive heterosis over SM 6-7. The heterobeltiosis varied from 3.14% in SM 6-2 x Pant Samrat to 45.15% in SM 6-7 x Pant Rituraj. SM 6-7 x Pant Rituraj (Fig. 1) produced fruits with maximum average fruit weight (96.25 g) which was 45.15% more over better parent, 63.05% over mid parent and 85.94% over SM 6-7. Maximum heterobeltiosis in disease free condition was observed in SM 6-2 x Pant Samrat (49.13%) which was 67.51% more than mid parent and 42.85% over SM 6-7.

Fig 1. SM 6-7 x Pant Rituraj

Fig 2. SM 6-6 x Arka Kusumkar

Fig 3. SM 6-7 x Arka Navneeth

Fig 4. SM 6-2 x Pant Samrat

Fig 5. SM6-6.

Fig 6. SM6-2

6. **Average fruit volume**

The estimate over better parent varied from -18.09% (SM 6-2 x Pant Samrat) to 40.73% (SM 6-6 x Arka Kusumkar). The maximum heterobeltiosis for average fruit volume was observed in SM 6-6 x Arka Kusumkar (Fig. 2) (126.00 cm) which was 40.73%, 48.57% and 10.13% over better parent, mid parent and SM 6-7 respectively. The maximum average fruit volume was observed in SM 6-7 x Arka Navneeth (Fig. 3) (223.75 cm^3) which was 94.56% more than SM 6-7. In disease free condition also maximum fruit volume was observed in SM 6-7 x Arka Navneeth which expressed heterosis to the extent of 107.92% over SM 6-7.

7. **Fruits/plant/harvest**

All the hybrids exhibited significant positive heterosis over SM 6-7 for fruits/plant/harvest. The maximum number of fruits/plant/harvest was obtained in SM 6-2 x Pant Samrat (7.30) which was 105.93% more than SM 6-7. Under disease free condition all the six hybrids exhibited heterosis over SM 6-7.

8. **Total fruits/plant**

SM 6-2 x Pant Samrat (Fig.4) produced maximum number of fruits/plant (19.95) which was 9.32% over better parent, 28.46% over mid parent and 73.48% over SM 6-7. Five hybrids exhibited significant positive heterosis over SM 6-7. In disease free condition also four exhibited significant positive heterosis over SM 6-7. SM 6-2 x Pant Samrat exhibited maximum heterobeltiosis (9.32%) which was 28.46% over mid parent and 73.48% over SM 6-7.

9. **Total yield/plant**

The estimate over better parent ranged from -34.43% (SM 6-6 x Arka Kusumkar) to 52.84% (SM 6-7 x Pant Rituraj). The highest yielding hybrid was SM 6-7 x Pant Rituraj (932.81 g) which was 52.84% over better parent, 66.46% over mid parent and 82.74% over SM 6-7. This was followed by SM 6-2 x Pusa Purple Cluster (904.06 g) which was 77.11% more than SM 6-7. In disease free condition none of the hybrids expressed heterosis over SM 6-7.

10. **Index to earliness**

Index to earliness for the parental lines and F_1 hybrids are given in Table 8. None of the hybrids were earlier than the earliest parent. The hybrids SM 6-6 x Arka Kusumkar (IE = 0.77) and SM 6-2 x Pant Samrat (IE = 0.72) were earlier among the hybrids. Among the parental lines SM 6-6 was the earliest followed by SM 6-2. (Fig. 5 and Fig. 6).

11. **Behaviour of F_1 hybrids at F_1 level for a few discrete characters.**

All the parental lines except SM-132 were non prickly. Among the F_1 hybrids, SM 6-6 x SM-132 was prickly indicating

Table 8. Index to earliness of lines and hybrids of brinjal

	Index to earliness
Lines	
Arka Kusumkar	0.56
SM-132	0.56
SM 6-7	0.50
Pant Rituraj	0.50
Arka Navneeth	0.84
SM 6-2	0.95
Pusa Purple Cluster	0.76
Pant Samrat	0.54
Hybrids	
SM 6-6 x Arka Kusumkar	0.77
SM 6-6 x SM-132	0.49
SM 6-7 x Pant Rituraj	0.60
SM 6-7 x Arka Navneeth	0.80
SM 6-2 x Pusa Purple Cluster	0.59
SM 6-2 x Pant Samrat	0.72

dominance of prickly over non-prickly character. Arka Kusumkar had white flowers among parental lines, but the F_1 SM 6-6 x Arka Kusumkar had purple flowers indicating dominance of purple flower over white. The F_1s generated by crossing lines with dark purple fruit colour and light purple fruit colour were having light purple colour for fruits. Oval fruit shape was dominant over round fruit shape.

C. Correlation and path analysis in brinjal

Significant positive phenotypic correlation was observed between yield and plant height (r_p = 0.54); primary branches/plant (r_p = 0.47); percentage of productive flowers (r_p = 0.27) and total fruits/plant (r_p = 0.43) (Table 9). Significant positive genotypic correlation was observed between yield and plant height, primary branches/plant, days to first fruit set, percentage of productive flowers and total fruits/plant. Significant negative genotypic correlation was observed between yield and average fruit volume.

When the yield was considered as a function of plant height, primary branches/plant, percentage of productive flowers, average fruit weight, average fruit volume and total fruits/plant the component characters explained 93.24% of variation in yield (R^2 = 0.9324). The direct and indirect effects of seven component characters on yield are presented in Table 10. Primary branches/plant had the maximum value of positive direct effect on yield (0.76).

Table 9. Genotypic (r_g) and phenotypic (r_p) correlations among yield and its components in brinjal

Characters	Yield	
	Genotypic correlation (r_g)	Phenotypic correlation (r_p)
Plant height (cm)	0.62**	0.54**
Primary branches/plant	0.51**	0.47**
Days to first fruit set	0.75**	-0.02
Percentage of productive flowers	0.30*	0.27*
Average fruit weight (g)	-0.03	-0.02
Average fruit volume (cm^3)	-0.26*	-0.22
Total fruits/plant	0.48**	0.43**

* p = 0.05

** p = 0.01

Table 10. Direct and indirect effects of seven component characters on yield/plant of brinjal

Character	(r_p)	Direct effect	Indirect effect via						
			Plant height	Primary branches/ plant	Days to first fruit set	Percentage of productive flowers	Average fruit weight	Average fruit volume (cm^3)	Total fruits/ plant
Plant height	0.54	0.06	-	-0.48	-0.02	0.08	-0.12	0.07	-0.002
Primary branches/ plant	0.47	0.76	0.04	-	-0.08	0.01	-0.03	0.05	-0.002
Days to first fruit set	-0.02	0.22	-0.01	-0.26	-	0.03	0.07	-0.08	0.002
Percentage of productive flowers	0.27	0.31	0.01	0.02	0.02	-	-0.19	0.10	-0.002
Average fruit weight	-0.02	0.40	-0.02	-0.05	0.04	-0.15	-	-0.24	0.003
Average fruit volume	-0.22	-0.34	-0.01	-0.12	0.05	-0.09	0.29	-	0.003
Total fruits/plant	0.43	-0.01	0.03	0.36	-0.12	0.14	-0.27	0.20	-

r_p = Phenotypic correlation coefficient between fruit yield and its component characters.

Plant height though having a correlation of 0.54 with yield had only 0.06 as direct effect. Average fruit volume and total fruits/plant had negative direct effects on yield. Days to first fruit set, percentage of productive flowers and average fruit weight had positive direct effect on yield.

D. Evaluation for field resistance to bacterial wilt and biochemical bases of resistance

The percentage of wilt incidence at 15, 30, 45 and 60 days after transplanting and the score are presented in Table 11. In the case of parental lines lowest percentage of wilt incidence was observed in SM-132 (0%), SM 6-6 (4.76%) and SM 6-2 (10.93%) which were scored as resistant. Among hybrids lowest percentage of wilt incidence was observed in SM 6-6 x SM-132 (5.26%) and SM 6-2 x Pusa Purple Cluster (12.50%). SM-132, SM 6-7, SM 6-6, SM 6-2 and PPC were resistant to bacterial wilt among parental lines and among hybrids SM 6-6 x SM-132 and SM 6-2 x Pusa Purple Cluster were resistant. SM 6-7 x Pant Rituraj and SM 6-7 x Arka Navneeth were moderately resistant; SM 6-2 x Pant Samrat was moderately susceptible and SM 6-6 x Arka Kusumkar was susceptible to wilt.

Total phenol content and orthodihydric phenol content expressed as catechol in ppm at different stages of growth are presented in Table 12 and Table 13. Total phenol

Table 11. Bacterial wilt incidence in parental lines and F_1 hybrids of brinjal

	Wilt incidence					
	15 DAT (%)	30 DAT (%)	45 DAT (%)	60 DAT (%)	Total	Score
Lines						
SM 6-6	1.59	0	0	3.18	4.76	R
Arka Kusumkar	3.64	18.18	21.82	36.36	80.00	S
SM-132	0	0	0	0	0	R
SM 6-7	1.64	4.92	3.28	6.56	16.39	R
Pant Rituraj	16.67	30.00	5.00	28.33	80.00	S
Arka Navneeth	28.33	16.67	5.00	30.00	80.00	S
SM 6-2	1.52	4.69	0	1.56	12.50	R
Pusa Purple Cluster	3.13	3.13	4.69	16.13	54.83	R
Pant Samrat	6.45	24.19	8.06	7.81	12.50	MS
Hybrids						
SM 6-6 x Arka Kusumkar	18.18	9.09	1.82	34.55	63.63	S
SM 6-6 x SM-132	0	0	1.75	3.51	5.26	R
SM 6-7 x Pant Rituraj	8.06	8.06	8.06	16.13	40.32	MR
SM 6-7 x Arka Navneeth	4.84	6.45	12.90	12.90	37.09	MR
SM 6-2 x Pusa Purple Cluster	3.13	1.56	0	7.81	12.50	R
SM 6-2 x Pant Samrat	12.50	7.81	7.81	15.63	43.75	MS

R - Resistant
MR - Moderately resistant
MS - Moderately susceptible
S - Susceptible

DAT - days after transplanting

Table 12. Total phenol content of roots in parental lines and hybrids at different growth stages (Expressed as catechol in ppm)

Lines and hybrids	30 days after sowing	45 days after transplanting	60 days after transplanting (fruit set stage)	Score
Lines				
SM 6-6	3×10^3	6.0×10^3	2.25×10^3	R
Arka Kusumkar	1.1×10^3	0.81×10^3	1.13×10^3	S
SM-132	3.5×10^3	6.0×10^3	2.25×10^3	R
SM 6-7	2.0×10^3	4.5×10^3	2.0×10^3	R
Pant Rituraj	2.5×10^3	3.75×10^3	1.5×10^3	S
Arka Navneeth	1.0×10^3	1.5×10^3	0.96×10^3	S
SM 6-2	2.6×10^3	4.5×10^3	1.75×10^3	R
Pusa Purple Cluster	1.5×10^3	4.5×10^3	1.5×10^3	R
Pant Samrat	2.0×10^3	1.5×10^3	1.7×10^3	MS
Hybrids				
SM 6-6 x Arka Kusumkar	2.0×10^3	3.75×10^3	1.88×10^3	S
SM 6-6 x SM-132	4.0×10^3	6.0×10^3	2.63×10^3	R
SM 6-7 x Pant Rituraj	1.5×10^3	3.0×10^3	1.88×10^3	MR
SM 6-7 x Arka Navneeth	1.5×10^3	4.5×10^3	0.75×10^3	MR
SM 6-2 x Pusa Purple Cluster	2.5×10^3	3.0×10^3	1.8×10^3	R
SM 6-2 x Pant Samrat	3.6×10^3	5.25×10^3	1.6×10^3	MS

Table 13. Orthodihydricphenols present in the roots of parental lines and hybrids at different growth stages (expressed as catechol in ppm)

Lines and hybrids	30 days after sowing	45 days after transplanting	60 days after transplanting (fruit set stage)	Score
Lines				
SM 6-6	110.00	108.33	105.50	R
Arka Kusumkar	45.25	54.16	45.10	S
SM-132	80.95	70.83	75.80	R
SM 6-7	65.83	70.83	72.83	R
Pant Rituraj	40.00	57.50	55.00	S
Arka Navneeth	40.50	37.50	36.50	S
SM 6-2	60.00	64.16	70.00	R
Pusa Purple Cluster	75.85	87.50	86.50	R
Pant Samrat	57.65	58.33	56.34	MS
Hybrids				
SM 6-6 x Arka Kusumkar	55.25	62.50	60.25	S
SM 6-6 x SM-132	70.00	75.00	80.00	R
SM 6-7 x Pant Rituraj	60.00	66.66	65.00	MR
SM 6-7 x Arka Navneeth	60.50	58.33	57.85	MR
SM 6-2 x Pusa Purple Cluster	110.65	104.16	100.30	R
SM 6-2 x Pant Samrat	70.65	66.66	67.82	MS

content in the roots was maximum in SM 6-6 x SM-132 (4000 ppm, 6000 ppm and 2625 ppm after 30 days of sowing, 45 days after transplanting and at fruit set stage respectively). The lowest total phenol content was observed in Arka Navneeth and Arka Kusumkar and both were susceptible to wilt. Among the parental lines, total phenol content was maximum in SM-132 (3500 ppm, 6000 ppm and 2250 ppm at 30 days after sowing, 45 days after transplanting and fruiting stage respectively). The OD phenol content was maximum in SM 6-6 among the parental lines and SM 6-2 x Pusa Purple Cluster among hybrids, both were resistant to wilt. The lowest OD phenol content in the roots was observed in Arka Kusumkar and Arka Navneeth.

E. Quality characters in parental lines and F_1 hybrids

The salient morphological characters of parental lines and hybrids are given in Table 14. Vitamin C content of brinjal fruits at vegetable stage varied from 2.12 mg (Arka Kusumkar and SM-132) to 6.44 mg/100 g (SM 6-7). Among the hybrids, maximum Vitamin C content was observed in SM 6-2 x Pant Samrat (5.01 mg/100 g) followed by SM 6-6 x SM-132 (Table 15). Carotene content varied from 0.35 μg/100 g in Arka Kusumkar to 12.39 μg/100 g in SM 6-6 x SM-132. Among the hybrids maximum carotene content was observed in SM 6-6 x SM-132 (12.39 μg) followed by SM 6-7 x Pant Rituraj (7.75 μg/100 g).

Table 14. Salient morphological characters of parental lines and hybrids of brinjal.

Lines/Hybrids	Prickly/ non-prickly	Flower colour	Fruit colour	Fruit shape
SM 6-6	Non prickly	Purple	White	Long
Arka Kusumkar	Non prickly	White	Green	Long
SM-132	Prickly	Purple	Green	Long
SM 6-7	Non prickly	Purple	Purple	Oval
Pant Rituraj	Non prickly	Purple	Dark purple	Round
Arka Navneeth	Non prickly	Purple	Dark purple	Cylindrical
SM 6-2	Non prickly	Purple	Light purple	Long
Pusa Purple Cluster	Non prickly	Purple	Dark purple	Long
Pant Samrat	Non prickly	Purple	Dark purple	Long
SM 6-6 x Arkam Kusumkar	Non prickly	Purple	Green	Long
SM 6-6 x SM-132	Prickly	Purple	Green	Long
SM 6-7 x Pant Rituraj	Non prickly	Purple	Purple	Oval
SM 6-7 x Arka Navneeth	Non prickly	Purple	Purple	Cylindrical
SM 6-6x Pusa Purple Cluster	Non prickly	Purple	Purple	Long
SM 6-2 x Pant Samrat	Non prickly	Purple	Purple	Long

Table 15. Quality characters of parental lines and F_1s of brinjal

Lines/hybrids	Vitamin C		Carotene		Iron	
	mg/100 g	g/ha/day	µg/100/g	mg/ha/day	mg/100g	g/ha/day
Lines						
SM 6-6	2.86	4.34	4.84	7.34	1.86	2.82
Arka Kusumkar	2.12	2.79	0.35	4.62	1.79	2.36
SM-132	2.12	2.77	9.99	13.05	1.60	2.09
SM 6-7	6.44	5.17	4.84	3.88	1.40	1.12
Pant Rituraj	5.72	5.49	3.66	3.51	1.02	0.98
Arka Navneeth	4.29	4.82	3.66	4.11	0.90	1.01
SM 6-2	4.29	2.93	3.27	2.2	1.20	0.82
Pusa Purple Cluster	3.93	5.26	1.06	1.4	1.30	1.74
Pant Samrat	3.93	5.45	3.27	4.53	1.10	1.52
Hybrids						
SM 6-6 x Arka Kusumkar	2.86	2.84	6.65	6.61	1.28	1.27
SM 6-6 x SM-132	4.29	6.01	12.39	17.36	1.39	1.95
SM 6-7 x Pant Rituraj	2.86	4.19	7.75	11.36	1.32	1.93
SM 6-7 x Arka Navneeth	2.86	3.49	3.27	3.99	1.24	1.51
SM 6-2 x Pusa Purple Cluster	2.86	4.06	4.44	6.30	1.16	1.65
SM 6-2 x Pant Samrat	5.01	7.01	5.65	7.91	1.86	2.60

The variability for iron content was 0.90 mg/100 g to 1.86 mg/100 g. Among the hybrids maximum iron content was observed in SM 6-2 x Pant Samrat (1.86 mg) followed by SM 6-6 x SM-132 (1.39 mg/100 g).

When the vitamin C yield/ha/day was calculated SM 6-2 x Pant Samrat gave the maximum vitamin C yield/ha/day (7.01 g) followed by SM 6-6 x SM-132 (6.01 g). Carotene yield/ha/day was maximum in SM 6-6 x SM-132 (17.36 mg) and iron yield/ha/day was maximum in SM 6-6 (2.82 g).

Observation on incidence of root galls caused by *Meloidogyne incognita*

Root galls were observed in roots of Pant Rituraj, Pant Samrat, Arka Kusumkar, Arka Navneeth, SM 6-7 x Pant Rituraj, SM 6-7 x Arka Navneeth and SM 6-6 x Arka Kusumkar.

Discussion

DISCUSSION

Brinjal (*Solanum melongena* L.) is one of the most important warm season fruit vegetables grown throughout India. One important objective of crop improvement programme in brinjal is of attainment of maximum yield. Development of improved cultivars through pedigree or pure line selection has so far been followed in this crop. Exploitation of hybrid vigour can be thought of, as earlier studies indicated that economic heterosis for yield existed in brinjal (Dutt, 1970; Peter, 1971; Lal *et al.* 1973; Mishra and Choudhury, 1975; Vijay and Nath, 1978, Singh *et al.* 1982 and Patil and Shinde, 1984). Further unique advantage associated with brinjal is that a large number of seeds are produced with relatively easy emasulation and pollination technique and high percentage of fruit set. Therefore, effort is made in the present study to identify heterotic hybrids for exploitation using three isogenic lines of brinjal (SM 6-2, SM 6-6 and SM 6-7) resistant to bacterial wilt.

In Kerala, bacterial wilt caused by *Pseudomonas solanacearum* E.F. Smith is one of the important limiting factors in brinjal cultivation. The brinjal line SM 6 was reported resistant to bacterial wilt (KAU, 1981). The line was segregating for fruit colour, shape and presence/absence of prickles. Sheela (1982) improved this line through simple selection. Further improvement of this line was made by Sankar (1984) and Jessykutty (1985). Twenty five lines improved through four methods of selection after four cycles were evaluated by Ushamani (1987) under two fertility levels during two seasons. SM 6-2, SM 6-6 and SM 6-7 were promising. Improvement in these three lines (SM 6-2, SM 6-6 and SM 6-7) through heterosis breeding would be appropriate to combine earliness, higher yield and resistance to bacterial wilt. Heterosis for earliness was reported by Singh (1980) and Kandaswamy *et al.* (1983).

The materials consisted of three isogenic lines of brinjal SM 6-2, SM 6-6 and SM 6-7 and five promising varieties namely Arka Kusumkar, Arka Navneeth, Pant Rituraj Pant Samrat, Pusa Purple Cluster and one accession (SM-132) found high yielding and resistant to bacterial wilt. Six hybrids were developed and were evaluated. The data were analysed and heterosis over better parent, mid parent and standard variety Surya (SM 6-7) were calculated. Correlation between yield and its components were studied. Path coefficient analysis was done to find out direct and indirect effect(s) of yield components on yield.

The most basic comparison that is of importance to a breeder is that of parental vs. hybrid performance. Analysis of variance clearly indicated significant differences among parental lines and hybrids for all characters studied. There was significant difference for all characters except plant height in the trial conducted under wilt free condition.

Since yield and its components are polygenic, they are complex in their nature. They are highly influenced by environmental factors. It becomes very difficult to judge how much of the variability is heritable and how much is non heritable. It is therefore necessary to resort to biometrical approach to partition the observed variability into heritable and nonheritable components by genetic parameters such as genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance. These parameters which give insight into the genetic variability of the population are prerequisites to formulate sound and successful breeding programme. In the present study the contribution of genotype to the phenotypic expression of different characters were studied. Genotypic coefficient of variation was maximum for total fruits/plant (51.84). High estimate of genotypic coefficient of variation for total fruits/plant was reported earlier by Bhutani *et al.* (1977), Salehuzzaman and Joarder (1980) and Chadha and Paul (1984).

Heritability values indicate effectiveness of selection on the basis of phenotypic performance. Heritability along with estimates of genetic advance should be considered more than heritability *per se* while making selection. High heritability was observed for fruits/plant (h^2 0.96) followed by average fruit weight (h^2 0.94). Goto (1953), Hiremath and Rao (1974), Bhutani *et al.* (1977), Salehuzzaman and Jorder (1980), Joarder *et al.* (1981) and Singh and Singh (1985) also observed high estimate of heritability for fruits/plant. High heritability coupled with high genetic advance was observed for fruits/plant followed by fruits/plant/harvest and average fruit weight. This reveals the involvement of additive gene action and offers more scope in predicting gain under selection. Involvement of additive gene action for fruits/plant was reported earlier by Peter (1971), Singh and Khanna (1978), Dixit *et al.* (1984) and Singh and Mital (1988). Average fruit volume had a low estimate of heritability and genetic advance (Table 5). This shows the impact of environment on fruit volume. High heritability and low genetic advance were observed for days to first fruit set. (h^2 = 0.74; GA = 14.64) which indicate involvement of nonadditive gene action for days to first fruit set. This was substanciated by reports of Peter (1971); Sidhu *et al.* (1980) and Singh and Mital (1988).

Heterosis breeding was extensively explored and utilized for boosting up yield in a number of economically important crops. Prevelance of heterosis has practical implication if heterosis is explored on rather extensive scale and high heterotic crosses were easily and quickly separated out. Information on genetic divergence of the material would fascilitate the choice of parents for hybridisation. F_1 heterosis is presumed related to the extent of genetic distance between parents. In the present investigation maximum genetic distance was observed between SM 6-6 and Arka Kusumkar. A clear cut relationship between genetic distance and F_1 performance could not be made from the present study as the F_1 heterosis expressed by SM 6-6 x Arka Kusumkar was not to the extent of some other hybrids, where the genetic distance was less. This may be because the genetic distance was calculated between nine varieties only.

Three out of six F_1 hybrids were taller than their parents and expressed heterobeltiosis. SM 6-6 x Arka Kusumkar exhibited significant negative heterosis over mid parental value for plant height. SM 6-6 x SM-132 was the tallest hybrid (79.51 cm) and expressed significant positive heterobeltiosis (17.27%), relative heterosis (24.98%) and heterosis over SM 6-7 (44.51%). All the hybrids expressed significant heterobeltiosis, relative heterosis, and heterosis over SM 6-7 for primary branches/ plant. In wilt disease free condition, only SM 6-7 x Arka Navneeth expressed heterobeltiosis (6.60%), relative heterosis (45.23%) and heterosis over SM 6-7 (6.06%). Heterosis for plant height has been reported earlier by Mishra (1961), Thakur *et al.* (1968) and Peter (1971). Singh and Mital (1988) reported that primary branches/plant is controlled by non additive gene action and therefore heterosis breeding could be used for improvement of this character. For days to first fruit set SM 6-7 x Arka Navneeth expressed relative heterosis. Heterosis for earliness was reported by Oganesyan (1971), Peter (1971), Viswanathan (1973), Hani *et al.* (1977), Singh *et al.* (1977) Dharmegowda *et al.* (1979), Hristakes (1979), Singh (1980) and Kandaswamy *et al.* (1983). A few attempts are only made so far to estimate extent of heterosis for percentage of productive flowers. In the present study, it was found that only SM 6-7 x Pant Rituraj expressed significant positive heterobeltiosis (7.6%) and relative heterosis (7.6%). Heterosis for average fruit weight was observed in five F_1 hybrids over their better parents, six F_1 hybrids over mid parents and over SM 6-7. Heterobeltiosis ranged from 3.14% to 45.15% and relative heterosis from 25.07% to 63.05%. For average fruit volume SM 6-7 x Arka Navneeth expressed heterobeltiosis (26.06%), relative heterosis (52.99%) and heterosis over SM 6-7 (94.56%). SM 6-6 x Arka Kusumkar also expressed heterobeltiosis (40.73%) and relative heterosis (48.57%) significant even at 1% level. Heterosis for average fruit volume was earlier reported by Joarder *et al.* (1981). In bacterial wilt free condition also SM 6-6 x Arka Kusumkar and SM 6-7 x Arka Navneeth exhibited heterobeltiosis. SM 6-2 x Pant Samrat produced maximum fruits/plant (19.95) which was 9.32% more than better parent, 28.46% more than mid parent and 73.48% more than SM 6-7. In disease free condition also, SM 6-2 x Pant Samrat expressed significant heterobeltiosis, relative heterosis and heterosis over SM 6-7. SM 6-7 x Pant Rituraj produced maximum yield/plant (932.81 g) exhibiting significant relative heterosis and heterosis over SM 6-7. The high yield of this hybrid may be due to increased average fruit weight (96.25 g). All the hybrids were high yielding than SM 6-7. In wilt free condition, none of the hybrids exhibited heterosis for yield. Varying extent of heterosis for yield has been reported earlier by Chadha and Sidhu (1982), Singh *et al.* (1982), Kandaswamy *et al.* (1983), Rajput *et al.* (1984), Dixit and Gautam (1987), Gopinath (1987) and Seethapathy (1987). Ram *et al.* (1981) reported that none of the crosses which they tried expressed heterosis for yield. SM 6-6 x Arka Kusumkar exhibited highest negative heterosis (-34.43%) over better parental value. Similar observations were made by Dharmegowda *et al.* (1979). When index to earliness was calculated, none of the hybrids were earlier than the earliest female parent SM 6-6.

Yield in brinjal is mainly governed by size, weight and number of fruits. In the present study it was found that fruit weight is mainly responsible for increased yield followed by fruits/plant.

Selection for yield *per se* may not be effective since implicitely or explicitely "there may not be genes for yield *per se* rather for the various components, the multiplicative interaction of which results in the artifact of yield" (Grafius, 1956). For rational improvement of yield and its components, the under standing of correlations is very useful. A knowledge of such relationship is essential if selection for the simultaneous improvement of yield components and in turn yield to be effective. Although correlations are helpful in determining the components of a complex character like yield they do not provide an exact picture of the relative importance of direct and indirect influences of each component characters towards yield. Path coefficient analysis proves helpful in partitioning the correlation coefficients into direct and indirect effects. In general, genotypic correlations were higher than phenotypic correlations as reported earlier by Goto (1956) and Hiremath and Rao (1974). Yield/plant showed significant positive phenotypic correlation with plant height, primary branches/plant, percentage of productive flowers and total fruits/plant and had a negative association with days to fruit set, average fruit weight and average fruit volume though the correlation was non significant. Singh and Singh (1981) observed positive correlation between yield and fruits/plant and a negative association with days to flower. Srivastava and Sachan (1974) observed a negative correlation between yield and fruit weight. It means that plant height, primary branches/plant and fruits/plant are the greatest contributing components of yield and by putting selection pressure on these characters, the yield/plant can be enhanced. Yield can also be enhanced by reducing average fruit weight and average fruit volume as reported earlier by Hiremath and Rao (1974). Path analysis indicated that primary branches/plant had the maximum positive direct effect on yield followed by average fruit weight. Plant height though having high positive correlation with yield, the direct effect was less, but it had the maximum indirect effect through primary branches/plant. Therefore much emphasis should be given for selection of plants with more primary branches. Average fruit volume had a negative correlation and negative direct effect on yield suggesting that yield can be increased by reducing the fruit volume.

Evaluation for wilt resistance showed that SM 6-2, SM 6-6, SM 6-7, Pusa Purple Cluster and SM-132 were resistant. The isogenic lines were evolved through different methods of selection over years giving emphasis on bacterial wilt resistance. Among the hybrids SM 6-2 x Pusa Purple Cluster, SM 6-6 x SM-132 were resistant, SM 6-7 x Pant Rituraj, SM 6-7 x Arka Navneeth were moderately resistant, SM 6-2 x Pant Samrat was moderately susceptible to wilt and SM 6-6 x Arka Kusumkar was susceptible to wilt. The observation of a moderating high percentage of susceptibility may be due to the fact that only a lower number of plants (16) were taken for evaluation.

Thapliyal and Nene (1967) opined that nondiffusible substances like tomatine and phenols have a key role in defense mechanism. In the present study, total phenol and O D phenol content in the roots were estimated. Total phenol in the roots was maximum 45 days after transplanting and decreased at the time of fruit set stages (Fig. 7). SM 6-6 x SM-132 had the maximum amount of total phenol in the roots at all the three stages (30 days after sowing, 45 days after transplanting and fruit set stage) among hybrids and SM 6-6 and SM-132 among parents. All these were resistant to wilt. The lowest phenol content at different stages of growth were observed in Arka Kusumkar and Arka Navneeth both were susceptible to wilt. But the susceptible line Pant Rituraj had more phenolic content in the roots compared to Pusa Purple Cluster which is resistant to bacterial wilt. Thus it is not possible to draw a clear association between total phenols in the roots and resistance/susceptibility to bacterial wilt. Maine and Kelman (1960) and Sitaramaih *et al.* (1985) were also unable to correlate the total phenol concentration in the roots to susceptibility/resistance to bacterial wilt in brinjal. With regard to O D phenol content, it was found that there is positive association between O D phenol content in the roots and resistance to bacterial wilt. The resistant lines and hybrids had higher O D phenol content in the roots compared to susceptible lines and hybrids. There is an increased O D phenol at 45 days after transplanting

Fig. 7 Biochemical status of parental lines and hybrids at different growth stages

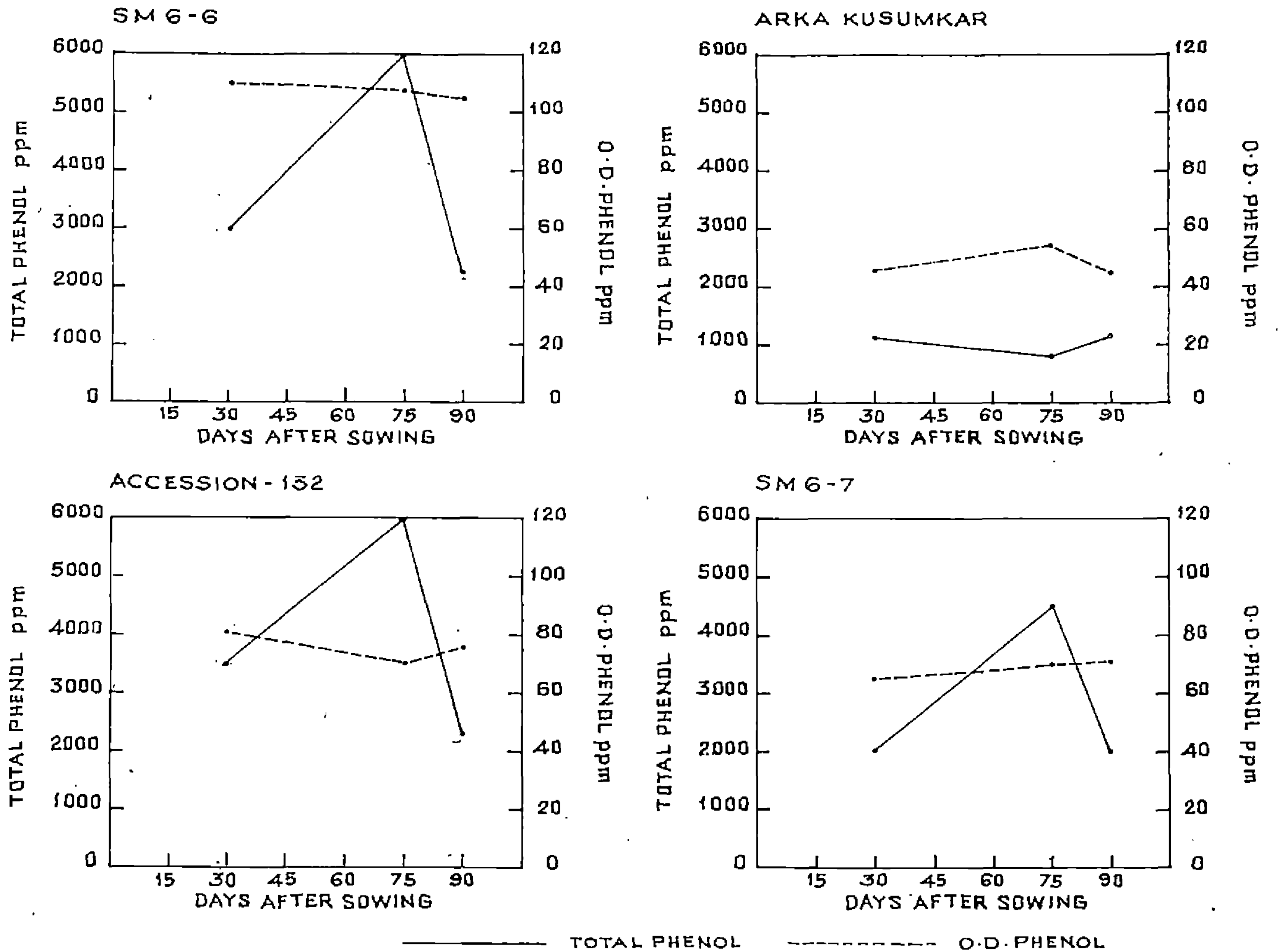
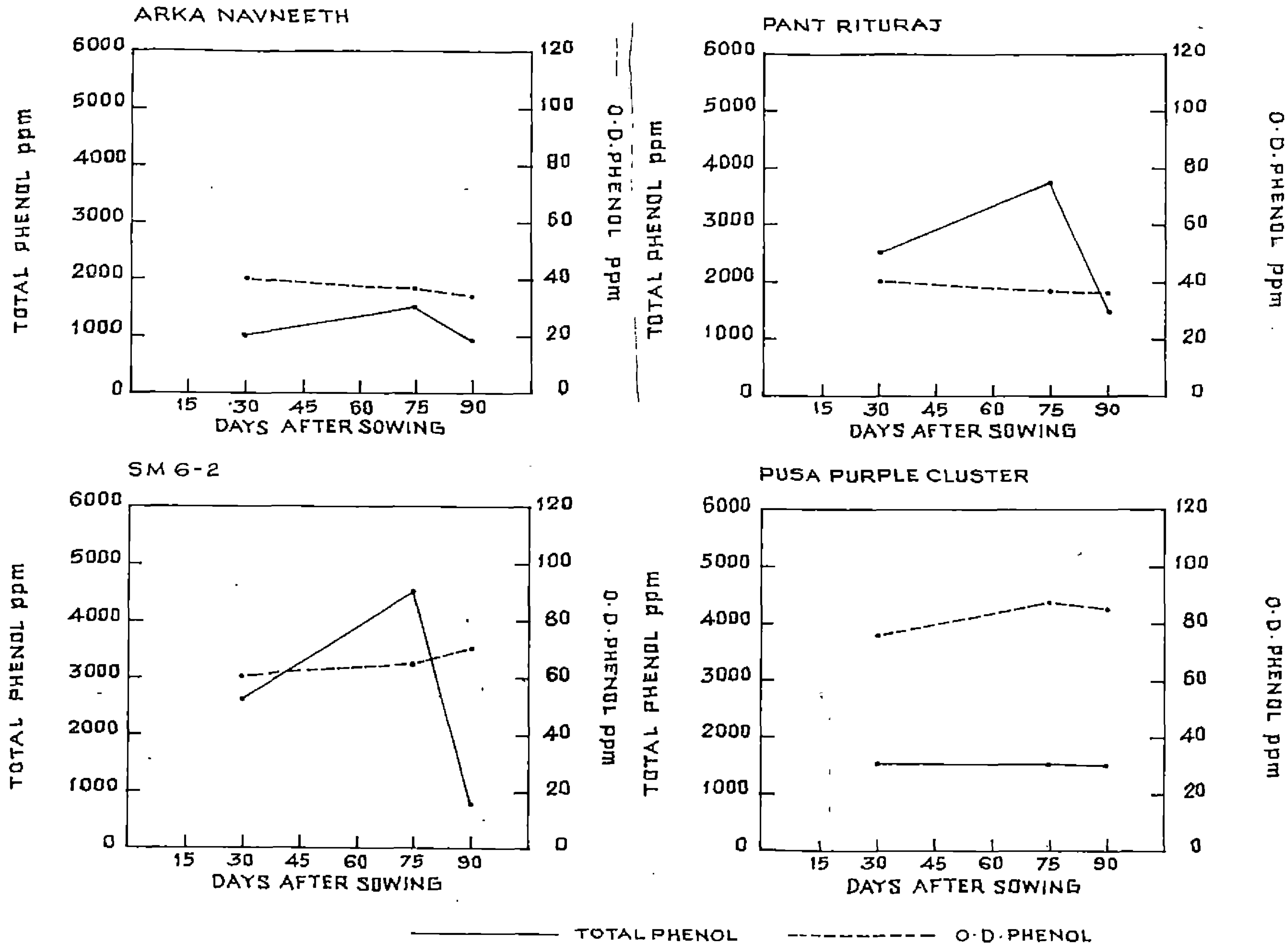
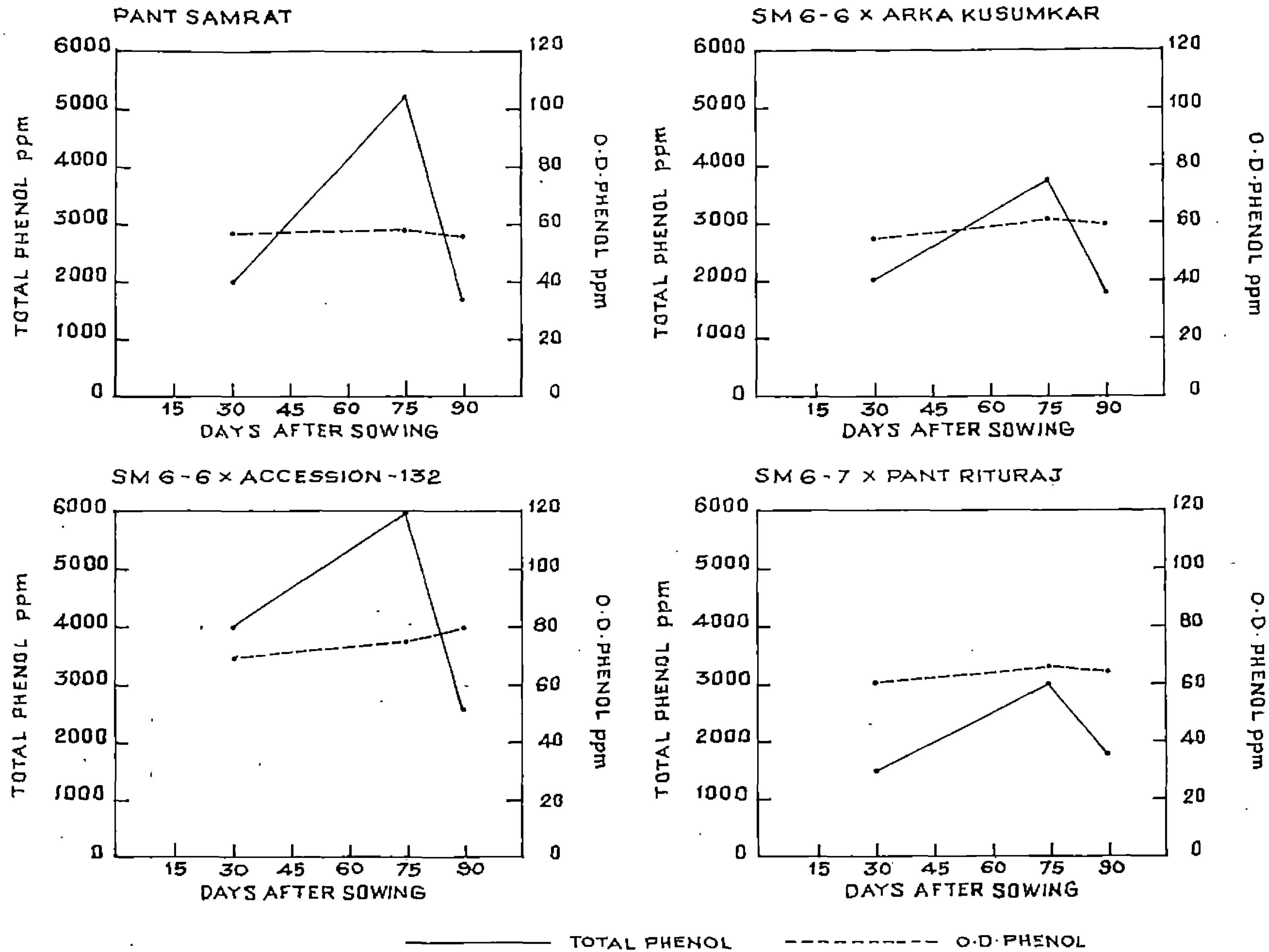


Fig. 7 (contd.)



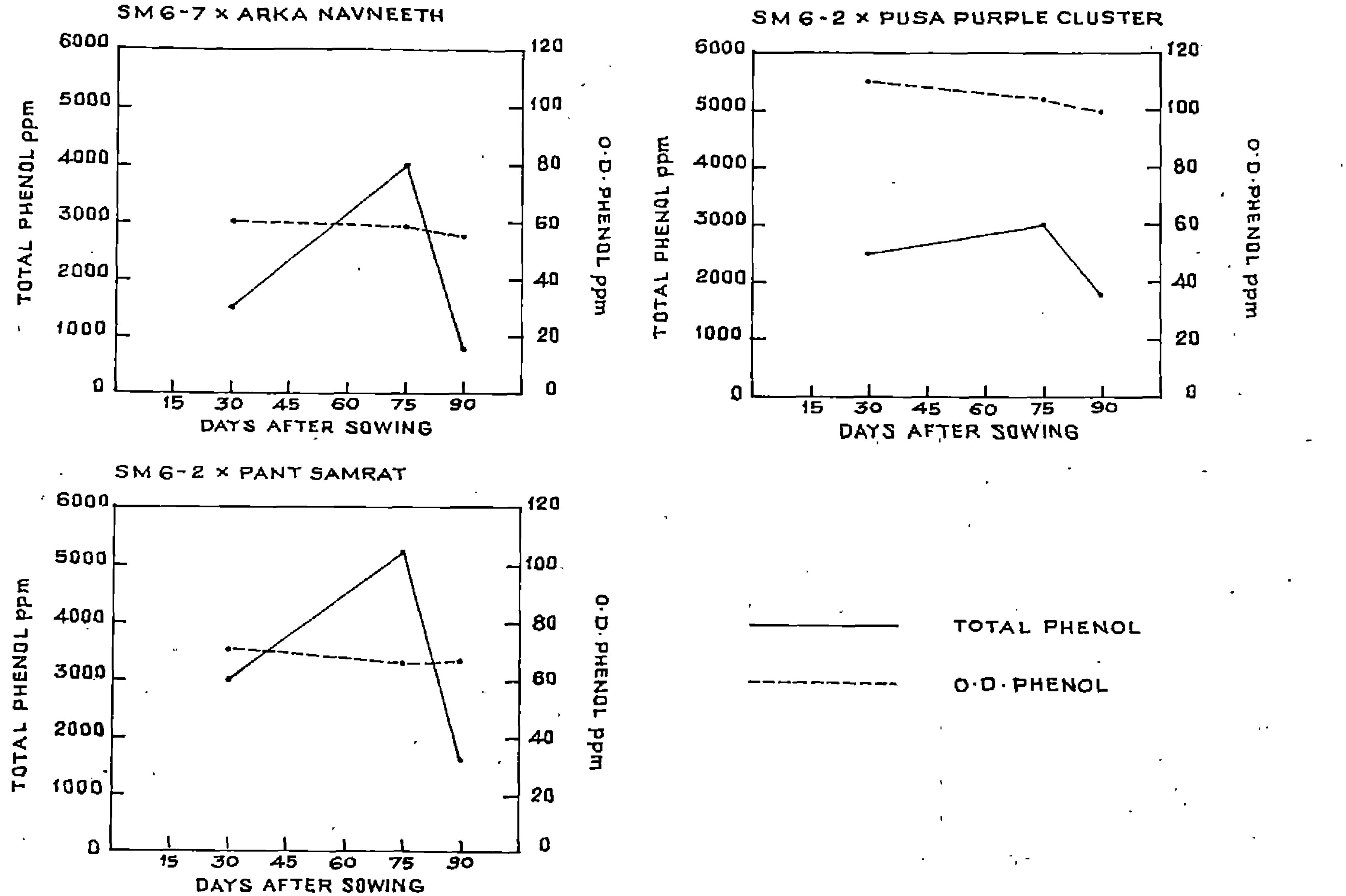
ARKA NAVNEETH
PANT RITURAJ
SM 6-2
PUSA PURPLE CLUSTER
TOTAL PHENOL ppm
O·D·PHENOL ppm
DAYS AFTER SOWING
0
1000
2000
3000
4000
5000
6000
0
20
40
60
80
100
120
15
30
45
60
75
90
TOTAL PHENOL
O·D·PHENOL

Fig. 7 (contd.)



PANT SAMRAT
SM 6-6 × ARKA KUSUMKAR
SM 6-6 × ACCESSION-132
SM 6-7 × PANT RITURAJ
TOTAL PHENOL ppm
O·D·PHENOL ppm
0
1000
2000
3000
4000
5000
6000
20
40
60
80
100
120
15
30
45
60
75
90
DAYS AFTER SOWING
TOTAL PHENOL
O·D·PHENOL

Fig. 7 (contd.)



SM 6-7 × ARKA NAVNEETH
SM 6-2 × PUSA PURPLE CLUSTER
SM 6-2 × PANT SAMRAT
TOTAL PHENOL ppm
O·D·PHENOL ppm
6000
5000
4000
3000
2000
1000
0
120
100
80
60
40
20
0
15
30
45
60
75
90
DAYS AFTER SOWING
TOTAL PHENOL
O·D·PHENOL

compared to 30 days after sowing but dropped at the time of fruit set which coincided with the higher mortality in susceptible genotypes. Gangappa (1986) obtained similar results with regard to total phenol. Bell (1981) reported that levels of resistance in stem and root generally increase rapidly during the first two weeks of seedlings or when new shoot grows and slowly there after. Levels of resistance frequently decline with age. Increased resistance to bacterial wilt because of the increased O D phenol content in tomato roots was observed by Rajan (1985). Mahadevan (1970) observed that prohibitins were particularly effective at the point of entry and penetration of microorganism and the quantity of prohibitins in the plant part largely determined resistance to parasites. Thomiyama (1963) observed that aromatic compounds like mono and dihydric phenols increased in host tissues invaded by parasites as a part of resistance mechanism.

Attempts to estimate nutritive values in terms of carotene, vitamin C and iron are very much limited in the conventional breeding programme in brinjal. The range for vitamin C content of fruit was 2.12 mg/100 g to 6.44 mg/100 g. This is inconfirmity with the reports of CSIR (1972) and Kalra *et al.* (1988). The carotene content of the fruits varied from 0.35 μg/100 g to 12.39 μg/100 g. Iron content of fruits varied from 0.9 mg/100 g to 1.86 mg/100g. Jaiswal *et al.* (1974) reported range of variability for iron content in round and oblong type of brinjal from

0.59 mg to 0.8 mg/100 g and in long type from 0.69 mg to 1.22 mg/100 g.

The present investigation was mainly undertaken to evolve early, high yielding brinjal F_1 hybrids resistant to bacterial wilt using three isogenic lines of brinjal namely SM 6-2, SM 6-6 and SM 6-7. Preference of fruit colour and shape are highly region specific. From the present study, it was observed that SM 6-6 x SM-132 among white long group and SM 6-2 x Pusa Purple Cluster among purple long group were early, high yielding and resistant to bacterial wilt (Fig. 8 and Fig. 9). Only resistant x resistant crosses were useful and other combinations were susceptible to bacterial wilt. The wilt resistant, high yielding, early F_1 hybrids namely, SM 6-6 x SM-132 and SM 6-2 x Pusa Purple Cluster can be used for cultivation in areas where bacterial wilt is a serious problem.

Fig 8. SM6-6 x ACC-132.

Fig 9. SM6-2 x Pusa Purple Cluster

Summary

SUMMARY

Present studies were conducted at the vegetable research plots of Kerala Agricultural University, Vellanikkara during October 1988 - March 1989. The materials for the present study comprised of three isogenic lines of brinjal, six high yielding parental lines and six F_1 hybrids. The magnitude of variability in the materials were assessed. The F_1 heterosis over better parent, mid parent and over Surya (SM 6-7) were estimated for exploitation of hybrid vigour. The genetic distances betwen parental lines of F_1 hybrids were assessed. Correlations between yield and its components were estimated. Path coefficient analysis was done to estimate the direct and indirect effect of yield components on yield. The F_1 hybrids and parental lines were evaluated for wilt resistance. The biochemical bases of resistance were studied in terms of total phenol and O D phenol. The quality characters of fruits were analysed at vegetable stage.

The genotypes differed significantly for plant height, primary branches/plant, days to first fruit set, percentage of productive flowers, average fruit weight, average fruit volume, fruits/plant/harvest, total fruits/plant and total yield/plant. Phenotypic coefficient of variation was maximum for fruits/plant.

High heritability coupled with high genetic advance was observed for fruits/plant. Average fruit weight and fruits/plant/harvest also had high heritability and genetic advance. Primary branches/plant and total yield though having moderately high heritability had a low genetic advance. The genetic distance was maximum between SM 6-6 and Arka Kusumkar.

Two hybrids exhibited significant positive heterobeltiosis for plant height. The tallest hybrid was SM 6-6 x SM-132 (79.51 cm.). All hybrids showed significant positive heterobeltiosis, relative heterosis and heterosis over SM 6-7 for primary branches/plant. Maximum number of primary branches was observed in SM 6-2 x Pant Samrat. Out of the six hybrids five hybrids were earlier than SM 6-7. All hybrids expressed heterobeltiosis, relative heterosis and heterosis over SM 6-7 for average fruit weight. SM 6-7 x Arka Navneeth expressed heterobeltiosis, relative heterosis and heterosis over SM 6-7 for average fruit volume. All hybrids exhibited heterosis over SM 6-7 for fruits/plant/harvest. Five hybrids exceeded SM 6-7 for total fruits/plant. One hybrid (SM 6-2 x Pant Samrat) expressed significant heterobeltiosis, relative heterosis and heterosis over SM 6-7 for fruits/plant. F_1 hybrids did not show positive significant heterobeltiosis for yield/plant. Taking into consideration of *per se* performance and heterosis SM 6-6 x SM-132 among white long group SM 6-7 x

Pant Rituraj among purple oval group and SM 6-2 x Pant Samrat among purple long group were promising.

Primary branches/plant, plant height, percentage of productive flowers and total fruits/plant were significantly and positively correlated with yield. Days to first fruit set, average fruit weight and average fruit volume had a negative association with yield. Path coefficient analysis revealed that fruits/plant had the maximum direct effect on yield followed by average fruit weight.

Evaluation for wilt resistance indicated that SM 6-2, SM 6-6, SM 6-7, Pusa Purple Cluster and SM-132 among the parental lines and SM 6-6 x SM-132 and SM 6-2 x Pusa Purple Cluster among hybrids were resistant. Investigation on biochemical bases of resistance revealed that total phenol had no association with resistance/susceptibility to wilt but O D phenol had a positive association with resistance.

Analysis of quality characters indicated a range of 2.12 mg to 6.44 mg/100 g for vitamin C, 0.35 γ g to 12.39 γ g/100 g for carotene and 0.90 mg to 1.86 mg/100 g for iron in the brinjal lines and hybrids studied.

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Appendices

Appendix I. Weather parameters during the crop growth period

Months		Maximum temperature °C	Minimum temperature °C	Relative humidity (%)	Rainfall (mm)	Sunshine (hours)
October	(1988)	31.7	23.3	78	116.6	7.1
November	(1988)	32.6	22.9	68	11.0	7.9
December	(1988)	32.6	22.3	57	14.9	9.0
January	(1989)	33.4	22.2	54	0	8.1
February	(1989)	36.3	21.2	45	0	9.8

Appendix II. Mean performance of nine parental lines and six hybrids of brinjal

Treatments	Plant height (cm)	Primary branches/ plant	Days to first fruit set	Percentage productive flowers	Average fruit weight (g)	Average fruit volume (cm^3)	Fruits/ Plant/ harvest	Total number of fruits/ plant	Total yield/ plant (g)
SM 6-6	59.44	5.06	36.07	37.07	43.00	90.00	6.10	29.76	965.32
Arka Kusumkar	59.64	4.73	44.44	48.73	33.75	80.50	3.86	20.61	839.22
SM-132	67.80	4.56	50.27	44.52	54.92	130.00	2.10	10.12	831.80
SM 6-6 x Arka Kusumar	54.97	5.50	42.66	40.88	57.38	126.67	4.72	13.75	632.90
SM 6-6 x SM-132	79.51	6.38	43.21	36.31	64.25	125.82	5.19	18.65	891.61
SM 6-7	55.02	4.56	45.63	33.65	51.76	115.00	3.54	11.50	510.43
Pant Rituraj	47.83	3.61	45.11	35.65	66.31	133.75	2.30	5.25	610.30
Arka Navneeth	42.42	3.67	48.71	33.65	83.38	177.50	2.80	3.56	715.36
SM 6-7 x Pant Rituraj	51.69	4.74	47.51	38.36	96.25	124.17	4.28	6.25	932.81
SM 6-7 x Arka Navneeth	61.54	5.31	44.31	33.22	95.07	223.75	3.50	6.38	776.56
SM 6-2	48.75	4.56	38.01	32.63	64.38	138.29	3.86	12.81	433.90
Pusa Purple Cluster	72.99	5.50	42.94	62.85	42.41	120.69	9.71	28.48	851.31
Pant Samrat	68.27	5.99	45.84	40.26	41.79	103.44	8.28	18.25	881.80
SM 6-2 x Pusa Purple Cluster	68.99	5.25	40.61	40.87	69.63	127.51	6.76	19.18	904.06
SM 6-2 x Pant Samrat	69.09	7.48	40.97	32.55	66.40	113.29	7.30	19.95	890.00
Mean	60.52	5.19	43.75	39.55	62.04	128.69	4.95	14.97	39.55
CD (p=0.05)	11.91	2.09	5.90	5.50	23.79	23.00	2.29	2.43	68.07
CD (p=0.01)	16.24	2.91	8.05	6.50	32.46	31.37	3.14	3.31	92.84
Sem±	2.88	0.33	1.10	2.38	2.34	6.52	0.71	15.53	14.85

Appendix III. Mean performance of parental lines and hybrids (*)

Treatments	Plant height (cm)	Primary branches/ plant	Days to first fruit set	Percentage of productive flowers	Average fruit weight (g)	Average fruit volume (cm^3)	Fruits/ plant/ harvest	Total fruits/ plant	Total yield/ plant (g)
SM 6-6	53.00	3	38.00	36.16	32.23	88.33	6.00	18	596.67
Arka Kusumkar	63.33	4.66	42.33	50.00	27.66	79.67	4.33	14	365.00
SM-132	68.46	5.33	44.33	42.40	40.33	113.33	1.67	5	270.00
SM 6-6 x Arka Kusumkar	57.63	3.66	41.67	39.07	38.33	120.00	5.00	11.67	420.00
SM 6-6 x SM-132	64.49	4.67	40.00	39.07	46.00	133.33	5.00	9.67	440.00
SM 6-7	48.70	5.00	48.67	34.75	39.67	101	2.33	6	536.67
Pant Rituraj	56.20	6.67	41.67	33.66	49.66	126.67	1.67	4.33	383.33
Arka Navneeth	68.16	2.33	50.00	36.73	150.00	183.33	1.67	2.00	296.67
SM 6-7 x Pant Rituraj	54.66	2.00	47.00	36.00	55.66	116.67	1.33	5.67	413.33
SM 6-7 x Arka Navneeth	61.00	5.33	43.33	33.17	163.67	210.00	3.00	5.33	460.00
SM 6-2	54.77	4.33	37.00	31.94	38.00	120.00	5.00	7.00	386.67
Pusa Purple Cluster	55.83	4.33	42.33	58.50	26.67	96.66	5.33	14.00	430.00
Pant Samrat	60.1	4.33	46.00	42.17	29.66	111.00	4.00	9.00	360.00
SM 6-2 x Pusa Purple Cluster	61.1	4.33	39.67	40.50	35.67	128.33	3.00	14.00	440.00
SM 6-2 x Pant Samrat	61.1	4.00	39.33	33.17	56.67	130.00	3.00	13.00	493.33
Mean	59.35	4.26	42.76	39.15	55.31	124.07	3.48	9.24	419.44
CD(p=0.05)	-	2.62	7.22	6.74	29.14	28.17	2.81	2.98	83.36
CD (p=0.01)	-	3.50	9.86	9.17	39.75	38.42	3.84	4.07	113.69
Sem ±	3.16	0.67	3.18	0.67	23.86	18.48	0.88	2.59	47.56

(*) The parental lines and hybrids were evaluated in a completely randomised design.

HETEROSIS AND GENETIC ANALYSIS INVOLVING ISOGENIC LINES IN BRINJAL RESISTANT TO BACTERIAL WILT

By

GEETHA. P. T.

ABSTRACT OF A THESIS

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ABSTRACT

The present studies "Heterosis and genetic analysis involving isogenic lines in brinjal resistant to bacterial wilt" were initiated during May 1988 and evaluation trial conducted during October 1988 to March 1989 in the vegetable research plots of Kerala Agricultural University, Vellanikkara. Evaluation of nine parental lines and six F_1 hybrids revealed considerable variation for many of the economic characters. Phenotypic coefficient of variation was maximum for fruits/ plant. High heritability along with high estimate of genetic advance was also observed for fruits/plant. The F_1 hybrids SM 6-6 x SM-132 and SM 6-2 x Pusa Purple Cluster were promising and were resistant to bacterial wilt. Genetic distance was maximum between SM 6-6 and Arka Kusumkar.

Significantly positive correlation was observed between yield and plant height, primary branches/plant, percentage of productive flowers and total fruits/plant. The yield had a negative association with days to first fruit set, average fruit weight and average fruit volume. Path analysis revealed that primary branches/plant had the maximum direct effect on yield. Plant height had the maximum indirect effect through primary branches.

SM 6-6, SM 6-2, SM 6-7, SM-132 and Pusa Purple Cluster among parental lines and SM 6-6 x SM-132, SM 6-2 x Pusa Purple Cluster among hybrids were resistant to bacterial wilt. Total phenol content in the roots at different growth stages had no association with resistance/ susceptibility to bacterial wilt. But O D phenol content in the roots had a positive association with bacterial wilt resistance. Estimation of quality characters in wilt resistance parental lines and hybrids revealed maximum vitamin C in SM 6-7 (6.44 mg/100 g), carotene content in SM-132 (9.99 μg/100 g) and iron content in SM 6-6 (1.86 mg/100 g) in fruits at vegetable stage.