GENETIC EVALUATION OF F_4 AND F_5 GENERATIONS OF IRRADIATED INTERSPECIFIC HYBRIDS IN OKRA (*Abelmoschus* spp.)

By

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THESIS
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DECLARATION

I hereby declare that this thesis entitled "**Genetic evaluation of F_4 and F_5 generations of irradiated interspecific hybrids in okra (*Abelmoschus* spp.)**" 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 of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled **"Genetic evaluation of F_4 and F_5 generations of irradiated interspecific hybrids in okra (*Abelmoschus* spp.)"** is a record of research work done independently by Mrs. Anu Mary C. Philip. 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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INTRODUCTION

1. INTRODUCTION

Resistance to yellow vein mosaic virus disease is the most important attribute sought for in okra (*Abelmoschus esculentus* (L.) Moench). The disease transmitted by the vectors, white fly (*Bemesia tabaci* Gen.) and leaf hopper (*Amrasca devastrans*) is the most important single constraint which stands in the way of augmenting production and productivity of the crop. Application of insecticides for controlling vector population will contribute to environmental hazards and leads to acute pesticide toxicity, since okra fruits are continuously harvested every second or third day. In this context more importance was given to host-parasite resistance and breeding for resistance to the virus gained more attention.

Almost all the cultivars of cultivated okra (*A. esculentus*) succumbed to the virus throughout the growth stages indicating the absence of varietal resistance to YVM virus in *A. esculentus*. Several recommended varieties like Kiran, Pusa Sawani and Pusa Makhmali exhibited tolerance to the disease at the time of release, but this tolerance has broken down with time. However several wild and semiwild relatives of cultivated okra showed high degrees of tolerance to the virus (Dutta, 1984). As a result interspecific hybridization assumed more importance. In Kerala, preference for the long light green fruits necessitated the adoption of location specific breeding programmes for okra.

Interspecific hybridization followed by selection in the segregating generations is an effective method for obtaining desirable recombinants. But free recombinations in these generations are hindered by the presence of

linkages between desirable and undesirable traits. In such cases, the linkage can be broken by inducing mutations and the heterozygosity of the interspecific hybrids offer broader genetic base for the specific mutagen to act upon, there by creating greater variability. Interspecific hybridization in conjugation with mutation breeding thus turns out to be a more effective method in isolating desirable recombinations.

A comprehensive approach in the breeding programme with the objective of induction of recombinations of the economic attributes of *A.esculentus* and YVM disease resistance of the wild species of *Abelmoschus* was attempted by Sheela (1994). The irradiation of F_1 seeds of interspecific crosses of *Abelmoschus* was effective in breaking the strong linkage between semiwild characters and YVM resistance in *A. manihot* (Animon, 1996). Desirable recombinants with respect to yield and YVM disease resistance were present in F_2 and F_3 generations of irradiated interspecific hybrids between *A. esculentus and A. manihot* (John, 1997). The present study was conducted with the objective of estimating the extent of variability exhibited in the F_4M_4 and F_4M_5 generations of the interspecific hybrids between *A. esculentus* and *A. manihot* and isolating high yielding YVM disease resistant types from the variable population of these generations in the process of developing a high yielding YVM resistant variety.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Okra or bhindi (*Abelmoschus esculentus* (L.) Moench) is an important annual vegetable crop grown throughout India for its tender green fruits. Due to its high adaptability, it can be cultivated under a wide range of environmental conditions. But the susceptibility of majority of the okra cultivars to yellow vein mosaic (YVM) virus disease is a major problem limiting the growth and yield of the crop considerably. However, attempts have been made to evolve resistant varieties with high yield by resorting to inter-specific hybridization, mutation and recombination. A review of the research results reported in the above context is presented here under.

2.1. Origin and cytogenetics

Okra belongs to the genus *Abelmoschus* which was established by Medikus (1787). The genus is believed to be of Asiatic origin, whereas the centre of origin of the major cultivated species, *A. esculentus* is controversial - the species is believed to have originated in India (Masters, 1875), Ethiopia (Candolle, 1883 ; Vavilov, 1951), West Africa (Chevalier, 1940) and tropical Asia (Grubben, 1977).

Joshi and Hardas (1956) proposed a polyphyletic origin for the species. They reported an allopolyploid genome for cultivated okra. The chromosome numbers of different species as well as different varieties within a species exhibited a wide range of variation.

The chromosome number reported for *A. esculentus* varied greatly from 2n = 66 to 144. However, the most frequently observed chromosome number was 2n = 130 (Siemonsma, 1982). Datta and Naug (1968) proposed that the 2n numbers, 2n = 72, 108, 120, 132 and 144 were an indication of a regular polyploid series with x = 12.

2.2. Yellow vein mosaic disease

Yellow vein mosaic (YVM) disease is one of the most serious constraints which limits the cultivation of okra. All stages of the crop succumbs to the disease causing severe reduction in growth and yield. Uppal *et al.* (1940) established the viral nature of the disease and named it yellow vein mosaic. The disease is spread by white fly (*Bemisia tabaci* Gen.) which is the main vector that effects inoculation of the virus to healthy plants (Capoor and Varma, 1950 and Varma, 1952).

The loss of yield due to virus infection ranged from 50 to 95 percent depending on the stage of crop growth at which infection occurs (Sastry and Singh, 1974). If the infection occurred in early stages, there was a total yield loss and plants infected within 50 days of germination caused a yield reduction of 80 percent while infection by the virus in 30 days old crop resulted in 88 per cent yield loss (Chelliah *et al.*, 1975).

Sinha and Chakrabarthi (1976) confirmed that the disease had an adverse effect on plant height, number of branches, number and size of fruits and seed yield. Khan (1983) reported 0.35 per cent seed transmission of the virus and established the seasonal nature of incidence of the disease. Atiri and

Ibidapo (1989) reported that bhindi mosaic virus and leaf curl virus had a synergistic effect in mixed infections.

Studies on biochemical changes associated with the virus incidence revealed that carotene content of fruits declined by 35 to 60 per cent and the protein nitrogen reduced by 16 per cent. The fruits turned yellow and the size was reduced (Chander, 1990).

Handa and Gupta (1993) reported that even with proper cultural practices, chemical control and use of resistant cultivars, complete eradication of the vector for YVM disease could not be achieved, since 26 to 30 per cent incidence was observed.

Raghupathy *et al.* (1997) reported that the varieties BO-1, HRB-55, HRB-9-2, Sel-10, Lorm-1, PB-57 and Co-3 were free from YVM virus incidence while P-7, KS-404 and Sel-4 recorded 0.98, 1.10 and 14.15 per cent disease incidence respectively. The varieties MDU-1 and Pusa Sawani recorded the highest incidence of 87.96 and 88.89 per cent respectively.

2.3. Sources of YVM disease resistance

Almost all the cultivars of *A. esculentus* surrender to the virus during different growth stages causing substantial yield loss. Hence it became necessary to locate the genes for YVM resistance in the wild and semi wild relatives of okra. However, most of the related species of okra exhibited noticeable degrees of field tolerance towards the virus.

Pal *et al.* (1952) reported that *A. tuberculatus* having similar cytogenetic structure to *A. esculentus* was resistant to YVM virus and immune

to attack of borer and hence could be used in interspecific hybridization efforts. Nariani and Seth (1958) reported field immunity to YVM virus exhibited by *A. manihot* var *pungens* , *A. crinitus, Hibiscus vitifolius* and *H. panduraeformis*. According to Sandhu *et al.* (1974), resistance to YVM virus was confined to the wild species, viz. *A. manihot, A. crinitis, A. moschatus* and *A. pungens*.

Ugale *et al.* (1976) and Mamidwar *et al.* (1979) identified *A. manihot* ssp. *tetraphyllus* as a promising source of YVM disease resistance.

The wild species, *A. manihot* ssp *manihot* (syn. *A. caillei*) belonged to symptomless carrier type, since it harboured the pathogen in a potential state in the field (Singh and Thakur, 1979). Atiri (1983) reported that several cultivars resistant to YVM virus were high yielding. Chelliah and Sreenivasan (1983) reported that *A. manihot* ssp. *tetraphyllus* and *A. manihot* were resistant to YVM disease.

Dutta (1984) used *A. manihot* ssp. *tetraphyllus* as the wild donor parent successfully for developing yellow vein mosaic resistant progenies with *A. esculentus*.

Sharma and Sharma (1984) reported that *A. manihot* ssp. *manihot* was useful source of resistant genes which could be exploited in breeding okra cultivars resistant to YVM infection.

According to Nerkar and Jambhale (1985), only the wild species, viz. *A. tetraphyllus, A. manihot* and *A. caillei* could be used as suitable donors of resistance for varietal improvement.

2.4. *A. manihot* as donor for resistance

A. manihot is one of the wild species of okra which has been highly exploited for the purpose of interspecific gene transfer to *A. esculentus* for resistance.

Arumugam *et al.* (1975) reported that several exotic accessions of *A. manihot* were resistant to YVM virus and the crosses made between *A. esculentus* and *A. manihot* yielded viable F_1 seeds. However, up to 40 per cent sterility appeared in F_2 generation.

Evaluation of okra cultivars for disease resistance conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani under research project on maintenance and evaluation of germplasm of crop plants have revealed that *A. manihot* remained completely resistant to YVM disease while twenty other cultivars in the germplasm succumbed to the virus at different stages (KAU, 1983).

Under field conditions of natural infection, four resistant lines derived from the back-crosses of *A. esculentus* with *A. manihot* exhibited only 4.09 to 19.37 per cent virus infection (Nerkar and Jambhale, 1985).

A. manihot, having the resistance gene for YVM virus was used as the donor parent in back-crosses with *A. esculentus* var Pusa Sawani leading to the development of the resistant variety, Parbhani Kranti (Jambhale and Nerkar, 1986).

Rajamony *et al.* (1995) reported that *A. manihot* exhibited very mild symptoms of virus infection especially in the young and terminal leaves and that too had recouping tendency later.

Chandran and Rajamony (1997) reported that when cultivated types were used as the female parent in hybridization using wild donors, maximum fruit set was obtained in crosses where *A. manihot* was used as pollen source. The percentage of viable seeds obtained was also maximum in crosses involving *A. manihot.*

2.5. Interspecific hybridization in *Abelmoschus*

Interspecific hybridization creates adequate genetic variability that can be effectively exploited through recombination breeding. Introgressing the desirable genes of the wild species into the cultivated types can be achieved by means of interspecific hybridization programmes. Interspecific hybridization has been employed as a crop improvement method in the genus *Abelmoschus* since 1930's.

Successful interspecific hybridization between *A. esculentus* and *A. manihot* was reported by Teshima (1933). In an attempt to transfer the symptomless type resistance of *A. tuberculatus* to the cultivated okra variety, Pusa Makhmali, Pal *et al.* (1952) reported that the F_1 hybrids were completely sterile and even repeated backcrosses yielded no viable seeds. However, the amphidiploids produced from the F_1 hybrids were adequately fertile, but were not free from YVM virus disease. Similarly crosses made between *A. manihot* var *pungens* and *A. esculentus* produced vigorous, but sterile hybrids.

Joshi and Hardas (1956) reported heterotic hybrids between *A. esculentus* and *A. tuberculatus*. The sterile F_1 hybrids when treated with colchicine produced a fertile plant. Gadwal *et al.* (1968) observed that the

hybrid embryo failed to grow in cross combinations of *A. esculentus* with *A. moschatus* and *A. ficulneus*, but *in vitro* culture of embryos can be effectively used to recover the hybrids.

High degree of sterility was observed in hybrids of the cross between *A. esculentus* and *A. ficulneus*. Besides, the hybrids resembled the wild parent in several morphological characters (Hossain and Chattopadhyay, 1976). Nair and Kuriachan (1976) reported that a spontaneous hybrid between *A. tuberculatus* and *A. esculentus* was highly pollen sterile and seed sterile in which selfing, open pollination and backcrossing produced only fruits with empty seeds.

Arumugam and Muthukrishnan (1978) reported that F_1's of cross between *A. manihot* and *A. esculentus* varieties Pusa Sawani and Co-1 were resistant to YVM virus. They isolated better recombinants from the F_2 and F_3 generations. Meshram and Dhapke (1981) reported that the hybrid between *A. esculentus* and *A. tetraphyllus* was spreading in habit, dwarf in stature and highly male sterile. YVM virus resistant hybrids were obtained from crosses between *A. manihot* and *A. esculentus* (Dhillon and Sharma, 1982). Sujatha (1983) observed satisfactory pollen fertility in interspecific hybrids of crosses between *A. esculentus* and *A. manihot*, but seedset was absent. Pillai (1984) obtained hybrids with complete resistance to YVM disease by crossing *A. manihot* to four susceptible cultivars of *A. esculentus* viz. AE 87, Pusa Sawani, Co-1 and Kilichundan. But none of the hybrids out yielded the highest yielding parent.

Nerkar and Jambhale (1985) crossed *A. tetraphyllus*, *A. manihot* and *A. caillei* with *A. esculentus* var. Pusa Sawani. Though most of the F_1 hybrids exhibited partial to complete sterility, the amphidiploids of the hybrids developed through colchicine treatment were fertile and resistant to YVM virus with good agronomic attributes. Cheriyan (1986) reported that there was no reciprocal difference in the crossability index in crosses of *A. esculentus* with *A. manihot* and *A. tetraphyllus.*

Successful intercrossing has been carried out between a 'Soudanien' and a 'Guineen' type of okra, of which the latter is reported to be immune to the yellow vein mosaic (YVM) virus disease. However, due to difference in chromosome numbers of the parents the hybrid exhibited abnormal meiosis leading to sterility and thereby hinders fruitful incorporation of the disease resistant gene to the former (Madhusoodanan and Nazeer, 1986)

The F_2 segregants of the interspecific hybrid between *A. esculentus* and *A. manihot* incorporated low yielding character and wild habit along with resistance for YVM diseases (Mathews, 1986).

Prabha (1986) reported that viable seed recovery was very low in hybrids of crosses between *A. esculentus* and *A. manihot*, though the two species were cross-compatible, presumably because of cytogenetic disturbances owing to chromosomal differences between two parents. Reproductive isolation of *A. moschatus* from all other speces of the genus *Abelmoschus* was reported by Pushparajan (1986).

Hybrid vigour in the F_1 hybrids of crosses between *A. esculentus* and *A. manihot* ssp *tetraphyllus* var *tetraphyllus* was reported by Suresh Babu (1987). Hybrid sterility resulted from the abnormal megaspore development. Bhargava (1989)

observed that embryo deterioration occured in hybrids of crosses between *A. manihot* and *A. esculentus* five days after pollination.

Suresh Babu and Dutta (1990) obtained heterotic hybrids from crosses of *A. esculentus* with *A. tetraphyllus*. Meiosis was abnormal in hybrids leading to hybrid sterility. They produced fully fertile amphidiploids (*A. esculentus - tetraphyllus)* by colchicine treatment, resembling the F_1 plants with YVM resistance and larger fruits. They also reported that progenies from the back cross of the amphidiploid of the cross between *A. esculentus* and *A. tetraphyllus* with the cultivated parent was readily feasible and they combined the YVM resistance of the wild species and the desirable fruit characters of the cultivated species. Failure of seed formation in interspecific hybrids may be due to slow pollen tube growth, abnormal pollen tube, abortion of fertilized ovules or sparsity of pollen grains (Swamy and Khanna, 1991).

In an attempt to transfer the true YVM resistance from *A. caillei* and *A. manihot* ssp *tetraphyllus* to the cultivated types, Sheela (1994) observed a higher proportion of low yielding YVM resistant types similar to the wild types in the F_2 and F_2M_2 populations indicating strong genetic mechanisms preventing recombination. However, more recombinants appeared in the F_2M_2 generation than in the F_2 indicating the breakage of undesirable linkages through irradiation.

Chandran *et al.* (1996) reported that transplantable seedlings could be obtained by embryo rescue technique through culturing twelve and fifteen days old embryos of the crosses between *A. esculentus* and *A. moschatus*. This suggested the potential of tissue culture methods to overcome the post-zygotic incompatability barriers in interspecific crosses.

Chandran and Rajamony (1997) noticed higher fruitset in interspecific crosses between *A. esculentus* and the wild types, viz. *A. moschatus*, *A. tetraphyllus* and *A. manihot*, when *A. esculentus* was used as the female parent. Percentage of viable seeds was low in all crosses compared to parents except in the cross *A. esculentus* cv Kiran X *A. manihot*, resulting from complete or partial endosperm deterioration.

2.6. Achievements

Since some of the tolerant varieties as well as intervarietal hybrids of okra lost their resistance of YVM disease in due course, attempts have been made to incorporate the resistance genes from wild species to otherwise superior but susceptible commercial types of okra through interspecific breeding programmes.

Pusa Sawani, the most widely cultivated variety of okra till recently was one of the earliest attempts in this regard. It was developed from a cross between IC 1542, an indigenous stock with symptomless carrier type of resistance and Pusa Makhmali, a high yielding, adapted but susceptible variety of *A. esculentus* (Singh *et al.*, 1962). However the initial resistance has given way to moderate susceptibility due to genetic and environmental factors.

Punjab Padmini, a yellow vein mosaic resistant variety was evolved by interspecific hybridization between *A. esculentus* and *A. manihot* ssp *manihot* and the segregating generations were advanced up to F_8 with selection at Punjab Agricultural University, Ludhiana (Sharma, 1982).

The Maharashtra State Seed Committee in 1985, released a YVM disease resistant variety, Prabhani Kranti developed from the backcrosses of *A. manihot* to *A. esculentus* cv. Pusa Sawani (Jambhale and Nerkar, 1986).

P-7, a YVM resistant variety was evolved from a cross between *A. esculentus* cv. Pusa sawani and *A. manihot* ssp *manihot*. The F_1 was back crossed to the cultivated parent for four generations and selection was followed in the selfing generations up to F_8 (Thakur and Arora, 1988).

Arka Anamika, a high yielding YVM resistant variety obtained by interspecific hybridization between *A. esculentus* and *A. manihot* ssp *tetraphyllus* was released for cultivation at national level by IIHR, Bangalore. Arka Abhay, another high yielding and resistant line derived from the same cross was released for state level cultivation (IIHR, 1991).

2.7. Variability through induced mutation in okra

Earlier workers have reported that YVM disease resistant genes are strongly linked with the wild characters in *A. manihot*. A practical approach to overcome such undesirable linkages is to break these linkages by means of irradiation thereby favouring recombination.

Kuwada (1970) reported induction of variability in okra through induced mutation. Thandapani *et al.* (1978) released a mutant variety, MDU-2 produced by treating seeds of variety Pusa Sawani with diethyl sulfoxide.

Nirmala Devi (1982) induced variability in *A. manihot* using 10, 15 and 20 kR gamma radiation. Significant heterosis was obtained for plant height, internodal length and length of leaves. Maximum variability was observed for fruit yield per plant.

Abraham and Bhatia (1984) reported that the highest mutation rates in M_2 occurred with 60-80 kR gamma rays. Some recombinants outyielded the check variety Pusa Sawani.

Abraham (1985) observed that the hybrids responded better than varietal seeds to mutation. A mutant similar to *A. tetraphyllus* was isolated with resistance to YVM disease from the M_2 generation of irradiated *A. esculentus* varieties.

Irradiation by higher doses of gamma rays resulted in a progressive decline in mean values in the case of germination percentage, plant height, number of branches, leaves and flowers and fruit yield per plant in the M_1 generation (Krishna, 1985). There was increased variability in the M_2 generation, but no significant change in the means of quantitative characters was recorded. Chlorophyll variation in M_2 was observed at low frequency.

Cheriyan (1986) attempted a study on radiation induced variability in interspecific hybrids involving *A. esculentus* and *A. manihot* wherein considerable extent of variability was noticed in the irradiated F_1 hybrids. Irradiation enhanced the pollen fertility of interspecific hybrids and doses above 25 kR created more recombination in interspecific hybrids.

Irradiation of higher doses of gamma rays on *A. esculentus* resulted in marked reduction in germination, survival and plant height, which were found to be maximum at 60 kR (Jeevanandam *et al.*, 1986). Regina (1986) reported higher variability in okra as a result of gamma irradiation in the M_4 generation and the irradiated hybrids showed maximum positive variability.

The effectiveness of the irradiation and the number of viable mutants obtained increases with increased doses of gamma rays, up to 40 kR in seeds of *A. esculentus* (Jeevanandam *et al.* 1987). 40 kR gamma irradiation of seeds of *A. esculentus* yielded a short fruit mutant, Parbhani Tillu in the M_2 generation. The plant had short stature, small leaves and desirable fruit texture after freezing, enabling fruit processing (Kulkarni and Nerkar, 1992).

Sheela (1994) reported that a radiation dose of 60 kR on the hybrid seeds of interspecific crosses between *A. caillei* and *A. tetraphyllus* with *A. esculentus* was optimum for inducing breakage of linkage and expression of variability. Majority of the segregants showed resistance under heavy epidemic condition. Selection of early flowering types with higher fruit weight increased the level of YVM disease resistance. However, there was a reduction in mean value for some yield components like number of flowers and fruits and average fruit weight. Maximum number of recombinants were produced in irradiated hybrids of *A. esculentus* and *A. caillei*.

Irradiated interspecific hybrids of *A.esculentus* X *A. manihot* resembled more towards the semiwild parent for several economic characters (Animon, 1996). The mean value of yield contributing characters like number of flowers per plant, number of fruits per plant and fruit weight did not vary much by irradiation. However, the hybrid treatments were high yielding and YVM disease resitant. Increased doses of radiation decreased the germination percentage and survival rate and also delayed the formation of flowers and fruits.

John (1997) reported that the irradiated plants produced more number of flowers and fruits per plant in the F_2M_2 and F_3M_3 generations. Irradiation reduced pollen fertility and seed set in the hybrids. However 20 kR gamma irradiation increased the average fruit weight and weight of fruits per plant while 40 kR extended the fruiting phase and duration of the crop. Several high yielding YVM disease resistant plants resembling the cultivated parent were isolated from the 30 kR treatment in the F_3M_3 generation.

2.8. Genetic variability in okra

High genotypic coefficient of variation coupled with high estimates of heritability and genetic advance for yield and yield components were observed by Rao (1972).

Majumdar *et al.* (1974) observed high magnitude of genotypic coefficient of variation for characters like yield per plant, number of fruits and weight of fruits per plant.

Rao and Kulkarni (1977) concluded that estimates of heritability and genetic advance were highest for number of fruits per plant. Considerable genetic variation for YVM virus infection, fruit yield and number of fruits per plant in okra was reported by Kaul *et al.* (1979).

Parthap *et al.* (1980) reported that fruit length contributed maximum to genetic divergence in okra. Palaniveluchamy *et al.* (1982) reported that plant height had the highest estimates of heritability and genetic advance among yield components.

High heritability of plant height, days to flowering and fruiting phase was recorded by the Alex (1986). El Macksoud *et al.* (1986) reported high

heritability values for earliness in flowering, number of fruits per plant and fruit weight. Mathews (1986) reported high phenotypic and genotypic coefficients of variation for weight of fruits per plant, number of leaves per plant and plant height.

Variability studies by Balakrishnan and Balakrishnan (1988) revealed high phenotypic and genotypic variances for fruit yield per plant and plant height. Number of fruits per plant and yield per plant exhibited high phenotypic and genotypic coefficients of variation, heritability and genetic advance. This suggested the efficiency of taking number of fruits per plant and fruit weight as reliable indices for improving yield in okra.

Sheela (1994) reported high heritability and genetic advance for fruit yield per plant, low heritability and genetic advance for yellow vein mosaic incidence and moderate phenotypic and genotypic coefficients of variation for average fruit weight.

According to John (1997) average fruit weight exhibited low phenotypic and genotypic coefficients of variation. High heritability coupled with moderate genetic advance was observed for plant height in the F_2M_2 generation.

2.9. Correlation analysis in okra

Several studies with regard to yield and yield components in okra have been done in the past to identify the effect of yield contributing characters.

The yield of okra was directly correlated with the length and girth of the fruit and number of fruits per plant (Kohle and Chavan, 1967).

Thamburaj and Kamalananthan (1973) reported significant positive correlation between yield, fruit weight and total number of nodes per plant. Majumdar *et al.* (1974) observed negative correlation between yield and days to flowering.

Rao *et al.* (1977) concluded that number of fruits per plant, branches per plant, plant height and fruit length were the important yield components in okra. Rao and Kulkarni (1978) observed significant positive correlation between plant height and number of pods per plant.

Arumugam and Muthukrishnan (1979) reported that there was significant association between YVM disease reaction and plant height, number of branches, days to flowering, fruit length and girth, number of seeds per fruit and number of fruits per plant which limited the scope for selection for resistance in the F_3, F_4 and backcross generation of interspecific crosses between *A. esculentus* and *A. manihot*.

Yield had a positive correlation with plant height, number of fruits per plant and fruit length (Mahajan and Sharma, 1979). Parthap *et al.* (1979) considered stem diameter, number of flowers per plant, pods per plant and plant height as the primary yield determining components and should be given major emphasis while practising selections.

Vashista *et al.* (1982) concluded that yield in okra depended mainly on number of fruits, plant height and fruit length.

Mathews (1986) reported that upto the F_2 generation of interspecific hybrids of *Abelmoschus*, number of fruits per plant, number of flowers per plant, plant height and earliness to flower were the major yield components.

Significant positive association of YVM disease intensity with number of branches per plant and length of fruits was revealed in the study . Negative association was reported between the intensity of mosaic incidence and days to flowering.

Sheela *et al.* (1988) observed that stem girth had maximum positive effect on yield. Sivagamasundhari *et al.* (1992) reported that number of pods per plant, pod weight , pod girth, pod length and internodal length should be considered together as primary yield components in okra.

Sheela (1994) reported that number of fruits per plant and single fruit weight recorded the maximum positive effects on yield of okra. Significant negative association of YVM disease incidence was noted with fruit girth and plant height whereas days to flowering had a positive correlation.

According to John (1997), at 20 kR, 30 kR and 40 kR of gamma ray irradiation in the F_2M_2 and F_3M_3 generations of crosses between *A. esculentus* var Kiran and *A. manihot*, the number of leaves, flowers and fruits per plant were positively correlated with the weight of fruits per plant. The number of fruits showed high positive correlation with number of branches also. At irradiation doses of 30kR, the fruit yield per plant had significant positive correlation with fruiting phase and duration of the plant. Number of flowers per plant and fruits per plant had significant negative correlation with average fruit weight in the treatments with 20 kR and 30 kR in the F_2M_2 generation, while in the F_3M_3, the same correlation was noted in all the irradiated treatments viz., 10 kR, 20 kR, 30 kR and 40 kR.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The study was undertaken in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 1997 - 98 with the objective of evaluating the genetic variability in the F_4 and F_5 generations of interspecific hybrids of okra (*Abelmoschus* spp) subjected to various doses of gamma ray irradiation. It also aimed to isolate desirable recombinants from the segregating generations with respect to yield and yellow vein mosaic disease resistance.

3.1. Materials

The present study was carried out as the continuation of a previous PG project undertaken in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani which accomplished an interspecific hybridization between Kiran (a high yielding widely adapted, but yellow vein mosaic susceptible cultivar of *Abelmoschus esculentus* [Plate 1]) and *Abelmoschus manihot* (a semiwild yellow vein mosaic disease resistant species [Plate 2]) and irradiation of the hybrid seeds with 0 kR (unirradiated), 10 kR, 20 kR, 30 kR and 40 kR of gamma rays. The F_1M_1, F_2M_2 and F_3M_3 generations were genetically evaluated and the superior recombinants were isolated in the previous studies.

The selfed seeds of the F_3M_3 population generated the F_4M_4 population needed for the present study. Superior genotypes from the F_4M_4 generation were selected on the basis of yield and field resistance to yellow vein mosaic

Abelmoschus esculentus **var. Kiran (P_1) - the cultivated parent**

Abelmoschus manihot **(P_2) - the wild parent**

Plate 1.

Plate 2.

disease. The selfed seeds obtained from the selected plants were used to raise the F_5M_5 generation. These generations were genetically evaluated along with the parents.

3.2. Methods

3.2.1. Genetic evaluation of F_4M_4 families

Fifty-two treatments, T_1 to T_{52} (families) including the two parents, Kiran and *A. manihot*, were laid out in a Randomised Block Design with two replications, each treatment in rows of ten plants. The experiment was conducted with the objective of evaluating the performance of the families along with the two parents in the F_4M_4 generation.

3.2.2. Genetic evaluation of F_5M_5 families

Twenty-five promising progenies (T_1 to T_{25}) were selected from the F_4M_4 generation with respect to YVM disease resistance under field conditions and fruit yield. The selfed seeds of these progenies were grown in rows (families) along with the two parents. The experiment was laid out in a Randomised Block Design with three replications, each family (treatment) in rows of ten plants, with the purpose of evaluating the performance of the F_5M_5 families.

Both the experiments were raised under natural epiphytotic conditions. All management practices recommended for okra, except application of insecticides that may reduce the vector population, were followed as per the

Package of Practices Recommendations ('Crops'- 1996) of Kerala Agricultural University.

3.3. Biometric observations

The following biometric observations were recorded from both the experiments. Five plants were selected at random, leaving the border ones in each treatment row and the averaged observations were recorded.

3.3.1. Days to first flowering

The number of days required for the first flower to open from the date of sowing was recorded in each plant.

.3.3.2. Leaf axil bearing the first flower

The number of leaf axil from which the first flower was produced was recorded.

3.3.3. Leaf number

The total number of leaves produced by the plants were counted from the base to the tip including those on the branches. Dropped leaves were estimated by their respective nodes.

3.3.4. Leaf area

Three leaves were collected from each plant from the third, sixth and ninth nodes. Leaf area was determined using a leaf area meter, averaged and expressed in square centimeters.

3.3.5. Number of branches per plant

The total number of primary branches in each plant were counted at the time of final harvest.

3.3.6. Number of flowers per plant

The total number of flowers produced in each plant were counted.

3.3.7. Pollen sterility

Pollen grains collected from the flowers in the early phase of flowering were stained with 1:1 glycerin acetocarmine mixture and the stainability was used as the criterion to assess pollen sterility. Shrivelled, unstained or partially stained pollen grains were scored as sterile. In each plant nearly 200 pollen grains from different microscopic fields on the slide were scored. The ratio of the number of sterile pollen to the total number of pollen scored indicate the pollen sterility and was expressed as percentage of sterile pollen.

3.3.8. First fruiting node

The number of node from which the first fruit was produced was recorded.

3.3.9. Number of fruits per plant

The total number of fruits produced from each plant were recorded.

3.3.10. Average fruit weight

The weight of the third, sixth and nineth fruits were taken at the time of harvest and the mean weight of fruit produced from each plant was estimated and expressed in grams.

3.3.11. Weight of fruits per plant

Weight of fruits per plant is obtained as the product of average fruit weight and number of fruits per plant and expressed in grams.

3.3.12. Length of fruits

The length of the third, sixth and nineth fruits were measured at the time of harvest and the mean calculated and expressed in centimetres.

3.3.13. Girth of fruit

The girth of the third, sixth and nineth fruits at the middle portion was measured at the time of harvest and the mean expressed in centimetres.

3.3.14. Number of seeds per fruit

The number of seeds in the third, sixth and nineth fruit of each plant was counted after extracting the seeds and the mean calculated.

3.3.15. Number of ridges per fruit

The number of ridges for fruits from the the third, sixth and nineth nodes were counted and mean estimated.

3.3.16. Fruiting phase

The number of days between the first and final harvest in each plant was recorded.

3.3.17. Height of the plant

The height of the plant from the base of the stem to the tip was measured at the final harvest and expressed in centimetres.

3.3.18. Incidence of YVM disease

The rating scale by Arumugam *et al.* (1975) was used for scoring YVM disease intensity. Each plant was observed for the characteristic gradation of symptoms on the leaves and fruits and scored accordingly.

Table 1. Yellow vein mosaic disease rating scale

Sl. No.	Symptom	Grade	Rating scale
1	No visible characteristics of the disease	Highly resistant	1
2	Very mild symptoms, basal half of primary veins remain green, mild yellowing of anterior half of primary veins, secondary veins and veinlets. Infection is also seen late in the season under field conditions.	Resistant	2
3	Vein and veinlets turn completely yellow	Moderately resistant	3
4	Pronounced yellowing of veins and veinlets, 50 % of leaf lamina turn yellow, fruits exhibit slight yellowing.	Susceptible	4
5	Petioles, veins, veinlets and intervenal area turn yellow in colour. Leaves start drying from margin. Fruits turn yellow.	Highly susceptible	5

3.3.19. Incidence of shoot and fruit borer

Infestation by shoot and fruit borer (*Earias vitella* F.) on the shoot and fruits of observational plants recorded, intensity of infestation assessed and expressed in percentage.

$$\text{Percentage infestation by shoot and fruit borer} = \frac{\text{Number of fruits infested}}{\text{Total number of fruits}} \times 100$$

3.3.20. Duration of the plant

The number of days from sowing to the final harvest was recorded.

3.3.21. Fibre content

Three fruits at the early flowering phase of each plant is harvested at uniform maturity and used for chemical estimation of crude fibre. The crude fibre content of the fruits was assessed by the method proposed by Chopra and Kanwar (1976) and expressed in percentage to fresh weight.

3.4. Statistical analysis

The observations taken from the experimental plants were tabulated and subjected to statistical analysis.

3.4.1. Analysis of variance

Analysis of variance for Randomised Block Design was carried out for comparison among different treatments and replications and to estimate variance components.

3.4.2. Estimation of variability components

The phenotypic and genotypic components of variance for each character were estimated by equating the expected value of mean squares (MS) to the respective variance components (Jain, 1982).

3.4.2.1. Phenotypic variance ($V_{(P)}$)

$V_{(P)} = V_{(G)} + V_{(E)}$

where $V_{(G)}$ = Genotypic variance

$V_{(E)}$ = Environmental variance estimated as mean square due to error.

3.4.2.2. Genotypic variance ($V_{(G)}$)

$$(V_{(G)}) = \frac{\text{Mean square (Treatment) - Mean square (Error)}}{\text{Number of replications}}$$

The phenotypic and genotypic coefficients of variation were worked out for each character by making use of the estimates of $V_{(P)}$ and $V_{(G)}$ and were expressed in percentage.

3.4.2.3. Phenotypic coefficient of variation (PCV)

$$PCV = \frac{\sqrt{V_{(P)}}}{\text{Mean}} \times 100$$

3.4.2.4. Genotypic coefficient of variation (GCV)

$$GCV = \frac{\sqrt{V_{(G)}}}{\text{Mean}} \times 100$$

In all the cases, the mean of a character was calculated over all the treatments.

3.4.3. Estimation of heritability

The heritability (in broad sense) for each character was worked out as the ratio of genotypic variance to the phenotypic variance and was expressed as percentage (Jain, 1982).

$$\text{Heritability } (h^2) = \frac{V_{(G)}}{V_{(P)}} \times 100$$

3.4.4. Estimation of genetic advance

The expected genetic improvement by selection was proportional to the product of heritability and phenotypic standard deviation (Allard, 1960).

$$\text{Genetic advance (GA)} = k.\ h^2 \sqrt{V_{(P)}}$$

where 'k' is the standardised selection differential, usually taken as 2.06 (at5 % selection) in large samples.

3.4.5. Correlation

The analysis of covariance was done between each pair of observations and the correlations were computed. The phenotypic correlation coefficient between two characters x and y was estimated as $\Upsilon p\ (x,y)$

$$\Upsilon p\ (x, y) = \frac{Cov_{(P)}\ (x, y)}{\sqrt{V_{(P)}\ x\ x\ V_{(P)}\ y}}$$

where $Cov_{(p)}$ (x,y) denote the phenotypic covariance between the characters x and y estimated by taking the respective expected values of mean sum of products.

$V_{(P)}x$ and $V_{(P)}$ y indicate the estimated phenotypic variances for x and y respectively.

The genotypic correlation coefficient between the characters x and y were estimated in the similar manner, replacing the phenotypic covariance by the genotypic covariance between the two characters and the phenotypic variances by the genotypic variances.

$$\Upsilon_G (x, y) = \frac{Cov_{(G)} (x, y)}{\sqrt{V_{(G)} x \times V_{(G)} y}}$$

RESULTS

4. RESULTS

The data collected from the two experiments were tabulated and subjected to statistical analysis. The results obtained are presented below.

4.1. Evaluation of $F_4 M_4$ families

The analysis of variance for the 21 characters studied in the F_4M_4 generation which was used to compare the performance among the different families and with both the parents are presented in Table 2. The mean values for the 21 characters relating to different treatments are given in Table 3.

Days to first flowering revealed high significant differences between the families and with the wild parent, P_2. The mean values for the character ranged from 39.0 in T_{44} to 54.7 in T_{11}. T_{43}, T_{45}, T_{46}, T_{47}, T_{48}, T_{49} and T_{50} were on par with T_{44}.

Significant differences were observed for leaf axil bearing the first flower among the families and with both the parents. T_{20}, T_{43} and T_{45} recorded the lowest mean (4.2) whereas the wild parent had the highest mean (7.1).

Leaf number per plant varied significantly among the families and with the two parents. The mean values ranged from 266.2 in T_{34} to 18.9 in T_{16}.

High significant differences were present among the families and with the wild parent, P_2 for leaf area. The mean values for leaf area ranged from 363.5 in T_{32} to 128.5 in T_5.

Table 2 ANOVA (mean squares) for the different characters in the F_4 M_4 generation

Characters	Treatments	P_1 vs families	P_2 vs families	Error
	df = 51	df = 1	df = 1	df = 51
1. Days to first flowering	34.40**	6.32	63.80**	1.71
2. Leaf axil bearing first flower	1.16**	1.00**	7.33**	0.07
3. Leaf number	15.45**	5.27**	1.84**	0.21
4. Leaf area (cm^2)	4656.45**	846.20	16895.42**	359.55
5. Number of branches per plant	1.14**	0.30**	0.30**	0.01
6. Number of flowers per plant	811.55**	184.87**	113.55**	9.22
7. Pollen sterility (%)	12.53**	34.24**	68.74**	0.36
8. First fruiting node	1.81**	1.26**	6.34**	0.14
9. Number of fruits per plant	3.89**	0.70*	0.46*	0.10
10. Average fruit weight (g)	18.12**	3.29*	27.22**	0.68
11. Weight of fruits per plant (g)	9599.18**	810.59	1045.19	893.09
12. Length of fruit (cm)	30.78**	1.78	12.51**	0.71
13. Girth of fruit (cm)	1.77**	0.07	13.64**	0.07
14. Number of seeds per fruit	3.16**	0.61**	10.19**	0.05
15. Number of ridges per fruit	1.43**	0.71**	9.84**	0.02
16. Fruiting phase	368.92**	68.90*	2392.09**	13.41
17. Height of plant (cm)	2677.12**	140.33	1934.46**	142.68
18. Incidence of YVM disease	1.77**	5.24**	0.63**	0.07
19. Incidence of shoot and fruit borer	82.73**	432.78**	121.55**	1.03
20. Duration of the plant	415.28**	14.68	2911.81**	9.56
21. Crude fibre content of fruits (%)	0.62**	0.21**	0.72**	0.01

* Significant at 5 % level

** Significant at 1 % level

Table 3. Mean values for the different characters in F_4 M_4 generation

Treatments	Days to first flowering 1	Leaf axil bearing first flower 2	Leaf number 3	Leaf area (cm^2) 4	Number of branches per plant 5	Number of flowers per plant 6	Pollen sterility (%) 7	First fruiting node 8	Number of fruits per plant 9
T_1	51.1	5.8	27.1 (5.3)	249.0	0.3 (1.1)	10.9	10.1	6.7	9.1 (3.1)
T_2	50.6	5.8	25.3 (5.10)	260.4	0.2 (1.1)	12.5	10.3	6.8	10.4 (3.4)
T_3	51.5	6.1	27.1 (5.3)	278.2	0.4 (1.1)	16.0	11.7	7.2	13.9 (3.9)
T_4	51.4	6.2	30.2 (5.6)	283.9	0.5 (1.2)	18.2	12.3	7.5	16.1(4.1)
T_5	51.6	6.4	71.9 (8.5)	128.5	8.7 (3.1)	53.7	4.1	7.3	46.1 (6.9)
T_6	51.8	6.4	30.6 (5.6)	325.3	0.3 (1.1)	17.4	12.0	7.4	15.3 (4.0)
T_7	51.5	5.8	28.4 (5.4)	253.5	0.4 (1.2)	16.1	10.5	6.8	14.0 (3.9)
T_8	52.1	6.6	27.6 (5.4)	232.0	0.1 (1.1)	14.3	10.4	7.2	12.3 (3.6)
T_9	52.7	6.1	27.5 (5.3)	259.8	0.4 (1.1)	14.8	10.7	6.9	12.5 (3.7)
T_{10}	54.2	6.6	28.3 (5.4)	231.7	0.5 (1.2)	14.1	8.5	7.5	12.5(3.7)
T_{11}	54.7	6.4	30.1 (5.6)	263.2	0.8 (1.3)	15.8	8.2	7.1	14.3 (3.9)
T_{12}	52.7	6.2	27.2 (5.3)	239.9	0.5 (1.2)	14.0	9.5	7.3	11.6 (3.5)
T_{13}	52.5	6.3	88.0 (9.4)	147.1	8.7 (3.1)	41.0	3.8	8.1	32.8 (5.8)
T_{14}	48.6	4.9	24.6 (5.1)	247.0	0.5 (1.2)	11.9	9.2	5.5	9.8 (3.3)
T_{15}	49.6	5.1	79.7 (9.0)	167.1	8.2 (3.0)	41.1	4.0	6.5	34.1 (5.9)
T_{16}	49.8	4.8	18.9 (4.5)	222.0	0.2 (1.1)	9.0	8.7	5.3	7.5 (2.9)
T_{17}	49.4	4.7	21.6 (4.8)	233.9	0.3 (1.1)	11.9	8.3	5.4	10.3 (3.4)
T_{18}	50.6	4.6	26.9 (5.3)	330.6	0.3 (1.1)	11.4	11.4	6.3	9.0 (3.2)
T_{19}	50.5	4.4	172.9 (13.1)	139.9	10.8 (3.4)	75.4	3.9	5.9	62.4 (8.0)
T_{20}	47.6	4.2	23.0 (4.9)	245.1	0.5 (1.2)	13.1	8.9	4.9	11.1 (3.5)
T_{21}	49.4	4.7	19.2 (4.5)	223.0	0.1 (1.1)	11.0	8.6	4.9	8.9 (3.1)
T_{22}	51.0	4.9	22.9 (4.9)	212.0	0.5 (1.2)	12.3	9.6	5.0	10.5 (3.4)
T_{23}	50.6	5.0	23.5 (5.0)	218.6	0.2 (1.1)	14.0	9.4	6.0	12.2 (3.6)
T_{24}	50.0	4.9	19.3 (4.5)	216.5	0.2 (1.1)	10.3	9.3	5.5	8.2 (3.0)
T_{25}	49.3	4.8	23.9 (5.0)	224.9	0.6 (1.3)	14.3	8.9	5.3	12.1 (3.6)
T_{26}	49.5	4.9	71.1 (8.5)	198.8	5.1 (2.5)	35.7	4.2	6.2	30.2 (5.6)
T_{27}	49.0	4.9	22.4 (4.8)	231.3	0.6 (1.3)	13.6	8.6	5.6	11.9 (3.6)

Table 3.continuted

	1	2	3	4	5	6	7	8	9
T_{28}	48.6	4.8	20.2 (4.6)	231.3	0.2 (1.1)	11.0	8.4	5.4	9.2 (3.2)
T_{29}	49.8	4.8	22.5 (4.8)	218.0	0.3 (1.1)	12.3	9.0	5.7	10.7 (3.4)
T_{30}	48.4	4.5	23.8 (5.0)	243.4	0.5 (1.2)	12.8	9.0	5.4	11.0 (3.4)
T_{31}	50.0	4.8	261.6 (16.2)	151.5	12.4 (3.7)	91.1	3.9	6.4	71.3 (8.5)
T_{32}	50.3	5.1	21.6 (4.8)	363.5	0.2 (1.1)	11.5	10.8	5.8	9.6 (3.3)
T_{33}	48.9	4.8	51.5 (7.2)	214.6	0.3 (1.1)	39.3	8.9	5.3	24.7 (5.1)
T_{34}	44.6	5.0	266.2 (16.4)	158.2	9.8 (3.3)	86.2	8.8	6.2	55.6 (7.5)
T_{35}	49.2	4.7	48.1 (7.0)	214.6	0.5 (1.2)	24.7	9.1	5.4	17.9 (4.3)
T_{36}	51.3	5.0	23.7 (5.0)	220.4	0.1 (1.1)	13.8	9.1	5.6	12.1 (3.6)
T_{37}	50.6	5.2	25.4 (5.1)	229.4	0.3 (1.1)	15.8	8.7	5.9	13.6 (3.8)
T_{38}	49.1	5.2	24.8 (5.1)	338.0	0.0 (1.0)	13.6	11.6	5.4	10.3 (3.4)
T_{39}	51.2	4.9	24.0 (5.0)	253.9	0.1 (1.1)	13.2	8.5	5.7	11.4 (3.5)
T_{40}	50.5	5.1	20.6 (4.7)	236.2	0.1 (1.1)	11.4	8.0	5.5	10.3 (3.4)
T_{41}	49.2	4.9	92.6 (9.7)	162.4	6.6 (2.8)	67.0	2.7	5.5	59.0 (7.8)
T_{42}	49.4	4.8	189.5 (13.8)	194.3	8.4 (3.1)	68.5	3.5	5.9	51.5 (7.3)
T_{43}	40.3	4.2	40.5 (6.4)	227.0	0.7 (1.3)	19.0	8.1	4.7	16.7 (4.2)
T_{44}	39.0	4.4	37.7 (6.2)	243.3	0.6 (1.3)	17.4	7.9	4.8	15.4 (4.1)
T_{45}	40.2	4.2	41.9 (6.5)	253.4	0.3 (1.1)	18.1	8.6	4.6	15.9 (4.1)
T_{46}	40.0	4.3	38.4 (6.3)	233.9	0.8 (1.3)	18.8	7.9	4.7	16.4 (4.2)
T_{47}	39.3	4.4	40.9 (6.5)	239.8	1.1 (1.5)	20.6	8.7	4.7	17.5 (4.3)
T_{48}	40.9	4.4	43.6 (6.7)	245.2	0.7 (1.4)	20.7	8.0	4.7	18.3 (4.4)
T_{49}	40.6	4.4	41.1 (6.5)	241.6	0.6 (1.3)	20.9	9.1	4.6	18.3 (4.4)
T_{50}	40.5	4.3	36.3 (6.1)	260.3	0.8 (1.3)	19.0	9.3	5.1	16.5 (4.2)
T_{51} (p_1)	46.9	4.4	22.9 (4.9)	212.0	0.3 (1.1)	14.1	4.3	5.1	12.7 (3.7)
T_{52} (P_2)	54.4	7.1	29.9 (5.6)	325.6	0.3 (1.1)	16.2	14.4	7.7	13.5 (3.8)
CD	2.63	0.55	0.92	38.11	0.22	6.10	1.21	0.75	0.63
SE	0.92	0.19	0.32	13.41	0.77	2.15	0.42	0.26	0.22

Figures in paranthesis represent values after $\sqrt{x+1}$ transformation

Table 3.continuted

Treatments	Average fruit weight (g) 10	Weight of fruits per plant 11	Length of fruit (cm) 12	Girth of fruit (cm) 13	Number of seeds per fruit 14	Number of ridges per fruit 15
T_1	11.4	101.9	10.5	4.9	24.8 (5.1)	5.0
T_2	12.1	126.2	10.7	5.1	26.4 (5.2)	5.0
T_3	11.2	153.7	11.5	5.4	26.5 (5.2)	5.0
T_4	11.5	184.5	11.2	5.6	19.9 (4.6)	5.1
T_5	5.8	264.3	4.8	4.6	7.7 (2.9)	5.3
T_6	14.9	226.0	8.7	8.1	43.4 (6.7)	7.7
T_7	12.9	181.5	10.5	5.6	22.6 (4.9)	5.6
T_8	11.8	145.8	10.9	5.4	23.4 (4.9)	5.1
T_9	11.7	146.5	10.8	5.5	27.2 (5.3)	5.1
T_{10}	11.6	142.9	11.0	5.5	26.1 (5.3)	5.7
T_{11}	11.9	166.0	10.4	5.0	26.3 (5.2)	5.8
T_{12}	11.8	138.9	10.1	5.3	22.9 (4.9)	5.3
T_{13}	5.6	186.4	4.7	4.7	6.6 (2.8)	5.1
T_{14}	11.3	110.7	9.8	5.2	24.9 (5.0)	5.9
T_{15}	8.3	184.0	4.7	4.6	7.5 (2.9)	5.2
T_{16}	12.1	89.9	10.0	4.9	23.3 (4.9)	5.7
T_{17}	11.5	120.1	10.9	5.1	26.4 (5.2)	5.0
T_{18}	14.7	132.9	9.1	7.8	47.1 (6.9)	7.7
T_{19}	5.4	336.6	4.7	4.7	8.1 (3.0)	5.3
T_{20}	11.1	121.8	11.6	5.2	27.1 (5.3)	5.8
T_{21}	11.7	103.1	11.0	5.0	26.0 (5.2)	5.1
T_{22}	11.5	119.5	11.9	5.2	27.4 (5.3)	5.6
T_{23}	12.0	145.0	11.2	5.3	27.9 (5.3)	5.0
T_{24}	11.9	96.8	12.1	5.0	27.4 (5.3)	5.1
T_{25}	11.4	139.4	12.7	4.9	28.6 (5.4)	5.1
T_{26}	5.4	165.1	4.9	4.5	5.8 (2.6)	5.1
T_{27}	12.4	149.8	11.5	5.0	25.7 (5.2)	5.2
T_{28}	11.7	105.8	12.3	5.1	27.8 (5.4)	5.9
T_{29}	12.7	139.0	12.1	5.1	27.8 (5.4)	5.2
T_{30}	12.4	126.6	12.4	5.2	28.5 (5.4)	5.1

Table 3 continuted

Treatments	10	11	12	13	14	15
T_{31}	5.4	387.8	4.8	4.7	5.8 (2.6)	5.2
T_{32}	14.0	133.1	9.5	7.7	45.2 (6.8)	7.7
T_{33}	13.1	322.7	11.3	5.4	25.5 (5.1)	5.0
T_{34}	5.1	277.7	7.5	4.6	10.4 (3.4)	5.1
T_{35}	15.0	266.1	10.7	5.3	30.6 (5.6)	5.0
T_{36}	12.6	138.1	11.6	5.0	28.7 (5.5)	6.2
T_{37}	12.6	169.8	12.1	5.3	39.7 (6.1)	6.6
T_{38}	15.5	184.9	9.5	8.1	50.5 (7.2)	7.8
T_{39}	13.2	149.4	11.9	5.4	30.9 (5.7)	5.6
T_{40}	13.1	134.6	11.6	5.2	25.9 (5.2)	5.7
T_{41}	5.1	297.7	4.8	4.7	10.4 (3.4)	5.1
T_{42}	5.3	273.7	4.6	4.7	5.3 (2.5)	5.2
T_{43}	14.2	236.7	16.0	6.0	34.6 (6.0)	5.1
T_{44}	14.5	222.1	15.4	6.2	34.8 (6.0)	5.3
T_{45}	14.5	228.6	18.0	6.4	38.4 (6.3)	5.2
T_{46}	14.1	230.3	19.5	6.2	40.1 (6.4)	5.4
T_{47}	14.8	255.2	18.9	6.3	44.7 (6.8)	6.1
T_{48}	14.6	271.2	19.2	6.2	47.1 (6.9)	6.2
T_{49}	14.1	258.6	18.8	6.2	42.8 (6.6)	7.5
T_{50}	13.3	233.0	19.2	6.2	42.6 (6.6)	6.3
T_{51} (P_1)	12.8	164.1	12.0	5.3	31.6 (5.7)	5.0
T_{52} (P_2)	15.2	207.5	8.5	8.1	54.2 (7.4)	7.9
CD	1.66	60.07	1.69	0.52	0.43	0.30
SE	0.58	21.13	0.59	0.18	0.15	0.10

Figures in paranthesis represent values after $\sqrt{x+1}$ transformation

Table 3 continuted

Treatments	Fruiting phase	Height of plant (cm)	Incidence of YVM disease	Incidence of fruit and shoot borer	Duration of the plant	Crude fibre content of fruits (%)
	16	17	18	19	20	21
T_1	48.2	64.5	1.9	13.9	103.9	1.9
T_2	48.7	72.5	1.4	17.9	106.6	1.7
T_3	48.2	73.1	1.2	20.1	106.8	1.4
T_4	55.7	78.7	1.1	19.0	112.7	1.6
T_5	84.7	140.5	1.2	3.5	146.0	2.4
T_6	93.1	126.6	1.0	3.1	155.0	2.5
T_7	52.4	89.5	1.1	13.9	110.5	1.6
T_8	46.3	86.9	1.3	16.9	104.6	1.6
T_9	52.8	86.1	3.1	13.3	110.4	2.7
T_{10}	52.6	98.4	1.2	16.2	114.0	1.6
T_{11}	52.2	98.5	1.0	14.7	112.1	1.4
T_{12}	53.7	94.7	4.1	15.9	111.6	2.2
T_{13}	79.5	145.5	1.0	3.4	140.1	2.5
T_{14}	57.5	90.6	1.0	10.1	111.9	1.4
T_{15}	80.5	141.5	1.0	1.6	139.9	2.4
T_{16}	57.7	69.7	1.2	16.0	115.4	1.5
T_{17}	56.5	86.0	1.0	14.8	115.5	1.5
T_{18}	97.9	122.6	1.0	4.7	155.0	2.4
T_{19}	80.5	199.0	1.0	10.0	138.1	2.4
T_{20}	58.7	85.5	1.2	16.2	112.0	1.7
T_{21}	55.6	79.2	1.3	15.5	110.7	1.7
T_{22}	55.1	91.2	1.0	10.5	111.5	1.6
T_{23}	53.7	83.3	4.1	14.3	111.7	2.9
T_{24}	53.3	81.1	1.2	13.2	114.2	1.6
T_{25}	57.9	98.0	1.0	10.8	113.2	1.5
T_{26}	76.7	150.7	1.1	1.8	133.1	2.7
T_{27}	57.7	87.6	4.0	13.4	113.5	2.9
T_{28}	56.6	83.4	1.0	16.8	113.4	1.4

Table 3 continuted

Treatments	16	17	18	19	20	21
T_{29}	60.0	74.0	3.6	14.2	116.5	2.8
T_{30}	61.6	86.4	1.1	14.8	11.50	1.4
T_{31}	66.8	221.5	1.2	3.7	127.2	2.6
T_{32}	94.8	122.5	1.0	4.7	155.4	2.9
T_{33}	65.9	122.8	4.1	13.0	120.9	2.9
T_{34}	68.5	212.8	1.0	2.2	120.5	2.7
T_{35}	53.1	130.8	1.1	15.5	118.4	1.6
T_{36}	57.0	90.8	1.0	23.2	114.6	1.4
T_{37}	64.9	88.7	1.7	14.6	120.6	2.3
T_{38}	96.8	83.6	1.1	5.11	153.5	2.9
T_{39}	58.0	84.7	1.5	14.6	116.5	2.1
T_{40}	62.6	81.1	1.8	14.4	115.5	1.8
T_{41}	67.6	160.1	1.0	1.4	125.4	2.7
T_{42}	66.7	172.6	1.1	2.5	124.8	2.3
T_{43}	67.7	130.9	1.3	18.5	114.2	1.7
T_{44}	72.3	126.4	1.3	14.7	116.9	1.3
T_{45}	64.4	125.8	1.3	14.9	112.3	1.4
T_{46}	63.4	136.9	1.4	20.8	111.0	1.6
T_{47}	66.2	132.6	1.9	16.5	117.7	2.6
T_{48}	63.6	135.3	3.1	23.2	117.6	2.6
T_{49}	63.8	135.3	1.3	16.9	113.1	1.3
T_{50}	64.1	127.3	1.7	21.4	112.2	1.5
T_{51} (P_1)	69.8	103.15	3.2	27.5	122.8	1.7
T_{52} (P_2)	98.8	80.2	1.0	4.8	158.6	2.6
			-			
CD	7.36	24.01	0.54	2.04	6.22	0.22
SE	2.59	8.45	0.19	0.72	2.19	0.08

Number of branches per plant revealed significant differences among the families and with the two parents. The maximum and minimum mean values for the character were recorded in T_{31} (12.4) and T_{38} (0.0) respectively.

Number of flowers per plant exhibited significant differences among the families and with the two parents. The mean values ranged from 91.1 in T_{31} to 9.0 in T_{16}.

The differences observed among the families and with both the parents were highly significant for pollen sterility. The mean values for pollen sterility ranged from 2.7 per cent in T_{41} to 14.4 per cent in the wild parent, T_{52}.

The mean values for the first fruiting node varied from 4.6 in T_{45} and T_{49} to 8.1 in T_{13}. Significant differences were observed among the families and with the two parents for first fruiting node.

Number of fruits per plant exhibited high significant differences among the families. With both the parents, the differences were significant. T_{31} and T_{16} recorded the highest (71.3) and lowest (7.5) mean values respectively.

Average fruit weight varied significantly among the families and with both the parents. The mean values for average fruit weight ranged from 15.5 in T_{38} to 5.1. in T_{34} and T_{41}.

The differences between the mean values among the families were significant for weight of fruits per plant. The mean values for weight of fruits per plant ranged from 387.8 in T_{31} to 89.9 in T_{16}. T_{19} was on par with T_{31}.

Length of fruit varied significantly between the families and with the wild parent, P_2. The means ranged from 19.5 in T_{46} to 4.6 in T_{42}. T_{45}, T_{47}, T_{48} and T_{50} were on par with T_{46}.

Girth of fruits revealed significant differences among the families and with the wild parent, P_2. The mean values for girth of fruits varied from 8.1 in T_6, T_{38} and the wild parent, T_{52} to 4.5 in T_{26}.

Significant differences were present for number of seeds per fruit between the families and with both the parents. Number of seeds per fruit was maximum for the wild parent, T_{52} (54.2) and minimum for T_{42} (5.3). T_3 was on par with T_{52}.

Number of ridges per fruit varied significantly between the families and with the two parents. The mean values ranged from 7.9 in the wild parent, T_{52} to 5.0 in T_1, T_2, T_3, T_{17}, T_{23}, T_{33}, T_{35} and in the cultivated parent, T_{51}.

Highly significant differences were observed for fruiting phase among the families and with the parents. The wild parent, T_{52} recorded the maximum (98.8) and T_8, the minimum (46.3) fruiting phase. T_6, T_{18}, T_{32} and T_{38} were on par with T_{52}.

Height of plant varied significantly among the different families and height of the wild parent, P_2 was significantly less than that of the families. Plant height was maximum for T_{31} (221.5) which was on par with T_{34} and T_{19} and minimum for T_1 (64.5).

Incidence of yellow vein mosaic differed significantly among the families and with both the parents. The disease incidence was maximum for T_{12}, T_{23} and T_{33} (4.1) whereas no infestation was noted on T_6, T_{11}, T_{13}, T_{14}, T_{15}, T_{17}, T_{18}, T_{19}, T_{22}, T_{25}, T_{28}, T_{32}, T_{34}, T_{36}, T_{41} and the wild parent, T_{52}.

High yielding and YVM disease resistant types in the F_4M_4 generation

Plate 3.

Plate 4.

Incidence of shoot and fruit borer varied significantly between the families and with both the parents. The mean values ranged from 1.4 percent in T_{41} to 27.5 per cent in the cultivated parent, T_{51}.

Significant differences were observed for duration of the crop among the families and duration of the wild parent, P_2 was significantly higher than that of the family means. The mean values for duration of the crop varied from 158.6 in the wild parent, T_{52} to 103.9 in T_1.

Crude fibre content of fruits varied significantly among the families and with both the parents. The mean values ranged from 2.9 in T_{23}, T_{27}, T_{32}, T_{33} and T_{38} to 1.3 in T_{44} and T_{49}.

Based on the incidence of YVM disease and yield, several superior types were selected from the F_4M_4 gerneration (Plates 3 and 4) and were used to raise the F_5M_5 populaiton.

4.2. Genetic parameters in F_4M_4 generation

The genetic parameters, viz., the phenotypic and genotypic coefficients of variation, heritability and genetic advance for each character under study in the F_4M_4 generation were estimated and are presented in Table 4.

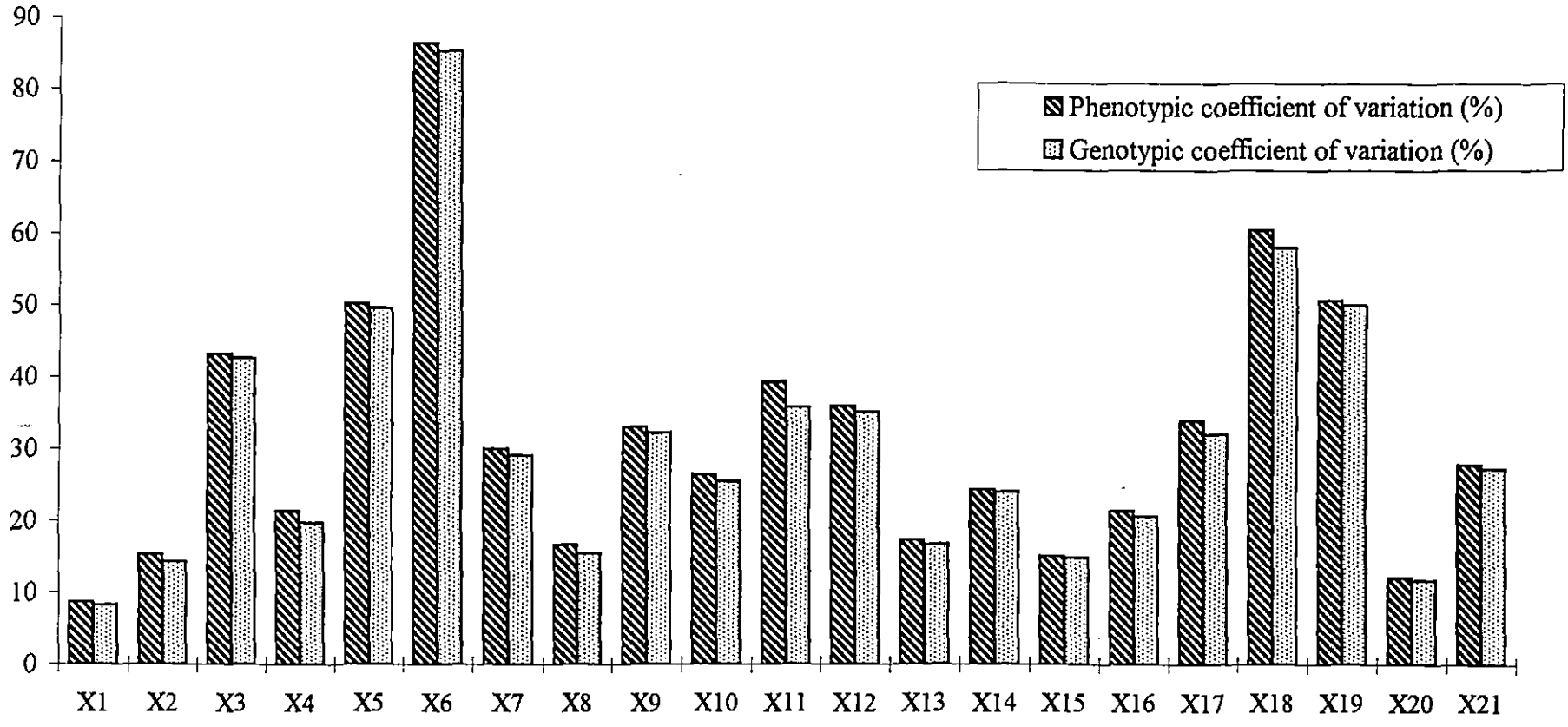
4.2.1. Phenotypic and genotypic coefficients of variation

The maximum values for phenotypic and genotypic coefficients of variation were recorded by number of flowers per plant (86.29 and 85.32 per cent respectively) followed by incidence of yellow vein mosaic disease (60.44 and 58.03 per cent respectively) incidence of shoot and fruit borer (50.65 and

Table 4. Genetic parameters for the different characters in F_4 M_4 generation

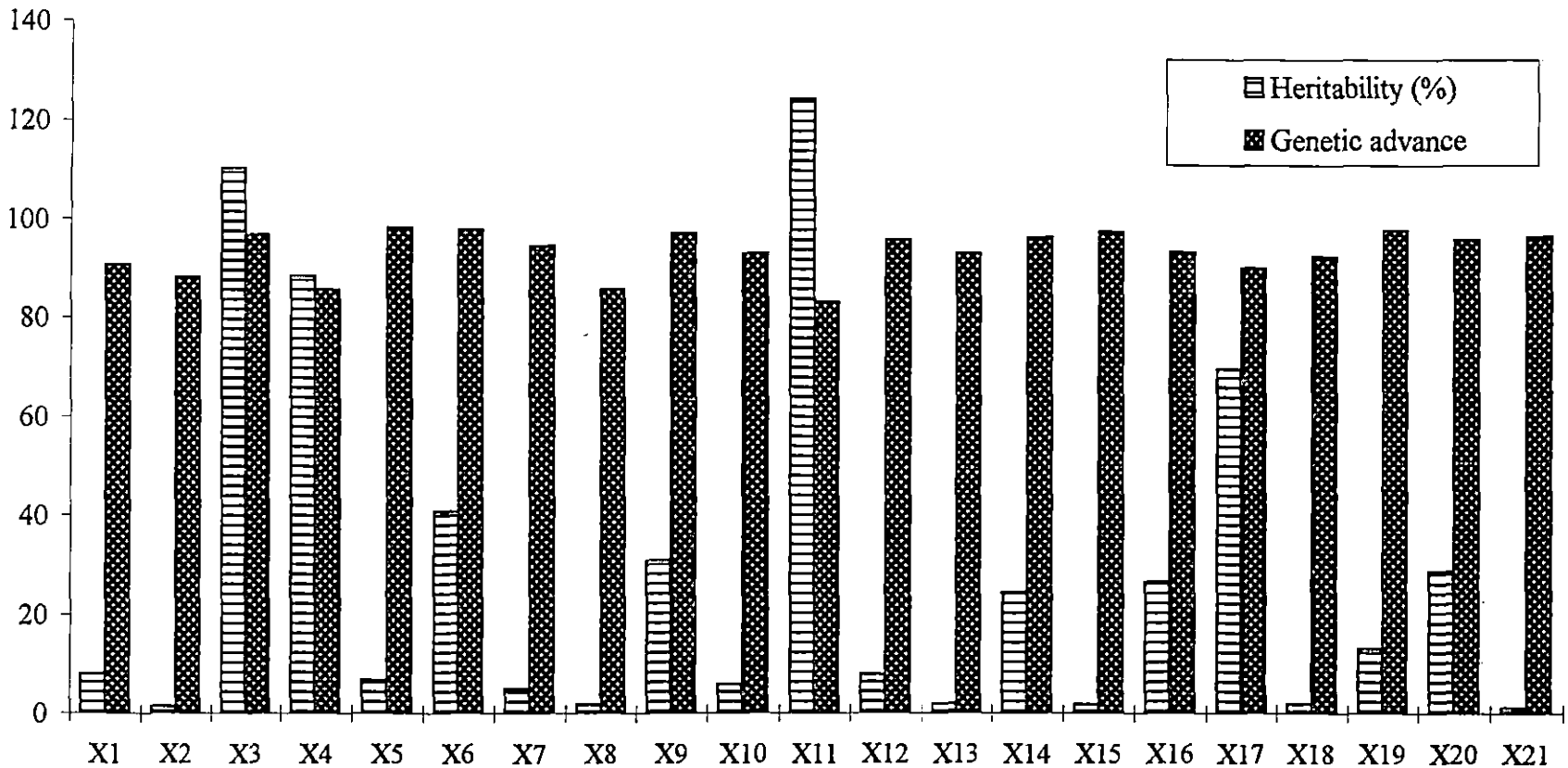
	Character	Phenotypic coefficient of variation (%)	Genotypic coefficient of variation (%)	Heritability (%)	Genetic advance
1	Days to first flowering	8.71	8.29	90.53	7.92
2	Leaf axil bearing first flower	15.27	14.33	88.04	1.42
3	Leaf number	43.21	42.62	96.63	110.10
4	Leaf area (cm^2)	21.39	19.80	85.66	88.38
5	Number of branches per plant	50.15	49.60	98.15	6.72
6	Number of flowers per plant	86.29	85.32	97.75	40.79
7	Pollen sterility (%)	30.00	29.15	94.39	4.94
8	First fruiting node	16.66	15.42	85.60	1.74
9	Number of fruits per plant	33.06	32.23	96.92	30.84
10	Average fruit weight (g)	26.40	25.43	92.77	5.86
11	Weight of fruits per plant (g)	39.26	35.76	82.98	123.81
12	Length of fruit (cm)	35.96	35.14	95.52	7.81
13	Girth of fruit (cm)	17.34	16.70	92.78	1.83
14	Number of seeds per fruit	24.33	23.99	96.05	24.41
15	Number of ridges per fruit	15.10	14.88	97.12	1.71
16	Fruiting phase	21.38	20.62	93.00	26.48
17	Height of plant (cm)	33.38	32.12	89.88	69.52
18	Incidence of YVM disease	60.44	58.03	92.21	1.82
19	Incidence of shoot and fruit borer	50.65	50.02	97.55	13.01
20	Duration of the plant	12.06	11.79	95.50	28.67
21	Crude fibre content of fruits (%)	27.81	27.27	96.16	1.11

Fig. 1.Phenotypic and genotypic coefficients of variation for characters in the F_4 M_4 generation



X1 Days to first flowering
X2 Leaf axil bearing first flower
X3 Leaf number
X4 Leaf area (cm^2)
X5 Number of branches per plant
X6 Number of flowers per plant
X7 Pollen sterility (%)
X8 First fruiting node
X9 Number of fruits per plant
X10 Average fruit weight (g)
X11 Weight of fruits per plant (g)
X12 Length of fruit (cm)
X13 Girth of fruit (cm)
X14 Number of seeds per fruit
X15 Number of ridges per fruit
X16 Fruiting phase
X17 Height of plant (cm)
X18 Incidence of YVM disease
X19 Incidence of fruit and shoot borer
X20 Duration of the plant
X21 Crude fibre content of fruits (%)

Fig. 2.Heritability and genetic advance for characters in the F_4 M_4 generation



X1 Days to first flowering
X2 Leaf axil bearing first flower
X3 Leaf number
X4 Leaf area (cm^2)
X5 Number of branches per plant
X6 Number of flowers per plant
X7 Pollen sterility (%)
X8 First fruiting node
X9 Number of fruits per plant
X10 Average fruit weight (g)
X11 Weight of fruits per plant (g)
X12 Length of fruit (cm)
X13 Girth of fruit (cm)
X14 Number of seeds per fruit
X15 Number of ridges per fruit
X16 Fruiting phase
X17 Height of plant (cm)
X18 Incidence of YVM disease
X19 Incidence of fruit and shoot borer
X20 Duration of the plant
X21 Crude fibre content of fruits (%)

50.02 per cent respectively) and number of branches per plant (50.15 and 49.60 per cent respectively) (Fig. 1).

The phenotypic and genotypic coefficients of variation were least for days to first flowering (8.71 and 8.29 per cent respectively) followed by duration of the plant (12.06 and 11.79 per cent respectively), number of ridges per fruit (15.10 and 14. 88 per cent respectively) and leaf axil bearing the first flower (15.27 and 14.33 per cent respectively).

4.2.2. Heritability and genetic advance

Majority of the characters exhibited very high heritability, the minimum being 82.98 per cent for weight of fruits per plant (Fig. 2). The heritability value was maximum for number of branches per plant (98.15 per cent) followed by number of flowers per plant (97.75 per cent), incidence of shoot and fruit borer (97.55 per cent) and number of ridges per fruit (97.12 per cent).

Maximum genetic advance was exhibited by weight of fruits per plant (123.81) followed by leaf number (110.10) and leaf area (88.38). The genetic advance was minimum for the character crude fibre content of fruits (1.11) followed by leaf axil bearing the first flower (1.42), number of ridges per fruit (1.71), first fruiting node (1.74), incidence of YVM disease (1.82) and girth of fruit (1.83).

4.3. Correlation in F_4M_4 generation

The data relating to the characters studied in the F_4M_4 generation were subjected to correlation analysis and the results are presented in Table 5.

Table 5. Genotypic and phenotypic correlation coefficients for characters in F_4M_4 generation

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1		0.689**	-0.0597	0.039	0.059	-0.0279	0.1192	0.7155**	-0.0262	-0.2566	-0.3345*	-0.6737**	-0.1725	-0.3331*	-0.0103	-0.0483	-0.3005*	0.1978	0.1632
X2	0.7311		-0.1028	0.1652	-0.0069	-0.0701	0.3014*	0.9041**	-0.0624	-0.0957	-0.1596	-0.3834**	0.0834	-0.118	0.0883	0.0094	-0.2442	0.1768	0.1005
X3	-0.0785	-0.1127		-0.5427**	0.8831**	0.9440**	-0.5214**	0.1101	0.9016**	-0.7071**	0.6668**	-0.4695**	-0.3073*	-0.5661**	-0.2099	0.1961	0.8492**	0.2037	0.3351*
X4	0.0432	0.1975	-0.6043		-0.6802**	-0.6254**	0.7712**	0.0339	-0.6298**	0.7197**	-0.3171*	0.3469*	0.7749**	0.7519**	0.6379**	0.1927	-0.4751**	0.1739	-0.0564
X5	0.061	0.004	0.8914	-0.7471		0.9321**	-0.7167**	0.2283	0.9365**	-0.8575**	0.5882**	-0.6362**	-0.4087**	-0.7185**	-0.2532	0.3093*	0.8017**	0.3483*	0.379**
X6	-0.0337	-0.0761	0.9534	-0.6981	0.9407		-0.6345**	0.1282	0.9847**	-0.7790**	0.7584**	-0.5400**	-0.3432*	-0.6330**	-0.2416	0.2548	0.8628**	0.2749*	0.4015**
X7	0.1244	0.3266	-0.5446	0.851	-0.7475	-0.6597		0.1313	-0.6802**	0.7000**	-0.3882**	0.3893**	0.5905**	0.6676**	0.4430**	-0.0771	-0.5892**	-0.0778	-0.149
X8	0.7584	0.9348	0.1163	0.0503	0.2561	0.1404	0.1448		0.1365	-0.3078	-0.0694	-0.5508**	-0.0164	-0.3080*	0.0074	0.0894	-0.0453	0.2648	0.1998
X9	-0.0254	-0.0684	0.9195	-0.7199	0.9544	0.9924	-0.7129	0.1443		-0.7883**	0.7698**	-0.5389**	-0.3388*	-0.6383**	-0.2382	0.2635	0.8573**	0.2855*	0.3828**
X10	-0.2932	-0.1106	-0.7436	0.7963	-0.8878	-0.8101	0.7443	-0.3243	-0.8252		-0.2711	0.7112**	0.6524**	0.8835**	0.4532	-0.0256	-0.5457**	-0.1052	-0.2500
X11	-0.398	-0.1926	0.7187	-0.4476	0.6414	0.7912	-0.4456	-0.087	0.7875	-0.3287		-0.066	0.055	-0.1997	-0.014	0.2976*	0.7980**	0.2474	0.3238*
X12	-0.7329	-0.4265	-0.4893	0.3567	-0.6584	-0.5647	0.396	-0.6212	-0.5734	0.7591	-0.1027		0.3256*	0.6828**	0.1214	-0.2985*	-0.2789*	-0.4811**	-0.4022**
X13	-0.1969	0.0832	-0.3222	0.8565	-0.4269	-0.3674	0.6136	-0.035	-0.3159	0.7054	0.0276	0.3136		0.8145**	0.7914**	0.5774**	-0.0959	0.5124**	0.1693
X14	-0.3602**	-0.1318	-0.5858	0.838	-0.7358	-0.6505	0.6991	-0.3402	-0.6593	0.9345	-0.1679	0.7074	0.856		0.6736**	0.2252	-0.3628**	0.1253	-0.0908
X15	-0.0042	0.1014	-0.2182	0.7006	-0.2615	-0.2478	0.4605	0.0077	-0.2449	0.4846	-0.0082	0.1297	0.8415	0.7001		0.6155**	-0.0495	0.5983**	0.189
X16	-0.0348	0.0035	0.2113	0.2353	0.3163	0.2689	-0.0891	0.0956	0.283	-0.0233	0.3574	-0.3201	0.6175	0.2274	0.6523		0.3830**	0.9469**	0.5228**
X17	-0.3507*	-0.2913	0.8759	-0.5454	0.8476	0.9017	-0.6437	-0.0707	0.8938	-0.5871	0.8686	-0.2975	-0.1169	-0.3931	-0.0559	0.4328		0.3435*	0.3346*
X18	0.2154	0.1788	0.448	0.2093	0.3539	0.2855	-0.0748	0.2845	0.3013	-0.104	0.2952	-0.4975	0.5425	0.1211	0.6193	0.9661	0.3727		0.5694**
X19	0.1715	0.1221	0.352	-0.059	0.3861	0.4176	-0.1596	0.2256	0.4071	-0.2605	0.3865	-0.4274	0.1773	-0.0877	0.2022	0.5366	0.3782	0.5873	

(Values above the diagonal indicate the phenotypic correlation coefficients and values below the diagonal indicate the genotypic correlation coefficients)

X1 Days to first flowering
X2 Leaf axil bearing first flower
X3 Leaf number
X4 Leaf area (cm^2)
X5 Number of branches per plant
X6 Number of flowers per plant
X7 Pollen sterility
X8 First fruiting node
X9 Number of fruits per plant
X10 Average fruit weight (g)
X11 Weight of fruits per plant (g)
X12 Length of fruit (cm)
X13 Girth of fruit (cm)
X14 Number of seeds per fruit
X15 Number of ridges per fruit
X16 Fruiting phase
X17 Height of plant (cm)
X18 Duration of the plant
X19 Crude fibre content of the fruits (%)

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

4.3.1. Phenotypic correlation

Days to first flowering had significant positive phenotypic correlation with leaf axil bearing the first flower, first fruiting node and significant negative correlation with weight of fruits per plant, length of the fruit, number of seeds per fruit and height of the plant. Leaf axil bearing the first flower exhibited significant positive phenotypic correlation with pollen sterility and first fruiting node. First fruiting node had high significant negative correlation with average fruit weight, length of fruit and number of seeds per fruit.

Leaf area had high significant positive phenotypic correlation with pollen sterility, average fruit weight, length of fruit, girth of fruit, number of seeds per fruit and number of ridges per fruit and highly significant negative phenotypic correlation with number of branches per plant, number of flowers per plant, number of fruits per plant, weight of fruits per plant and height of the plant. Pollen sterility recorded significant positive phenotypic correlation with average fruit weight, length of fruit, girth of fruit, number of seeds per fruit and number of ridges per fruit. However, pollen sterility was significantly and negatively correlated with number of fruits per plant, weight of fruits per plant and height of the plant.

Significant positive phenotypic correlation was present for leaf number with number of branches per plant, number of flowers per plant, number of fruits per plant, weight of fruits per plant, height of the plant and crude fibre content of fruits. Number of branches per plant exhibited significant positive phenotypic correlation with number of flowers per plant, number of fruits per plant, weight of fruits per plant, fruiting phase, height of the plant, duration of

the plant and crude fibre content of the fruits. Significant positive phenotypic correlation was recorded for the character, number of flowers per plant with number of fruits per plant, weight of fruits per plant, height of the plant, duration of the plant and crude fibre content of fruits.

Number of fruits per plant showed significant positive phenotypic correlation with number of leaves, branches and flowers per plant, weight of fruits per plant, height of the plant, duration of the plant and crude fibre content of fruits while the correlation was negative and highly significant with average fruit weight. Average fruit weight recorded highly significant positive phenotypic correlation with length and girth of fruit, number of seeds per fruit and number of ridges per fruit while highly significant negative phenotypic correlation were recorded with number of branches, flowers and fruits per plant and plant height. Significant positive phenotypic correlation was observed for weight of fruits per plant with number of branches, flowers and fruits per plant, fruiting phase, height of the plant and crude fibre content of fruits.

Significant positive phenotypic correlation was noticed for length of fruit with girth of fruit and number of seeds per fruit. Girth of fruit had highly significant positive phenotypic correlation with number of seeds per fruit, number of ridges per fruit, fruiting phase and duration of the plant. Number of seeds per fruit exhibited highly significant positive phenotypic correlation with leaf area, pollen sterility, average fruit weight, length and girth of fruit and number of ridges per fruit. Highly significant positive phenotypic association was noted for number of ridges per fruit with fruiting phase and

duration of the crop. Crude fibre content of fruits was significantly and positively correlated with number of branches, flowers and fruits per plant, weight of fruits per plant, fruiting phase, plant height and duration of the plant.

Fruiting phase recorded highly significant positive phenotypic correlation with height of the plant, duration of the plant and crude fibre content of fruits. Significant positive phenotypic correlation was observed for height of the plant with duration of the plant and crude fibre content of fruits. Duration of the plant showed highly significant positive association with girth of fruit, number of ridges per fruit, fruiting phase and crude fibre content of fruits and significant negative correlation with fruit length.

4.3.2. Genotypic correlation

Days to first flowering showed high positive genotypic correlation with leaf axil bearing the first flower and first fruiting node and negative association with average fruit weight, weight of fruits per plant, length of fruit, number of seeds per fruit and height of the plant. The genotypic correlation of leaf axil bearing the first flower was highly significant and positive with pollen sterility and first fruiting node. First fruiting node had high positive correlation with duration of the plant.

Highly positive genotypic correlation was recorded for leaf number with number of branches per plant, number of flowers per plant, number of fruits per plant, weight of fruits per plant, height of the plant and crude fibre content of fruits, whereas highly negative genotypic correlation was recorded with leaf

area, pollen sterility, average fruit weight, length of fruit, girth of fruit and number of seeds per fruit.

Leaf area had high positive genotypic correlation with average fruit weight and high negative genotypic correlation with number of branches per plant, number of flowers per plant, number of fruits per plant, weight of fruits per plant and height of the plant. High positive genotypic correlations were recorded for pollen sterility with average fruit weight, length of fruit, girth of fruit, number of seeds per fruit and number of ridges per fruit, whereas the genotypic correlation was highly negative for the character with number of fruits per plant, weight of fruits per plant and height of the plant.

The genotypic association of number of branches per plant was high and positive with number of flowers per plant, number of fruits per plant, weight of fruits per plant, fruiting phase, height of the plant, duration of the plant and crude fibre content of the fruits. Number of flowers per plant exhibited high positive genotypic correlation with number of fruits per plant, weight of fruits per plant, height of the plant, duration of the plant and crude fibre content of fruits.

Number of fruits per plant exhibited high positive genotypic correlation with number of leaves, branches and flowers per plant, weight of fruits per plant, fruiting phase, height of the plant, duration of the plant and crude fibre content of fruits. High positive genotypic correlation was observed for average fruit weight with length of fruit, girth of fruit, number of seeds per fruit and number of ridges per fruit, while high negative correlation was noted for the character with number of leaves, branches, flowers and fruits per plant,

first fruiting node, weight of fruits per plant and height of the plant. Weight of fruits per plant exhibited high positive genotypic correlation with number of leaves, branches, flowers and fruits per plant, fruiting phase, height of the plant, duration of the plant and crude fibre content of fruits and negative correlation with average fruit weight.

Length of fruit recorded high positive genotypic association with girth of fruit and number of seeds per fruit. High positive genotypic correlation was observed for girth of fruit with number of seeds per fruit, number of ridges per fruit, fruiting phase and duration of the plant. The genotypic association of number of seeds per fruit was maximum and positive with leaf area, pollen sterility, average fruit weight, length and girth of fruit and number of ridges per fruit. Number of ridges per fruit recorded high positive genotypic correlations with fruiting phase and duration of the plant.

Fruiting phase recorded high positive genotypic correlation with height of the plant, duration of the plant and crude fibre content of fruits. The genotypic association of height of the plant was positive with duration of the plant, crude fibre content of fruits and several other characters. Duration of the plant showed positive genotypic correlation with number of branches, flowers and fruits per plant, number of ridges per fruit, fruiting phase, plant height and crude fibre content of fruits.

4.4. Evaluation of F_5M_5 families

The data pertaining to the 21 characters studied in the F_5M_5 generation were tabulated and subjected to analysis of variance and are presented in Table

Table 6. ANOVA (Mean squares) for the different characters in F_5 M_5 generation

	Characters	Source			
		Treatments	P_1 vs families	P_2 vs families	Error
		df = 26	df = 1	df = 1	df = 52
1	Days to first flowering	26.81**	157.28**	471.44**	0.42
2	Leaf axil bearing first flower	0.88**	0.21*	21.55**	0.04
3	Lear number	61.72**	614.66**	763.03**	1.59
4	Leaf area (cm^2)	860.90**	38.78	21235.5**	47.42
5	Number of branches per plant	0.05**	0.07**	0.26**	0.1
6	Number of flowers per plant	11.78**	100.82**	129.96**	0.45
7	Pollen sterility (%)	4.40**	31.24**	63.98**	0.16
8	First fruiting node	1.87**	0.47**	46.22**	0.04
9	Number of fruits per plant	8.56**	48.96**	105.70**	0.39
10	Average fruit weight (g)	5.44**	66.41**	5.27**	0.53
11	Weight of fruits per plant (g)	5924.35**	44926.09	39769.71**	248.19
12	Length of fruit (cm)	7.46**	21.2**	118.31**	0.32
13	Girth of fruit (cm)	0.46**	0.98**	10.24**	0.01
14	Number of seeds per fruit	69.50**	10.30	1322.29**	4.67
15	Number of ridges per fruit	0.73**	0.01	18.15**	0.01
16	Fruiting phase	145.58**	1267.27**	1293.29**	10.29
17	Height of plant (cm)	550.12**	2830.85**	10813.57**	10.62
18	Incidence of YVM disease	0.73**	18.47**	0.01	0.01
19	Incidence of shoot and fruit borer	26.75**	503.25**	117.71**	0.93
20	Duration of the plant	178.64**	602.82**	3323.64**	2.16
21	Fibre content	0.17**	0.12**	4.14**	0.00

* Significant at 5 % level

** Significant at 1 % level

Table 7. Mean values for the different characters in F_5 M_5 generation

Treatments	Days to first flowering	Leaf axil bearing first flower	Leaf number	Leaf area (cm^2)	Number of branches per plant	Number of flowers per plant	Pollen sterility (%)	First fruiting node
	1	2	3	4	5	6	7	8
T_1	41.0	4.8	37.5	249.3	0.8 (1.3)	16.6	9.2	5.2
T_2	40.5	4.9	40.2	244.6	0.9 (1.4)	17.2	9.1	5.3
T_3	40.8	4.7	40.1	255.4	1.0 (1.4)	16.8	8.9	5.4
T_4	41.5	4.5	40.8	251.5	1.0 (1.4)	18.1	8.7	4.9
T_5	41.7	4.7	41.2	246.7	0.8 (1.3)	17.8	8.6	4.9
T_6	41.5	4.5	42.1	256.9	0.5 (1.2)	17.5	8.6	4.8
T_7	41.2	4.7	42.5	250.9	0.7 (1.3)	17.2	8.5	4.9
T_8	41.1	4.8	41.9	255.7	0.7 (1.3)	17.3	8.7	5.0
T_9	41.9	4.5	42.7	251.5	0.6 (1.3)	16.9	8.1	4.7
T_{10}	42.0	4.7	41.7	245.4	0.5 (1.2)	17.1	8.5	4.8
T_{11}	41.6	4.6	42.7	257.8	0.5 (1.2)	16.4	7.9	4.7
T_{12}	42.1	4.5	43.4	256.4	0.6 (1.3)	18.0	8.0	4.8
T_{13}	41.6	4.4	42.5	254.3	0.4 (1.2)	18.3	7.8	4.8
T_{14}	42.3	4.4	44.3	252.3	0.1 (1.0)	18.5	8.6	4.9
T_{15}	42.1	4.8	45.3	256.2	0.6 (1.3)	17.7	8.2	5.1
T_{16}	41.8	4.5	43.7	247.1	0.6 (1.3)	18.1	7.7	4.9
T_{17}	39.2	4.8	45.6	251.7	1.5 (1.6)	19.7	8.2	4.7
T_{18}	39.4	4.5	45.8	253.1	1.3 (1.5)	19.4	7.6	4.9
T_{19}	38.7	4.5	45.1	250.9	1.1 (1.4)	20.1	7.7	4.9
T_{20}	39.3	4.5	49.7	252.0	1.3 (1.5)	20.3	7.6	4.9
T_{21}	40.1	4.4	42.0	249.9	0.7 (1.3)	18.7	8.5	4.7
T_{22}	40.4	4.7	42.0	246.0	0.9 (1.4)	18.9	7.9	4.9
T_{23}	39.5	4.6	42.9	249.9	1.1 (1.4)	18.5	8.4	5.0
T_{24}	39.5	4.4	43.2	253.8	0.9 (1.4)	18.9	7.7	5.1
T_{25}	39.6	4.5	43.2	251.5	1.1 (1.4)	18.7	7.9	5.1
T_{26} (P_1)	48.2	4.9	28.1	247.9	0.4 (1.2)	12.2	5.0	5.3
T_{27} (P_2)	53.6	7.3	26.5	337.4	0.1 (1.0)	11.4	13.0	8.9
CD	0.06	0.32	2.07	11.30	0.14	1.10	0.66	0.34
SE	0.37	0.11	0.73	3.98	0.05	0.39	0.23	0.12

Figures in paranthesis represent values after $\sqrt{x+1}$ transformation

Table 7 continued

Treatments	Number of fruits per plant 9	Average fruit weight (g) 10	Weight of fruits per plant (g) 11	Length of fruit (cm) 12	Girth of fruit (cm) 13	Number of seeds per fruit 14	Number of ridges per fruit 15
T_1	14.2	16.0	227.6	15.3	5.8	34.6	5.0
T_2	14.7	16.5	243.1	15.3	5.9	32.8	5.1
T_3	14.5	16.4	238.4	15.6	5.9	31.2	5.0
T_4	15.5	16.6	258.1	15.8	5.9	31.1	5.0
T_5	15.0	16.5	247.1	15.1	6.0	31.7	5.0
T_6	15.1	16.9	255.1	15.7	5.9	29.4	5.0
T_7	14.7	16.3	240.2	15.3	5.8	32.5	5.0
T_8	14.7	15.9	235.4	15.7	6.0	31.9	5.0
T_9	14.4	16.2	233.3	15.7	5.8	33.3	5.0
T_{10}	14.4	16.5	238.1	16.1	5.8	33.3	5.0
T_{11}	13.9	16.5	229.1	16.4	5.9	36.8	5.0
T_{12}	15.5	16.5	257.2	16.2	5.9	36.2	5.0
T_{13}	15.5	16.3	256.0	16.1	5.9	30.4	5.1
T_{14}	16.1	16.2	259.4	15.7	5.9	29.3	5.0
T_{15}	15.3	15.9	243.7	15.3	6.0	32.0	5.0
T_{16}	15.3	16.0	245.3	15.5	5.9	29.2	5.0
T_{17}	17.1	18.8	322.0	18.1	6.0	36.5	5.0
T_{18}	16.9	18.2	308.2	18.1	5.9	37.6	5.0
T_{19}	17.4	18.6	324.5	17.9	6.0	35.2	5.0
T_{20}	17.7	18.6	329.5	17.7	6.0	38.4	5.0
T_{21}	16.0	18.1	290.2	16.4	6.0	33.9	5.0
T_{22}	16.2	18.1	292.7	16.2	5.9	34.0	5.0
T_{23}	15.7	18.2	286.2	15.7	5.8	33.9	5.5
T_{24}	16.1	17.8	289.9	16.2	5.9	33.0	5.3
T_{25}	15.9	17.9	284.4	15.8	5.9	33.4	5.2
T_{26} (P_1)	11.4	12.2	140.6	13.4	5.3	31.4	5.0
T_{27} (P_2)	9.5	15.7	148.0	9.7	7.8	54.7	7.6
CD	1.03	1.20	25.86	0.92	0.17	3.55	0.12
SE	0.36	0.42	9.10	0.33	0.06	1.25	0.04

Table 7 continued

Treatments	Fruiting phase	Height of plant (cm)	Incidence of YVM disease	Incidence of fruit and shoot norer	Duration of the plant	Crude fibre content of fruits (%)
	16	17	18	19	20	21
T_1	73.3	117.0	1.1	9.2	120.0	1.3
T_2	74.5	115.2	1.0	10.2	121.1	1.3
T_3	73.5	116.2	1.3	10.1	124.5	1.3
T_4	73.6	116.6	1.1	9.8	123.2	1.3
T_5	74.9	117.7	1.1	10.0	123.2	1.3
T_6	74.6	117.6	1.0	10.0	124.0	1.3
T_7	74.7	116.3	1.3	10.6	123.5	1.3
T_8	77.0	117.7	1.0	10.5	124.9	1.3
T_9	70.8	117.7	1.0	10.2	124.8	1.3
T_{10}	73.9	118.1	1.1	10.2	122.9	1.3
T_{11}	81.3	113.7	1.2	9.4	128.8	1.3
T_{12}	76.6	118.2	1.0	8.4	123.2	1.3
T_{13}	81.8	112.8	1.1	8.0	129.1	1.3
T_{14}	75.7	113.6	1.0	9.7	124.0	1.3
T_{15}	77.1	115.0	1.1	8.4	126.9	1.2
T_{16}	72.6	114.5	1.0	8.6	122.4	1.3
T_{17}	85.3	125.4	1.0	7.7	130.0	1.2
T_{18}	81.5	124.0	1.0	7.8	129.0	1.2
T_{19}	84.3	125.6	1.0	7.5	129.8	1.2
T_{20}	84.6	126.9	1.0	7.7	130.0	1.2
T_{21}	76.7	119.0	1.1	9.5	123.1	1.2
T_{22}	76.9	121.0	1.1	9.4	124.1	1.2
T_{23}	77.3	120.6	1.1	9.5	123.8	1.2
T_{24}	78.5	119.1	1.0	9.5	123.9	1.2
T_{25}	77.9	121.2	1.1	9.5	122.9	1.2
T_{26} (P_1)	56.2	97.1	3.6	22.5	110.5	1.3
T_{27} (P_2)	98.3	71.2	1.0	3.0	158.9	2.5
CD	5.26	5.35	0.19	1.59	2.41	0.07
SE	1.85	1.88	0.07	0.56	0.85	0.02

6. The mean values for all the characters relating to different treatments in the F_5M_5 generation are given in Table 7.

Significant differences were observed among the families and both the parents showed significantly higher values than the family means for number of days to first flowering. The mean values for number of days to first flowering varied from 38.7 in T_{19} to 53.6 in the wild parent, P_2. T_{17}, T_{18}, T_{20}, T_{23}, T_{24} and T_{25} were on par with T_{19}.

Leaf axil bearing the first flower varied significantly among the different families and with the wild parent, P_2. The mean values for leaf axil bearing the first flower ranged from 4.4 in T_{13}, T_{14}, T_{21} and T_{24} to 7.3 in the wild parent T_{27}.

The variations among the families and with both the parents were highly significant for the character, leaf number. Maximum leaf number was recorded in T_{18} (45.8) which was on par with T_{14}, T_{15}, T_{17}, T_{19} and T_{20} and the minimum leaf number was recorded in the wild parent, T_{27} (26.5).

The families exhibited highly significant variation from the wild parent P_2 and among themselves for leaf area. The mean values for leaf area ranged from 337.4 in the wild parent, T_{27} to 244.6 in T_2.

Number of branches per plant differed significantly among the families and with both the parents. The means ranged from 1.5 in T_{17} to 0.1 in T_{14} and the wild parent, T_{27}. T_{18} and T_{20} were on par with T_{17}.

Significant differences among the families and with the two parents for number of flowers per plant were observed. Maximum number of flowers was

present in T_{20} (20.3), which was on par with T_{17}, T_{18} and T_{19} and the number of flowers was minimum in the wild parent, T_{27} (11.4).

Pollen sterility varied significantly among the families and with the two parents. The mean values ranged from 13.0 in the wild parent, T_{27} to 5.0 in the cultivated parent, T_{26}.

First fruiting node differed significantly among the families and with both the parents. The mean values for first fruiting node ranged from 8.9 in the wild parent, T_{27} to 4.7 in T_9, T_{11}, T_{17} and T_{21}.

Highly significant differences were observed for number of fruits per plant between the different families and with the two parents. The maximum number of fruits was recorded in T_{20} (17.7) and the minimum in the wild parent, T_{27} (9.5). T_{17}, T_{18} and T_{19} were on par with T_{20}.

Variations among the families and with both the parents were highly significant for average fruit weight. The mean values for average fruit weight ranged from 18.8 in T_{17} to 12.2 in the cultivated parent, T_{26}.

Weight of fruits per plant ranged from 329.5 in T_{20} to 140.6 in the cultivated parent, T_{26}. The variations among the families and with both the parents were highly significant. T_{17}, T_{18} and T_{19} were on par with T_{20}.

Highly significant differences among the families and with both the parents were observed for length of fruit. The mean values for length of fruit ranged from 18.1 in T_{17} and T_{18}, which was on par with T_{19} and T_{20}, to 9.7 in the wild parent, T_{27}.

The families differed significantly among themselves and with the two parents for girth of fruit. Maximum girth was recorded in the wild parent, T_{27} (7.8) and the minimum, in the cultivated parent, T_{26} (5.3).

Number of seeds per fruit varied from 29.2 in T_{16} to 54.7 in the wild parent, T_{27}. The means for the character varied significantly among the families and with both the parents.

The families differed among themselves and with the wild parent, P_2 for number of ridges per fruit. The mean values ranged from 7.6 in the wild parent, T_{27} to 5.0 in the cultivated parent, T_{26} and twenty other families.

Highly significant differences were observed among the families and with the two parents for fruiting phase. The longest fruiting phase was recorded in the wild parent, T_{27} (98.3) and the shortest, in the cultivated parent, T_{26} (56.2).

The differences among the families and with the two parents were found significant for plant height. The height of both the parents were significantly lower than the families.The means ranged from 126.9 in T_{20} to 71.2 in the wild parent, T_{27}. T_{17}, T_{18} and T_{19} were on par with T_{20}.

Incidence of yellow vein mosaic disease in the different families varied significantly among themselves and with the cultivated parent, P_1. The scores for the disease varied from 3.6 in the cultivated parent, T_{26} to 0.0 in the wild parent, T_{27} and twelve other families.

Significant differences among the families and the two parents were exhibited for incidence of shoot and fruit borer. The means ranged from 3.0 per cent in the wild parent, T_{27} to 22.5 per cent in the cultivated parent, T_{26}.

High yielding and YVM resistant types in the F_5M_5 generation

Plate 5.

Plate 6.

Plate 7.

Duration of plant varied significantly among the families and with both the parents. The wild parent, T_{27} recorded the maximum duration (158.9) and the cultivated parent, T_{26} had the minimum duration (110.5).

Differences among the families and with the two parents were found significant for crude fibre content of fruits. The mean values ranged from 2.5 in the wild parent, T_{27} to 1.2 in ten other families.

From the F_5M_5 generation, several superior types were selected based on their field reaction to YVM disease incidence and yield (Plates 5,6 and 7) which will be used to raise the further generations in the process of developing high yielding YVM resitstance okra varieties.

4.5. Genetic parameters in F_5M_5 generation

All the characters studied in the F_5M_5 generation were subjected to estimation of genetic parameters viz., phenotypic and genotypic coefficients of variation, heritability and genetic advance and the results are given in Table 8.

4.5.1. Phenotypic and genotypic coefficients of variation

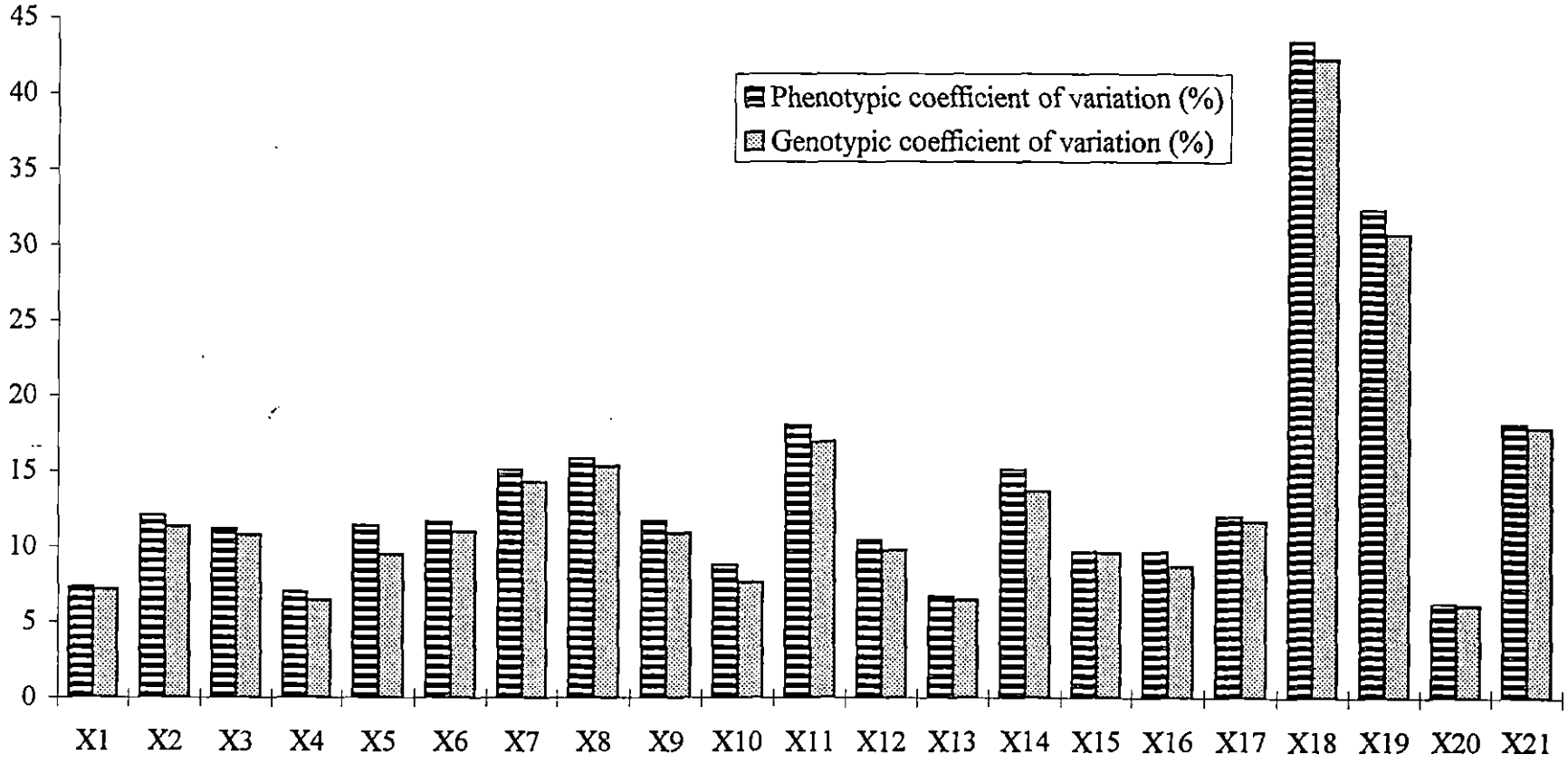
The maximum values of phenotypic and genotypic coefficients of variation were observed for incidence of yellow vein mosaic disease (43.39 and 42.22 per cent respectively) followed by incidence of shoot and fruit borer (32.28 and 30.66 per cent respectively) (Fig. 3).

Phenotypic and genotypic coefficients of variation were the minimum for duration of the plant (6.22 and 6.10 per cent respectively) followed by girth of fruit (6.70 and 6.47 per cent respectively), leaf area (7.01 and 6.47 per

Table 8. Genetic parameters for the different characters in F_5 M_5 generation

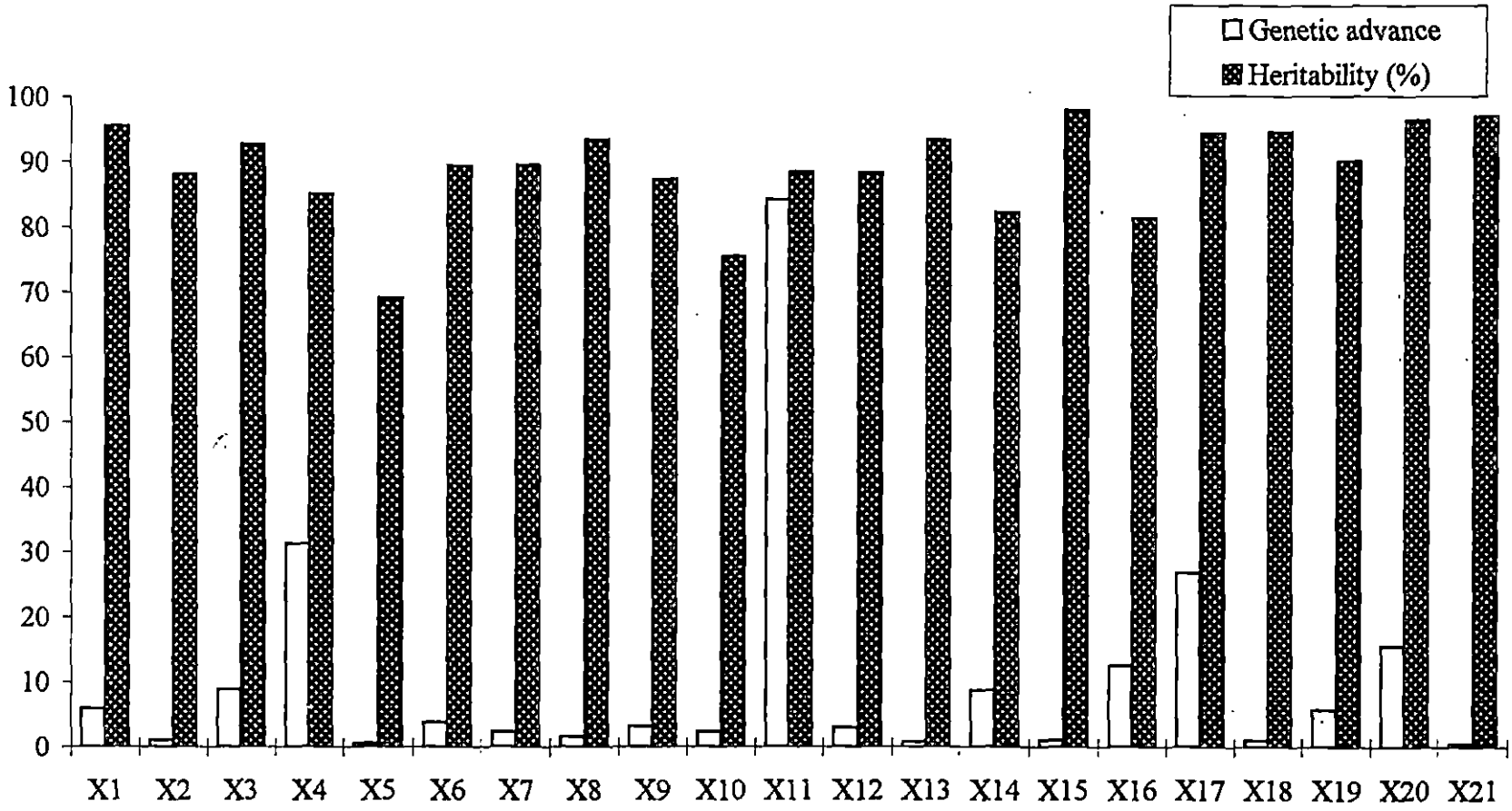
	Characters	Phenotypic coefficient of variation (%)	Genotypic coefficient of variation (%)	Heritability (%)	Genetic advance
1	Days to first flowering	7.30	7.14	95.44	5.97
2	Leaf axil bearing first flower	12.03	11.30	88.08	1.03
3	Lear number	11.18	10.77	92.67	8.88
4	Leaf area (cm^2)	7.01	6.47	85.11	31.30
5	Number of branches per plant	11.41	9.51	69.17	0.56
6	Number of flowers per plant	11.65	11.01	89.43	3.97
7	Pollen sterility (%)	15.11	14.31	89.65	2.32
8	First fruiting node	15.86	15.32	93.41	1.55
9	Number of fruits per plant	11.66	10.89	87.35	3.18
10	Average fruit weight (g)	8.76	7.62	75.49	2.29
11	Weight of fruits per plant (g)	18.04	16.97	88.40	84.25
12	Length of fruit (cm)	10.41	9.78	88.24	2.99
13	Girth of fruit (cm)	6.70	6.47	93.37	0.77
14	Number of seeds per fruit	15.09	13.68	82.22	8.68
15	Number of ridges per fruit	9.66	9.57	97.96	1.00
16	Fruiting phase	9.64	8.70	81.43	12.48
17	Height of plant (cm)	12.01	11.66	94.42	26.84
18	Incidence of YVM disease	43.39	42.22	94.46	0.98
19	Incidence of shoot and fruit borer	32.28	30.66	90.22	5.74
20	Duration of the plant	6.22	6.10	96.46	15.52
21	Crude fibre content of fruits (%)	18.09	17.82	97.05	0.47

Fig. 3.Phenotypic and genotypic coefficients of variation for characters in the F_5M_5 generation



X1 Days to first flowering
X2 Leaf axil bearing first flower
X3 Leaf number
X4 Leaf area (cm^2)
X5 Number of branches per plant
X6 Number of flowers per plant
X7 Pollen sterility (%)
X8 First fruiting node
X9 Number of fruits per plant
X10 Average fruit weight (g)
X11 Weight of fruits per plant (g)
X12 Length of fruit (cm)
X13 Girth of fruit (cm)
X14 Number of seeds per fruit
X15 Number of ridges per fruit
X16 Fruiting phase
X17 Height of plant (cm)
X18 Incidence of YVM disease
X19 Incidence of fruit and shoot borer
X20 Duration of the plant
X21 Crude fibre content of fruits (%)

Fig. 4.Heritability and genetic advance for characters in the F_5 M_5 generation



X1 Days to first flowering
X2 Leaf axil bearing first flower
X3 Leaf number
X4 Leaf area (cm^2)
X5 Number of branches per plant
X6 Number of flowers per plant
X7 Pollen sterility (%)
X8 First fruiting node
X9 Number of fruits per plant
X10 Average fruit weight (g)
X11 Weight of fruits per plant (g)
X12 Length of fruit (cm)
X13 Girth of fruit (cm)
X14 Number of seeds per fruit
X15 Number of ridges per fruit
X16 Fruiting phase
X17 Height of plant (cm)
X18 Incidence of YVM disease
X19 Incidence of fruit and shoot borer
X20 Duration of the plant
X21 Crude fibre content of fruits (%)

cent respectively) and days to first flowering (7.30 and 7.14 per cent respectively).

4.5.2. Heritability and genetic advance

High heritability was recorded for all the 21 characters studied (Fig. 4). Maximum heritability was noticed for number of ridges per fruit (97.96 per cent) followed by crude fibre content of fruits (97.05 per cent), duration of the plant (96.46 per cent) and days to first flowering (95.44 per cent). The heritability value was minimum for number of branches per plant (69.17 per cent).

The highest genetic advance was estimated for the character weight of fruits per plant (84.25) followed by leaf area (31.30 per cent). Crude fibre content of fruits (0.47), number of branches per plant (0.56), girth of fruit (0.77) and incidence of yellow vein mosaic (0.98) recorded very low genetic advance.

4.6. Correlation in F_5 M_5 generation

The different characters studied in the F_5 M_5 generation were subjected to correlation analysis and the results are presented in Table 9.

4.6.1. Phenotypic correlation

Days to first flowering, leaf axil bearing the first flower and first fruiting node were significantly correlated among themselves and exhibited significantly high positive phenotypic correlation with leaf area, pollen sterility, girth of

Table 9. Genotypic and phenotypic correlation coefficients for characters in F_5M_5 generation

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1		0.8005**	-0.8409**	0.7329**	-0.6020**	-0.8624**	0.4011*	0.7864**	-0.8457**	-0.6060**	-0.7964**	-0.8502**	0.5700**	0.5086**	0.7315**	0.0750	-0.9383**	0.4627*	0.8491**
X2	0.8685		-0.7029**	0.8388**	-0.3822*	-0.6766**	0.7113**	0.9606**	-0.7093**	-0.2603	-0.5593**	-0.7711**	0.8174**	0.7164**	0.8817**	0.4237*	-0.8431**	0.7103**	0.9265**
X3	-0.8945	-0.7799		-0.5475**	0.4241**	0.8893**	-0.2867	-0.7132**	0.8665**	-0.6108**	0.7999**	0.8184**	-0.3891*	-0.4390*	-0.6122**	0.0952	0.8517**	-0.2335	-0.7127**
X4	0.7989	0.9731	-0.6295		-0.3346	-0.5304**	0.6935**	0.8825**	-0.5580**	-0.1206	-0.4048*	-0.6734**	0.8521**	0.7304**	0.8870**	0.5459**	-0.7733**	0.8294**	0.8953**
X5	-0.7364	-0.4422	0.5223	-0.4481		0.5547	-0.2475	-0.3421	0.5761	0.5974	0.6545	0.5688	-0.1952	-0.0258	-0.2969	0.1114	0.5569	-0.1214	-0.4345
X6	-0.9356	-0.7553	0.9474	-0.6421	0.6996		-0.2932	-0.6486**	0.9834**	0.7164**	0.9384**	0.8483**	-0.3670	-0.3583	-0.5656**	0.1020	0.8373**	-0.2377	-0.6895**
X7	0.4227	0.7647	-0.3130	0.7944	-0.2674	-0.3072		0.6976**	-0.3703	0.0918	-0.2212	-0.5108**	0.8045**	0.5563**	0.7156**	0.5833**	-0.4336*	0.7283**	0.7254**
X8	0.8278	0.9891	-0.7641	0.9731	-0.3753	-0.7133	0.7465		-0.6750**	-0.21121	-0.5122**	-0.7726**	0.8420**	0.7372**	0.9199**	-0.4527*	-0.8505**	0.7367**	0.9308**
X9	-0.9354	-0.7908	0.9310	-0.6874	0.7215	0.9993	-0.4057	-0.7459		0.6788**	0.9837**	0.8577**	-0.4220*	-0.3906*	-0.6098*	0.0484	0.8376**	-0.2906	-0.7208**
X10	-0.7311	-0.3422	0.7236	-0.1738	0.7509	0.8629	0.1072	-0.2761	0.8205		0.8831**	0.5498**	0.0981	0.1119	-0.0974	0.4448*	0.5588**	0.1863	-0.2901
X11	-0.8809	-0.6342	0.8630	-0.4985	0.7925	0.9749	-0.2441	-0.5718	0.9686	0.9304		0.7948**	-0.2267	-0.1770	-0.4215*	0.2301	0.7687**	-0.1004	-0.5842**
X12	-0.9339	-0.8811	0.8925	-0.7511	0.7279	0.9128	-0.5558	-0.8470	0.9451	0.7185	0.8978		-0.5542**	-0.3810*	-0.7188**	-0.0369	0.8655**	-0.3784	-0.7984**
X13	0.6145	0.9058	-0.4220	0.9879	-0.2797	-0.3757	0.8804	0.9067	-0.4433	0.0772	-0.2491	-0.5990		0.7844**	0.8944**	0.7316**	0.6206**	0.9172**	0.8674**
X14	0.5819	0.8622	-0.4638	-0.9175	-0.0756	-0.4150	0.6637	0.8539	-0.4426	0.1332	-0.2023	-0.4726	0.8809		0.7908**	0.6253**	-05484**	0.7861**	0.7370**
X15	0.7597	0.9616	-0.6529	0.9925	-0.3769	-0.6048	0.7731	0.9775	-0.6548	-0.1059	-0.4481	-0.7825	0.9300	0.8727		0.5728**	-0.7952**	0.8252**	0.9314**
X16	0.1015	0.5263	0.1053	0.7111	0.1277	0.1826	0.6873	0.5421	0.1114	0.6314	0.3336	-0.0247	0.8264	0.8012	0.6336		-0.1569	0.8676**	0.4550*
X17	-0.9972	-0.9235	0.9235	-0.8481	0.6810	0.9385	-0.4842	-0.8927	0.9384	0.6523	0.8456	0.9511	-0.6714	-0.6355	-0.8334	-0.1782		-0.5105**	-0.8656**
X18	0.4818	-0.2467	-0.2467	0.9223	-0.1772	-0.2349	0.7862	0.7937	-0.2972	0.2386	-0.0860	-0.3994	0.9612	0.8891	0.8440	0.9157	-0.5395		0.7721**
X19	0.8746	-0.7568	-0.7568	0.9903	-0.5216	-0.7445	0.7802	0.9798	-0.7877	-0.3252	-0.6288	-0.8615	0.9083	0.8138	0.9517	0.5133	-0.9144	0.7985	

(All values above the diagonal represent the phenotypic correlation coefficients and values below the diagonal represent the genotypic correlation coefficients)

X1 Days to first flowering
X2 Leaf axil bearing first flower
X3 Leaf number
X4 Leaf area (cm^2)
X5 Number of branches per plant
X6 Number of flowers per plant
X7 Pollen sterility
X8 First fruiting node
X9 Number of fruits per plant
X10 Average fruit weight (g)
X11 Weight of fruits per plant (g)
X12 Length of fruit (cm)
X13 Girth of fruit (cm)
X14 Number of seeds per fruit
X15 Number of ridges per fruit
X16 Fruiting phase
X17 Height of plant (cm)
X18 Duration of the plant
X19 Crude fibre content of the fruits (%)

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

fruit, number of seeds per fruit, number of ridges per fruit, fruiting phase, duration of the plant and crude fibre content of the fruits whereas highly significant negative phenotypic correlation was exhibited with leaf number, number of flowers per plant, number of fruits per plant, weight of fruits per plant, length of the fruit and height of the plant.

Leaf number had significant positive phenotypic association with number of branches per plant, number of flowers per plant, number of fruits per plant, average fruit weight, weight of fruits per plant, length of fruit and height of the plant. Number of branches per plant recorded highly significant positive phenotypic correlation with number of leaves, flowers and fruits per plant, average fruit weight, weight of fruits per plant, length of fruit and height of the plant.

Leaf area and pollen sterility had highly significant positive correlation among themselves and with first fruiting node, girth of fruit, number of seeds per fruit, number of ridges per fruit, fruiting phase, duration of the plant and crude fibre content of fruits.

The phenotypic association of number of flowers per plant was significantly positive with number of leaves, branches and fruits per plant, average fruit weight, weight of fruits per plant, length of fruit and height of the plant.

Number of fruits per plant recorded highly significant and positive phenotypic association with number of leaves, branches and flowers per plant, average fruit weight, weight of fruits per plant, length of fruit and height of the plant while the phenotypic correlation with girth of fruit, number of seeds per

fruit, number of ridges per fruit and crude fibre content of the fruits was significantly negative. The phenotypic correlation of average fruit weight was significantly positive with number of leaves, branches, flowers and fruits per plant, weight of fruits per plant, length of fruit, fruiting phase and height of the plant. Highly significant positive phenotypic association was present for weight of fruits per plant with number of leaves, branches, flowers and fruits per plant, average fruit weight, length of the fruit and height of the plant. Significantly negative phenotypic correlation for weight of fruits per plant was recorded with number of ridges per fruit and crude fibre content of the fruits. Number of leaves, branches, flowers and fruits per plant, average fruit weight and weight of fruits per plant were significantly and positively correlated among themselves.

Length of fruit recorded highly significant positive phenotypic correlation with height of the plant and significantly negative association with girth of fruit, number of seeds per fruit, number of ridges per fruit and crude fibre content of the fruits. The phenotypic correlation coefficient for girth of fruit was positive and highly significant with number of seeds per fruit, number of ridges per fruit, fruiting phase, duration of the plant and crude fibre content of the fruits. Highly significant positive phenotypic correlation was recorded for number of seeds per fruit with number of ridges per fruit, fruiting phase, duration of the plant and crude fibre content of the fruits. Number of ridges per fruit showed highly significant positive correlation with fruiting phase, duration of the plant and crude fibre content of the fruits.

Fruiting phase exhibited significantly positive phenotypic association with duration of the plant and crude fibre content of the fruits. The phenotypic correlation coefficient for height of the plant was highly significant and negative with girth of fruits, number of seeds per fruits, numebr of ridges per fruit, duration of the plant and crude fibre content of the fruits. Duration of the plant and crude fibre content of fruits were significantly and positively correlated among themselves and with days to first flowering, leaf axil bearing the first flower, leaf area, pollen sterility, first fruiting node, fruit girth, number of seeds per fruit, number of ridges per fruit and fruiting phase and negatively correlated with plant height.

4.6.2. Genotypic correlation

Days to first flowering, leaf axil bearing the first flower and first fruiting node had high positive genotypic correlation among themselves and with leaf area, pollen sterility, girth of fruit, number of seeds per fruit, number of ridges per fruit, duration of the plant and crude fibre content of the fruits. However, the characters had highly significant negative genotypic correlation with leaf number, number of flowers per plant, number of fruits per plant, weight of fruits per plant, length of fruit and height of the plant.

High positive genotypic correlation was recorded for leaf number with number of branches per plant, number of flowers per plant, number of fruits per plant, average fruit weight, weight of fruits per plant, length of fruit and height of the plant. The genotypic correlation coefficient for number of branches per plant was high and positive with number of leaves and flowers per

plant, number of fruits per plant, average fruit weight, weight of fruits per plant, length of fruit and height of the plant and significantly negative correlation with crude fibre content of fruits.

Leaf area and pollen steirlity exhibited high positive genotypic association with first fruiting node, girth of the fruit, number of seeds per fruit, number of ridges per fruit, fruiting phase, duration of the plant and crude fibre content of fruits and high negative correlation with number of flowers per plant, number of fruits per plant, weight of fruits per plant, length of fruit and height of the plant.

Number of flowers per plant exhibited high and positive genotypic correlation with number of leaves, branches and fruits per plant, average fruit weight, weight of fruits per plant, length of fruit and height of the plant. However, number of flowers per plant had high negative genotypic correlation with first fruiting node, number of seeds per fruit, number of ridges per fruit and crude fibre content of the fruits.

The genotypic correlation of number of fruits per plant was high and positive with number of leaves, branches and flowers per plant, average fruit weight, weight of fruits per plant, length of fruit and height of the plant and high and negative with girth of fruit, number of seeds per fruit, number of ridges per fruit and crude fibre content of fruits. Average fruit weight had high positive genoypic correlation coefficient with number of leaves, branches, flowers and fruits per plant, weight of fruits per plant, length of fruit, fruiting phase and height of the plant. High positive genotypic correlation was observed for weight of fruits per plant with number of leaves, branches,

flowers and fruits per plant, average fruit weight, length of fruit and height of the plant.

Length of fruit recorded high positive genotypic correlation coefficient with height of the plant and high negative correlation coefficient with girth of fruit, number of seeds per fruit, number of ridges per fruit, duration of the plant and crude fibre content of fruits. Girth of fruit and number of seeds per fruit were positively correlated among themselves and both had high positive genotypic correlation with number of ridges per fruit, fruiting phase, duration of the plant and crude fibre content of the fruits and negative correlation with plant height. Number of ridges per fruit and fruiting phase were positively correlated and both the characters exhibited high positive genotypic correlation with duration of the plant and crude fibre content of the fruits and high negative correlation with plant height.

Plant duration and crude fibre content of fruits had high positive genotypic correlation among themselves and with leaf axil bearing first flower, leaf area, pollen sterility, first fruiting node, fruit girth, number of seeds per fruits, number of ridges per fruit and fruiting phase. Crude fibre content of fruits exhibited high negative genotypic correlation with number of leaves, branches, flowers and fruits per plant, weight of fruits per plant, fruit length and plant height.

DISCUSSION

5. DISCUSSION

In interspecific hybridization programmes, progenies developed from the crosses are expected to exhibit a broad spectrum of genetic variability, thereby offering greater scope for isolating high yielding segregants in the advanced generations. The earlier attempts of interspecific hybridization has shown the preponderance of yellow vein mosaic resistant plants having wild characters in the segregating generations of wide crosses of *Abelmoschus*. Irradiation of the interspecific hybrids of *Abelmoschus* creates more genetic variability by mutation in the further generations indicating the breakage of undesirable linkages through irradiation (Cheriyan, 1986 ; Sheela, 1994 ; Animon, 1996 and John, 1997).

The present study aimed at evaluating the genetic variability in the F_4M_4 and F_5M_5 generations created by interspecific hybridization and hybrid irradiation and also to isolate disease resistant high yielding segregants from these generations. The results obtained are discussed in the following section.

5.1. Evaluation of F_4M_4 families

Majority of the characters studied in the F_4M_4 generation exhibited wide range of variability between the different families (Table 2).

Nine of the fifty F_4M_4 families recorded less number of days to first flowering than the cultivated parent (Table 3). All other families had delayed flowering compared to the cultivated parent. This result is in conformity with

the findings of Animon (1996) and John (1997) that irradiation induced delayed flowering.

Forty five families had higher mean values for leaf axil bearing the first flower than the cultivated parent. This is in accordance to the observations made by John (1997). However, the wild parent recorded the highest mean value.

Significant variation was observed for leaf number in the F_4M_4 families. Forty one families recorded higher mean values for the character than the cultivated parent. Sheela (1994) and Animon (1996) reported increased leaf number as a result of irradiation.

Leaf area recorded in the F_4M_4 families were on par with the cultivated parent. However, forty eight families recorded significantly lesser leaf area than the wild parent.

Significant variation was noted for number of branches per plant in the F_4M_4 families. Several wild types with higher mean value for the character were observed in the population. Kuwada (1970) reported higher number of branches on irradiation in okra, while Animon (1996) observed a reduction in mean value of the character as a result of irradiation.

The F_4M_4 families exhibited significant variation for number of flowers per plant. Occurrence of wild types with higher mean values for the character than both the parental means was noticed. Animon (1996) reported increased number of flowers per plant with higher doses of irradiation.

Pollen sterility was maximum for the wild parent. Eight families recorded lesser pollen sterility compared to the cultivated parent. This is in

agreement with the findings of Cheriyan (1986) and Animon (1996) who reported that radiation induced pollen fertility.

The wild parent recorded the maximum mean value for first fruiting node. Ten families fruited at lower nodes compared to the cultivated parent.

Significant variability was exhibited for number of fruits per plant among the F_4M_4 families. Several wild segregants recorded higher number of fruits. However, some of the progenies resembling the cultivated type had higher mean values than the cultivated parent. Animon (1996) reported more number of fruits in irradiated treatments.

Thirty three families exhibited lower mean values for average fruit weight compared to the cultivated parent. Segregants with the highest mean value for the character were on par with the wild parent. John (1997) reported reduced fruit weight in the $F_2 M_2$ population.

Twenty five families showed higher values for weight of fruits per plant compared to the cultivated parent out of which seventeen families outyielded the higher yielding wild parent also. This is in conformity with the findings of Animon (1996). However, Abraham (1985) reported that gamma irradiation reduced fruit yield.

Fruit length varied significantly among the F_4M_4 families. Majority of the cultivated types in the population recorded higher values for the character compared to the wild parent. Fourteen families produced longer fruits than the cultivated parent also. Animon (1996) and John (1997) reported a reduction in fruit length due to irradiation.

Significant variation was recorded among the families for girth of fruit. Maximum fruit girth was noted in the wild parent and two other families. However, twenty four families had mean values for the character higher than or equal to the cultivated parent. Animon (1996) reported that irradiated treatments recorded higher fruit girth than the cultivated parent.

Number of seeds per fruit was maximum for the wild parent. Thirty six families recorded mean values lower than the cultivated parent. Animon (1996) and John (1997) have reported radiation induced seed sterility in okra leading to lower number of seeds per fruit.

The wild parent had the maximum mean value for number of ridges per fruit while the minimum value was observed for the cultivated parent and seven other families. This had been earlier reported by John (1997) in the F_2M_2 generation.

Maximum fruiting phase was recorded in the wild parent, and ten families had the mean values higher than the cultivated parent. All the cultivated types recorded lower values for fruiting phase compared to the cultivated parent. Contrary to this, Animon (1996) and John (1997) reported longer fruiting phase due to irradiation.

The F_4M_4 families varied significantly with respect to plant height. Twenty two families recorded higher mean values for the character over both the parents. However Animon (1996) reported a progressive decline in plant height with increase in dose of gamma irradiation.

Incidence of yellow vein mosaic differed significantly among the different families. The wild parent and other fifteen families were free from

disease infestation while five families recorded more severe mosaic incidence compared to the cultivated parent. Some families having resistance to the mosaic and high yield resembling the cultivated parent were present. Animon (1996) observed yellow vein mosaic resistant hybrids in irradiated treatments.

Incidence of shoot and fruit borer was highest in the cultivated parent and much lower in the wild parent. Ten families recorded even lower incidence of the insect compared to the wild parent. Animon (1996) observed that the irradiated hybrids recorded significantly less shoot and fruit borer incidence than the cultivated parent.

Significant variation was present among the families for duration of the plant. The wild parent recorded the maximum mean value for the character. Ten families had longer duration compared to the cultivated parent.

Crude fibre content of fruits varied significantly among the F_4M_4 families. Twenty one families recorded lesser values for the character than both the parents. The wild parent had high crude fibre content. However, ten families had higher crude fibre content than the wild parent.

5.2. Genetic parameters in F_4M_4 generation

The variability available in the breeding population is important in the selection of superior plant types. The total variability can be studied by means of genetic parameters like coefficients of variation, heritability and genetic advance.

The highest values for phenotypic and genotypic coefficients of variation were observed by number of flowers per plant (Table 4). This is in

agreement with reports of Mathews (1986) and Alex (1988). Incidence of yellow vein mosaic disease and incidence of shoot and fruit borer also exhibited high estimates of phenotypic and genotypic coefficients of variation. John (1997) reported low estimates of variation for incidence of shoot and fruit borer in F_2M_2. High values of phenotypic and genotypic coefficients of variation were present for number of branches per plant which is in conformity with the findings of Alex (1988), Sheela (1994) and John (1997). These results show that improvement through selection can be effective provided selection is done for these characters since there is considerable extent of genetic variability.

Days to first flowering, leaf axil bearing the first flower, number of ridges per fruit and duration recorded low values for genotypic and phenotypic coefficients of variation. The low variability noticed for these characters indicate the difficulty in improving these characters by selection. John (1997) also reported low degree of genetic variability for the above four characters. Balachandran (1984) and Sheela (1994) observed very low genotypic coefficient of variation for days to flowering but Rao (1972) observed high genetic variability for the character.

Selection acts on genetic differences and gains from selection for a specific character depends largely on the heritability of the character (Allard, 1960). A high genetic advance along with high heritability offers more effective situation for selection. Heritable variation may be effectively used with greater degree of accuracy when heritability is studied in conjunction with genetic advance (Majumdar *et al.*, 1974).

Almost all the characters recorded very high heritability values. High heritability with high genetic advance was recorded for the character leaf number. John (1997) also reported high heritability and genetic advance for the character. Weight of fruits per plant also recorded high heritability combined with high genetic advance. Sheela (1994) reported high heritability and genetic advance for fruit yield per plant. High heritability combined with high genetic advance for these characters indicate the predominance of additive genes which can be considered as a desirable feature for selection (Panse, 1957).

Number of branches per plant, pollen sterility, average fruit weight, length of fruit, girth of fruit, number of ridges per fruit, incidence of yellow vein mosaic and crude fibre content of fruits recorded low genetic advance inspite of high heritability values. Mathews (1986) reported the same result for number of branches per plant and John (1997) for length of fruit and girth of fruit. Mathews (1986) and Alex (1988) reported high heritability and low genetic advance for yellow vein mosaic incidence, whereas Sheela (1994) and John (1997) reported low heritability and genetic advance for the character.

Height of the plant also recorded high heritability and high genetic advance. Alex (1988) reported high heritability and moderately high genetic advance for plant height indicating low influence of environment and scope of direct selection of this character based on phenotype.

Number of flowers per plant showed high heritability estimates and moderately high genetic advance. This is in conformity with the findings of John (1997) in the F_2M_2 generation.

5.3. Correlation in F_4M_4 generation

The efficiency of selection mainly depends upon the direction and magnitude of correlation between the different characters studied. Correlation analysis provides reliable information on nature, extent and direction of selection. The phenotypic and genotypic correlation coefficients were worked out among the different characters to gather information on the association of the characters.

The results on correlation indicated similar trend in genotypic and phenotypic correlations (Table 5). Days to first flowering had significant positive correlation with leaf axil bearing the first flower and first fruiting node and significant negative association with weight of fruits per plant, length of fruit, number of seeds per fruit and plant height. Alex (1988) reported significant positive correlation for the character with number of seeds per fruit and significant negative association with length of fruit. John (1997) reported significant negative correlation for days to first flowering with length of fruit and number of seeds per fruit.

Leaf number had significant positive correlation with number of branches per plant, number of flowers and fruits per plant, fruit yield per plant, plant height and crude fibre content of fruits. Mathews (1986), Sheela (1994) and John (1997) noted positive correlation of fruit yield per plant with number

of leaves, flowers and fruits per plant, suggesting the selection of types with more leaf number as an effective criterion for improving fruit yield.

Significant positive correlation was present for number of branches per plant with number of flowers and fruits per plant, weight of fruits per plant, fruiting phase, plant height and duration . Alex (1988) and John (1997) observed that the character was positively correlated with number of flowers and fruits per plant. Sheela (1994) reported the positive correlation of number of branches per plant with fruit yield per plant.

Number of flowers per plant exhibited significant positive correlation with number of fruits per plant, weight of fruits per plant and plant height. Sheela (1997) noticed the strong positive correlation of fruit yield with number of flowers and fruits per plant. The number of flowers and fruits per plant recorded significant negative correlation with average fruit weight. This has been earlier reported by John (1997).

Pollen sterility exhibited significant positive correlation with average fruit weight, length and girth of fruit, number of seeds per fruit and number of ridges per fruit and significant negative correlation with number of fruits, fruit yield and plant height. John (1997) observed positive correlation of the character with length and girth of fruit, average fruit weight and number of seeds per fruit and negative correlation with plant height and number of fruits per plant.

First fruiting node had significant positive correlation with leaf axil bearing the first flower and significant negative correlation with average fruit weight. Number of fruits per plant had significant positive correlation with

weight of fruits per plant, plant height and duration. The positive correlation of number of fruits per plant with fruit yield has been stressed by Arumugam and Muthukrishnan (1981) and Balachandran (1984) who suggested the importance of fruit number per plant as a selection criterion for increasing yield. Ariyo (1992) and Sheela (1994) also observed strong positive association between number of fruits per plant and weight of fruits per plant.

Average fruit weight exhibited significant positive correlation with length and girth of fruit, number of seeds per fruit and number of ridges per fruit. However, average fruit weight had significant negative correlation with plant height. Alex (1988) reported significant positive correlation of average fruit weight with length and girth of fruit. John (1997) observed positive correlation for the character with length and girth of fruits and number of ridges per fruit and negative correlation with plant height.

Fruit yield per plant had significant positive correlation with leaf number, number of branches, number of flowers and fruits per plant, fruiting phase and plant height. Sheela (1994) observed that fruit yield was significantly correlated with leaf number, number of flowers and fruits per plant and number of branches per plant. Significant and positive association of number of branches per plant has also been reported by Balachandran (1984), Mathews (1986), Alex (1988) and John (1997). Non-significant positive correlation between fruit yield and plant height was established by Sheela (1994).

Girth of fruits recorded significant positive correlation with length of fruit, number of seeds per fruit and number of ridges per fruit. All these

characters exhibited significant positive correlation among themselves. Number of seeds per fruit exhibited significant negative correlation with plant height. This is in agreement with the findings of Alex (1988).

Fruiting phase, plant height and duration were significantly and positively correlated among themselves. This has been reported earlier by John (1997). Crude fibre content of fruits recorded significant positive correlations with duration, fruiting phase, number of flowers and fruits per plant, number of branches per plant, fruit yield and plant height.

5.4. Evaluation of F_5M_5 families

All the characters studied in the F_5M_5 generation exhibited significant variation among the different families (Table 6). Days to first flowering recorded the highest mean values in the parents (Table 7). The wild parent took the maximum number of days to first flowering. All the F_5M_5 families flowered significantly earlier than both the parents. This is in accordance with the report of Sheela (1994) that irradiated population was early flowering than unirradiated ones. However, John (1997) observed a delay in flowering in the F_2M_2 and F_3M_3 populations.

The wild parent had the maximum mean value for leaf axil bearing the first flower. All the F_5M_5 families had the mean values for the character less than or equal to the cultivated parent. John (1997) noticed that irradiation induced flowering at lower nodes in the F_3M_3 population.

The wild parent recorded the lowest number of leaves. All the families in the F_5M_5 generation had significantly more number of leaves than the

cultivated parent also. Sheela (1994) and John (1997) observed an increase in leaf number in the irradiated population, while Animon (1996) reported a reduction in leaf number due to irradiation.

Maximum leaf area was recorded in the wild parent. However, twenty families had higher leaf area compared to the cultivated parent. John (1997) observed that irradiation increased leaf area in the F_2M_2 and F_3M_3 generations.

Twenty three families recorded higher mean values for number of branches per plant than both parents. The wild parent had the minimum number of branches per plant. Animon (1996) observed a reduction in number of branches on irradiation while John (1997) reported an increase in number of branches per plant due to irradiation.

The wild parent recorded the minimum number of flowers per plant. All the F_5M_5 families exhibited significantly higher means for number of flowers per plant. Sheela (1994) reported lesser number of flowers in the segregants, but John (1997) noticed an increase in the number of flowers per plant following irradiation.

Pollen sterility was the least in the cultivated parent and the highest in the wild parent. Segregants of the F_5M_5 generation showed lower mean values for the character compared to the wild parent. Animon (1996) and John (1997) observed fertile segregants in the irradiated population, whereas Krishna (1985) reported higher pollen sterility in the irradiated hybrids.

The wild parent had the highest mean value for first fruiting node. Twenty four families of the F_5M_5 generation had mean values of the character less than or equal to the cultivated parent. Contrary to this Sheela (1994) and

John (1997) reported that the segregants resembled the wild parent with respect to this character.

The wild parent had the lowest number of fruits per plant. All the families in the F_5M_5 generation had higher mean values for number of fruits per plant than both the parents. John (1997) also reported an increase in fruit number in the F_3M_3 generation, but Animon (1996) observed no significant difference between the irradiated and unirradiated treatments for the character.

The lowest value for average fruit weight was recorded in the cultivated parent. The F_5M_5 families recorded significantly higher fruit weight than both the parents. However, Sheela (1994) and John (1997) have reported a reduction in average fruit weight in the segregants due to irradiation.

The cultivated parent had the lowest value for fruit yield. However, all the F_5M_5 families recorded significantly higher fruit yield per plant. According to Abraham (1985) and Sheela (1994), irradiation resulted in a reduction in the weight of fruits per plant, but John (1997) reported an increase in fruit yield in the F_3M_3 generation. The positive shift in the mean values for weight of fruits per plant may be the result of effective response to selection of higher yielding plant types from the previous generations.

Length of fruit was least in the wild parent followed by the cultivated parent. All the segregants produced longer fruits compared to both the parents Animon (1996) and John (1997) have observed an increase in fruit length with higher doses of irradiation.

The wild parent had the fruits with maximum girth while the cultivated parent had the minimum fruit girth. All the segregants recorded higher mean

values for the character compared to the cultivated parent. Animon (1996) and John (1997) reported that irradiation produced fruits with lesser girth.

Number of seeds per fruit was maximum in the wild parent. Twenty families had higher values for number of seeds per fruit than the cultivated parent. Animon (1996) and John (1997) observed that irradiation produced fruits with lesser number of seeds.

The wild parent recorded the highest mean value for number of ridges per fruit. All the families in the F_5M_5 generation had the values for the character greater than or equal to the cultivated parent. Similar results were observed by John (1997) in the F_3 M_3 generation.

The cultivated parent had the shortest fruiting phase while the longest fruiting phase was recorded in the wild parent. All the F_5M_5 segregants had longer fruiting phase compared to the cultivated parent. Increase in the fruiting phase by irradiation was reported by John (1997).

Plant height was the least for the wild parent followed by the cultivated parent. All the F_5M_5 families had significantly taller plants compared to the parents. Animon (1996) reported that no significant difference in plant height was produced by irradiation.

Yellow vein mosaic disease incidence was maximum in the cultivated parent while the wild parent and twelve other F_5M_5 families were completely resistant to the virus. All the families recorded significantly low scores of YVM disease incidence compared to the cultivated parent. Animon (1996) observed no significant difference between the irradiated and unirradiated treatments for YVM disease incidence.

The cultivated parent recorded the maximum incidence of shoot and fruit borer, whereas the wild parent had the minimum incidence of the pest. All the F_5M_5 families recorded significantly lower mean values for the character compared to the cultivated parent. Animon (1996) and John (1997) reported increased incidence of shoot and fruit borer at gamma radiation dose of 30 kR.

Plant duration was maximum for the wild parent and minimum for the cultivated parent. The duration of the plants in the F_5M_5 families were significantly higher compared to the cultivated parent. John (1997) observed that duration of the plant has been increased by irradiation.

The crude fibre content of the fruits was maximum in the wild parent. All the F_5M_5 families had fruits with crude fibre content equal to or less than the cultivated parent.

5.5. Genetic parameters in F_5M_5 generation

Moderately high phenotypic and genotypic coefficients of variation were exhibited by incidence of yellow vein mosaic and incidence of shoot and fruit borer (Table 8). Alex (1988) observed high genotypic coefficient of variation for incidence of YVM, but Mathews (1986) and John (1997) reported low phenotypic and genotypic coefficients of variation for YVM incidence. John (1997) noticed low phenotypic and genotypic coefficients of variation for shoot and fruit borer also.

Duration of the plant, girth of fruit, leaf area, days to first flowering and average fruit weight recorded low estimates of phenotypic and genotypic

variation. John (1997) observed low phenotypic and genotypic coefficients of variation for days to first flowering, girth of fruit and duration of the plant in the irradiated treatments. Alex (1988) and John (1997) noticed low phenotypic and genotypic coefficients of variation for average fruit weight, whereas Sheela (1994) reported moderate phenotypic and genotypic coefficients of variation for this character.

All the 21 characters studied in the F_5M_5 generation exhibited high heritability. Weight of fruits per plant had high heritability value combined with high genetic advance, suggesting the suitability of this character in selection for yield improvement. This result is in agreement with the findings by Sheela (1994) and John (1997), but contrary to the results of Balachandran (1984) and Alex (1988). High heritability and moderate genetic advance were exhibited by leaf area. Sheela (1994) reported high heritability and high genetic advance for leaf area, while John (1997) observed moderately high heritability and moderately low genetic advance for the character. Weight of fruits per plant exhibited the same trend in both the generations studied.

Number of branches per plant recorded comparatively low heritability and low genetic advance indicating high environmental influence on this trait. John (1997) noticed high heritability and high genetic advance for the character. Number of ridges per fruit and crude fibre content of fruits recorded very high heritability estimates, but very low genetic advance. John (1997) reported moderately high to high heritability for number of ridges per plant in irradiated treatments.

Duration of the plant and days to first flowering also recorded very high heritability but low genetic advance. Sheela (1994) observed high heritability and low genetic advance for days to flowering and John (1997)reported moderately high to high heritability for plant duration in irradiated treatments.

5.6. Correlation in F_5M_5 generation

The magnitude and direction of association among the 19 characters studied in the F_5M_5 generation were assessed by means of correlation analysis (Table 9).

Days to first flowering was positively correlated with leaf axil bearing first flower, leaf area, pollen sterility, first fruiting node, girth of fruit, number of seeds per fruit, number of ridges per fruit, duration and crude fibre content of fruits and negatively correlated with leaf number, number of branches, number of flowers and fruits per plant, average fruit weight, fruit yield per plant, length of fruit and plant height. Korla and Rastogi (1978) and Sheela (1994) obtained negative non-significant correlation between yield and days to flowering and suggested this selection of early flowering types with more number of fruits for yield improvement in okra. Alex (1998) reported significant positive correlation for days to first flowering with first flowering node, girth of fruit and number of seeds per fruit and significant negative association with number of flowers per plant, fruits per plant and length of fruit. John (1997) reported that days to first flowering had significant positive correlation with leaf area, pollen sterility, girth of fruit, number of seeds per fruit and duration of the plant and negative correlation with length of fruit,

average fruit weight and plant height. However, positive correlation was reported for the character with leaf number, number of branches per plant, flowers per plant and fruits per plant in some irradiated treatments.

Number of leaves had high positive correlation with number of branches, number of flowers and fruits per plant, average fruit weight, weight of fruits per plant, length of fruit and height of the plant. Sheela (1994) and John (1997) observed high positive correlation of leaf number with fruit yield. Leaf number, number of branches, number of flowers and fruits per plant and average fruit weight were significantly and positively correlated among themselves and with yield of fruits per plant. Alex (1988) and John (1997) reported that number of branches per plant was positively correlated with number of flowers and fruits per plant. Mathews (1986) and Sheela (1994) observed significant positive correlation of fruit yield per plant with leaf number, flowers per plant and fruits per plant. Significant positive association of fruit yield per plant with number of fruits per plant has been reported by several workers (Elangovan *et al.*, 1980 ; Vashista *et al.*, 1982 ; Ariyo, 1992 ; Sheela, 1994 and John, 1997). Alex (1988) reported significant positive correlation of number of fruits per plant with number of branches per plant and average fruit weight. However, John (1997) reported negative association between number of flowers and fruits per plant with average fruit weight. Singh *et al.* (1974) and Parthap *et al.* (1979) reported significant positive correlation of fruit yield with number of flowers per plant.

Pollen sterility was positively and significantly correlated with leaf area, first fruiting node, girth of fruit, number of seeds per fruit, number of ridges

per fruit, fruiting phase, duration and crude fibre content of fruits and negatively correlated with number of fruits per plant, length of fruit and plant height. John (1997) observed positive correlation for the character with leaf area, girth of fruit, number of seeds per fruit, fruiting phase and duration and negative correlation with number of fruits per plant and plant height in different irradiated treatments.

Average fruit weight had high significant positive correlation with leaf number, number of branches, number of flowers and fruits per plant, weight of fruits per plant, length of fruit, fruiting phase and plant height. Alex (1988) and Sheela (1994) observed positive correlation of average fruit weight with weight of fruits per plant and length of fruit. (John 1997) reported significant positive correlation of the character with weight of fruits per plant, length of fruit, number of branches per plant, fruiting phase and plant height. Alex (1988) observed significant negative correlation for the character with number of branches per plant.

Weight of fruits per plant recorded significant positive correlation with leaf number, number of branches, flowers and fruits per plant, average fruit weight, length of fruit and plant height and significant negative correlation with days to flowering, leaf axil bearing the first flower, leaf area, first fruiting node, number of ridges per fruit and crude fibre content of fruits. Sheela (1994) reported positive correlation for fruit yield with leaf number, number of branches, number of flowers and fruits per plant, single fruit weight and plant height. Several scientists have identified fruit length as one of the traits having strong positive association with yield (Mahajan and Sharma, 1979 and Sheela,

1994). John (1997) observed positive correlation of fruit yield with number of branches per plant and plant height and negative correlation with number of ridges per fruit and length of fruit.

Girth of fruit, number of seeds per fruit, number of ridges per fruit, fruiting phase and duration were positively and significantly correlated among themselves but negatively correlated with fruit length. John (1997) observed positive correlation of number of seeds per fruit with number of ridges per fruit and plant duration. Positive correlation of number of seeds per fruit with number of ridges per fruit and girth of fruit was established by Alex (1988). According to John (1997) the number of ridges per fruit was positively correlated with girth of fruit and plant duration. Significant negative correlation between number of seeds per fruit and plant height was observed by Alex (1988).

Fruiting phase had significant correlation with leaf axil bearing the first flower, leaf area, pollen sterility, first fruiting node, average fruit weight, girth of fruit, number of seeds per fruit, number of ridges per fruit, duration and crude fibre content of the fruits. John (1997) reported negative association for the character with number of seeds per fruit and number of ridges per fruit in unirradiated treatments; and positive correlation between pollen sterility and fruiting phase. Alex (1988) reported significant positive correlation between fruiting phase and first flowering node.

Height of the plant recorded significant positive association with leaf number, number of branches, flowers and fruits per plant, average fruit weight, weight of fruits per plant, fruit length and negative correlation with days to

first flowering, leaf axil bearing the first flower, leaf area, pollen sterility, first fruiting node, girth of fruit, number of seeds per fruit, number of ridges per fruit, duration and crude fibre content of fruits. John (1997) reported positive correlation of the character with days to first flowering, fruit yield per plant and duration and negative correlation with pollen sterility, average fruit weight and number of seeds per fruit in different irradiated treatments.

Duration of the plant and crude fibre content of the fruits were significantly and positively correlated. Crude fibre content of the fruits had high significant positive correlation with days to first flowering, leaf axil bearing the first flower, leaf area, pollen sterility, first fruiting node, girth of fruit, number of seeds per fruit, number of ridges per fruit and fruiting phase and negatively significant correlation with leaf number, number of branches, flowers and fruits, weight of fruits per plant, length of fruit and plant height.

Several superior types combining high yield and resistance to YVM disease were selected from the F_5M_5 generation of the present study, which will be further evaluated for the stability of the desirable attributes, in the process of releasing high yielding and YVM disease resistance varieties.

SUMMARY

SUMMARY

Interspecific hybrids offer broader genetic base for creating variability through irradiation enabling more effective selection of desirable recombinants in the segregating generations. A study was undertaken in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani to estimate the extent of variability and correlation among the different characters in the F_4M_4 and F_5M_5 generations of interspecific hybrids of okra with the objective of isolating high yielding yellow vein mosaic disease resistant lines from those segregating populations. The salient findings obtained are given below.

Evaluation of the F_4M_4 families

Significant variability was present for all the 21 characters studied in the F_4M_4 families. Delayed flowering and fruiting at higher nodes compared to the cultivated parent were noted in majority of the families. Number of leaves, number of branches, number of flowers and fruits per plant recorded an increase in the mean values with respect to the cultivated parent. The families in general showed lesser pollen sterility also.

Average fruit weight exhibited a reduction in the mean values whereas the fruit yield per plant increased as a result of increase in number of fruits per plant. The means for length and girth of fruits also recorded a positive shift. However, the number of seeds per fruit was lower in the F_4M_4 families than the cultivated parent.

A reduction in the fruiting phase and duration of the plant was observed; whereas the plant height was increased. Incidence of YVM disease and shoot and fruit borer also recorded lower values. The crude fibre content of fruits was also lower in majority of the families compared to the parents.

The phenotypic and genotypic coefficients of variation were maximum for number of flowers per plant, incidence of YVM disease and incidence of shoot and fruit borer suggesting the suitability of these traits for selection.

High heritability was observed for all the characters studied. Leaf number and weight of fruits per plant recorded high heritability and genetic advance indicating effective yield improvement through selection for these characters.

Yield of fruits per plant was significantly and positively correlated with leaf number, number of branches, number of flowers and fruits per plant and plant height. All these characters have significant positive correlation among themselves, which indicates ample scope for yield improvement through selection for these characters.

Evaluation of F_5M_5 families

All the families in the F_5M_5 generation exhibited significant variation for the different characters studied. Earlier flowering and fruiting at lower nodes compared to the cultivated parent was observed in the families unlike in the F_4M_4 families. An increase in leaf area, pollen sterility and number of branches was also noted in the F_5M_5 families compared to the cultivated parent.

Leaf number, number of flowers and fruits per plant recorded higher mean values in all the families compared to both the parents indicating good response to selection for these characters in the previous generations.

Average fruit weight and yield of fruits per plant were higher in all the families than both the parents. The mean values for length and girth of the fruits increased in the F_5 M_5 families compared to the F_4M_4 families.

Higher number of seeds per fruit and number of ridges per fruits was present in majority of the families than the cultivated parent. The fruiting phase and duration of all the F_5M_5 families were longer than the cultivated parent. The plant height of the progenies in the F_5M_5 population exceeded both the parents.

Incidence of YVM disease and shoot and fruit borer infestation was lower in the families compared to the cultivated parent. The crude fibre content of the fruits was also low compared to the parent.

The genotypic and phenotypic coefficients of variation were maximum for incidence of YVM disease and incidence of shoot and fruit borer, whereas duration of the plant and average fruit weight exhibited low variation.

All the characters recorded high heritability. High heritability and high genetic advance were noticed for yield of fruits per plant as in the F_4M_4 generation. Number of branches per plant recorded comparatively low heritability and genetic advance suggesting the predominant role of environment on the expression of this character.

Fruit yield per plant recorded significant positive correlation with leaf number, number of branches, number of flowers and fruits per plant, average

fruit weight, length of fruit and plant height thereby indicating the plant and fruit characters that should be considered while selection for yield improvement.

By the F_5M_5 generation, majority of the families exhibited increase in mean values for the economically important characters and combined high yield with resistance to YVM disease. The best lines of these families can be selected and advanced to further generations to obtain stability for the characters under consideration so that the resultant lines can be released as high yielding YVM disease resistant varieties.

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GENETIC EVALUATION OF F_4 AND F_5 GENERATIONS OF IRRADIATED INTERSPECIFIC HYBRIDS IN OKRA (*Abelmoschus* spp.)

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ABSTRACT OF THE THESIS
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ABSTRACT

A study was undertaken in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 1997-98 for the genetic evaluation of the F_4 and F_5 generations of irradiated interspecific hybrids between *A. esculentus* and *A. manihot* with the objective of isolating high yielding yellow vein mosaic disease resistant lines from the segregating generations.

The families in the F_4M_4 generation were found to be late flowering and recorded higher mean values for number of leaves, number of branches, number of flowers and number of fruits per plant compared to the cultivated parent. The fruit yield per plant was higher than the parents inspite of the reduction noticed in average fruit weight. The families recorded lesser values for fruiting phase and duration and higher values for plant height. The crude fibre content of the fruits, yellow vein mosaic incidence and shoot and fruit borer infestation were lower in the families. This provided scope for the selection of several high yielding and YVM disease resistant types from the F_4M_4 generation.

Number of flowers per plant and incidence of YVM disease recorded high phenotypic and genotypic coefficients of variation. High heritability and genetic advance were observed for leaf number and weight of fruits per plant. Fruit yield per plant had high positive correlations with leaf number, number of branches, number of flowers and fruits per plant and plant height. Hence effective selection can be done for these characters for yield improvement.

In the F_5M_5 generation, the families were early flowering and recorded increase in leaf area, pollen sterility and number of branches per plant. The families also recorded higher mean values for leaf number, number of flowers and fruits per plant and plant height compared to the parents. The fruit yield per plant, average fruit weight and number of seeds per fruit were higher in the F_5M_5 families. The fruiting phase and duration recorded an increase while the crude fibre content of fruits, incidence of YVM and incidence of shoot and fruit borer recorded lower mean values.

Incidence of YVM disease had the maximum phenotypic and genotypic coefficients of variation. High heritability and genetic advance were observed for yield of fruits per plant. Weight of fruits per plant was significantly and positively correlated with leaf number, number of branches, number of flowers and fruits per plant, average fruit weight and plant height. Selection based on these characters will be effective in improving the yield of the crop. At the same time, high variation noted for YVM disease incidence offers more scope for selection based on disease incidence, in the process of selection for high yielding disease resistant types.