EVALUATION OF THE F_2 GENERATION OF INTERSPECIFIC HYBRIDS OF *Abelmoschus* WITH REFERENCE TO YELLOW VEIN MOSAIC RESISTANCE AND YIELD

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "EVALUATION OF THE F_2 GENERATION OF INTERSPECIFIC HYBRIDS OF ABELMOSCHUS WITH REFERENCE TO YELLOW VEIN MOSAIC RESISTANCE AND YIELD" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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INTRODUCTION

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Bhindi (*Abelmoschus esculentus* (L.) Moench) is one of the most important vegetable crops grown in tropical conditions. It is extensively grown all over India due to its wide range of adaptability and ease of cultivation. However, the widespread incidence of a destructive virus disease, the yellow vein mosaic, in this crop has very much affected its successful cultivation.

Yellow vein mosaic is the most serious disease of bhindi which can lead to heavy yield loss. Being a virus disease transmitted by the whitefly (*Bemisia tabaci* Genn.) a possible method of control is the use of insecticides to kill the vector. However, since the bhindi fruits are continuously harvested every second or third day from the time the first pods are formed, application of insecticides has to be restricted. The problem of pesticide residue is acute, in view of indiscriminate use of the pesticides and their adulteration. Also, there is practically no insecticide that will kill whiteflies rapidly enough to prevent inoculation of the virus (Costa, 1976). Hence the development of varieties resistant to this disease assumes great importance. The first tolerant variety released, Pusa Sawani, has not sustained its tolerance and a new stable resistant variety is an imminent necessity.

Adequate levels of resistance to the yellow vein mosaic virus have not so far been located in the cultivated species. But several related species of bhindi like *A. tuberculatus*, *A. manihot* var. *pungens*, *A. crinitus* etc. were found to show high degree of resistance (Nariani and Seth, 1958). However, they could not be made use of in resistance breeding with *A. esculentus* owing to sterility barriers.

There are many reports in recent literature on the resistance of the semi-wild species, *A. manihot* to yellow vein mosaic disease and the transference of this character to F_1 generation. Unnikrishna Pillai (1984) have reported that the F_1 hybrids of the crosses between *A. manihot* and four susceptible cultivars of *A. esculentus* were completely resistant to yellow vein mosaic disease, while all the parents except *A. manihot* were susceptible to the disease at varying levels under natural infection condition as well as artificial grafting trials. However, none of these hybrids outyielded the highest yielding parent variety. Hence it was suggested that further improvement of these resistant hybrids could be brought about by selection for better recombinants with resistance to yellow vein mosaic and higher yield among the segregating generations. The present investigation was taken up with the objective of evaluating the F_2 populations derived from interspecific crosses involving A.manihot (L.) Medik, resistant to yellow vein mosaic and two susceptible cultivars namely, Co.1 and Kilichundan Selection 17 and selecting desirable F_2 recombinants. If some useful recombinants with resistance and yield combined, are obtained they can be carried through further segregating generations to evolve a resistant variety. The study also aims at the genetic analysis of the F_2 populations of crosses involving this semi-wild species and susceptible cultivars, so that it may reveal the genetic nature of yellow vein mosaic resistance observed in the semi-wild species, A. manihot. The methods used for this study and the results obtained are presented and discussed in the following chapters.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

I. Breeding for resistance to yellow vein mosaic of bhindi

1. History and nature of the disease

Yellow vein mosaic was first reported by Kulkarni in 1924 from the Bombay region. Later, the viral nature of the disease was established by Uppal et al. in 1940 and gave it its present name - yellow vein mosaic. The symptomatology and host range were described by Capoor and Varma (1950). Transmission of the virus by the whitefly, *Bemisia tabaci* Genn. was also established by these workers. The virus is neither seed nor sap transmissible but is readily transmitted through the whiteflies and also by grafting.

Varma (1952, 1955) studied the virus-vector relationship and found that though a single whitefly could transmit the virus, the transmission was more when large number of insects were employed. Ability and efficiency of the whiteflies to acquire and transmit the virus was found to increase when the vectors were pre-fasted for one hour before acquisition feeding. The incubation period of the virus was reported to be seven hours (Varma, 1952). Sangappa (1966) reported that though the whiteflies do not occur in a pest form on bhindi a few viruliferous insects in a field could do incalculable damage to the crop.

2. Effect of the viral infection on growth and yield of bhindi

The disease occurs all over the plains and also in the lower hills of India. It is more prevalent during the rainy season and in years of heavy infection, the crop fails badly (Singh *et al.*, 1962).

The virus can infect at all stages of growth of the crop. The loss in yield depends on the stage of growth of crop at which infection occurs (Sastry and Singh, 1974). They have reported a loss of 93.8 per cent in yield when the infection occurred 35 days after germination. Chelliah and Murugesan (1975) also reported that infection by the virus in 30 days old crop resulted in 88 per cent loss in yield. In an investigation by Sinha and Chakrabarti (1978) it was seen that the disease had an adverse effect on plant height, number of branches, number and size of fruits and seed yield.

3. Sources of resistance

An essential pre-requisite for breeding for disease resistance is the availability of a suitable source of resistance. Attempts to locate resistance sources to yellow vein mosaic were made after the viral nature of the disease was established by Uppal *et al.*(1940). The variability in genus *Abelmoschus* in respect of mosaic resistance has been studied extensively at the Indian Agricultural Research Institute, New Delhi in 1948. None of the cultivars of *Abelmoschus esculentus* showed true resistance to the disease. One variety from West Bengal accessioned as IC 1542, which consistently showed freedom from the disease under field conditions, was found to be a symptomless carrier of the virus (Singh *et al*., 1962). In 1952, a survey of over hundred cultivated varieties and hybrids of bhindi grown in IARI was made, but all were found to be susceptible (Nariani and Seth, 1958). Varma and Mukherjee (1955) screened 43 varieties of bhindi in West Bengal and reported that pink types appeared to be resistant.

Different species of *Abelmoschus* and *Hibiscus* were screened for their reaction to yellow vein mosaic virus by graft inoculation as well as by feeding viruliferous whiteflies (Nariani and Seth, 1958). Results of the inoculation showed that *A. manihot* var. *pungens*, *A. crinitus*, *H. vitifolius* and *H. panduraeformis* could not be infected by either method and this indicated that they were immune to infection. However, the other species of *Abelmoschus* and *Hibiscus* which were infected with the virus showed great variation in symptoms from the typical mosaic to mild forms. Some species like *A. tuberculatus*, *A. manihot*, *A. angulosus*, *H. Cannabinus* and *H. sabdariffa* carry the virus without showing symptoms such as veinal chlorosis, although numerous vein swellings on the undersurface of leaves are noticed. A. esculentus, A. moschatus and A. ficulneus showed vein clearing and veinal mosaic.

Premnath (1970) reported that resistance to the yellow vein mosaic virus was noticed among 267 indigenous collections of H. esculentus and the lines IHR-20-1 and IHR-15-1 showed high resistance. Three lines of A. esculentus and five wild species of Hibiscus were found to show field resistance to yellow vein mosaic under conditions of heavy natural infection in a screening trial conducted by Sandhu et al. (1974). They have also reported that an accession of okra received from Ghana (identified as A. manihot (L.) Medicus Ssp. manihot) has shown considerable amount of resistance to yellow vein mosaic.

Two forms of A. manihot introduced from Africa and Japan proved to be highly resistant to the yellow vein mosaic as reported by Arumugam et al. (1975). However, the African accession was found to be a symptomless carrier as revealed by further studies. Singh et al. (1975) identified an accession from Ghana as being immune to yellow vein mosaic, from among a number of cultivars from West Africa.

Singh and Thakur (1979) conclusively proved that *A. manihot* Ssp. *manihot* is a symptomless carrier of yellow vein mosaic virus based on graft inoculation studies.

Forty six strains of *A. esculentus* were assessed for yield and virus infection under unsprayed field conditions by Chauhan *et al.* (1981). They found no strains showing resistance and the supposedly resistant "Pusa Sawani" had a mean infection rate of 75.8 per cent.

Atiri (1983) reported from Nigeria some cultivars of *A.* (*H.*) *esculentus* with high yield and resistance to the *H. esculentus* mosaic virus. A high degree of the symptomless carrier type of resistance was identified in the *A. esculentus* var. EC 31830 (= Asuntemkolo) from Ghana (Sharman and Sharma, 1984).

Chelliah and Srinivasan (1983) reported that resistance to yellow vein mosaic virus transmitted by *Bemisia tabaci* was found in *A. manihot* and *A. manihot* Ssp. *tetraphyllus*.

The preliminary evaluation of Bhindi types under the research project on "Maintenance and evaluation of germplasm of crop plants" in the Department of Plant Breeding, College of Agriculture, Vellayani have revealed that a semi-wild species, *A. manihot* is completely resistant to yellow vein mosaic disease while twenty other cultures in the germplasm were severely affected by the disease (Anon., 1983).

4. Genetics of resistance

The genetic basis of resistance to yellow vein mosaic was studied by many workers. Inheritance studies by Singh *et al.* (1962) in crosses between the *Abelmoschus esculentus* stocks, IC 1542, as the resistant parent and Pusa Makhmali, S-91 and S-72 as susceptible parents suggested that two loci are involved in controlling resistance, the presence of dominant alleles at both loci being necessary to cause susceptibility to the disease. The field resistant variety IC 1542 was assigned the genotype $yv_1 yv_1 yv_2 yv_2$ and the susceptible parents $Yv_1 Yv_1 Yv_2 Yv_2$.

Thakur (1976) reported that resistance was conditioned by complementary dominant genes, after studying a cross between *A. esculentus* variety Pusa Sawani and *A. manihot* Ssp. *manihot*. According to him, *A. esculentus* is having the genotype $yv_1 / yv_1 yv_2 / yv_2$ and *A. manihot* $Yv_1 / Yv_1 Yv_2/Yv_2$.

F_1- F_3 segregation data from crosses involving 2 resistant wild forms of *A. manihot* and susceptible varieties of *A. esculentus* revealed that resistance was conditioned by a single dominant gene designated as 'Y' (Arumugam and Muthukrishnan, 1980). Similarly, Jambhale and Nerkar (1981) reported the involvement of a single dominant gene in conferring resistance to the virus in *A. manihot* and *A. manihot* Ssp. *manihot*. Unnikrishna Pillai (1984) also suggested that resistance to yellow vein mosaic is controlled by dominant nuclear gene(s).

Sharma and Dhillon (1983) studied the genetics of resistance to yellow vein mosaic in crosses between a resistant cultivated form of *A. manihot* Ssp. *manihot* from Ghana and two susceptible cultivars of *A. esculentus*. They hypothesized that resistance is controlled by two complementary dominant genes with additive effects. Sharman and Sharma (1984) based on limited inheritance studies have suggested that tolerance to the virus is controlled by two dominant complementary genes or is under polygenic control.

5. Exploitation of resistance within the species *A. esculentus*

The earlier attempts in India to breed a field tolerant variety led to the evolution of Pusa Sawani (Singh *et al.*, 1962). It was developed at IARI from a cross between IC 1542, a West Bengal stock with symptomless carrier type of resistance and Pusa Makhmali, an otherwise superior but susceptible commercial variety of bhindi. However, this widely cultivated variety, which had been reported to be a symptomless carrier of the virus (Singh et al., 1962) has lost this reaction due to various genetic and agroclimatic factors (Singh and Thakur, 1979).

It was reported from SriLanka that L-63 derived from a backcrossing programme involving the mosaic virus tolerant strain VT (= Jaffna Local, a strain of the Indian Introduction Pusa Sawani) and H10, a high yielding strain, although giving lower yields than two standard varieties M15 and M17, was more resistant than these varieties and had fruits of better quality (Regunathan, 1980).

6. Interspecific transfer of resistance

When resistance to yellow vein mosaic was located in wild species of Abelmoschus, attempts were made to incorporate the resistant genes from these wild species to the cultivated species. Interspecific hybridisation, aimed at understanding the evolutionary stages in the origin of cultivated bhindi, has been carried out in the genus Abelmoschus for the last half a century. The reports of the earlier works include the success of a cross between H. esculentus and H. manlhot by Teshima (1933), Chizaki (1934), Skovsted (1935), Ustinova (1937, 1949) and Singh et al. (1938) as reviewed by Dhillon and Sharma (1982). However during the recent past, crosses have been attempted amongst the different species of okra mainly for transferring genes for resistance to pests and diseases from suitable sources to the cultivated species.

Attempts were made at IARI to transfer the true resistance of A. manihot var. pungens and "Symptomless" type resistance of A. tuberculatus. These species were crossed with Pusa Makhmali, a variety of A. esculentus. In the case of crosses with A. tuberculatus, the F_1 hybrids were completely sterile and no viable seeds were obtained even from backcrosses (Pal et al., 1952). The chromosomes of the F_1 hybrid were doubled by colchicine treatment but the amphidiploid ($2n = 188$) although seed fertile was not free from yellow vein mosaic (Singh et al., 1962). Similarly, the true resistance discovered in A. pungens could not be made use of owing to the high sterility of the hybrids ($2n = 134$) with A. esculentus.

Joshi and Hardas (1956) made cytogenetic investigations in A. esculentus x A. tuberculatus hybrids, based on which they established that A. esculentus has an allo-ploid origin with 2 genomes, one genome being contributed by *A. tuberculatus*.

Kuwada (1961) reported that the hybrid between *A. esculentus* and *A. manihot* was partially sterile. Ovule and embryo culture techniques were employed to raise viable hybrids in crosses involving *A. esculentus* and two related species viz., *A. moschatus* and *A. ficulneus* (Gadwal *et al.* 1968). Kuwada (1974) reported that the hybridisation between *A. tuberculatus* and *A. manihot* was successful only when *A. tuberculatus* was the female parent but the hybrid was completely sterile.

Singh *et al.* (1975) reported that the hybrids of an accession from Ghana, which was identified as being immune to yellow vein mosaic, with Indian okra were only partially fertile while those between the Ghanaian accession and *A. tetraphyllus* were completely sterile.

Interspecific hybrids of *H. esculentus* and *H. ficulneus* studied by Hossain and Chattopadhyay (1976) were resistant to yellow vein mosaic. But they were self sterile and produced many fruits without seeds or with only rudimentary seeds and resembled their wild parent in several morphological characters.

Nair and Kuriachan (1976) reported a spontaneous hybrid between *A. tuberculatus* and *A. esculentus* which was highly pollen sterile and totally seed sterile in which selfing, open-pollination and backcrossing produced only fruits with empty seeds.

Morphological characters of the hybrid between H. esculentus and H. tetraphyllus were intermediate between those of the parents and it was resistant to virus and wilt diseases (Ugale et al.1976). They have suggested that the factors governing the resistance to virus and wilt diseases in genome B of H. tetraphyllus could be incorporated into the cultivated H. esculentus by backcrossing.

Arumugam and Muthukrishnan (1978a) reported that all F_1s from four crosses involving two wild forms of A. manihot and two susceptible cultivars of A. esculentus namely, Pusa Sawani and Co.1 were resistant to the virus. They have noted remarkable recovery of the cultivar build in the recombinants obtained from F_2 and F_3 segregation generations.

Mamidwar et al. (1979) have studied crosses between A. esculentus and wild forms of A. manihot and A. tetraphyllus and found that fruit set was highest when A. esculentus was the female parent. The hybrids produced seedless fruits or fruits with shrivelled seeds.

Meshram and Dhapake (1981) reported that the hybrid between A. esculentus and A. tetraphyllus was spreading in habit and dwarf in stature. The hybrid was highly male sterile.

Dhillon and Sharma (1982) reported successful interspecific crosses between two cultivars of A. esculentus, susceptible to yellow vein mosaic virus and one resistant cultivar of A. manihot. The hybrids showed resistance to the virus.

Interspecific hybrids between an unnamed West African species of Abelmoschus (Hibiscus) and A. (H.) esculentus were studied by Martin (1982). The hybrids were comparatively sterile but a few produced germinable seeds. Backcrosses were more fertile with almost complete fertility in the BC_2. It is suggested that transfer of genes from the new species to common okra is possible.

Transfer of resistance from A. manihot to A. esculentus var. Pusa Sawani was effected by Jambhale and Nerkar in 1983. The hybrids from crosses between the resistant wild species with A. esculentus var. Pusa Sawani, though resistant, were partially sterile. Resistant segregates from the F_5 generation could not be carried further due to complete seed sterility. However, the backcross of F_1 hybrid to Pusa Sawani was successful. Some plants resistant to yellow vein mosaic virus were obtained from the backcross generations.

which had about 58 to 88 per cent seed fertility (Jambhale and Nerkar, 1983).

Unnikrishna Pillai (1984) obtained hybrids with complete resistance to yellow vein mosaic by crossing A. manihot with four susceptible cultivars of A. esculentus viz., AE-87, Pusa Sawani, Co.1 and Kilichundan Selection 17. But none of them outyielded the highest yielding parent variety (K.S.17). For further improvement of the resistant hybrids, selection for better recombinants with resistance to yellow vein mosaic disease and higher yield among the segregation populations in the backcross or selfing series was suggested.

Varying degrees of sterility was observed by many workers in the different interspecific hybrids of Abelmoschus. In some cases, fertile amphidiploids were developed by doubling the chromosomes of the sterile hybrids. An amphidiploid plant named Abelmoschus tubercular esculentus (2n = 182) was bred by Kuwada (1966) from a cross between A. tuberculatus (2n = 58) and A. esculentus (2n = 114).

A spontaneous amphidiploid of A. esculentus and A. tetraphyllus was reported by Jambhale and Nerkar (1981). They suggested that the amphidiploid evolved by the fusion of unreduced gametes in the F_1.

Two very distinct types, provisionally called Soudanien and Guinéen, were distinguished among 314 cultivated okras from Ivory coast on the basis of morphology, chromosome number and interspecific crossing behaviour (Siemonsma, 1982). Soudanien corresponded to botanical descriptions and previously reported chromosome numbers of A. esculentus. Guineen type is thought to be a natural amphidiploid of A. esculentus (2n = 130-140) and A. (H.) manihot (2n = 60-68) with 185-199 chromosomes. Soudanien and Guineen lines crossed readily and the progeny were intermediate in appearance.

An amphidiploid was produced from the F_1 of the cross A. esculentus (2n = 130) x A. manihot (2n = 194) by colchicine treatment by Jambhale and Nerkar (1982 a,b). The amphidiploid differed from the F_1 in several characteristics. Seed fertility of the amphidiploid was 88.1 per cent while that of the F_1 was 7.1 per cent. Field screening under artificial epiphytotics of yellow vein mosaic and graft inoculation studies indicated that the amphidiploid was resistant to yellow vein mosaic (symptomless carrier) like F_1 and the wild parent.

7. Mechanism of resistance

Ramiah (1970) and Potty and Wilson (1973) working on the physiology of yellow vein mosaic disease of okra reported a higher total nitrogen and protein nitrogen in the leaves of susceptible cultivars after infection. Studies by Arumugam and Muthukrishnan (1978c) also showed that A. manihot and its hybrids with A. esculentus cultivars which were resistant, had lower contents of total nitrogen, total crude protein, protein nitrogen, ammoniacal nitrogen and nitrite nitrogen and higher contents of amide nitrogen and nitrate nitrogen than the susceptible types.

All fractions of sugars were higher in the resistant parents and F_1 hybrids than in susceptible parents (Arumugam and Muthukrishnan, 1978 d). Vidhyasekharan (1971) opined that increase in the sugar content of the leaves might cause accumulation of phenolics toxic to the pathogens. Arumugam and Muthukrishnan (1977) reported higher total phenolics in A. manihot resistant to yellow vein mosaic disease while Ramiah (1970) recorded higher phenolic compounds in the healthy plants of bhindi.

Arumugam and Muthukrishnan (1978b) found that the total amino acid content was relatively higher in the resistant parents than the susceptible cultivars while the F_1 progenies were inconsistent in this respect. Aspartic acid and glutamic acid were higher in the resistant wild parents and the F_1 progenies compared to the susceptible cultivar parents, the increase being two fold. They have opined that the unidentified amino acids present in the resistant wild parents and inherited by the F_1 progenies might play a greater role in conferring resistance to yellow vein mosaic disease of bhindi.

II. Breeding for resistance to important pests of Bhindi

1. Shoot and fruit borer (*Earias vitella* Fabricius)

The shoot and fruit borer is one of the most serious pests of bhindi which causes considerable damage to tender shoots, buds and fruits. The extent of damage has been reported to vary from 3.5 to 90 per cent (Kashyap and Verma, 1983). In recent years, attempts are being made to evolve insect resistant varieties. Shehata (1966) tested four varieties of okra against cotton boll worm and reported that none of the varieties was resistant to this pest but infestation was heavier on late flowering varieties. Dahatonde (1970) and Patil (1975) have screened 24 varieties of okra against this pest and concluded that the variety with more hair density on fruits showed more fruit infestation. However, screening trials of okra varieties under the All India Co-ordinated Vegetable Improvement Project at Rahuri revealed that there was no shoot borer infestation on a wild species, *A. manihot* (Anon, 1977).

Teli and Dalaya (1981) screened fourteen varieties of okra for resistance to shoot and fruit borer. More number of eggs were laid on fruits having maximum hair density and vice versa. The hard-skinned, tough and sparsely haired varieties showed more resistance to the larval entry which was easier in soft-skinned, smooth-surfaced and dense-haired varieties.

However, Mote (1982) found that varieties like AE-79, AE-72, AE-57, AE-3 and Wonderful Pink, all with dense and long hairs, had the best resistance with the least number of eggs laid and least entry of larvae into fruits, as well as the lowest fruit infestation in the field.

Relative susceptibility of seventy two okra genotypes to shoot and fruit borer was studied by Kashyap and Verma (1983). It was found that fruit infestation was less than 10 per cent (on weight basis) in some varieties compared to more than 50 per cent in some others. Kishore *et al.* (1983) also observed significant difference of infestation among 44 F_5 lines of *A. esculentus* in the field.

Chelliah and Srinivasan (1983) reported that five varieties of *A. esculentus* and the wild species *A. manihot* proved to be resistant to *Earias* species.

2. Leaf hopper (*Amrasca biguttula biguttula* (Ishida))

Bhindi is ravaged by many insects of which the leaf hopper is one of the most serious. The extent of damage varies a great deal with weather conditions and populations of pest and alternate hosts available. According to Rawat and Sahu (1973), the extent of leaf hopper damage to number and weight of fruits would approach 54 per cent.

Screening trials by Teli and Dalaya (1981) showed that leaf hopper population decreased with an increase in hair density and such varieties were less preferred for oviposition. Some varieties like Sel-22 showed more hopper infestation, but tolerated higher population as they exhibited less hopper burn (chlorotic) symptoms.

Chelliah and Srinivasan (1983) found that *A. esculentus* cultivars, AE-22 and AE-104 were resistant to leaf hopper and had a higher density of long hairs on the leaf mid rib and lamina than the susceptible varieties.

Genetics of tolerance to the leaf hopper was studied by Mahal and Singh (1982) in crosses involving the resistant *H. esculentus* varieties New selection, IC 7194 and Sel 2-2 and susceptible Pusa Sawani. Segregation studies indicated that tolerance is governed by a single dominant gene in New Selection and IC 7194. Tolerance was lacking in Sel 2-2.

Genetic analysis of data from crosses between five resistant inbred lines and two susceptible lines of *A. esculentus* indicated that resistance involved dominant genes (Sharma and Gill, 1984).

Uthamasamy and Subramoniam (1985) suggested that a single gene governs the resistance, as the F_2 plants segregated in a 3: 1 (Susceptible: Resistant) pattern.

III. Genetic variability and correlation studies in bhindi

1. Phenotypic and genotypic variability, heritability and genetic advance for yield and its components.

Trivedi and Prakash (1969) observed greater variability and heritability values in the yield contributing fruit characters, length and thickness of pods.

High estimates of phenotypic and genotypic variances were observed for yellow vein mosaic infection, yield per plant and plant height by Padda *et al.* (1970). High genotypic coefficient of variation in case of seeds per pod, yield per plant and mosaic infection indicated high degree of genetic variability in these characters. Heritability values were high for mosaic infection, plant height, days to flower and yield per plant.

Rao (1972) reported that plant height and number of days to flowering showed high genetic coefficient of variation coupled with high estimates of heritability and genetic advance. Length of fruit offered less scope for selection as it was greatly influenced by environment. Ngah and Graham (1973) found the highest heritability value of as much as 84 per cent for fruit length and lowest value of 48 per cent for weight of fruits.

Fruit diameter followed by sugar content, number of flowers, fruit yield and number of fruits per plant exhibited high values phenotypic coefficient of variation as reported by Singh et al. (1974). The genotypic coefficient of variation was high for fruit diameter and yield. High values of heritability and genetic advance were recorded for fruit diameter and fruit length, while the number of fruits per branch, number of fruits per plant, weight of fruit and stem diameter showed low values of genetic advance.

Genetic studies in bhindi by Lal et al. (1977) showed high phenotypic and genotypic variability and heritability estimates for all characters studied except for yield per plant. Days to flowering, internodal length, fruit length and fruit thickness had the highest estimates of heritability. The low heritability values for yield per plant indicated that yield in this material is largely influenced by environmental factors. High estimates of genetic advance were noted for internodal length, number of branches per plant and number of fruits per plant and the lowest estimates of genetic advance was exhibited by fruit thickness and yield per plant.

Estimates of heritability and expected genetic advance were highest for number of fruits per plant as reported by Rao and Kulkarni (1977). In a study with twenty varieties of bhindi, Rao et al. (1977) observed good amount of genetic variability in the population for all the quantitative characters under study. They obtained high heritability values for days to flowering, plant height, number of pods and yield per plant. Expected genetic advance was moderate for number of pods and yield per plant, whereas it was very low for other characters. Rao and Sathyavathi (1977) observed high heritability values for number of days to flowering and number of pods per plant but it was low for height of plant in the F_2. Expected genetic advance was high for number of pods per plant and height of plant, but low for number of days to flowering.

Rao and Kulkarni (1978) found that the contribution of height to the total variability was 57 to 75 per cent higher than that of days to flowering. Singh and Singh (1978) reported that broad sense heritability estimates and expected genetic advance were greatest for days to flowering, yield per plant and number of fruits per plant.

Kaul et al. (1979) observed considerable genetic variation for yellow vein mosaic virus infection, pod yield per plant and number of pods per plant in the twenty genotypes of bhindi studied. Mahajan and Sharma (1979) noticed high heritability estimates for number of fruits, fruit length and fruit diameter.

In a study of Mishra and Chhonkar (1979), maximum genotypic variance was shown by yield per plant followed by yellow vein mosaic infection and plant height and minimum by fruit girth. The genotypic coefficient of variation ranged from 2.73 for days to flower to 29.00 for yellow vein mosaic infection. Branches per plant, yield per plant and pod length indicated higher degrees of genetic variability. Heritability estimates and expected genetic advance were found to be high for number of branches per plant, pods per plant, seeds per pod, pod length, plant height and percentage of plants infected with yellow vein mosaic virus, indicating scope for improvement of these characters by selection and breeding. Singh and Singh (1979a) found that days to flower, number of fruits per plant and fruit bearing branches were found to be important contributors to genetic divergence and hence the importance of these characters in increasing yield is emphasized.

Considerable amount of variability in case of fruit length, number of fruits and fruit yield per plant was reported by Murthy and Bavaji (1980). Plant height, days to flowering, fruit length and yield displayed high heritability. Yield exhibited high estimate of genetic advance while days to flowering had very low genetic advance.

Partap et al. (1980) reported that high heritability in the narrow sense was found for all characters except yield per plant, number of fruits per plant and plant height.

Thaker et al. (1981) observed wide range of phenotypic variability for most of the plant characters studied. The genetic coefficient of variation was high for plant height, leaf area, fruits per plant, fruit weight and yield per plant. The heritability values were moderate for plant height, fruits per plant and fruit length whereas it was low for leaf area, fruit weight and yield. High genetic advance was found for five characters namely, plant height, leaf area, fruits per plant, fruit weight and yield per plant. Since plant height and fruits per plant possessed high genetic coefficient of variation along with high genetic advance and moderate heritability, improvement in these characters could be brought about by practising phenotypic selection.

In a study of 56 F_2 hybrids of A. esculentus from crosses involving fourteen lines and four testers, Palaniveluchamy et al. (1982) found the highest estimate of heritability and genetic advance for plant height. Vashistha et al. (1982) reported high values for heritability and genetic advance for fruits per plant, plant height and root length indicating scope for improving these characters by selection. Yield variability was dependent primarily on the above characters. Balachandran (1984) reported that total yield and its prime component, number of fruits per plant displayed maximum phenotypic and environmental coefficient of variation. The genotypic coefficient of variation was maximum for percentage of fruit set. Days to 50 per cent flowering, flowering duration, number of branches per plant and percentage of fruit set displayed relative high heritability. Plant yield and its major components, number of fruits per plant and weight of single fruit registered low estimates of heritability and genetic advance.

2. Correlation studies on yield and its components

Padda *et al.* (1970) found positive correlation of plant height with mosaic infection, yield per plant and seeds per pod. Similarly mosaic infection was positively correlated with days to flower. Significant correlation co-efficients were observed between days to flower and seeds per pod (positive) and between days to flower and yield per plant (negative) only. The other correlation coefficients were statistically non-significant indicating non-usefulness of selection of one character for the improvement of the other.

Majumdar *et al.* (1974) reported that days to flowering was negatively correlated with yield per plant. Inter-relations between yield and other contributing characters like number of flowers, height, number of branches, leaves per plant and fruits per plant were found to be positive and significant (Singh *et al.*, 1974). Variability for yield was primarily dependent on weight of fruit, number of fruits per plant and number of flowers per plant.

Rao and Ramu (1975) found that yield per plant was significantly correlated with pod and node number and plant height; pod number per plant with node number and plant height; node number with plant height; and seed number with pod ridge number per plant. From a study of the relationship of yield with different growth characters in okra. Roy and Chhonkar (1976) concluded that fruit number per plant and branch per plant were the most important yield contributing characters.

Rao et al. (1977) opined that number of pods per plant and plant height should be given major emphasis in bhindi selection programmes to increase yield. According to Kawthalkar and Kunte (1978) the height of plant was more useful for the prediction of yield than the number of leaves per plant.

Correlation and path coefficient study by Korla and Rastogi (1978) revealed that yield was correlated with number of fruits per plant and days to flowering and could be improved by selecting early flowering types that produce a large number of fruits. Rao and Kulkarni (1978) observed a highly significant positive correlation between height and number of pods per plant. Singh and Singh (1978) reported that yield was positively correlated with fruits per plant, branches per plant, plant height and fruit length.

Ajimal et al. (1979) reported that fruit yield was positively correlated with fruit number and number and length of nodes. Number of days to first flowering made the greatest direct contribution to yield followed by node number. Mahajan and Sharma (1979) observed a positive and significant association between yield and plant height, number of fruits per plant and fruit length in both parents and hybrids, in a parent-offspring correlation study. It was suggested that number of fruits per plant and fruit length and diameter should be considered as selection criteria.

The main characters contributing to yield were stem diameter, flower number per plant, fruit number per branch and plant, fruit length and weight(Partap et al.1979). An analysis of nine quantitative characters in thirty A.esculentus varieties by Singh and Singh (1979b) indicated that fruit yield was positively and significantly correlated with number of fruits per plant, number of branches per plant, fruit length and plant height, followed by internode length. Fruit number per plant had the greatest direct effect on fruit yield.

Arumugam and Muthukrishnan (1979) studied the association of resistance to yellow vein mosaic with economic characters in okra in the F_3, F_4 and backcross generations of crosses between the H. esculentus varieties Co.1 and Pusa Sawani and an African and a Japanese form of H. manihot. It was found that there was no association between 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, indicating the scope for effective selection for resistance.

Elangovan *et al.* (1980) from a study of correlation analysis in bhindi reported that number of fruits per plant, fruit length, fruit width and number of branches could be considered as the primary yield determining components for exercising selection in bhindi. Murthy and Bavaji (1980) observed that fruit number per plant and number of days to flowering had the greatest direct effect on yield.

Arumugam and Muthukrishnan (1981) reported that fruit yield was highly correlated with number, length and seed content of fruit, and to a lower degree with plant height and days to flowering.

Correlation studies by Balachandran (1984) unveiled that number of fruits per plant, earliness in flowering, flowering duration and length of fruit were the important contributing characters of yield. Number of branches per plant was found to contribute negatively to total yield.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani during the period from September 1984 to November 1985.

A. Materials

Two yellow vein mosaic susceptible cultivars of bhindi (*Ablemoschus esculentus* (L.) Moench) viz., Co.1 and Kilichundan Selection 17 and *A. manihot* (L.) Medik, a semi-wild species resistant to yellow vein mosaic were used for the study. Pure seeds of these were collected from the germplasm of bhindi maintained at the Department of Plant Breeding, College of Agriculture, Vellayani.

B. Experimental Methods

The following experiments were conducted for the study.

I. Crossing *A. manihot* with the two *A. esculentus* cultivars without reciprocals to produce two hybrids.

A crossing plot consisting of three rows of seven plants each of *A. manihot*, Co.1 and Kilichundan Selection 17 was raised. Since *A. manihot* is having a longer pre-flowering period compared to the other two parents, phased planting was adopted for synchronisation of flowering. The following cross-combinations were attempted and F_1 seeds were collected.

(i) Co.1 x A. manihot

(ii) Kilichundan Selection 17 x A. manihot

No reciprocal difference was reported in these crosses (Unnikrishna Pillai, 1984) and hence reciprocal crosses were not made.

Technique of crossing

The technique of crossing suggested by Giriraj and Rao (1973) was followed. The mature flower buds which would open the next day morning were selected in the previous evening. A shallow circular cut was made around the fused calyx, at about one cm from its base. The calyx cup along with corolla were removed as a hood exposing the stigma and staminal tube. The staminal tube was cut open lengthwise without injuring the ovary or style, and removed carefully. The calyx cone which was removed earlier was used for protecting the emasculated flower. As an additional protection, it was covered with a butter paper cover also.

Mature flower buds of the pollen parent, A. manihot, were protected by butter paper covers on the previous day of blooming. Pollination was done on the next day morning between 8 a.m. to 9.30 a.m. by rubbing the stigma of the emasculated flowers with the staminal column taken from the male parent. The pollinated flowers were again protected and labelled.

The mature dry fruits were collected 30 to 40 days after pollination and seeds were extracted after sundrying the fruits for three days.

II. Raising the F_1 plants and selfing them to produce F_2 seeds, along with a crossing plot consisting of the three parents to produce fresh F_1 seeds.

Thirty F_1 plants from each of the crosses in the first experiment were grown and selfed to produce sufficient F_2 seeds. The parents were also raised to repeat the crosses and to produce fresh F_1 seeds.

Technique of selfing

Mature flower buds which would open the next day were covered with butter paper covers in the previous evening. The covers were retained for two days. The mature dry fruits were harvested 30 to 40 days after pollination and dried in sun for three days and seeds were extracted.

III. Evaluation of the F_2 generation along with parents and F_1s.

The evaluation trial was conducted in four Randomised Blocks during May to September 1985. The seven treatments were:

1. Co.1 (P_1)
2. Kilichundan Selection 17 (P_2)
3. *A. manihot* (P_3)

4. F_1 of P_1 x P_3

5. F_1 of P_2 x P_3

6. F_2 of P_1 x P_3

7. F_2 of P_2 x P_3

A population strength of 30 plants per plot was maintained for the parents and F_1s where as a larger population of 60 plants per plot was maintained for F_2s for studying the segregation pattern. The planting was done in trench system with a spacing of 0.8 x 0.5 m. Unsprayed field condition was provided for natural incidence of yellow vein mosaic(Chauhan et al., 1981). A single row of the highly susceptible variety Kilichundan Selection 17 was grown around each replication as a border row to counter the border effect and to enhance the yellow vein mosaic disease incidence. All agronomic practices except insecticidal sprays were followed as per the Package of Practices Recommendations of the Kerala Agricultural University (Anon., 1982).

Observations recorded

The following observations were taken on ten randomly selected plants for each of the parents and F_1s. But in F_2 all the available plants were used for taking observations.

1. Germination

The germinability of the seeds in each treatment was observed both under laboratory and field conditions. In the laboratory, the number of seeds germinated in petri-dishes provided with moist blotting paper (20/ dish) was counted every day for a period of eight days. In the field, the number of seeds germinated was counted every - day for 15 days.

2. Height of plant

Height of plant from the ground level to the tip was measured using a metre scale after the final harvest and expressed in centimetres.

3. Number of branches per plant

Total number of primary branches were counted after the final harvest and were recorded.

4. Number of leaves per plant

Total number of leaves from the base to the tip of the plant including the branches were counted after the final harvest. Dropped leaves were counted by their respective nodes.

5. Internodal length

Length of five internodes from the fifth node was measured in each plant, their mean was calculated and expressed in centimetres.

6. Days to flowering

Number of days taken from sowing to the opening of first flower in each plant was recorded.

7. Number of flowers per plant

The total number of flowers produced per plant was counted everyday and recorded.

8. Number of fruits per plant

The total number of fruits produced by each plant was counted at every harvest and recorded.

9. Weight of fruits per plant

The fruits produced by each plant at each harvest were weighed and the total yield per plant calculated after the final harvest and expressed in grams.

10. Length of fruits

A random sample of three fruits were taken from third, sixth and nineth harvest and length of fruits were measured from base to tip, averaged and expressed in centimetres.

11. Girth of fruits

The fruits used for recording length were also used for measuring girth. Maximum girth of the fruit was measured and expressed in centimetres.

12. Diseases and pest scoring

(i) Yellow vein mosaic intensity

The rating scale suggested by Arumugam *et al.* (1975) was used for scoring yellow vein mosaic disease intensity (Table 1). The symptoms were noted on all plants in the F_2 generation and on observational plants in parents and F_1s. The scoring was done according to the characteristic symptom appeared on the leaves or fruits of each plant.

The mean disease rating for each treatment in a replication was calculated as follows:

$$\text{Mean disease rating} = \frac{\text{Sum of disease scores of plants observed}}{\text{Number of plants}}$$

(ii) Fruit borer incidence

Observations on fruit infestation by the borer (*Earias vitella* F.) was recorded at each picking by counting healthy and infested fruits separately for each treatment and percentage of infestation of fruits was worked out (Teli and Dalaya, 1981).

(iii) Leaf hopper population and hopper burn

The first observation on the population count was taken as soon as the leaf hopper nymphs (*Amrasca biguttula biguttula* Ishida.) were noticed on the plants. Subsequent observations were taken at an interval of seven days till harvest. All the available F_2 plants were examined while in

Table 1. Yellow vein mosaic disease rating scale

Symptoms	Grade	Rating scale
i. No visible symptoms characteristic of the disease.	Highly resistant	1
ii. Very mild symptoms, basal half of the primary veins 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
iii Veins and veinlets turn completely yellow. Interveinal areas green and normal.	Moderately resistant	3
iv. Pronounced yellowing of veins and veinlets; 50% of the leaf lamina turned yellow; fruits exhibit slight yellowing.	Susceptible	4
v. Petiole, veins, veinlets and interveinal area turn yellow in colour; Leaves start drying from the margin. Fruits turn yellow in colour.	Highly susceptible	5

parents and F_1s five plants were selected randomly from among the observational plants and in each plant, six leaves- two each from top, middle and bottom of the plants were examined. The average population per plant was worked out (Teli and Dalaya, 1981).

Hopper burn was assessed by taking observations on the third, fourth and fifth leaves from the terminal end, as described by Jayaraj (1966), by placing a glass plate marked with square centimetres on the leaf surface and observing the affected leaf area. The hopper burn area was expressed as a percentage to the total leaf area.

In assessing susceptibility or otherwise of a treatment, the quantum of damage exhibited and the population were considered as criterion. In classifying the treatments based on these criteria, those which showed hopper burn of (i) less than 20 per cent with low population of upto 10 per plant unit were grouped as resistant (ii) 21 to 50 per cent damage with medium population of 10-15 per plant unit as tolerant and (iii) 51 per cent and above hopper burn with medium to high incidence of 10-20 and above per plant unit as susceptible varieties (Uthamaswamy et al., 1973). This classification was based on a similar pattern of classification of castor varieties susceptible to Empoasca flavescens adopted by Jayaraj (1967).

IV. Grafting trial to study the segregation of yellow vein mosaic resistance.

A sample population of 50 F_2 plants of the combination $P_2 \times P_3$ was raised in pots. When the plants attained the age of 30 to 40 days, they were grafted on with diseased scions, by wedge grafting method as described earlier. The inoculated plants were scored after one month using the rating scale developed by Arumugam et al. (1975).

V. Grafting trial to confirm the resistance of desirable F_2 recombinants

The resistance of the selected F_2 recombinants were confirmed by grafting trials (Unnikrishna Pillai, 1984). Diseased shoots collected from yellow vein mosaic affected plants were grafted on to the selected F_2 recombinants by wedge grafting method (Nariani and Seth, 1958). In order to prevent slipping over of cut ends due to mucilage, bits of sharpened coconut midribs were punctured through the junction of stock and scion before tying up with polythene strips. New shoots arising from the stock portion were observed for symptoms of the disease at weekly intervals.

c. Statistical analysis

The data collected from the evaluation trial and screening trial were subjected to statistical analysis.

I Analysis of variance

The V = 7 treatments were replicated r = 4 times and observations were recorded for each character from k = 10 plants per experimental plot. The data were subjected to the following analysis of variance (Federer, 1967).

ANOVA

Source	df		MS
Replication	r-1	= 3	
Treatments	v-1	= 6	
Plot error	(r-1) (v-1)	= 18	MSE_1
Sampling error	rv (k-1)	= 252	MSE_2
Total	rvk - 1	= 279	

The sampling error is estimated as $\hat{\sigma}_s^2 = MSE_2$

The plot error is estimated as $\hat{\sigma}_e^2 = \frac{MSE_1 - MSE_2}{k}$

When $\hat{\sigma}_e^2$ is negative, it is taken as zero. The mean square per plot (MSE_1) is first tested against MSE_2, and if (1) MSE_1 is significant, then the treatments are tested against MSE_1 and if (2) MSE_1 is not significant, the treatments are tested against the pooled mean square of MSE_1 and MSE_2.

The standard error (S.E) of the difference of two treatment means = $\sqrt{\frac{2MSE_1}{rk}}$ if plot error significant; otherwise MSE_1 is replaced by pooled mean square.

II. Test for proportions

The plants were classified into five classes and the proportion of plants that come under each class was tested by the test criterion given by

$$= \frac{|P_1 - P_2|}{SE\ (P_1 - P_2)}$$

Where $SE\ (P_1 - P_2) = \sqrt{\frac{pq}{n}}$,

$$\hat{p} = \frac{n_1 p_1 + n_2 p_2}{n_1 + n_2}, \quad \hat{q} = 1 - \hat{p}, \quad n = n_1 + n_2$$

(Panse and Sukhatme, 1957)

III. Estimation of phenotypic variance, genotypic variance and genetic parameters

1. Phenotypic variance,

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

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

$V_{(E)}$ = Environmental variance

2. Genotypic variance,

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

The genetic parameters were worked out as per Allard (1960) and Jain (1982).

(a) Phenotypic coefficient of variation (P.C.V.)

$$\frac{\sqrt{V_{(P)}}}{\bar{X}} \times 100$$

Where $V_{(P)}$ = Phenotypic variance and

$\bar{X}$ = Mean of the character

(b) Genotypic coefficient of variation (G.C.V.)

$$\frac{\sqrt{V_{(G)}}}{\bar{X}} \times 100$$

(c) Heritability in broad sense

$$H^2 = \frac{V_{(G)}}{V_{(P)}} \times 100, \text{ where}$$

H^2 = Heritability in broad sense

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

$V_{(P)}$ = Phenotypic variance

(d) Expected genetic advance under selection,

$$GA = k.\ H^2 \sqrt{V_{(P)}}$$

where k = selection differential expressed in phenotypic standard deviation, whose value is 2.06 for 5 per cent selection in large samples.

IV. Test for correlation coefficients

Correlation coefficients were worked out among pairs of characters under study and their significance were tested (Fisher and Yates, 1965).

The significance of the difference between correlation coefficients for all characters under parents, F_1s and F_2s was tested by the test criterion.

$$= \frac{|Z_i - Z_j|}{SE\ (Z_i - Z_j)},$$

where Z_i and Z_j are the transformed values of correlation coefficients (Panse and Skuhatme, 1957) and

$$SE\ (Z_i - Z_j) = \sqrt{\frac{1}{n_1-3} + \frac{1}{n_2-3}}$$

V. Metroglyph analysis

The metroglyph method of analysis proposed by Anderson (1957) was followed, assigning scores for expression of characters. The scatter diagram was constructed using height of plant as ordinate and weight of fruits per plant as abscissa. The absence of a ray, the presence of a short ray or a long ray on a metroglyph designates low, medium or high values respectively of each character.

RESULTS

RESULTS

I. Evaluation of parents and hybrids

The analysis of variance pertaining to the different characters studied showed that the genotypes differed significantly for all the characters. The abstract of ANOVA is presented in Appendix I and II.

The variation and frequency distribution of the various traits in the different generations were studied.

1. Germination

The results are presented in Table 2.

There was significant difference between the treatments in respect of this character. However, the difference was not significant within the parents, F_1s and F_2s. Germination was found drastically reduced in the F_2s (29.17 and 27.30 per cent) when compared to the parents and F_1s.

2. Height of plant

The results are presented in Tables 3 and 4.

Significant difference was observed for height of plant among parents, F_1s and F_2s. However, the plant height was not significantly different among the three parents and between the two F_2s. The height of F_1 of

Table 2. Percentage of germination of parents and hybrids

Treatments	Mean percentage of germination (transformed values in parantheses)	
	Laboratory	Field
Co.1 (P_1)	85.00 (67.21)	82.50 (65.27)
K.S.17 (P_2)	85.00 (67.21)	80.33 (63.65)
A. manihot (P_3)	90.00 (71.56)	83.50 (66.03)
F_1 of $P_1 \times P_3$	80.00 (63.44)	78.00 (62.03)
F_1 of $P_2 \times P_3$	80.00 (63.44)	77.67 (61.82)
F_2 of $P_1 \times P_3$	35.00 (36.27)	29.17 (32.71)
F_2 of $P_2 \times P_3$	30.00 (33.21)	27.30 (31.50)

CD (for transformed values) at 5% = 2.89

Plate 1. Co.1 - (P_1)

Plate 2. Kilichundan Selection 17 (P_2)

Plate 1(x0.09)

Plate 2 (x0.13)

Table 3. Variations for height of plant (cm) in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control (P_1)	CV (in %)
	P_1	95.80	4.83	100.00	31.88
Parents	P_2	84.65	2.82	88.36	21.10
	P_3	82.83	2.29	86.46	17.45
Hybrids					
F_1	F_1 of $P_1 \times P_3$	163.05	5.22	170.20	20.24
	F_1 of $P_2 \times P_3$	114.28	3.68	119.29	20.37
F_2	F_2 of $P_1 \times P_3$	74.53	4.05	77.80	34.41
	F_2 of $P_2 \times P_3$	78.53	4.42	81.97	35.61

CD at 5% = 22.739

Table 4. Distribution of height of plant (cm) in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)					Total number of plants observed
		< 46	46-90	91-135	136-180	> 180	
P_1	56-180	Nil	23 (57.5)	12 (30.0)	5 (12.5)	Nil	40
P_2	46-115	Nil	25 (62.5)	15 (37.5)	Nil	Nil	40
P_3	50-116	Nil	27 (67.5)	13 (32.5)	Nil	Nil	40
F_1 of P_1x P_3	75-242	Nil	1 (2.5)	5 (12.5)	25 (62.5)	9 (22.5)	40
F_1 of P_2x P_3	69-158	Nil	6 (15.0)	25 (62.5)	9 (22.5)	Nil	40
F_2 of P_1x P_3	27-141	10 (7.14)	97 (69.29)	29 (20.71)	4 (2.86)	Nil	140
F_2 of P_2x P_3	26-136	17 (12.98)	79 (60.31)	33 (25.19)	2 (1.52)	Nil	131

$P_1 \times P_3$ (163.05 cm) was found to be significantly higher when compared to the F_1 of $P_2 \times P_3$ (114.28 cm).

The variation for this trait among plants of F_1 of $P_1 \times P_3$ and F_1 of $P_2 \times P_3$ were almost same (20.24 and 20.37 per cent). The two F_2s also showed a similar trend in variation (34.41 and 35.61 per cent) except that it was higher when compared to that of F_1s. The variation among the plants of P_1 was more than that of P_3. Variation was minimum in P_3.

Majority of the plants of the parents and F_2s came under the height group of 46-90 cm. However, there were only very few F_1 plants under this group. More than 60 per cent of the plants of F_1 of $P_1 \times P_3$ were under the 136-180 cm group. Some positive variants (greater than 180 cm) were also observed for this hybrid. However, in the F_1 of $P_2 \times P_3$, 62.5 per cent of the plants belonged to the 91-135 cm group and 22.5 per cent plants were observed in 136-180 cm group, though neither of its parents had plants under this height group. Negative variants for height were present in both the F_2s.

3. Number of branches per plant

The results are presented in Tables 5 and 6.

The parents, F_1s and F_2s differed significantly with respect to this character. The F_1 of $P_2 \times P_3$ had significantly

Table 5. Variation for number of branches per plant in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control(P_2)	CV (in %)
Parents	P_1	2.05	0.17	74.55	52.25
	P_2	2.75	0.18	100.00	40.45
	P_3	2.20	0.20	80.00	57.68
Hybrids					
F_1	F_1 of $P_1 \times P_3$	3.13	0.21	113.82	41.84
	F_1 of $P_2 \times P_3$	3.88	0.24	141.09	39.64
F_2	F_2 of $P_1 \times P_3$	2.28	0.28	82.91	76.76
	F_2 of $P_2 \times P_3$	3.65	0.37	132.73	63.05

CD at 5% = 0.690

Plate 3. *Abelmoschus manihot* - (P_3)

Plate 4. A high yielding F_1 plant of the cross Co.1 x *A. manihot*

Plate 3 (x0.10)

Plate 4 (x0.10)

Table 6. Distribution of number of branches per plant in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)				Total number of plants observed
		0-1	2-3	4-5	>5	
P_1	0-4	11 (27.5)	26 (65.0)	3 (7.5)	Nil	40
P_2	0-5	4 (10.0)	27 (67.5)	9 (22.5)	Nil	40
P_3	0-4	12 (30.0)	21 (52.5)	7 (17.5)	Nil	40
F_1 of $P_1 \times P_3$	0-5	5 (12.5)	19 (47.5)	16 (40.0)	Nil	40
F_1 of $P_2 \times P_3$	1-9	1 (2.5)	16 (40.0)	18 (45.0)	5 (12.5)	40
F_2 of $P_1 \times P_3$	0-7	50 (35.71)	44 (31.43)	39 (27.86)	7 (5.00)	140
F_2 of $P_2 \times P_3$	0-14	30 (22.90)	37 (28.24)	45 (34.35)	19 (14.50)	131

higher number of branches (3.88) than its parents (2.75 and 2.20) while it was on par with its F_2 (3.65) for this character.

Large variation for number of branches existed in the two F_2 populations. The variation in F_2 of P_1 x P_3 was 76.76 per cent while that of the other F_2 was 63.05 per cent. The parents and F_1s also showed considerable variation for this character.

The distribution of plants under different classes of branching (table 5) showed the preponderance of highly branching plants among P_2, F_1 of P_2 x P_3 and F_2 of P_2 x P_3. Almost 15 per cent of the F_2 plants of P_2 x P_3 were having more than five branches per plant while no such plants appeared among the F_1s of P_1 x P_3 and their proportion was limited to five per cent among F_2s of P_1 x P_3.

4. Number of leaves per plant

The results are presented in Tables 7 and 8.

There was significant difference between the parents, F_1s and F_2s for number of leaves per plant. However, the parents did not differ significantly among themselves. The F_1 s had significantly higher number of leaves (52.68 and 61.60) than their corresponding parents and F_2s except in case of F_1 and F_2 of the cross P_2 x P_3 which were on par for this character.

Table 7. Variations for number of leaves per plant in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control (P_3)	CV (in %)
Parents	P_1	22.93	1.31	63.91	36.09
	P_2	35.38	1.84	98.61	32.81
	P_3	35.88	1.95	100.00	34.46
Hybrids					
F_1	F_1 of $P_1 \times P_3$	52.68	2.75	146.82	33.01
	F_1 of $P_2 \times P_3$	61.60	3.77	171.68	38.70
F_2	F_2 of $P_1 \times P_3$	33.50	2.56	93.37	48.35
	F_2 of $P_2 \times P_3$	50.63	3.65	141.11	45.60

CD at 5% = 11.392

Plate 5. The highest yielding F_2 plant of the cross Co.1 x *A. manihot*

Plate 6. A sterile F_2 plant of the Co.1 x *A. manihot*

plate 5 (x 0.10)

plate 6 (x 0. 07)

Table 8. Distribution of number of leaves per plant in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)					Total number of plants observed.
		< 12	12-31	32-51	52-71	>71	
P_1	12-49	Nil	33 (82.5)	7 (17.5)	Nil	Nil	40
P_2	16-70	Nil	17 (42.5)	22 (55.0)	1 (2.5)	Nil	40
P_3	14-60	Nil	14 (32.0)	21 (52.5)	5 (12.5)	Nil	40
F_1 of $P_1 \times P_3$	18-96	Nil	6 (15.0)	11 (27.5)	18 (45.0)	5 (12.5)	40
F_1 of $P_2 \times P_3$	25-139	Nil	1 (2.5)	15 (37.5)	13 (32.5)	11 (27.5)	40
F_2 of $P_1 \times P_3$	11-78	4 (2.86)	69 (49.29)	40 (28.57)	24 (17.14)	3 (2.14)	140
F_2 of $P_2 \times P_3$	11-124	1 (0.76)	47 (35.88)	32 (24.43)	28 (21.37)	23 (17.56)	131

The variation for this character was found ranging from 32.81 to 38.70 per cent in the parents and hybrids while it showed much higher values (45.60 and 48.35) for the two F_2 populations.

The frequency distribution of plants for this character showed a definite tendency of gradual increase of the proportion of more leafy plants from parents to hybrids and from P_1 to P_3 within parents and F_1 to F_2 within hybrids. The F_1 of $P_2 \times P_3$ showed the maximum proportion (27.50 per cent) of plants with more than 71 leaves per plant.

5. Internodal length

The results are presented in Tables 9 and 10.

The treatments differed significantly for this character. Among the parents, the shortest internodal length was observed for P_2 (4.66 cm) and it was significantly lower than that of P_1 (6.54 cm) and P_3 (5.93 cm) which were on par. This reduction in internodal length was seen in both F_1s and F_2s involving the parent P_2.

The variation for internodal length among the plants of the parents and F_1s ranged from 15.27 to 21.39 per cent while that of F_2s was 34.30 per cent ($P_1 \times P_3$) and 37.62 per cent ($P_2 \times P_3$).

The frequency distribution showed that P_1 and P_3 had most of the plants in the group with 5.3 -7.5 cm internodal length while P_2 had majority of its plants in the group of

Table 9. Variations for internodal length (cm) in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control (P_1)	CV (in %)
	P_1	6.54	0.20	100.00	19.68
Parents	P_2	4.66	0.12	71.25	16.54
	P_3	5.93	0.20	90.67	21.39
Hybrids					
F_1	F_1 of $P_1 \times P_3$	8.01	0.19	122.48	15.27
	F_1 of $P_2 \times P_3$	6.46	0.18	98.78	18.04
F_2	F_2 of $P_1 \times P_3$	5.03	0.27	76.91	34.30
	F_2 of $P_2 \times P_3$	4.46	0.27	68.20	37.62

CD at 5% = 0.838

Plate 7. A profusely branching F_2 plant of the cross Co.1 x *A. manihot*

Plate 8. A resistant low yielding F_2 of the Cross Co.1 x *A. manihot*.

Plate 7 (x 0.10)

Plate 8 (x 0.10)

Table 10. Distribution of internodal length (cm) in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)					Total number of plants observed
		<3.0	3.0-5.2	5.3-7.5	7.6-9.8	>9.8	
P_1	4.0-9.2	Nil	8 (20.0)	24 (60.0)	8 (20.0)	Nil	40
P_2	3.0-6.2	Nil	30 (75.0)	10 (25.0)	Nil	Nil	40
P_3	3.6-9.6	Nil	13 (32.5)	23 (57.5)	4 (10.0)	Nil	40
F_1 of P_1 x P_3	5.2-10.6	Nil	1 (2.5)	15 (37.5)	21 (52.5)	3 (7.5)	40
F_1 of P_2 x P_3	4.4- 9.8	Nil	6 (15.0)	26 (65.0)	8 (20.0)	Nil	40
F_2 of P_1 x P_3	2.5-10.5	3 (2.14)	87 (62.14)	39 (27.86)	6 (4.29)	5 (3.57)	140
F_2 of P_2 x P_3	2.5-10.5	20 (15.27)	84 (64.12)	22 (16.79)	3 (2.29)	2 (1.53)	131

3.0 - 5.2 cm. Among the F_1s of $P_1 \times P_3$, three positive variants were observed. Both positive and negative variants were observed in both F_2s. More than 60 per cent of the plants of the F_2s had shorter internodes of the range 3.0 - 5.2 cm.

6. Days to flowering

The results are presented in Tables 11 and 12.

The parents and hybrids showed significant difference for days to flowering. P_1 and P_2 showed earliness in flowering and were on par. But P_3 showed a significantly higher number of days to flowering (71.28). The F_1s were late in flowering compared to their cultivated parents. Both F_2s took longer periods to flower compared to parents and F_1s.

Large variation was noticed for days to flowering among the plants of the F_2 populations compared to the parents and F_1s. Among the two F_2s, the F_2 of $P_1 \times P_3$ showed more variation (21.80 per cent) for this character.

The frequency distribution of this character in the three generations showed that all the plants of P_1 and 92.50 per cent plants of P_2 came under the range of 47-56 days to flowering. However, the F_1s were distributed more in the 57-66 days group, to which majority of the plants of the semi-wild parent (P_3) also belonged. The F_2s showed more late

Table 11. Variations for days to flowering in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control (P_1)	CV (in %)
Parents	P_1	50.30	0.34	100.00	4.22
	P_2	53.40	0.28	106.16	3.37
	P_3	71.28	0.33	141.71	2.89
Hybrids					
F_1	F_1 of $P_1 \times P_3$	58.75	0.43	116.80	4.58
	F_1 of $P_2 \times P_3$	60.43	0.36	120.14	3.79
F_2	F_2 of $P_1 \times P_3$	78.83	2.72	156.72	21.80
	F_2 of $P_2 \times P_3$	72.39	1.56	143.92	13.62

CD at 5% = 3.267

Plate 9. A high yielding F_1 plant of the Cross K.S.17 x *A. manihot*

Plate 10. The highest yielding F_2 plant of the Cross K.S.17 x *A. manihot*

Plate 9 (x 0.10)

Plate 10 (x0 .09)

Table 12. Distribution of days to flowering in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)					Total number of plants observed
		< 47	47-56	57-66	67-76	>76	
P_1	47-54	Nil	40 (100.00)	Nil	Nil	Nil	40
P_2	50-57	Nil	37 (92.5)	3 (7.5)	Nil	Nil	40
P_3	66-75	Nil	1 (2.5)	39 (97.5)	Nil	Nil	40
F_1 of $P_1 \times P_3$	53-65	Nil	8 (20.0)	32 (80.0)	Nil	Nil	40
F_1 of $P_2 \times P_3$	56-65	Nil	3 (7.5)	37 (92.5)	Nil	Nil	40
F_2 of $P_1 \times P_3$	50-112	Nil	1 (0.79)	4 (3.15)	62 (48.82)	60 (47.24)	127
F_2 of $P_2 \times P_3$	54-115	Nil	4 (3.77)	13 (12.26)	65 (61.32)	24 (22.64)	106

flowering habit and they were mainly distributed in the 67-76 and greater than 76 days groups.

7. Number of flowers per plant

The results are presented in Tables 13 and 14.

Significant difference was noticed for this character among the parents, F_1s and F_2s. Among the parents, P_2 had significantly higher number of flowers per plant (19.78) than P_1 and P_3. The F_1s also differed significantly and F_1 of $P_1 \times P_3$ produced higher number of flowers per plant (23.85) than its parents (15.33 and 12.63). However, the F_1 of $P_2 \times P_3$ was inferior to its cultivar parent (P_2) with respect to this character. Similarly, both the F_2 populations produced only lesser number of flowers per plant (8.15 and 10.60) compared to parents and F_1s.

There was wide variation for number of flowers per plant among the plants of the F_2s. It was as high as 81.87 per cent in the F_2 of $P_1 \times P_3$ and 65.18 per cent in the F_2 of $P_2 \times P_3$. However, in the F_1s the variation was much lesser (21.02 and 26.88 per cent). Among the parents, P_1 showed more variation (52.41 per cent) than the other two parents.

Most of the P_1 and P_3 plants produced flowers in the range 8-17 while in P_2 there was almost equal distribution of plants in the 8-17 and 18-27 groups. The F_1 of $P_1 \times P_3$

Table 13. Variations for number of flowers per plant in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control (P_2)	CV (in %)
	P_1	15.33	1.27	77.50	52.41
Parents	P_2	19.78	0.93	100.00	29.63
	P_3	12.63	0.34	63.85	17.14
Hybrids					
F_1	F_1 of P_1 x P_3	23.85	0.79	120.58	21.02
	F_1 of P_2 x P_3	15.30	0.65	77.35	26.88
F_2	F_2 of P_1 x P_3	8.15	1.03	41.20	81.87
	F_2 of P_2 x P_3	10.60	1.09	53.59	65.18

CD at 5% = 4.441

Plate 11. A resistant low yielding F_2 plant of the Cross K.S.17 x A. manihot

Plate 12. A non-branching F_2 plant of the Cross K.S. 17 x A. manihot

Plate 11 (x 0.10)

Plate 12 (x 0.10)

Table 14. Distribution of number of flowers per plant in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)					Total number of plants observed
		< 8	8-17	18-27	28-37	> 37	
P_1	8-37	Nil	32 (80.0)	3 (7.5)	5 (12.5)	Nil	40
P_2	10-32	Nil	17 (42.5)	21 (52.5)	2 (5.0)	Nil	40
P_3	8-18	Nil	39 (97.5)	1 (2.5)	Nil	Nil	40
F_1 of $P_1 \times P_3$	16-35	Nil	5 (12.5)	25 (62.5)	10 (25.0)	Nil	40
F_1 of $P_2 \times P_3$	9-27	Nil	31 (77.5)	9 (22.5)	Nil	Nil	40
F_2 of $P_1 \times P_3$	0-35	72 (51.43)	62 (44.29)	5 (3.57)	1 (0.71)	Nil	140
F_2 of $P_2 \times P_3$	0-38	60 (45.80)	62 (47.33)	8 (6.11)	Nil	1 (0.76)	131

had more plants in the 18-27 group while the 8-17 group predominated in the F_1 of P_2 x P_3. In the F_2 generation, plants with fewer number of flowers (lower than the parental values) were more compared to parents and F_1s. However, one F_2 plant of the cross P_2 x P_3 produced more number of flowers than the parents.

8. Number of fruits per plant

The results are presented in Tables 15 and 16.

The parents, F_1s and F_2s showed significant difference for number of fruits per plant. Both the cultivar parents, P_1 and P_2 were found superior to the semi-wild parent, P_3 in this character. The F_1 of P_1 x P_3 produced significantly higher number of fruits per plant than its parents. However, the F_1 of P_2 x P_3 was far inferior to its cultivar parent, P_2 in this character though it was on par with P_3. The F_2 progenies of both crosses produced significantly lesser number of fruits per plant compared to the cultivar parents but were on par with the semi-wild parent P_3.

The two F_2 populations registered very high coefficient of variation (130.84 and 132.43 per cent) compared to parents and F_1s (23.61 to 64.41 per cent).

The frequency distribution of plants for number of fruits produced per plant (Table 16) showed distinct pattern

Table 15. Variations for number of fruits per plant in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control (P_2)	CV (in %)
Parents	P_1	11.55	1.18	78.31	64.41
	P_2	14.75	0.84	100.00	35.96
	P_3	7.35	0.32	49.83	27.13
Hybrids					
F_1	F_1 of P_1 x P_3	15.80	0.59	107.12	23.61
	F_1 of P_2 x P_3	6.05	0.32	41.02	33.25
F_2	F_2 of P_1 x P_3	3.98	0.81	26.98	130.84
	F_2 of P_2 x P_3	3.93	0.82	26.64	132.43

CD at 5% = 3.791

Plate 13. The fruits of the parents and hybrids of the Cross Co.1 (P_1) x *A. manihot* (P_3)

Plate 14. The fruits of the parents and hybrids of the Cross K.S.17 (P_2) x *A. manihot* (P_3)

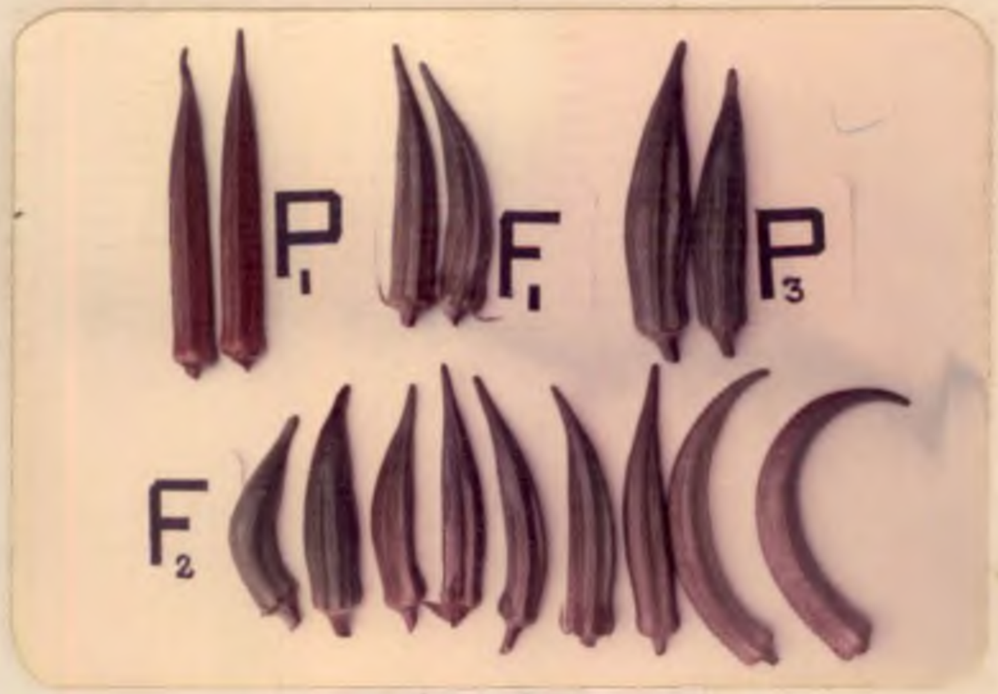


Plate 13 (x 0.32)

Plate 14 (x 0.33)

Table 16. Distribution of number of fruits per plant in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)					Total number of plants observed
		< 4	4-12	13-21	22-30	> 30	
P_1	5-30	Nil	32 (82.0)	2 (5.0)	6 (15.0)	Nil	40
P_2	7.28	Nil	15 (37.5)	21 (52.5)	4 (10.0)	Nil	40
P_3	4-12	Nil	40 (100.0)	Nil	Nil	Nil	40
F_1 of $P_1 \times P_3$	9-22	Nil	9 (22.5)	30 (75.0)	1 (2.5)	Nil	40
F_1 of $P_2 \times P_3$	3-12	1 (2.5)	39 (97.5)	Nil	Nil	Nil	40
F_2 of $P_1 \times P_3$	0-30	75 (53.57)	64 (45.71)	Nil	1 (0.71)	Nil	140
F_2 of $P_2 \times P_3$	0-29	84 (64.12)	45 (34.35)	1 (0.76)	1 (0.76)	Nil	131

for parents and hybrids. Among the 40 plants under each parent studied, all the P_3 plants were found in the range of 4-12 fruits per plant. The F_1 of P_1 x P_3 showed an intermediate pattern with 75 per cent of plants belonging to 13-21 range while the F_1 of P_2 x P_3 showed a pattern very similar to that of P_3 with 97.5 per cent of plants belonging to 4-12 range. Both F_2s have showed more or less a similar pattern with most of the plants belonging to 4-12 and less than 4 range.

9. Weight of fruits per plant

The results presented in Tables 17 and 18.

Among the parents, P_2 gave the highest yield (347.63 g) with highly significant superiority over others. Between the two F_1s, P_1 x P_3 gave the best yield (254 g) which was well ahead of P_2 x P_3. However, the F_1 of P_1 x P_3 was not significantly different from its cultivar parent, P_1 (198.88 g). But the F_1 of P_2 x P_3 was far inferior to its cultivar parent, P_2. Both the F_2s were far inferior compared to their cultivar parents.

Great variation for weight of fruits per plant was registered by the F_2 populations. It was as high as 155 per cent in F_2 of P_1 x P_3 and 150 per cent in F_2 of P_2 x P_3. The variation in F_1s was comparatively low (22.57 and 34.17 per cent). Among the parents, P_1 showed considerable variation for this character (59.75 per cent).

Table 17. Variations for weight of fruits per plant (g) in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control (P_2)	CV (in %)
Parents	P_1	198.88	18.79	57.21	59.75
	P_2	347.63	19.32	100.00	35.15
	P_3	150.50	6.69	43.29	28.11
Hybrids					
F_1	F_1 of $P_1 \times P_3$	254.00	9.07	73.07	22.57
	F_1 of $P_2 \times P_3$	99.75	5.39	28.69	34.17
F_2	F_2 of $P_1 \times P_3$	78.00	19.13	22.44	155.12
	F_2 of $P_2 \times P_3$	66.38	15.67	19.10	149.33

CD at 5% = 72.845

Table 18. Distribution of weight of fruits per plant (g) in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)					Total number of plants observed
		< 85	85-265	266-446	447-627	> 627	
P_1	85-510	Nil	33 (82.5)	3 (7.5)	4 (10.0)	Nil	40
P_2	135-625	Nil	11 (27.5)	22 (55.0)	7 (17.5)	Nil	40
P_3	85-250	Nil	40 (100.0)	Nil	Nil	Nil	40
F_1 of $P_1 x P_3$	155-345	Nil	20 (50.0)	20 (50.0)	Nil	Nil	40
F_1 of $P_2 x P_3$	45-180	16	24 (40.0)	Nil (60.0)	Nil	Nil	40
F_2 of $P_1 x P_3$	0-745	70 (63.64)	39 (35.45)	Nil	Nil	1 (0.91)	110
F_2 of $P_2 x P_3$	0-600	52 (62.65)	30 (36.14)	Nil	1 (1.20)	Nil	83

All the plants of the semi-wild parent, P_3 and 82.5 per cent plants of P_1, belonged to the low yield range of 85-265 g of fruits per plant. But in the case of P_2, 55 per cent of the plants belonged to the medium range of 266-446 g of fruits per plant. The F_1 of $P_1 \times P_3$ was equally distributed in the low and medium ranges, while in the F_1 of $P_2 \times P_3$, 40 per cent of the plants showed a negative trend in weight of fruits per plant compared to parents. Similarly both the F_2s clearly showed a reduction in yield with majority of the plants being distributed in the group with less than 85 g of fruits per plant (lesser than the parental values). However, one plant of F_2 of $P_1 \times P_3$ gave higher yield than either of its parents.

10. Length of fruits

The results are presented in Tables 19 and 20.

The three parents differed significantly for length of fruits. P_2 was found superior to P_1 and P_3 with 22.6 cm fruit length. However, the F_1s did not differ significantly with respect to this character. The F_1 of $P_2 \times P_3$ was inferior to its cultivar parent, P_2. Both F_2 were found significantly inferior in fruit length to parents and F_1s except the semi-wild parent, P_3 which was found to be significantly inferior to the F_2 of $P_2 \times P_3$.

Table 19. Variations for length of fruits (cm) in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control (P_2)	CV (in %)
Parents	P_1	15.64	0.20	69.20	8.15
	P_2	22.60	0.27	100.00	7.57
	P_3	13.08	0.17	57.88	8.14
Hybrids					
F_1	F_1 of $P_1 \times P_3$	15.54	0.13	68.76	5.56
	F_1 of $P_2 \times P_3$	16.03	0.19	70.93	7.32
F_2	F_2 of $P_1 \times P_3$	12.31	0.29	54.47	14.55
	F_2 of $P_2 \times P_3$	14.08	1.55	62.30	6.97

CD at 5% = 0.963

Table 20. Distribution of length of fruits (cm) in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parentheses)					Total number of plants observed
		< 11.5	11.5-16.1	16.2-20.8	20.9-25.5	>25.5	
P_1	13.8-19.5	Nil	28 (70.0)	12 (30.0)	Nil	Nil	40
P_2	18.5-25.5	Nil	Nil	6 (15.0)	34 (85.0)	Nil	40
P_3	11.5-15.5	Nil	40 (100.0)	Nil	Nil	Nil	40
F_1 of P_1xP_3	13.0-16.5	Nil	39 (97.5)	1 (2.5)	Nil	Nil	40
F_1 of P_2xP_3	14.0-19.0	Nil	26 (65.0)	14 (35.0)	Nil	Nil	40
F_2 of P_1xP_3	9.0-19.59	24 (21.82)	84 (76.36)	2 (1.82)	Nil	Nil	110
F_2 of P_2xP_3	9.0-16.5	2 (2.41)	79 (95.18)	2 (2.41)	Nil	Nil	83

The coefficient of variation was comparatively low for all the treatments. Maximum variation (14.55 per cent) was shown by the F_2 population of $P_1 \times P_3$ which was twice that of F_2 of $P_2 \times P_3$ (6.97 per cent). The variation in the parents and F_1s was within the range of 5.56 to 8.15 per cent.

The frequency distribution of length of fruits within each population (Table 20) has shown that all the plants of P_3 and 70 per cent plants of P_1 were having fruit length in the range of 11.5 - 16.1 cm, while 85 per cent plants of P_2 were having long fruits with length in the range of 20.9 to 25.5 cm. The F_1s had majority of their plants in the 11.5 - 16.1 cm group. Though most of the F_2 plants also came under this group, some negative variants with fruit length lesser than the parental value of 11.5 cm were noticed. The proportion of such negative variants was significantly higher in the F_2 of $P_1 \times P_3$ than the F_2 of $P_2 \times P_3$. None of the F_1 or F_2 plants showed positive transgression for this character.

11. Girth of fruits

The results are presented in Tables 21 and 22.

There was significant difference among the three parents for this character. The maximum girth of fruits was exhibited by the semi-wild parent, P_3. However, there was no significant difference in girth of fruits within or between the F_1s and F_2s.

Table 21. Variations for girth of fruits (cm) in different generations

Genera-tions	Treatments	Mean	± S.E.	Per cent over con-trol (P_3)	CV (in %)
	P_1	6.24	0.10	77.13	10.21
Parents	P_2	7.09	0.10	87.64	8.55
	P_3	8.09	0.12	100.00	9.47
Hybrids					
F_1	F_1 of $P_1 \times P_3$	7.24	0.07	89.49	6.53
	F_1 of $P_2 \times P_3$	7.31	0.08	90.36	7.12
F_2	F_2 of $P_1 \times P_3$	7.45	0.12	92.09	10.32
	F_2 of $P_2 \times P_3$	6.97	0.09	86.16	8.36

CD at 5% = 0.558

Table 22. Distribution of girth of fruits (cm) in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)					Total number of plants observed
		<5.0	5.0-6.5	6.6-8.1	8.2-9.7	>9.7	
P_1	5.0-8.0	Nil	30 (75.0)	10 (25.0)	Nil	Nil	40
P_2	6.0-8.2	Nil	9 (22.5)	30 (75.0)	1 (2.5)	Nil	40
P_3	6.5-9.5	Nil	2 (5.0)	22 (55.0)	16 (40.0)	Nil	40
F_1 of P_1xP_3	6.5-8.5	Nil	3 (7.5)	35 (87.5)	2 (5.0)	Nil	40
F_1 of P_2xP_3	6.5-8.5	Nil	7 (17.5)	32 (80.0)	1 (2.5)	Nil	40
F_2 of $P_1x\ P_3$	5.75-9.5	Nil	22 (20.0)	72 (65.45)	16 (14.55)	Nil	110
F_2 of $P_2x\ P_3$	5.5-9.5	Nil	33 (39.76)	47 (56.63)	3 (3.61)	Nil	83

The variation among the plants of the different treatments was comparatively low in respect of girth of fruits. The variation was less in the F_1s compared to the parents and F_2s.

The distribution of this character among the different populations was found somewhat uniform with majority of the plants belonging to the 6.6 - 8.1 cm range except in P_1 in which 75 per cent of plants were having fruit girth in 5-6.5 cm range. About 40 per cent of the F_2 plants P_2 x P_3 combination also showed this trend of producing slender fruits of 5-6.5 cm range. In the semi-wild parent, 40 per cent of plants belonged to the thicker group of fruits in the range of 8.2 -9.7 cm. About 15 per cent of plants in the F_2 of P_1 x P_3 also showed this trend.

12. Yellow vein mosaic intensity

The results are presented in Tables 23 and 24.

There was significant difference among the treatments for yellow vein mosaic intensity. Among the parents, the highest disease intensity was shown by P_2 which was significantly higher to that of P_1. The semi-wild parent P_3, F_1s and F_2 of P_1 x P_3 were completely free from any disease symptoms with a score of one. The F_2 of P_2 x P_3 showed a mean intensity of 1.2 which was not significantly different from the score of one.

Plate 15. A graft inoculated F_2 plant of the Cross K.S. 17 x *A. manihot* showing no disease symptoms.

Plate 15 (x 0.28)

Table 23. Variations for yellow vein mosaic intensity in different generations

Generations	Treatments	Mean	± S.E.	Per cent over control (P_3)	CV (in %)
	P_1	1.30	0.09	130.00	46.15
Parents	P_2	3.43	0.21	343.00	38.01
	P_3	1.00	0	100.00	0
Hybrids					
F_1	F_1 of $P_1 \times P_3$	1.00	0	100.00	0
	F_1 of $P_2 \times P_3$	1.00	0	100.00	0
F_2	F_2 of $P_1 \times P_3$	1.00	0	100.00	0
	F_2 of $P_2 \times P_3$	1.20	0.14	120.00	72.65

CD at 5% = 0.508

Table 24. Distribution of yellow vein mosaic intensity in parents and hybrids

Treatments	Range	Number of plants under each class (per cent in parantheses)					Total number of plants observed
		Score 1	Score 2	Score 3	Score 4	Score 5	
P_1	1-4	29 (72.5)	9 (22.5)	1 (2.5)	1 (2.5)	Nil	40
P_2	1-5	2 (5.0)	10 (25.0)	10 (25.0)	5 (12.5)	13 (32.5)	40
P_3	1	40 (100.0)	Nil	Nil	Nil	Nil	40
F_1 of P_1 x P_3	1	40 (100.0)	Nil	Nil	Nil	Nil	40
F_1 of P_2 x P_3	1	40 (100.0)	Nil	Nil	Nil	Nil	40
F_2 of P_1 x P_3	1	140 (100.0)	Nil	Nil	Nil	Nil	140
F_2 of P_2 x P_3	1-5	126 (96.18)	Nil	Nil	Nil	5 (3.82)	131

There was no variation among the plants of P_3, F_1s and F_2 of $P_1 \times P_3$ for the disease incidence. F_2 of $P_2 \times P_3$ showed maximum variation for this character (72.65 per cent) followed by P_1 and P_2.

The frequency distribution (Table 24) for this character has shown the high susceptibility of P_2 for yellow vein mosaic disease. 32.5 per cent of its population was under the score 5 indicating the maximum expression of symptoms whereas there were only 5 per cent of plants which was completely free from the disease. Among the other treatments P_3, F_1s and F_2 of $P_1 \times P_3$ have shown complete resistance against the disease as 100 per cent of plants were having the score one. Of the total 131 plants grown under F_2 of $P_2 \times P_3$, five have shown intense symptoms of the disease and got a score of five.

13. Pest scoring

(a). Fruit borer incidence

The results are presented in Table 25.

The treatments differed significantly for fruit borer infestation. The semi-wild parent, P_3 showed the least infestation by the fruit borer (9.22 per cent). The cultivar parents, P_1 and P_2 were on par and showed significantly higher percentage of infestation than P_3. The highest percentage of fruit infestation was noticed on the two F_1 populations (55.06 and 43.61 per

Table 25. Fruit borer incidence on parents and hybrids

Treatments	Mean percentage of fruit infestation (transformed values in parantheses)
Co.1 (P_1)	19.74 (26.35)
K.S.17 (P_2)	21.64 (27.69)
A. manihot (P_3)	9.22 (17.66)
F_1 of $P_1 \times P_3$	55.06 (47.93)
F_1 of $P_2 \times P_3$	43.61 (41.32)
F_2 of $P_1 \times P_3$	33.18 (35.18)
F_2 of $P_2 \times P_3$	32.63 (34.82)

CD (for transformed values) at 5% = 6.93

Plate 16. A graft inoculated F_2 plant of the cross K.S. 17 x A. manihot showing disease symptoms.

Plate 17. An F_2 plant of the cross K.S. 17 x A.manihot with unsuccessful graft union showing disease symptoms.

Plate 16 (x 0.30)

Plate 17 (x 0.30)

cent). However the F_2s showed lesser infestation than the F_1s (33 per cent).

(b) Leaf hopper infestation and hopper burn damage

The results are presented in Table 26 (a).

There was significant difference among the treatments for this character. Among the parents, the maximum leaf hopper count (24.1 per plant) and hopper burn damage (30.17 per cent) was recorded by the Semi-wild parent, P_3. Considering the classification system suggested by Uthamasamy et al. (1973) the cultivar parents, P_1 and P_2 were found resistant to this pest since the population of hoppers and hopper burn percentage was low. However, the F_1s had the highest hopper incidence and hopper burn and were classified as tolerant types. Both the F_2s also belonged to the same group though the population count and hopper burn damage were less than that of the F_1s. The segregation pattern of the F2 population for leaf hopper (jassid) resistance is given in Table 26 (b) (See page 105).

II. Genotypic and phenotypic variance and coefficients of variation for the different characters

The results are presented in Table 27.

a) Genotypic variance

The maximum genotypic variance was shown by weight of fruits per plant (100354.03) followed by height of plant, number of leaves per plant and days to flowering. The lowest value for genotypic variance (2.74) was given by girth of fruits.

Table 26 (a). Population of leaf hopper and hopper burn percentage on parents and hybrids.

Treatments	Mean population count per plant (transformed values in parantheses)		Hopper burn percentage (transformed values in parantheses)		Remarks (Uthamasamy *et al.* 1973)
Co.1 (P_1)	4.3	(2.07)	14.63	(22.46)	Resistant
K.S.17 (P_2)	4.7	(2.17)	13.86	(21.89)	Resistant
A. manihot (P_3)	24.1	(4.91)	30.17	(33.34)	Tolerant
F_1 of $P_1 \times P_3$	22.8	(4.77)	32.62	(34.82)	Tolerant
F_1 of $P_2 \times P_3$	21.2	(4.60)	26.93	(31.24)	Tolerant
F_2 of $P_1 \times P_3$	18.4	(4.29)	20.54	(26.92)	Tolerant
F_2 of $P_2 \times P_3$	16.4	(4.05)	18.71	(25.62)	Tolerant
CD (for transformed values) at 5%		0.67		4.66	

Table 27. Genotypic and Phenotypic Variances (GV and PV) and Coefficients of Variation (GCV & PCV) of different characters.

Sl. No.	Characters	Mean	GV	PV	GCV	PCV
1.	Height of plant	99.10	9133.82	11476.63	96.44	108.10
2.	Number of branches per plant	2.85	4.74	6.90	76.39	92.17
3.	Number of leaves per plant	41.8	1669.21	2257.24	97.74	113.66
4.	Internodal length	5.87	15.10	18.28	66.20	72.84
5.	Days to flowering.	63.63	1125.67	1174.02	52.73	53.85
6.	Number of flowers per plant	15.09	266.31	355.65	108.14	124.97
7.	Number of fruits per plant	9.06	230.75	295.86	167.67	189.85
8.	Weight of fruits per plant	170.73	100354.03	124396.21	185.55	206.58
9.	Length of fruits	15.58	116.66	120.86	69.33	70.56
10.	Girth of fruits	7.20	2.74	4.15	22.99	28.29
11.	Yellow vein Mosaic intensity	1.42	7.67	8.84	1.95	2.09

b) Phenotypic variance

Weight of fruits per plant registered the maximum phenotypic variance (124396.21) followed by height of plant (11476.63). The lowest value was given by girth of fruits (4.15).

c) Genotypic coefficient of variation (GCV)

The genotypic coefficient of variation was very high for weight of fruits per plant (185.55), number of fruits per plant (167.67), and number of flowers per plant (108.14). Number of leaves per plant (97.74) and height of plant (96.44) also exhibited high values of GCV. The minimum GCV was shown by yellow vein mosaic intensity (1.95).

d) Phenotypic coefficient of variation (PCV)

Weight of fruits per plant (206.58) exhibited the maximum phenotypic coefficient of variation followed by number of fruits per plant (189.85), number of flowers per plant (124.97), number of leaves per plant (113.66) and height of plant (108.10). The lowest PCV was given by yellow vein mosaic intensity (2.09). Girth of fruits also exhibited low PCV (28.29).

III Estimates of heritability in broad sense and expected genetic advance of different characters

The results are presented in Table 28.

a) Heritability in broad sense

Very high values of heritability were exhibited by length of fruits (96.5 per cent) and days to flowering (95.9 per cent). Yellow vein mosaic intensity, internodal length and weight of fruits per plant also showed high estimates of heritability. The lowest value was registered by girth of fruits (66 per cent).

b) Expected genetic advance

The highest estimate of expected genetic advance was given by weight of fruits per plant (586.12) followed by the height of plant (175.64). Moderate values were noticed for number of leaves per plant (72.38) and days to flowering (67.68). Girth of fruits exhibited the lowest value for genetic advance (2.77).

IV. Correlations among the various characters in different generations

The results are presented in Table 29.

The test of significance of the correlation coefficients between weight of fruits per plant and its contributing characters are given in Table 30.

Table 28. Heritability in broad sense and expected genetic advance of different characters

Characters	Heritability (%)	Expected genetic advance
1. Height of the plant	79.59	175.64
2. Number of branches per plant	68.70	3.72
3. Number of leaves per plant	73.95	72.38
4. Internodal length	82.60	7.28
5. Days to flowering	95.88	67.68
6. Number of flowers per plant	74.88	29.09
7. Number of fruits per plant	77.99	27.63
8. Weight of fruits per plant	80.67	586.12
9. Length of fruits	96.52	21.86
10. Girth of fruits	66.02	2.77
11. Yellow vein mosaic intensity	86.76	5.31

Height of plant

Height of plant was significantly correlated with number of leaves per plant, internodal length, number of flowers per plant, number of fruits per plant and weight of fruits per plant in all the three generations. Though this character exhibited significant positive correlation with number of branches in the parental and F_2 generations, it was negative and non-significant in the F_1 generation. The correlation with days to flowering was negative and significant in the three groups except in the case of parents.

The test of significance of the correlation coefficients between weight of fruits per plant and height of the plant in the three generations revealed significant differences. The correlation in the F_1 generation was significantly higher than that of parents and F_2 generation.

Number of branches per plant

Number of branches per plant displayed significant positive association with number of leaves per plant and length of fruits in all the three generations, whereas its correlation with height, number of flowers per plant, number of fruits per plant and weight of fruits per plant was significant only in parents and F_2s. In the case of parents, the character was found to be significantly and positively correlated with yellow vein mosaic intensity.

Though the association of number of branches per plant with weight of fruits per plant was significant in the parental and F_2 generations, the correlation in parents was significantly higher than that of F_2s.

Number of leaves per plant

This character was found to show significant positive correlation with height of plant, number of branches per plant and length of fruits when all the three generations were considered together. But in the case of parents and F_2s, this was significantly correlated with number of flowers per plant, number of fruits per plant and weight of fruits per plant, whereas the association was significant with days to flowering and girth of fruits in the parents only. Significant negative association of the character with internodal length was observed in the F_1 generation.

The correlation with weight of fruits per plant was significantly higher in the parents than that of the F_2s, while there was no significant difference between the correlations in F_1 and F_2 generations.

Internodal length

Internodal length exhibited significant positive correlation only with height of the plant in all the three generations, whereas it was significantly correlated with number of flowers per plant in the F_1 and F_2 generations and with number of fruits per plant and weight of fruits per plant in the F_1s. However, the character showed significant negative association with days to flowering in the F_1s and F_2s and with length of fruits in parents and F_1s. In the case of the F_1 generation, internodal length had significant negative correlation with number of branches per plant, number of leaves per plant and girth of fruits. There was negative correlation with yellow vein mosaic intensity in the parents.

The correlation of internodal length with weight of fruits per plant was positive and significant in the F_1s and non-significant in the F_2s whereas it was negative and significant in the parents. The test of significance of these correlation coefficients showed that all the three are significantly different.

Days to flowering

The character had significant negative correlation with number of flowers per plant, number of fruits per plant and weight of fruits per plant in all the three generations and with height of plant and internodal length in the F_1 and F_2 generations, and length of fruits in parents and F_2s. In the case of parents, there was significant positive association with number of leaves per plant and girth of fruits while it was negatively and significantly associated with yellow vein mosaic intensity.

The correlation with weight of fruits per plant was negative and significant in all the generations and they did not differ significantly.

Number of flowers per plant

There was significant positive association of this character with height of plant, number of fruits per plant and weight of fruits per plant in the three generations, whereas such an association with number of branches per plant, number of leaves per plant and length of fruits was seen in parents and F_2s only. The association was positive and significant with internodal length in F_1 and F_2 generations and with yellow vein mosaic intensity in parents. However, the character was significantly and negatively correlated with days to flowering in all the three generations.

Significant positive association of this character with weight of fruits per plant was noticed in the three generations. However, the correlations in parents and F_1s were not significantly different though both the estimates were superior to that of the F_2s.

Number of fruits per plant

This character exhibited significant positive correlation with height of plant, number of flowers per plant and weight of fruits per plant in all the generations, whereas its correlation with number of branches per plant and number of leaves per plant was positive and significant only in the case of parents and F_2s. Though there was significant positive association of this character with length of fruits in the parental and F_2 generations, it was however, negative and significant in the F_1s. The character also exhibited positive and significant association with internodal length in F_1 and with yellow vein mosaic intensity in parents. The correlation with days to flowering was negative and significant in all the three generations.

The association of this character with weight of fruits per plant was positive and significant in the three generations. However, the correlation in the F_1s was significantly higher than that of the parents and F_2s.

Weight of fruits per plant

The character was significantly and positively correlated with height of plant, number of flowers per plant and number of fruits per plant in all the generations, whereas such an association with number of branches per plant and number of leaves per plant existed only in parents and F_2s. The character displayed significant negative correlation with days to flowering in the three generations. Internodal length showed a significant negative association with yield in parents whereas the association was positive

Table 30. Significance of the correlation coefficients between weight of fruits per plant and the contributing characters among parents, F_1s and F_2s

	Height of plant	Number of branches per plant	Number of leaves per plant	Internodal length	Days to flowering.	Number of flowers per plant	Number of fruits per plant	Length of fruits	Girth of fruits	Yellow vein mosaic intensity.
r_P Vs r_{F_1}	3.75*	3.98*	4.47*	4.76*	1.07	1.82	5.71*	10.08*	0.02	3.48*
r_P Vs r_{F_2}	1.10	3.46*	3.59*	2.98*	1.07	5.96*	1.12	7.84*	0.16	4.74*
r_{F_1} Vs r_{F_2}	5.10*	1.41	1.84	2.83*	0.26	3.14*	7.28*	4.37*	0.16	0.25

and significant in F_1s. Yellow vein mosaic intensity had a significant positive association with yield in parents.

Length of fruits

The character was found to be positively and significantly correlated with number of branches per plant and number of leaves per plant in all the generations, whereas the correlation with number of flowers per plant, number of fruits per plant and weight of fruits per plant was positive and significant only in case of parents and F_2s. The correlation was positive and significant with plant height in the F_2 generation, and with yellow vein mosaic intensity in parents. The character showed significant negative association with internodal length in parents and F_1s and with days to flowering in parents and F_2s. In the F_1 generation, the character was found to be significantly and negatively correlated with number of fruits per plant and yield of fruits per plant. There was positive and significant association with girth of fruits in F_1s while it was negative and significant in F_2s.

There was significant positive correlation with weight of fruits per plant in the parental and F_2 generations. But the correlation in parents was significantly higher than that of F_2s. The significant negative correlation noticed in F_1 generation was significantly different from the other two correlations.

Table 30. Significance of the correlation coefficients between weight of fruits per plant and the contributing characters among parents, F_1s and F_2s

	Height of plant	Number of branches per plant	Number of leaves per plant	Internodal length	Days to flowering.	Number of flowers per plant	Number of fruits per plant	Length of fruits	Girth of fruits	Yellow vein mosaic intensity.
r_P Vs r_{F_1}	3.75*	3.98*	4.47*	4.76*	1.07	1.82	5.71*	10.08*	0.02	3.48*
r_P Vs r_{F_2}	1.10	3.46*	3.59*	2.98*	1.07	5.96*	1.12	7.84*	0.16	4.74*
r_{F_1} Vs r_{F_2}	5.10*	1.41	1.84	2.83*	0.26	3.14*	7.28*	4.37*	0.16	0.25

Girth of fruits

This character was found to have no significant and positive association with any of the characters when all the three generations were considered together. However, the association with number of leaves per plant and days to flowering was positive and significant in case of parents. In case of F_1 generations, there was significant negative association with internodal length. The character had significant correlation with length of fruits in F_1s and F_2s of which the association in F_2s was negative.

There was no significant correlation with weight of fruits per plant in any of the three generations.

Yellow vein mosaic intensity

This character displayed significant associations only in parents. The correlation was positive and significant with number of branches per plant, number of flowers per plant, number of fruits per plant, weight of fruits per plant and length of fruits, whereas the character showed negative and significant correlation with internodal length and days to flowering.

V. Metroglyph analysis of parents and hybrids

Table 34 shows the index scores and position of rays for the different characters.

Table 31. Index scores and signs for the different traits

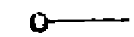
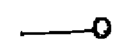
Sl. No.	Characters	Range of means	Score 1		Score 2		Score 3	
			Value	Sign	Value from - to -	Sign	Value	Sign
1	Number of branches per plant	1.07 to 4.90	Below 2.35	0	2.35 to 3.63		Above 3.63	
2	Number of leaves per plant	19.1 to 83.3	Below 40.50	0	40.50 to 61.90		Above 61.90	
3	Internodal length (cm)	3.40 to 8.22	Above 6.62	0	5.01 to 6.62		Below 5.01	
4	Days to flowering	49.20 to 81.50	Above 70.74	0	59.97 to 70.74		Below 59.97	
5	Number of flowers per plant	4.50 to 24.50	Below 11.17	0	11.17 to 17.84		Above 17.84	
6	Number of fruits per plant	1.41 to 21.00	Below 7.94	0	7.94 to 14.47		Above 14.47	
7	Length of fruits (cm)	11.38 to 23.5	Below 15.42	0	15.42 to 19.46		Above 19.46	
8	Girth of fruits (cm)	5.88 to 8.60	Below 6.79	0	6.79 to 7.70		Above 7.70	

FIG. 1. SCATTER DIAGRAM IN METROGLYPH ANALYSIS — parents and hybrids of the cross Co.1 × *A. manihot*

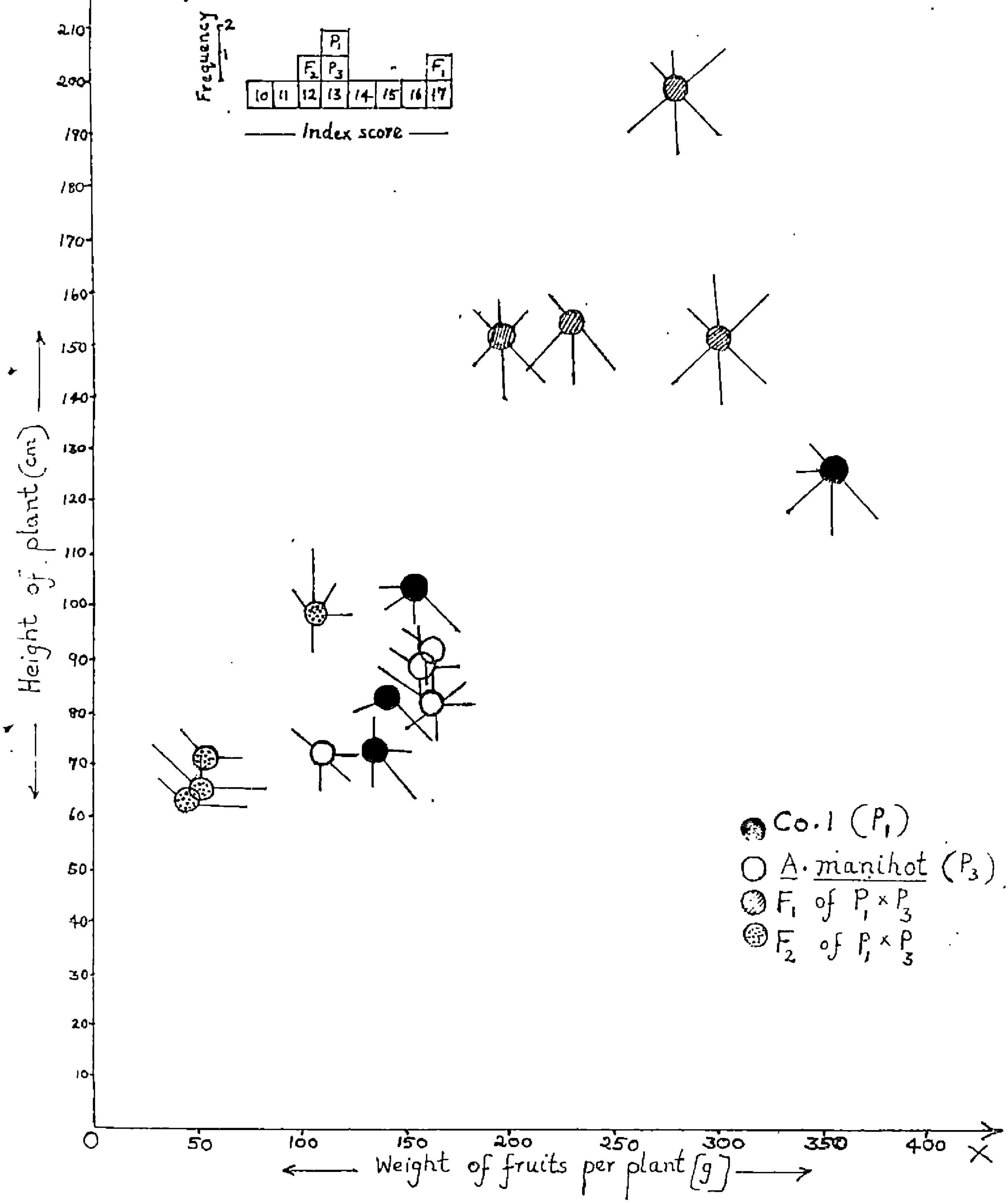
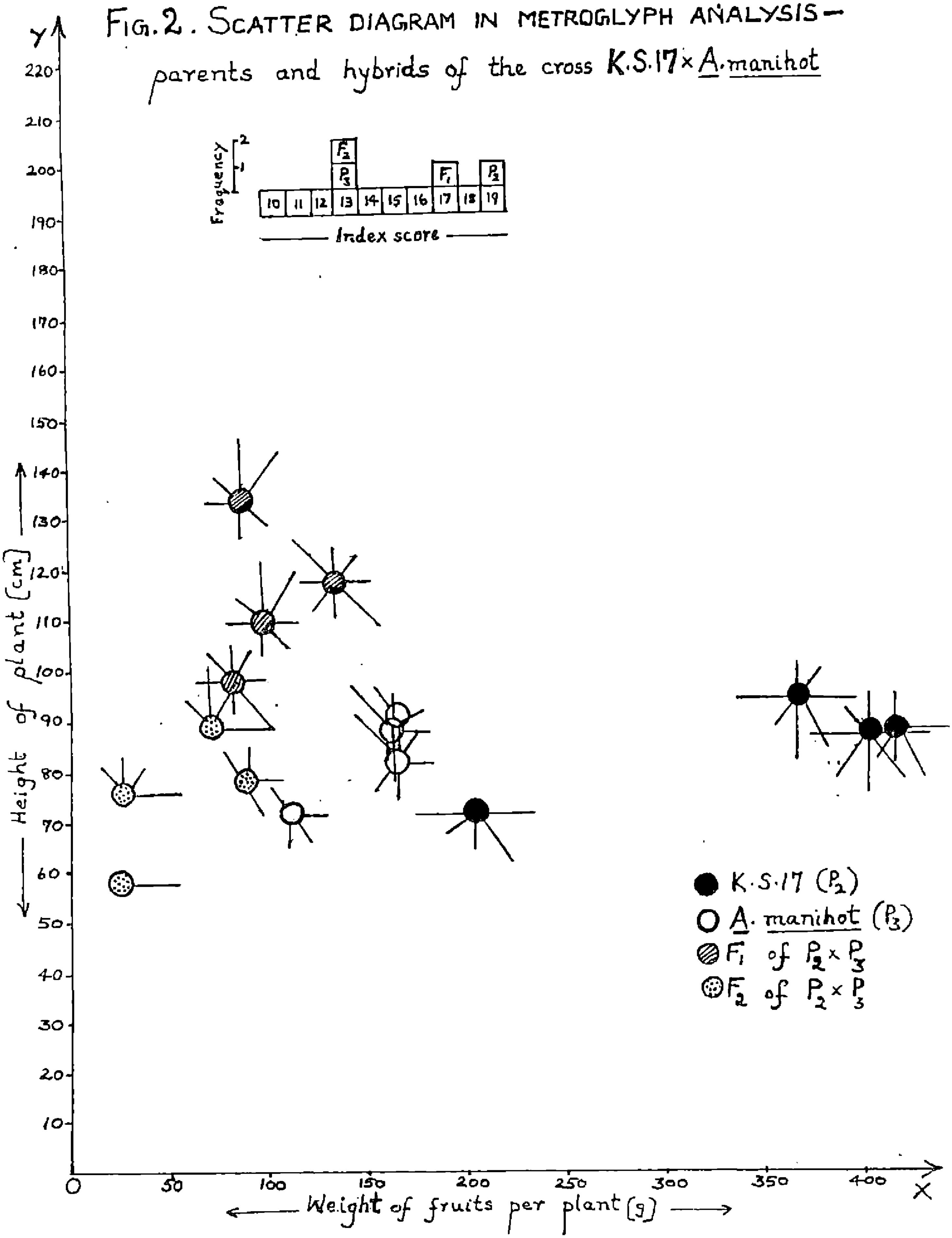


FIG. 2. SCATTER DIAGRAM IN METROGLYPH ANALYSIS — parents and hybrids of the cross K.S.17 × *A. manihot*



The scatter diagram of the 2 cross combinations are presented in Fig.1 and 2. The relative position of the parents and hybrids based on their performance is given by this diagram. The frequency diagram (Fig.1) in respect of the cross $P_1 \times P_3$ showed that among the parents and hybrids the maximum score was for F_1 of $P_1 \times P_3$ while the F_2 got the least score. But in the other cross, the cultivar parent (P_2) obtained the maximum score followed by its F_1 (Fig.2). The lowest score was recorded by the semi-wild parent P_3 and the F_2.

On comparing the two crosses, it was found that the highest score (19) was recorded by P_2 followed by F_1 of $P_1 \times P_3$ (17). The least score was shown by F_2 of $P_1 \times P_3$ (12).

VI. Grafting trial to study the segregation of yellow vein mosaic resistance

Results of the screening trial to study the segregation of yellow vein mosaic resistance in the F_2 plants of the cross between K.S.17 (P_2) and A. manihot (P_3) are presented in Table 32. Out of the 50 plants inoculated by grafting, graft union was established in 23 plants with 46 per cent success.

Majority of the inoculated plants scored a disease rating of one indicative of high resistance and the dominance of resistance over susceptibility to the disease. Only 7 out of the 50 plants inoculated, developed severe yellow vein

Table 32. Results of screening the F_2 of $P_2 \times P_3$ for yellow vein mosaic resistance by graft inoculation

Condition of the graft	Number of grafts	Number of plants scored under each yellow vein mosaic disease score					Mean disease rating	Number of resistant plant	Number of susceptible plants	χ^2	Probability
		1	2	3	4	5					
Successful	23	19	2	-	-	2	1.43	21	2	3.27	0.05-0.10
Unsuccessful	27	18	3	1	-	5	1.93	22	5	0.60	0.30-0.50
Total	50	37	5	1	-	7	1.70	43	7	3.23	0.05-0.10

mosaic symptoms. Severe disease symptoms developed in five cases where the graft union was not successful.

The segregation in this cross was found to agree well with the expected 3:1 ratio of resistant and susceptible plants.

VII. Grafting trial to confirm the resistance of desirable F_2 recombinants

On evaluation of F_2 plants for fruit yield, only two plants, one each from the two cross combinations gave fruit yields significantly higher than that of the best parent namely, KS.17. After the last harvest of fruits, including those retained for seed purpose, these two plants were specially nurtured to prolong their life period and subjected to grafting trial. Eventhough the scions remained alive for one week they failed to establish probably due to the overthickness and maturity of the root stock. Many new sprouts appeared from the portion below the graft point which were completely free from any yellow vein mosaic symptoms.

DISCUSSION

DISCUSSION

One of the basic objectives of plant breeding is the incorporation of resistance genes for protection from pests, diseases and environmental extremes into existing susceptible cultivars. The effective execution of this objective through conventional breeding methods is always difficult since the breeder has to see that he improves or at least maintains the important agronomic characters that vary during the breeding programme. The task becomes more difficult if the source of resistance is of a wild type with many undesirable genes under recombination circuit.

In the present study a semi-wild bhindi species *Abelmoschus manihot* was found to be highly resistant to the destructive disease of yellow vein mosaic. This was used as one parent to cross with two susceptible cultivars viz. Co-1 and K.S.17. The F_1s and F_2s of these crosses along with the parents were evaluated for resistance to yellow vein mosaic disease and various other characters which are associated with yield. The results are discussed in the following pages.

I. Evaluation of parents and hybrids

1. Variations for different traits

A programme of breeding aimed at the improvement of yield and disease resistance characters requires adequate information on the extent of variation available in the population. The scope for selection in the breeding population depends on the extent of altered mean values and genetic variability present in the segregating generation.

a. Mean values

The mean values for the second generation showed a decreasing trend for germination, height of plant, internodal length, number of flowers per plant, number of fruits per plant and weight of fruits per plant compared to the parents and first generation hybrids. However, the mean values for days to flowering in both the F_2s showed an increase over that of the parents and F_1s. The decreased mean values in the case of most of the important characters and the increased mean value for days to flowering indicate the presence of a genetic phenomenon which lead to a general shift of the characters towards the genotype of the wild parent, P_3 which was inferior to the cultivar parents P_1 and P_2 in most of the economic traits. In the case of number of branches per plant, number of leaves per plant and length of fruits, though there was no such definite trend, a decrease in the mean values of F_2 generation compared to the F_1 was noticed. But the F_2 of P_1 x P_3 showed an increase in mean value for girth of fruits over its F_1 while the other F_2 showed a decreasing trend. This decrease in mean values when compared to F_1 generation may be the result of inbreeding depression in the F_2 generation.

Yellow vein mosaic intensity showed a distinct pattern over generations. The F_1s were completely free from the disease with a mean score of one. The F_2 of $P_1 \times P_3$ also showed the same score. However, the F_2 of the cross involving the highly susceptible parent, P_2(K.S.17) showed an increase in the mean value of disease score over F_1s (Table 24) due to the presence of five plants in the population with severe disease symptoms. These results show the influence of the background genome of each individual F_2 plant for the expression of disease symptom under field conditions.

The mean percentage of fruit borer infestation was higher in both the F_1s (Table 25). But the F_2s showed a significant decrease in mean value for this character. The semi-wild parent P_3 showed maximum resistance (9.22 per cent) to this pest. This result is in agreement with the anonymous report of 1977 and that of Chelliah and Srinivasan (1983). The lesser infestation in F_2 populations is probably due to the preponderance of plants with fruit characters closely resembling the semi-wild parent.

In the case of leaf hopper incidence also, a decrease in mean values of F_2s compared to the F_1s was noticed (Table 26a). The population of hopper and the extent of hopper burn was maximum in the semi-wild species, A. manihot (P_3). The cultivar parents P_1 and P_2 were grouped as resistant types since the population count and hopper burn percentage were low in them. The susceptible nature of the semi-wild parent, P_3 to this pest was found fully inherited by the F_1 and segregated into 4:2:1 tolerant, resistant and susceptible in the F_2 of $P_1 \times P_3$ and 4:2:1 resistant, tolerant and susceptible types in the F_2 of $P_2 \times P_3$ (Table 26b). This suggests a complex inheritance pattern for the incidence of this pest in the plant materials under study. In general the susceptibility to this pest can be considered as recessive to the resistant/tolerant nature.

The tolerance to this pest was reported to be governed by a single dominant gene (Mahal and Singh, 1982). According to Sharma and Gill (1984), resistance to this pest involve dominant genes. However, Uthamaswamy and Subramoniam (1985) suggested that a single recessive gene governs the resistance.

b. Variability

The coefficient of variation worked out for the different populations has given a statistical measure of the extent of variability present in the populations. In general, the variability was higher in the F_2 populations compared to the parents and F_1s. Such a diversity of types appearing in F_2 and later generations is the result of

Table 26(b). Segregation of jassid resistance in the F_2 populations.

Cross combination	Number of plants under each class (per cent in parantheses)			Total number of plants observed
	Resistant	Tolerant	Susceptible	
F_2 of $P_1 \times P_3$	49 (35.00)	71 (50.71)	20 (14.29)	140
F_2 of $P_2 \times P_3$	68 (51.91)	45 (34.35)	18 (13.74)	131

extreme heterozygocity of interspecific hybrids (Allard, 1960). However, in both crosses the F_2 populations never revealed the full recombination potential of the extremes of various traits in the parents involved. There was a preponderance of low yielding plants with resistance to yellow vein mosaic similar to the semi-wild parent, P_3. This suggests the presence of powerful genetic mechanisms which restrict free recombinations. Anderson (1939) believed that these restrictions are caused by genetic or zygotic elimination, pleiotropy and linkage. The restrictive effect of linkage on recombination was found to be severe. Stephens (1949) found that the viable fraction of F_2 hybrids of G. hirsutum and G. barbadence consists primarily of plants resembling the parental species or the F_1 hybrid. In several other plant genera, F_2 and later generation hybrids have frequency distribution of phenotypes skewed towards a parental type (Rick, 1963).

Siddiqui (1971) opined that interspecific crosses in Gossypium both at the diploid and tetraploid level mostly fail to yield desirable recombinants owing to a rapid reversion of the hybrid population to one or other of the parental genotypes.

Another expression of restricted recombination in species crosses is the large proportion of inviable and abnormal segregates in the F_2 population (Levin, 1979). In the present study, the F_2 populations showed various degrees of breakdown. There was considerable reduction in germination of the F_2 seeds while the parents and F_1s recorded high germination (Table 2). This indicates the elimination of hybrid progenies in the post zygotic stage (Hussain, 1972). Various degrees of sterility, including the presence of plants which did not flower at all, were observed in the F_2 populations. Such hybrid breakdown (Stebbins, 1950) leading to reduction in the productivity of F_2 generation has been reported in different species of plants (Hussain, 1972). Muller (1940) attributed the degeneration in the F_2 to the results of segregation of complementary gene systems of parental species. Stephens (1950) observed that recombination in later generations of *G. hirsutum* x *G. barbadense* are accompanied by reduction in fertility and departures from expected Mendelian ratios. He concluded that due to cryptic structural differentiation, selfing in interspecific hybrids results in most of the segregates resembling either parental species or the F_1. This is because, the cross over gametes are at a selective disadvantage resulting from duplications and deficiencies in the gametes due to cryptic structural differentiation. The true causes of drastic reduction in fertility in the hybrids in the present study could be ascertained only through an indepth cytogenetic study of the species involved which has not been attempted here.

2. Genetic parameters

The progress in breeding depends upon the magnitude and nature of genetic variability. Hence a knowledge of total variability and the magnitude of heritable and non-heritable components is important. The total variability can be partitioned into its heritable and non-heritable components with the help of genetic parameters like genotypic coefficient of variation, heritability and genetic advance.

Yellow vein mosaic intensity recorded the lowest phenotypic and genotypic coefficient of variation indicating little scope for improvement of this trait through selection. This observation differs from those of Padda et al. (1970), Kaul et al. (1979) and Mishra and Chhonkar (1979) who obtained high genotypic coefficient of variation for mosaic infection. This difference may be due to the difference in the populations involved in the studies.

High values of phenotypic and genotypic coefficients of variation were observed for weight of fruits per plant, number of fruits per plant, number of flowers per plant, number of leaves per plant and height of plant. The high genotypic coefficient of variation values indicate the high degree of genetic variability in these characters and suggests scope for better selection for these characters in breeding programmes. The high values of phenotypic and genotypic coefficient of variation observed for yield and number of fruits was in conformity with the findings of Kaul et al. (1979), Mishra and Chhonkar (1979) and Thaker et al. (1981) and contrary to the observations of Lal et al. (1977) and Balachandran (1984). High genetic variability for height of plant was reported by Padda et al. (1970), Rao (1972), Rao et al. (1977), Rao and Kulkarni (1978), Mishra and Chhonkar (1979) and Thaker et al. (1981).

The characters like number of branches per plant, internodal length and length of fruits also showed moderately high phenotypic and genotypic coefficient of variation values, indicating scope for selection. This was in agreement with the observations of Mishra and Chhonkar (1979) who obtained high degree of genetic variability for branches per plant and fruit length. High genetic variability for length of fruits was also reported by Trivedi and Prakash (1969). However, this was contrary to the results obtained for Balachandran (1984) who found low genotypic coefficient of variation for length of fruits, number of flowers per plant and height of plant.

Among the eleven characters studied, the heritability values were moderately high for all the characters indicating the low influence of environment. Length of fruits and days to flowering recorded the highest values of heritability. High heritability values for fruit length was reported by Trivedi and Prakash (1969), Ngah and Graham (1973), Singh *et al.* (1974), Lal *et al.* (1977), Mahajan and Sharma (1979), Mishra and Chhonkar (1979) and Murthy and Bavaji (1980). Padda *et al.* (1970), Lal *et al.* (1977), Rao *et al.* (1977), Rao and Sathyavathi (1977), Singh and Singh (1978), Murthy and Bavaji (1980), Partap *et al.* (1980) and Balachandran (1984) also reported high estimates of heritability for number of days to flowering, an important attribute having vital influence on the number of fruits produced and the total fruit yield.

The high heritability values for most of the characters studied show that one can attempt selection for these characters directly based on phenotypic performance. Similar results were reported by Padda *et al.* (1970) for mosaic infection, plant height and yield per plant, Rao (1972) for plant height, Lal *et al.* (1977) for all the characters studied except yield per plant, Rao and Kulkarni (1977) for number of fruits per plant, Rao *et al.* (1977) for plant height, number of fruits and yield per plant, Rao and

Sathyavathi (1977) for number of fruits per plant, Singh and Singh (1978) for yield per plant and number of fruits per plant, Mahajan and Sharma (1979) for number of fruits, Mishra and Chhonkar (1979) for number of branches per plant, pods per plant, plant height and percentage of plants infected with yellow vein mosaic virus, Murthy and Bavaji (1980) for plant height and yield, Palanivelu-chamy et al. (1982) for plant height, Vashistha et al. (1982) for fruits per plant and plant height. However, Lal et al. (1977) and Balachandran (1984) reported that yield per plant is having low heritability since it is largely influenced by environmental factors. Similarly, Rao (1972) found that length of fruit offered less scope for selection as it was greatly influenced by environment.

It has been suggested by Johnson et al. (1955) that heritability together with genetic advance will bring out the advance expected from selection. High heritability together with high genetic advance was observed for weight of fruits per plant and height of plant. A high heritability and genetic advance suggests that the character is governed by additive genes (Panse, 1957). This observation regarding yield of fruits per plant was in agreement with those of Singh and Singh (1978), Mishra and Chhonkar (1979) and Murthy and Bavaji (1980) but contrary to the results of

Lal *et al.* (1977) and Balachandran (1984). High heritability and genetic advance for plant height was reported by many workers like Rao (1972), Mishra and Chhonkar (1979), Thaker *et al.* (1981), Palaniveluchamy *et al.* (1982) and Vashistha *et al.* (1982)

Days to flowering and number of leaves per plant also recorded high heritability and genetic advance estimates, indicating additive gene effects in the expression of these characters. Similar results were reported by Rao (1972) and Singh and Singh (1978) for days to flowering. However, Rao *et al.* (1977), Rao and Sathyavathi (1977), Murthy and Bavaji (1980) and Balachandran (1984) found that days to flowering was under the influence of non-additive genes.

Though heritability estimates were high, the expected genetic advance was low for number of branches per plant, internodal length, number of flowers per plant, number of fruits per plant, length and girth of fruits and yellow vein mosaic intensity. This suggests the role played by non-additive genes in the expression of the above characters. Balachandran (1984) also suggested the involvement of non-additive gene effect for number of flowers per plant, number of fruits per plant and length and girth of fruits. However, Singh *et al.* (1974) reported high heritability and genetic advance for fruit diameter and fruit length. Similar observations were made by Lal et al. (1977) for internodal length, number of branches per plant and number of fruits per plant, Rao and Kulkarni (1977), Singh and Singh (1978), Thaker et al. (1981) and Vashistha et al. (1982) for number of fruits per plant, Mishra and Chhonkar (1979) for number of branches per plant, fruits per plant, fruit length and percentage of plants infected with yellow vein mosaic virus.

3. Correlation studies

In order to obtain information on the association of traits in different generations, simple correlation coefficients were worked out among the eleven characters separately for each generation. The results are presented in Table 29.

Number of fruits per plant, number of flowers per plant and height of plant were found to be the most important yield contributing characters in all the three generations. Singh et al. (1974) reported positive and significant association of yield with these characters. The studies by Rao and Ramu (1975), Rao et al. (1977), Singh and Singh (1978, 1979b) and Mahajan and Sharma (1979), showed that number of fruits per plant and height of plant should be given more emphasis in bhindi selection programmes to increase the yield. The importance of fruit number per plant as a selection criterion was stressed by many other workers like Roy and Chhonkar (1976), Korla and Rastogi (1978), Ajimal et al. (1979), Partap et al. (1979), Elangovan et al. (1980), Murthy and Bavaji (1980), Arumugam and Muthukrishnan (1981) and Balachandran (1984).

Positive and significant association of yield with number of branches per plant and number of leaves per plant was exhibited by parents and F_2s, while in F_1s there was non-significant association of yield with number of branches per plant (negative) and number of leaves per plant (positive). Such a positive and significant association of yield with number of branches and number of leaves per plant was reported by Singh et al. (1974). Branches per plant was found to be an important yield contributing character in the studies conducted by Roy and Chhonkar (1976), Singh and Singh (1978, 1979 b), Elangovan et al. (1980) while contrary views were requested by Balachandran (1984).

There was significant negative correlation of yield with days to flowering in the three generations. The reports by Padda et al. (1970), Majumdar et al. (1974), Korla and Rastogi (1978), Ajimal et al. (1979), Murthy and Bavaji (1980), Arumugam and Muthukrishnan (1981) and Balachandran (1984) are in agreement with this finding. Hence days to flowering could be considered as an important yield determining component for exercising selection in bhindi. Korla and Rastogi (1978) suggested that yield could be improved by selecting early flowering types producing a large number of fruits.

Length and girth of fruits were reported to be important in selection programmes by many workers. In the present study, positive and significant association of length of fruits with yield was observed only in parents and F_2s, while in the F_1s the association was found to be significantly negative. Girth of fruits was not correlated with yield in any of the generations.

Yield was found to be negatively and significantly correlated with internodal length in parents while the association was positive and significant in the case of F_1 generation and non-significant in the F_2 generation.

Breeding for disease resistance employing wild species require information on the association of resistance with other economic characters. The progress in breeding may be hampered if there is association between desirable and undesirable traits which is commonly seen in resistance breeding programmes involving wild relatives. Based on the study of segregating generations of crosses between

H. esculentus varieties and *H. manihot* forms, Arumugam and Muthukrishnan (1979) reported that there was no association of yellow vein mosaic resistance with any of the economic characters like plant height, number of branches, days to flowering, fruit length and girth, number of fruits per plant and number of seeds per fruits indicating the scope for effective selection for resistance. However, in the present study it was found that significant associations between yellow vein mosaic intensity and other characters existed in parents. The correlation was positive and significant with number of branches per plant, number of flowers per plant, number of fruits per plant, weight of fruits per plant, and length of fruits. However there was significant negative correlation with internodal length and days to flowering. Such anomalous associations of important yield characters like number of branches per plant, number of flowers per plant, number of fruits per plant, length of fruits, internodal length and days to flowering with disease reaction are the result of high incidence of the disease in the highest yielding parent, P_2 (K.S.17).

Interrelations between characters given an idea about the effect of selection for one character on the improvement of the others. The major yield components recognised in the present study were plant height, number of flowers per plant, number of fruits per plant and days to flowering. It was found that the first three characters exhibited significant positive association among themselves in the three generations. Hence the selection for any one of these characters is sure to bring about an improvement of the other two characters. Height of plant also displayed significant positive association with number of leaves per plant and internodal length.

Negative association of days to flowering was found to be significant with number of flowers per plant and number of fruits per plant apart from yield of fruits per plant, in all the generations. Though the association of days to flowering with height of plant was negative, it was significant only in the case of F_1s and F_2s.

4. Metroglyph analysis

The frequency diagrams (Fig.1 and 2) show that P_2 is getting the highest score of 19 among the parents and the hybrids when subjected to the classificatory analysis done on the basis of index score method suggested by Anderson (1957). This clearly indicates the superiority of P_2 over all the other treatments.

II. Segregation of yellow vein mosaic resistance.

The disease rating scale (Table 32) showed that out of the 50 plants inoculated 37 plants came under the highly resistant category without showing any symptoms characteristic of the disease while six plants produced mild symptoms and were hence, grouped as resistant and moderately resistant types. However, from a genetic point of view it can be seen that these six plants are susceptible to the disease since they developed disease symptoms. Hence the actual ratio in the F_2 becomes 37 resistant: 13 susceptible plants which is a close fit to the expected 3:1 ratio of resistant and susceptible plants. Such a segregation would suggest that resistance to yellow vein mosaic is controlled by a single dominant gene. This is in agreement with the views of Arumugam and Muthukrishnan (1980), Jambhale and Nerkar (1981) and Unnikrishna Pillai (1984).

III. Selection of desirable F_2 recombinants

The distribution of weight of fruits per plant among the populations of parents and hybrids presented in Table 18 indicates a definite reversal of the F_2 plants towards the Semi-wild parent in this character. Only one plant each in the two F_2s showed an yield level above 447 g per plant. All other F_2 plants gave fruit yield only upto 265 g per plant like the semi-wild parent A. manihot. Those two F_2 plants one each from the two cross combinations were selected on the basis of their superior performance, after confirming their resistant nature by grafting trials. Though the scions failed to establish in both the cases, the new sprouts from the rootstock portion did not show any symptoms characteristic of yellow vein mosaic.

Further back crossing of the selfed progeny of these two resistant F_2 plants with the cultivar parents taking the latter as male parent is suggested as future line of work.

SUMMARY

SUMMARY

The experiment on evaluation of the F_2 generation derived from an interspecific hybridisation programme involving two yellow vein mosaic susceptible cultivars of *Abelmoschus esculentus* viz., Co.1 and K.S.17 and a semi-wild species *A. manihot* resistant to the disease was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani during 1984-85.

The cultivar parents were crossed with *A. manihot* taking the latter as male parent and F_1 seeds were collected. Selfed seeds from F_1 plants were used to raise the next generation. The F_2 populations were grown along with the parents and F_1s in a field trial in Randomized Block Design with four replications and evaluated for resistance to yellow vein mosaic disease and various other characters associated with yield.

The anlysis of variance revealed significant difference for all the characters among the seven treatments. The variations for the different traits were studied based on the extent of alteration in mean values and amount of variability present in the populations.

A decreasing trend in the mean values of the two F_2 populations was noticed for most of the characters studied. A drastic reduction in the germination of both F_2s was observed both under field and laboratory conditions. This is attributed to the elimination of hybrid progenies in the post zygotic stage. There was a preponderance of low yielding plants with resistance to yellow vein mosaic in the F_2 generation. Majority of the F_2 progenies were inferior to the cultivar parents in most of the economic characters indicating the presence of a genetic mechanism leading to a strong reversal to the semi-wild parent, A. manihot. The inferiority of F_2 generation when compared to the F_1 is explained as due to inbreeding depression.

The parents and hybrids were evaluated for yellow vein mosaic resistance, fruit borer infestation and leaf hopper incidence under natural infection conditions.

The highest yielding parent, P_2 (K.S.17) showed the maximum susceptibility to the yellow vein mosaic disease. The semi-wild parent, P_3 (A.manihot), the F_1s and the F_2 of P_1 x P_3 exhibited freedom from the disease. But in the F_2 of the cross involving the highly susceptible parent P_2, five plants showed severe disease symptoms while all the other plants did not show any mosaic symptoms.

The semi-wild parent, P_3 was found to show maximum resistance to the fruit borer. The percentage of infestation was found to decrease from F_1 to F_2 generation due to the reversion to the semi-wild parent type.

The incidence of leaf hopper in the plant materials under study was found to be under the control of complex inheritance mechanisms. Based on the F_2 segregation ratios, it is inferred that susceptibility to this pest is recessive to the resistant/tolerant nature.

The variability in both the F_2 populations was higher when compared to that of the parents and F_1s. However, this was only a narrow segment of the total diversity of types that could have originated from free genetic recombinations. Such a restriction to recombinationis believed to be due to gametic or zygotic elimination, pleiotropy and linkage.

The F_2 generation exhibited various degree of sterility including the presence of completely sterile plants. The exact cause of this reduction in fertility can be understood only through cytogenetical studies which have not been attempted here.

The appearance of positive transgressors was observed in both F_2 populations for number of branches per plant, number of leaves per plant, internodal length and days to flowering. Positive transgression for number of flowers per plant was exhibited by one plant in the F_2 of $P_2 \times P_3$ (38 flowers per plant) while one F_2 plant of the cross $P_1 \times P_3$ gave higher weight of fruits per plant (745 g) than either of its parents. The proportion of negative variants for height of plant, number of leaves per plant, internodal length, number of flowers per plant, number of fruits per plant, weight of fruits per plant and length of fruits was considerable in the F_2 populations.

The genetic parameters like genotypic coefficient of variation, heritability and expected genetic advance were estimated for elevent characters. Among the characters studied, weight of fruits per plant, number of fruits per plant, number of leaves per plant and height of plant displayed high phenotypic and genotypic coefficients of variation indicating the scope for selection. Yellow vein mosaic intensity recorded the lowest phenotypic and genotypic coefficients of variation suggesting little scope for improvement of this trait through selection. The contrary results obtained for many other workers may be because of the different populations involved in the studies.

Heritability values were moderately high for all the characters indicating the low influence of environment and the scope for direct selection of these characters based on phenotypic performance.

Weight of fruits per plant, height of plant, days to flowering and number of leaves per plant recorded high heritability and genetic advance estimates indicating that these characters are under the control of additive genes. The involvement of non-additive gene effects was observed for number of branches per plant, internodal length, number of flowers per plant, number of fruits per plant, length and girth of fruits and yellow vein mosaic intensity.

Correlation studies showed that number of fruits per plant, number of flowers per plant, height of plant and earliness in flowering were the major yield contributing characters in all the three generations studied, namely parents, F_1s and F_2s. Positive and significant association of important yield characters like number of branches per plant, number of flowers per plant, number of fruits per plant, weight of fruits per plant and length of fruits with yellow vein mosaic intensity was observed in the parents. This anomalous result is supposed to be due to the high incidence of disease in the highest yielding parent, P_2 (K.S.17).

From the F_2 generation, two F_2 plants, one each from the two cross combinations were selected based on their superior performance. The resistance of these plants to yellow vein mosaic was confirmed by graft inoculation. Further back crossing of the selfed progeny of these resistant F_2 plants with the cultivar parents is suggested as future line of work.

The inheritance of yellow vein mosaic resistance was studied by screening the F_2 of P_2 x P_3 under artificial inoculation by grafting. The segregation of the F_2 plants into a 3:1 ratio of resistant: susceptible plants indicate the involvement of a single dominant gene in governing resistance to the disease.

REFERENCE

REFERENCES

Ajimal, H.R., Rattan, R.S. and Saini, S.S. 1979. Correlation and path coefficient analysis in okra. (Abelmoschus esculentus (L) Moench). Haryana J. Hortic Sci., 8: 58-63.

Allard, R.W.1960. Principles of Plant Breeding. John Wiley & Sons, New York, London, pp.428-432.

*Anderson, E. 1939. Recombination in species crosses. Genetics, 24: 668-698.

*Anderson, E. 1957. A Semigraphical Method for the analysis of complex problems. Proc. natn. Acad. Sci. U.S.A., 43: 923-27.

*Anonymous, 1977. Screening of okra varieties for resistance to shoot and fruit borer. Report of the All India Co-ordinated Vegetable Improvement Project. AGRESCO, Mahatma Phule Krishi Vidyapeeth, Rahuri. p.103.

Anonymous, 1982. Package of Practices Recommendations. Kerala Agricultural University, Mannuthy, pp.173.

Anonymous, 1983. Annual Report of the Department of Plant Breeding, College of Agriculture, Vellayani for the year 1983.

Arumugam, R., Chelliah, S. and Muthukrishnan, C.R. 1975. Abelmoschus manihot - A source of resistance to bhindi yellow vein mosaic. Madras agric. J., 62: 310-312.

Arumugam, R. and Muthukrishnan, C.R. 1977. Phenolics and flavonoids composition of yellow vein mosaic affected leaves of bhindi (Abelmoschus esculentus (L) Moench). Madras agric. J., 64: 838-840.

Arumugam, R. and Muthukrishnan, C.R. 1978 a. Evaluation of interspecific hybrid progenies of bhindi with a hybrid index. Madras agric. J., 65: 315-319.

Arumugam, R., Muthukrishnan, C.R. 1978b. Free amino acids in the resistance meachnism of yellow vein mosaic disease of bhindi (Abelmoschus esculentus (L.) Moench). Madras agric. J., 65: 208-210.

Arumugam, R. and Muthukrishnan, C.R. 1978c. Nitrogenous compounds in relation to resistance to yellow vein mosaic disease of okra (Abelmoschus esculentus (L.) Moench). Progr. Hortic., 10: 17-21.

Arumugam, R. and Muthukrishnan, C.R. 1978d. Sugars in the resistance mechanism of yellow vein mosaic disease of bhindi (Abelmoschus esculentus (L.) Moench). Veg. Sci., 5: 100-103.

Arumugam, R. and Muthukrishnan, C.R. 1979. Association of resistance to yellow vein mosaic with economic charactersin okra. Indian J. agric. Sci. 49: 605-608.

Arumugam, R. and Muthukrishnan, C.R. 1980. Studies on resistance to yellow vein mosaic in bhindi (Abelmoschus esculentus (L.)Moench). Proceedings of the National Seminar on disease resistance in crop plants, Coimbatore. 105-108.

Arumugam, R. and Muthukrishnan, C.R. 1981. Association of metric traits in bhindi. South Indian Hort., 29: 1-3.

Atiri, G.I. 1983. Identification of resistance to okra mosaic virus in locally grown okra varieties. Annals of Applied Biology, 102: 132-133.

Balachandran, P.V. 1984. Estimation of heterosis in bhindi (Abelmoschus esculentus (L.)Moench). M.Sc.(Ag) thesis submitted to the Kerala Agricultural University, Trichur.

Capoor, S.P. and Varma, P.M. 1950. Yellow vein mosaic of Hibiscus esculentus L. Indian J. agric. Sci., 20: 217-230.

Chauhan, M.S., Duhan, J.C. and Dhankar, B.S. 1981. Infection of genetic stock of okra to yellow vein mosaic virus. Haryana Agric. Univ. J. Res., 11: 45-48.

*Chelliah, S. and Murugesan, S. 1975. Estimation of loss due to yellow vein mosaic disease in bhindi. Annamalai Univ. Agric. Res. Ann., 6: 169-170.

*Chelliah, S. and Srinivasan, K. 1983. Resistance in bhindi, brinjal and tomato to major insect and mite pests. In National Seminar on breeding crop plants for resistance to pests and diseases, Coimbatore. 43-44.

*Chizaki, Y. 1934. Breeding of a new interspecific hybrid between Hibiscus esculentus L. and H. manihot L. Proc. Crop Sci. Soc. Japan., 6: 164-172.

Costa, A.S. 1976. White fly transmitted plant diseases. Ann. Rev. Phyto path., 14: 429-449.

*Dahatonde, M.P. 1970. Studies on resistance in some of the bhindi varieties to the jassid Empoasca devastans D. and shoot and fruit borer, Earias faba Stoll. M.Sc. (Ag) thesis submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri (Unpublished).

Dhillon, T.S. and Sharma, B.R. 1982. Interspecific hybridisation in okra (Abelmoschus species) Genet. Agr., 36: 247-255.

Elangovan, M., Muthukrishnan, C.R. and Irulappan, I. 1980. A study of correlation analysis in bhindi (Abelmoschus esculentus (L) Moench). South Indian Hort., 28: 28-30.

Federer, W.T. 1967. Experimental design- Theory and Application. Oxford and IBH Publishing Co. Indian Ed. pp. 120-124.

Fisher, R. And Yates, F. 1965. Statistical Tables for Biological, Agricultural and Medical Research. Edinburgh: Oliver and Boyd Ltd.

Gadwal, V.R., Joshi, A.B. and Iyer, R.D. 1968. Interspecific hybrids in Abelmoschus through ovule and embryo culture. Indian J. Genet., 28: 269-274.

Giriraj, K. and Rao, T.S. 1973. Note on a simple crossing technique in okra. Indian J. agric. Sci., 43: 1089.

*Hossain, M. and Chattopadhyay, T.K. 1976. Morphological features and resistance to yellow vein mosaic virus disease of the F_1 interspecific hybrids of Abelmoschus species. Plant Science, 8: 49-51.

Hussain, H.S.J. 1972. Heterosis and hybrid breakdown in interspecific hybrids of Gossypium hirsutum and G. barbadense. M.Sc.(Ag) thesis submitted to Tamil Nadu Agricultural University, Coimbatore.

Jain, J.P. 1982. Statistical techniques in quantitative genetics. Tata Mc Graw- Hill Publishing Company Ltd. New Delhi, pp.43.

Jambhale, N.D. and Nerkar, Y.S. 1981. Occurrence of spontaneous amphidiploidy in an interspecific cross Abelmoschus esculentus x A. tetraphyllus. J. Maharashtra Agric. Univ., 6: 1967.

Jambhale, N.D. and Nerkar, Y.S. 1982a. Induced amphidiploidy in the cross Abelmoschus esculentus (L.) Moench x A. manihot (L.) Medik ssp. manihot. Genet. Agr., 36: 19-22.

Jambhale, N.D. and Nerkar, Y.S. 1982b. An induced amphidiploid of Abelmoschus. Indian J. Genet., 42: 372-375.

Jambhale, N.E. and Nerkar, Y.S. 1983. Interspecific transfer of resistance to yellow vein mosaic disease in okra. J. Maharashtra Agric. Univ., 8: 197.

*Jayaraj, S. 1966. Influence of sowing times of castor varieties on their resistance to the leaf hopper, Empoasca flavescens (F.) (Homoptera:Jassidae). Entomologia exp. appl., 9: 359-369.

*Jayaraj, S. 1967. Studies on the resistance of castor plants (Ricinus communis L.) to the leaf hopper, Empoasca flavescens (F.) (Homoptera: Jassidae). Z. ang. Ent., 59: 117-126.

*Johnson, H.W., Robinson, H.F. and Comstock, R.E.1955. Estimates of genetic and environmental variability in soybean. Agron. J., 47: 314-318.

Joshi, A.B. and Hardas, M.W. 1956. Alloploid nature of okra, Abelmoschus esculentus (L.) Moench. Nature, 178:1190.

* Kashyap, R.K. and Verma, A.N. 1983. Relative susceptibility of okra to shoot and fruit borer (Earias spp.) Indian Journal of Ecology, 10 (2): 303-309.

Kaul, T., Lal, G. and Peter, K.V. 1979. Correlation and path coefficient analysis of components of earliness, pod yield and seed yield in okra. Indian J. Agric. Sci., 48: 459-463.

* Kawthalkar, M.P. and Kunte, Y.N. 1978. Correlation studies in bhindi. College of Agriculture, Nagpur Magazine. 50: 48.

*Kishore, N., Kashyap, R.K. and Dhankhar, B.S.1983. Field resistance of okra lines against jassid and fruit borer. Annals of Applied Biology, 102: 130-131.

Korla, B.N. and Rastogi, K.B. 1978. Correlation and path coefficient analysis and their implications in selection for high fruit yield in bhindi (Abelmoschus esculentus (L.) Moench) Haryana J. Hortic. Sci., 7: 83-85.

*Kulkarni, G.S.1924. Mosaic and other diseases of crops in the Bombay Presidency. Proc. 11th Science Cong., 42:3

*Kuwada, H.1961. Studies on interspecific crossing between Abelmoschus esculentus (L.) Moench and A. manihot Medik and the various hybrids and polyploids derived from the above two species. Memoirs of Faculty of Agriculture, Kagawa University, 8: 1-91.

*Kuwada, H. 1966. The new amphidiploid plant Abelmoschus tubercular esculentus obtained from the progeny of the reciprocal crossing between A. tuberculatus and A. esculentus. Japaneese J. Breed., 16: 21-30.

*Kuwada, H. 1974. F_1 hybrids of Abelmoschus tuberculatus x A. manihot[1] with reference to genome relationship. Studies on interspecific and intergeneric hybridisation in the Malvaceae. Japanese J. Breed., 24: 207-210.

Lal, S., Shekhar, C. and Srivastava, J.P. 1977. A note on genetical studies in bhindi (Abelmoschus esculentus (L) Moench) - Heritability and genetic advance. Indian J. Hort., 34: 49-50.

Levin, D.A. 1979. Hybridisation - An evolutionary perspective. Ed. Levin, D.A. Dowden, Hutchinson and Ross, Inc. Pennysylvania.

Mahajan, Y.P. and Sharma, B.R. 1979. Parent-offspring correlations and heritability of some characters in okra. Sci. Hortic., 10: 135-139.

Mahal, M.S. and Singh, B. 1982. Genetics of tolerance in okra seedlings to damage by the cotton jassid, Amrasca biguttula biguttula (Ishida). Indian J. agric. Sci., 52: 225-228.

Majumdar, M.K., Chatterjee, S.D., Bose, P. and Bhattacharya, G.1974. Variability, interrelationship and path coefficient analysis for same quantitative characters in okra (Abelmoschus esculentus (L.) Moench). Indian Agric., 18:13-20.

Mamidwar, R.B., Nerkar, Y.S. and Jambhale, N.D.1979. Cytogenetics of interspecific hybrids in the genus Abelmoschus. Indian J. Hered., 11: 35-40.

*Martin, F.W.1982. A second edible okra species and its hybrids with common okra. Annals of Botany, 50: 277-283.

*Meshram, L.D. and Dhapake, D.K. 1981. Cytogenetical studies on an interspecific hybrid between *Abelmoschus esculentus* (L). Moench x *A. tetraphyllus* L. In *Fourth International SABRAO Congress*, 1981, Kulalampur.

Mishra, R.S. and Chhonkar, V.S.1979. Genetic divergence in okra. *Indian J. agric. Sci.*, **49**: 247-249.

Mote, U.N. 1982. Studies on the varietal resistance of okra to fruit borer. *J. Maharashtra Agric. Univ.*, **7**: 188.

*Muller, H.J. 1940. in *The Systematics*, J. Huxley, ed. New York: Oxford University Press. pp.185-268.

Murthy, N.S. and Bavaji, J.N.1980. Correlation and path coefficient analysis in bhindi (*Ablemoschus esculentus*). *South IndianHort.*, **28**: 35-38.

Nair, P.G. and Kuriachan, P.1976. A spontaneous hybrid between *Abelmoschus tuberculatus* (Pal et Singh) and *A. esculentus* (L)Moench. *New Botanist*, **3**: 48-53.

Nariani, T.K. and Seth, M.L. 1958. Reaction of *Abelmoschus* and *Hibiscus* species to yellow vein mosaic virus. *Indian Phyopath.*, **11**: 137-140.

*Ngah, A.W. and Graham, K.M. 1973. Heritability of four characters in okra (*Hibiscus esculentus* (L.)*Malaysian Agricultural Research*, **2**: 15-21.

Padda, D.S., Saimbhi, M.S. and Singh, J. 1970. Genetic evaluation and correlation studies in okra (*Abelmoschus esculentus* (L.)Moench). *Indian J. Hort.*, **27**: 39-41.

Pal, B.P., Singh, H.B. and Swarup, V. 1952. Taxonomic relationships and breeding possibilities of species related to okra (*Abelmoschus esculentus*). *Bot. Gaz.*, **113**: 455-464.

Palniveluchamy, K., Muthukrishnan, C.R. and Irulappan, I. 1982. Studies on heritability and genetic advance in bhindi (*Abelmoschus esculentus* (L.)Moench). *Madras agric. J.*, **69**: 597-599.

Panse, V.G. 1957. Genetics of quantitative characters in relation to plant breeding. Indian J. Genet., 17: 318-328.

Panse, V.G. and Sukhatme, P.V. 1957. Statistical Methods for Agricultural Workers. ICAR, New Delhi.

Partap, P.S., Dhankar, B.S. and Pandita, M.L.1979. Inter-relationship and path analysis studies in okra (Abelmoschus esculentus (L.) Moench). Haryana Agric. Univ. J. Res., 9: 317-321.

Partap, P.S., Dhankar, B.S. and Pandita, M.L. 1980. Genetics of yield and its components in okra. Indian J. agric. Sci.,50: 320-323.

*Patil, A.S.1975. Studies on resistance in some of the bhindi varieties to jassid and shoot and fruit borer. M.Sc. (Ag)thesis submitted to Mahatma Phule Krishi Vidyapeetha, Rahuri. (Unpublished).

*Premnath, 1970. Problem oriented breeding projects in vegetable crops. SABRAO Newsl., 2: 125-134.

Potty, V.P. and Wilson, K.I. 1973. Studies on the physiology of virus disease of bhindi plant. Agric. Res. J. Kerala., 11: 65-68.

Ramiah, M. 1970. Studies on the physiology of bhindi infected by yellow vein mosaic virus. M.Sc.(Ag)thesis submitted to the University of Madras (Unpublished).

Rao, T.S.1972. Note on the natural variability for some qualitative and quantitative characters in okra. (Abelmoschus esculentus (L.)Moench). Indian J. agric. Sci., 42: 437-438.

Rao, T.S. and Kulkarni, R.S. 1977. Genetic variation in bhindi. Haryana Agric. Univ. J. Res., 7: 58-59.

Rao, T.S. and Kulkarni, R.S. 1978. Interrelationship of yield components in bhindi. Agric. Res. J. Kerala, 16: 76-78.

Rao, T.S. and Ramu, P.M. 1975. A study of correlation and regression coefficients in bhindi (Ablemoschus esculentus (L.) Moench). Current Research, 4: 135-137.

Rao, T.S., Ramu, P.M. and Kulkarni, R.S. 1977. Genetic variability and path coefficient analysis in bhindi. Punjab Horticultural Journal, 18: 78-83.

Rao, T.S. and Sathyavathi, G.P. 1977. Genetic and environmental variability in okra. Indian J. agric. Sci., 47: 80-81.

Rawat, R.R. and Sahu, H.R. 1973. Estimation of losses in growth and yield of okra due to Empoasca devastans Dist. and Earias spp. Indian J. Ent., 35: 252-254.

*Regunathan, B. 1980. A note on the improvement of okra (Hibiscus esculentus). Tropical Agriculturist, 136: 149-151.

Rick, C.M. 1963. Differential zygotic lethality in a tomato species hybrid. Genetics, 48: 1497-1507.

*Roy, S. and Chhonkar, V.S. 1976. Relationship of yield with different growth characters in okra (Abelmoschus esculentus (L.) Moench). Proc. Bihar Acad. agric. Sci., 24: 170-172.

Sandhu, G.S., Sharma, B.R., Singh, B. and Bhalla, J.S. 1974. Sources of resistance to jassids and whitefly in okra germplasm. Crop Improv., 1: 77-81.

*Sangappa, H.K. 1966. Investigations on the whitefly, Bemisia tabaci Gen. and its relationship with yellow vein mosaic of bhindi. Thesis submitted to the University of Madras.

Sastry, K.S.M. and Singh, S.J. 1974. Effect of yellow vein mosaic virus infection on growth and yield of okra crop. Indian Phytopath., 27: 294-297.

Sharma, B.R. and Dhillon, T.S. 1983. Genetics of resistance to yellow vein mosaic virus in interspecific crosses of okra (Abelmoschus species). Genet. Agr., 37: 267-275.

Sharma, B.R. and Gill, B.S. 1984. Genetics of resistance to Cotton Jassid, Amrasca biguttula biguttula (Ishida) in okra. Euphytica, 33: 215-220.

Sharman, B.R. and Sharma, O.P. 1984. Breeding for resistance to yellow vein mosaic virus in okra. Indian J. agric. Sci., 54: 917-920.

*Shehata, T. 1966. The susceptibility of four varieties of okra to cotton boll worm infestation. Bull Soc. Ent. Egypt, 49: 207-217.

Siddiqui, J.A. 1971. Polygenic variation following irradiation in interspecific crosses of cotton. Indian J. Genet., 31: 461-469.

Siemonsma, J.S. 1982. West African okra- morphological and cytogenetical indications for the existence of a natural amphidiploid of Abelmoschus esculentus (L.) Moench and A. manihot (L.) Medik. Euphytica, 31: 241-252.

Singh, B.N., Chakravarty, S.C. and Kapoor, G.P. 1938. An interspecific Hibiscus hybrid between H. ficulneus and H. esculentus. J. Hered., 29: 37-41.

Singh, H.B., Joshi, B.S., Khanna, P.P. and Gupta, P.S. 1962. Breeding for field resistance to yellow vein mosaic in bhindi. Indian J. Genet., 22: 137-144.

Singh, H.B., Swarup, V. and Singh, B. 1975. Three Decades of Vegetable Research in India. ICAR, New Delhi.

Singh, K., Malik, Y.S., Kalloo and Mehrotra, N. 1974. Genetic variability and correlation studies in bhindi, (Abelmoschus esculentus (L.) Moench). Veg. Sci., 1: 47-54.

Singh, M. and Thakur, M.R. 1979. Nature of resistance to yellow vein mosaic in Abelmoschus manihot Ssp. manihot. Curr. Sci., 48: 164-165.

Singh, S.P. and Singh, H.N. 1978. Study of genetic variability and inheritance of certain characters in okra (Abelmoschus esculentus (L.) Moench). Haryana J. Hortic. Sci., 7: 68-73.

Singh, S.P. and Singh, H.N. 1979a. Genetic divergence in okra (Hibiscus esculentus (L.) Moench). Indian J. Hort., 36: 165-170.

Singh, S.P. and Singh, H.N. 1979b. Path coefficient analysis for yield components in okra. Indian J. agric. Sci., 49: 244-246.

*Sinha, S.N. and Chakrabarti, A.K. 1978. Effect of yellow vein mosaic virus infection on okra seed production. Seed Research, New Delhi, 6: 67-70.

Skovsted, A. 1935. Chromosome number of Malvaceae. Indian J. Genet., 31: 263-296.

Stebbins, G.L., Jr. 1950. Variation and evolution in plants. Columbia University Press, New York.

Stephens, S.G.1949. The cytogenetics of speciation in Gossypium. I. Selective elimination of donor parent genotype in interspecific backcrosses. Genetics, 34: 627-637.

*Stephens, S.G. 1950. The internal mechanism of speciation in Gossypium. Bot. Rev., 16: 115-149.

Teli, V.S. and Dalaya, V.P. 1981. Studies on varietal resistance in okra (Abelmoschus esculentus (Linn). Moench) to the shoot and fruit borer, Earias Vitella Fabricius South Indian Hort., 29: 54-60.

*Teshima, T. 1933. Genetical and cytological studies on the interspecific hybrid of Hibiscus esculentus L. and H. manihot L.J. Fac. Agric. Hokkaido Univ., 34: 155.

Thaker, D.N., Tikka, S.B.S., Patel, K.K. and Ukani, S.J. 1981. Analysis of parameters of variability in okra (Abelmoschus esculentus (L.) Moench). Indian J. Hort., 38: 232-235.

*Thakur, M.R. 1976. Inheritance of resistance to yellow vein mosaic in a cross of okra species, Abelmoschus esculentus x A. manihot Ssp. manihot. SABRAO J., 8: 69-73.

Trivedi, H.B. and Prakash, R. 1969. Heritability of fruit size in bhindi (*Abelmoschus esculentus* (L.) Moench). *Sci. Cult.*, *35*: 318-319.

Ugale, S.D., Patil, R.C. and Khupse, S.S.1976. Cytogenetic studies in the cross between *Abelmoschus esculentus* L. and *A. tetraphyllus* W & L. *J. Maharashtra Agric. Univ.*, *1*: 106-110.

Unnikrishna Pillai, P.R. 1984. Evaluation of interpsecific hybrids of bhindi with reference to yellow vein mosaic resistance and heterosis. M.Sc.(Ag) thesis submitted to Kerala Agricultural University, Trichur.

Uppal, B.N., Varma, P.M. and Capoor, S.P. 1940. Yellow vein mosaic of bhindi.*Curr. Sci.*, *9*: 227-228.

*Ustinova, E.I. 1937. Interspecific hybrization in the genus *Hibiscus*. *Genetica*, *19*: 356-366.

*Ustinova, E.I. 1949. A description of interspecific hybrid *H. esculentus* and *H. manihot*. Prioroda(*Nature*), *6*: 58-60.

Uthamasamy, S. and Subramoniam, T.R. 1985. Inheritance of leaf hopper resistance in okra. *Indian J. agric. Sci.*, *55*: 159-166.

Uthamasamy , S., Subramoniam, T.R. and Jayaraj, S. 1973. Studies on the varietal resistance of bhindi (*Ablemoschus esculentus*) to the leaf hopper, *Amrasca* (= *Empoasca*) *devastans* (Dist) - (Homoptera: Jassidae). I.Screening of varieties under field conditions. *Madras agric. J.*, *60*: 27-31.

Varma, P.M. 1952. Studies on the relationship of bhindi yellow vein mosaic virus and its vector, the whitefly (*Bemisia tabaci*). *Indian J. agric. Sci.*, *22*: 75-91.

Varma. P.M. 1955. Persistence of yellow vein mosaic virus of *Abelmoschus esculentus* (L.)Moench in its vector, *Bemisia tabaci*. *Indian J. agric. Sci.*, *25*: 293-302.

*Varma, P.S. and Mukherjee, S.K. 1955. Studies on the varietal classification and virus resistance in lady's finger, Abelmoschus esculentus L. Proc. Indian Sci. Cong. Assn., 42nd session Part III: 371-372.

Vashishtha, R.N., Pandita, M.L. and Bhutani, R.D. 1982. Variability studies in okra (Abelmoschus esculentus (L.)Moench) under dry farming conditions. Haryana J. Hortic. Sci., 11: 117-121.

*Vidhyasekharan, P. 1971. Studies on Helminthosporiose of ragi in relation to disease resistance. Ph.D. thesis submitted to Tamil Nadu Agricultural University, Coimbatore (Unpublished).

* Originals not seen.

APPENDIX

Appendix I - Abstract of analysis of variance table

Source	df	Mean squares					
		Height of plant	Number of branches per plant	Number of leaves per plant	Inter-nodal lengh	Days to flowering	Number of flowers per plant
Replication	3	6131.5667	44.3750	6931.5655	6.3746	67.1161	570.3560
Treatment	6	38878.0809**	21.1286**	7264.8536**	63.5698**	4551.0228**	1154.5738**
Plot Error	18	2342.8111	2.1556	588.0266	3.1781	48.3480	89.3421
Sampling Error	252	478.9278	1.9353	196.4091	1.6828	35.9253	24.2147
Total	279						

Source	df	Mean squares				
		Number of fruits per plant	Weight of fruits per plant	Length of fruits	Girth of fruits	Yellow vein mosaic intensity
Replication	3	438.1429	164792.9460	13.0625	3.8306	1.8417
Treatment	6	988.0893**	425458.3330**	470.8544**	12.3560**	31.8583**
Plot Error	18	65.1067	24042.1825	4.2024	1.4098	1.1694
Sampling Error	252	15.2548	5863.0853	1.5454	0.2637	0.35198

** Significant at 1 per cent level of probability.

Appendix-II. Abstract of analysis of variance for germination and pest scoring

Source	df	Mean squares: Percentage of germination in field	Fruit borer incidence	Leaf hopper incidence: Population count	Hopper burn percentage
Replication	3	9.4734	47.6754	0.3176	23.4953
Treatment	6	970.3226**	413.4677**	5.7886**	108.0140**
Error	18	3.7855	21.7319	0.2023	9.8598
Total	27				

** Significant at 1 per cent level of probability

EVALUATION OF THE F_2 GENERATION OF INTERSPECIFIC HYBRIDS OF *Abelmoschus* WITH REFERENCE TO YELLOW VEIN MOSAIC RESISTANCE AND YIELD

BY

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ABSTRACT OF A THESIS
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ABSTRACT

A study was conducted at the College of Agriculture, Vellayani during 1984-'85 aimed at evaluating the F_2 generation of interspecific hybrids between two yellow vein mosaic susceptible cultivars of *Abelmoschus esculentus* and the resistant semi-wild species, *A. manihot* for yellow vein mosaic resistance and yield and selecting desirable F_2 recombinants. Study of the genetic nature of yellow vein mosaic resistance observed in *A. manihot* was another objective. The estimation of genetic parameters of important economic characters and the association among these characters were also studied.

The F_2 populations along with the parents and F_1s were evaluated in an RBD with four replications. A preponderance of low yielding yellow vein mosaic resistant plants similar to the semi-wild parent was observed among the F_2 populations, suggesting the presence of powerful genetic mechanisms which restrict free recombinations. Varying degrees of sterility were exhibited by the F_2 progenies. Both positive and negative variants (transgressors) for the different characters were seen in the F_2 generation. Based on the superiority in performance, two F_2 plants, one each from the two cross combinations were selected and their resistance was confirmed by graft inoculation. The selfed seeds of these plants were collected so that they can be used for further back crossing programmes with the cultivar parents.

High phenotypic and genotypic coefficients of variation were exhibited by weight of fruits per plant, number of fruits per plant, number of flowers per plant, number of leaves per plant and height of plant, indicating scope for selection. Yellow vein mosaic intensity registered the lowest phenotypic and genotypic coefficients of variation suggesting little scope for improvement of this character through selection. Moderately high heritability values were recorded by all the characters. Weight of fruits per plant, height of plant, days to flowering and number of leaves per plant were found to be under additive gene action as they recorded high heritability values together with high genetic advance whereas all the other characters like number of branches per plant, internodal length, number of flowers per plant, number of fruits per plant, length and girth of fruits and yellow vein mosaic intensity showed non-additive gene action.

Correlation studies revealed that number of fruits per plant, number of flowers per plant, height of plant and earliness in flowering could be considered as the major characters contributing to yield in the different generations studied. Anomalous associations of important yield characters with yellow vein mosaic intensity was observed in the parental generation.

Artificial inoculation of the F_2 of K.S. 17 x <u>A. manihot</u> by grafting revealed the single gene dominance of resistance over susceptibility as one fourth of the F_2 plants succumbed to the yellow vein mosaic disease.