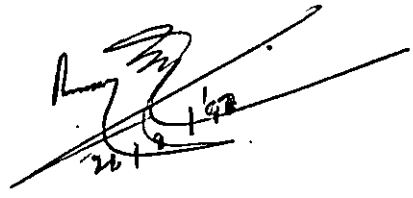
GENETIC ANALYSIS OF SEGREGATING GENERATIONS OF IRRADIATED INTERSPECIFIC HYBRIDS IN OKRA (*Abelmoschus* spp.)



By

SOPHIA JOHN

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DEPARTMENT OF PLANT BREEDING AND GENETICS
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1997

DECLARATION

I hereby declare that this thesis entitled **"Genetic analysis of segregating generations of irradiated interspecific hybrids in okra (*Abelmoschus* spp.)"** is a *bonafide* record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Sophia John

SOPHIA JOHN

Vellayani,
25-9-1997.

CERTIFICATE

Certified that this thesis entitled **"Genetic analysis of segregating generations of irradiated interspecific hybrids in okra (*Abelmoschus* spp.)"** is a record of research work done independently by **Ms. SOPHIA JOHN** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani,
25-9 -1997.

Dr. P. MANJU
(Chairman, Advisory Committee)
Associate Professor,
Department of Plant Breeding & Genetics,
College of Agriculture, Vellayani
Thiruvananthapuram.

Approved by

Chairman :

Dr. P. MANJU

Members :

1. Dr. R. GOPIMONY

2. Dr. L. RAJAMONY

3. Dr. (Mrs.) P. SARASWATHI

External Examiner : 25.11.94

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CONTENTS

Page No.

1. INTRODUCTION 1

2. REVIEW OF LITERATURE 3

3. MATERIALS AND METHODS 22

4. RESULTS 35

5. DISCUSSION 138

SUMMARY 162

REFERENCES i

LIST OF TABLES

Table Number	Title	Page Number
1.	Yellow vein mosaic disease rating scale	29
2.	ANOVA for the Compact Family Block Design	30
3.	Pooled ANOVA for the Compact Family Block Design	31
4.	Pooled ANOVA of 20 characters for the seven treatments in F_2M_2	36
5.	Days to first flowering in F_2M_2	38
6.	Leaf axil bearing the first flower in F_2M_2	39
7.	Leaf number in F_2M_2	40
8.	Leaf area (cm^2) in F_2M_2	42
9.	Number of branches per plant in F_2M_2	43
10.	Number of flowers per plant in F_2M_2	44
11.	Pollen sterility (%) in F_2M_2	46
12.	First fruiting node in F_2M_2	47
13.	Number of fruits per plant in F_2M_2	49
14.	Average fruit weight (g) in F_2M_2	50
15.	Weight of fruits per plant (g) in F_2M_2	51

Table Number	Title	Page Number
16.	Length of fruit (cm) in F_2M_2	53
17.	Girth of fruit (cm) in F_2M_2	55
18.	Number of seeds per fruit in F_2M_2	56
19.	Number of ridges per fruit in F_2M_2	57
20.	Fruiting phase in F_2M_2	59
21.	Height of the plant (cm) in F_2M_2	60
22.	Incidence of YVM disease in F_2M_2	62
23.	Incidence of fruit and shoot borer in F_2M_2	63
24.	Duration of the plant in F_2M_2	64
25.	Phenotypic and genotypic coefficients of variation in F_2M_2	66
26.	Heritability and genetic advance in F_2M_2	68
27.	Correlation in F_2M_2 – 0 kR	75
28.	Correlation in F_2M_2 – 10 kR	77
29.	Correlation in F_2M_2 – 20 kR	78
30	Correlation in F_2M_2 – 30 kR	80
31.	Correlation in F_2M_2 – 40 kR	83
32.	Correlation in F_2M_2 – P_1	84

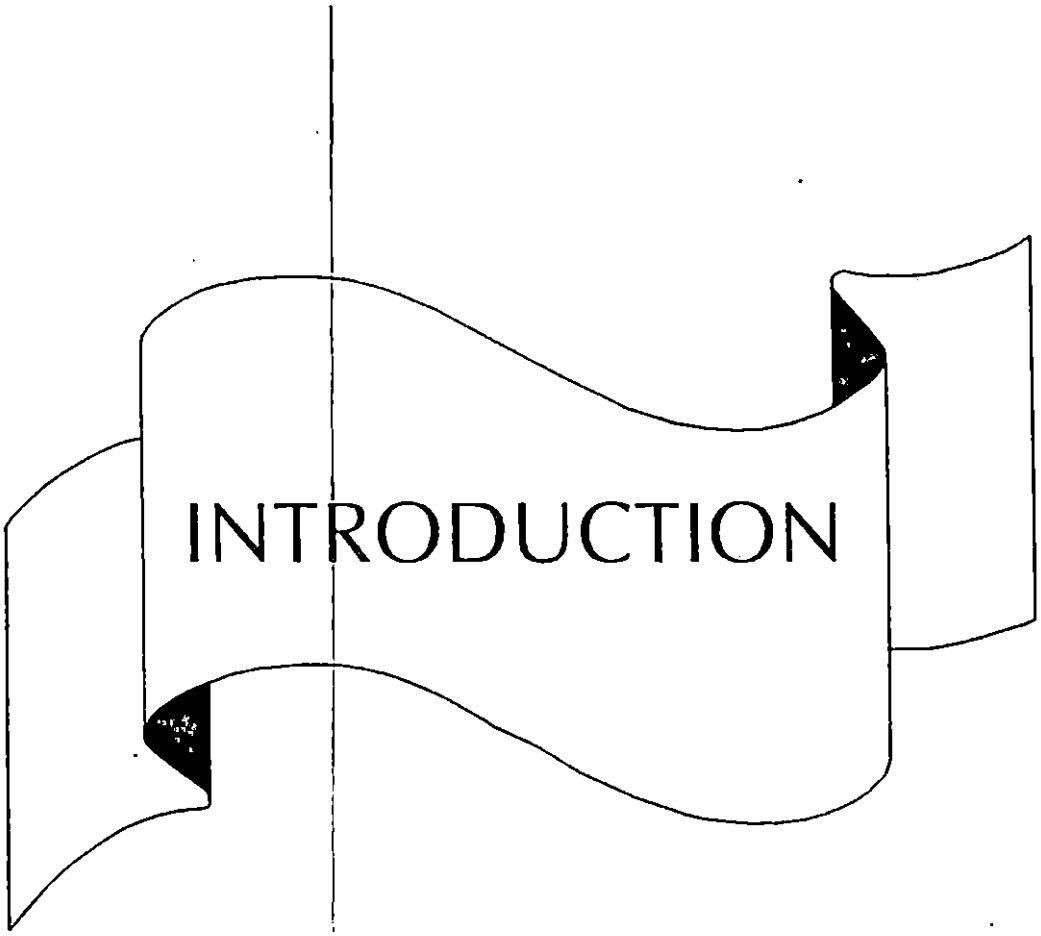
Table Number	Title	Page Number
33.	Correlation in F_2M_2 – P_2	86
34.	Pooled ANOVA OF 20 characters for the seven treatments in F_3M_3	87
35.	Days to first flowering in F_3M_3	89
36.	Leaf axil bearing the first flower in F_3M_3	90
37.	Leaf number in F_3M_3	92
38.	Leaf area (cm^2) in F_3M_3	93
39.	Number of branches per plant in F_3M_3.	94
40.	Number of flowers per plant in F_3M_3	96
41.	Pollen sterility (%) in F_3M_3	97
42.	First fruiting node in F_3M_3	98
43.	Number of fruits per plant in F_3M_3	100
44.	Average fruit weight (g) in F_3M_3	101
45.	Weight of fruits per plant in F_3M_3	103
46.	Length of fruit (cm) in F_3M_3	104
47.	Girth of fruit (cm) in F_3M_3	106
48.	Number of seeds per fruit in F_3M_3	107
49.	Number of ridges per fruit in F_3M_3	108

Table Number	Title	Page Number
50.	Fruiting phase in F_3M_3	110
51.	Height of the plant (cm) in F_3M_3	111
52.	Incidence of YVM disease in F_3M_3	112
53.	Incidence of fruit and shoot borer in F_3M_3	114
54.	Duration of the plant in F_3M_3	115
55.	Phenotypic and genotypic coefficients of variation in F_3M_3	116
56.	Heritability and genetic advance in F_3M_3	118
57.	Correlation in F_3M_3 – 0 kR	125
58.	Correlation in F_3M_3 – 10 kR	127
59.	Correlation in F_3M_3 – 20 kR	129
60.	Correlation in F_3M_3 – 30 kR	130
61.	Correlation in F_3M_3 – 40 kR	133
62.	Correlation in F_3M_3 – P_1	135
63	Correlation in F_3M_3 – P_2	136

LIST OF FIGURES

Figure Number	Title	Between Pages
1-10	Variability in plant characters in F_2M_2	60-61
11	Genetic variability in F_2M_2 - 0 kR	70-71
12	Genetic variability in F_2M_2 - 10 kR	70-71
13	Genetic variability in F_2M_2 - 20 kR	70-71
14	Genetic variability in F_2M_2 - 30 kR	71-72
15	Genetic variability in F_2M_2 - 40 kR	71-72
16	Genetic variability in F_2M_2 - *A. esculentus* (P_1)	73-74
17	Genetic variability in F_2M_2 - *A. manihot* (P_2)	73-74
18-20	High yielding YVM resistant plants in F_3M_3	112-113
21	Genetic variability in F_3M_3 - 0 kR	120-121
22	Genetic variability in F_3M_3 - 10 kR	120-121
23	Genetic variability in F_3M_3 - 20 kR	121-122
24	Genetic variability in F_3M_3 - 30 kR	121-122
25	Genetic variability in F_3M_3 - 40 kR	122-123
26	Genetic variability in F_3M_3 - *A. esculentus* (P_1)	123-124
27	Genetic variability in F_3M_3 - *A. manihot* (P_2)	123-124

For my
most beloved
Amma and Daddy


INTRODUCTION

1. INTRODUCTION

The conventional breeding programme involving hybridisation of chosen parents followed by selection in the segregating generations is an effective crop improvement method for obtaining desirable recombinants. But the recovery of such recombinants is limited by linkages that may exist between desirable and undesirable traits. In such situations induced mutations can be of great help in breaking undesirable linkages. Conventional breeding method in conjunction with mutation breeding thus serve as an effective and innovative approach by which new and desirable recombinants can be isolated. Heterozygosity in hybrids offer broad genetic base for the mutagen to act upon in creating greater variability thereby providing much scope for selection. Hybrid seeds have been subjected to mutations with this objective in groundnut (Gregory, 1961), rice (Jalilmiah and Yamaguchi, 1965), cotton (Peter, 1976), brinjal (Gopimony, 1983) and okra (Cheriyan, 1986., Sheela, 1994 and Animon, 1996).

Okra is an important vegetable crop grown in the tropics. It is extensively cultivated in India, due to its wide range of adaptability and easiness for cultivation. But many of the okra cultivars now in vogue are highly susceptible to yellow vein mosaic disease which reduces the growth and yield of the crop considerably. Being a virus disease, transmitted by white fly (*Bemisia*

tabaci), a possible method of control is by use of insecticides to destroy the vector. But since the crop is adapted to alternate day harvest during fruiting period, application of insecticides after flowering will lead to problem of acute insecticide toxicity. Intervarietal breeding programmes have not been fully successful. A few varieties like Pusa Sawani, Kiran etc. which were tolerant to the disease initially are now susceptible to the disease. Interspecific hybridisation between disease resistant semi wild species and cultivated types of okra has been attempted in order to isolate high yielding disease resistant recombinants from among the segregating generations. Preponderance of yellow vein mosaic disease resistant plants having semi wild characters was obtained in interspecific crosses of okra involving *Abelmoschus manihot*, a semi wild resistant species and *Abelmoschus esculentus*, a cultivated type which is susceptible (Mathews, 1986).

Possibility of breaking strong linkage between the semi wild characters and YVM resistance in *A. manihot* through irradiation in F_1 seeds was suggested by earlier workers (Sheela, 1994 and Animon, 1996). The present study aimed to estimate the extent of variability generated in F_2M_2 and F_3M_3 generations as a result of hybrid irradiation of the interspecific hybrids between *A. esculentus* and *A. manihot* and to select high yielding yellow vein mosaic disease resistant types from among the variable populations so that it can ultimately be developed into a yellow vein mosaic disease resistant variety.


REVIEW OF
LITERATURE

2. REVIEW OF LITERATURE

Okra, commonly known as bhindi (*Abelmoschus esculentus* (L.) Moench) is one of the most important fruit vegetables grown throughout the tropics and subtropics of the world. Attempts have been made to evolve high yielding yellow vein mosaic disease resistant varieties through interspecific hybridisation, irradiation and recombination. A review of the reports on research in the above context is being attempted here.

2.1. Origin and taxonomy

Okra belongs to genus *Abelmoschus* which was established by Medikus (1787). However, most authors followed Candolle (1824) and treated it as a section of *Hibiscus*. It was Hochreutiner (1924) who reinstated the genus *Abelmoschus* stating that calyx, corolla and stamens are fused together at the base and fall as one piece after anthesis whereas in the case of *Hibiscus*, these are persistent.

Though the genus is of Asiatic origin, the origin of cultigen *A. esculentus* is variable-India (Masters, 1875), Ethiopia (Candolle, 1883; Vavilov, 1951); West Africa (Chevalier, 1940; Murdock, 1959) and tropical Asia (Grubben, 1977). According to Joshi and Hardas (1956) okra is believed to be polyphyletic in origin and might have originally been present in Africa and India.

Index Kewensis lists over 30 species of *Abelmoschus* in the old world, four in the new world and four in Australia. Waalkes (1966) has a more conservative point of view retaining only six species. These are *A. moschatus* Medikus, *A. manihot* (L.) Medikus, *A. esculentus* (L.) Moench, *A. ficulneus* (L.) Wt and Art. ex Wt, *A. crinitus* Wall. and *A. angulosus* Wall. ex Wt and Art. The former three species consisted of wild and cultivated forms and the latter three species consisted of wild forms only. Bates (1968) suggested some additional modifications like inclusion of *A. tuberculatus* and the grouping of all subspecies and varieties of *A. manihot*. The genus became more complex by the discovery of an African cultivated species by Siemonsma (1982) and described as *A. caillei* (Stevels, 1988). Based on the available cytogenetical evidence, the International Okra Workshop (1990) adopted a classification in which nine species were included in the genus *Abelmoschus*. This classification also included the new cultivated species *A. caillei* which was wrongly identified earlier as *A. manihot* ssp. *manihot*.

2.2. Cytogenetics of *Abelmoschus*

Joshi and Hardas (1956) reported that cultivated okra is allopolyploid in nature. The chromosome number of *A. esculentus*, has been reported to range from 2n = 66 to 144 (Siemonsma, 1982). However, the most frequently observed chromosome number was 2n = 130. The chromosome number of other species reported are 2n = 60 to 68 for *A. manihot*, 72 for *A. moschatus*, 72 for *A. ficulneus* and 130 to 138 for *A. tetraphyllus*. The highest number reported was close to 200 for *A. caillei* (Singh and Bhatnagar, 1975 and Siemonsma, 1982).

2.3. Yellow vein mosaic disease

Yellow vein mosaic is the most serious disease affecting okra. In India, the disease was first reported by Kulkarni (1924). The viral nature of the disease was first established by Uppal *et al.* (1940). The disease was first described by Capoor and Varma (1950). Varma (1952) studied the relationship of yellow vein mosaic virus and its vector, the white fly - *Bemisia tabaci*. The white flies could secure the virus after feeding for one hour on diseased plants and the viruliferous insects could transmit the virus to healthy plants after feeding on them for thirty minutes. Handa and Gupta (1993) reported that the causal agent of YVM disease of bhindi was gemini virus (18 x 30 mm) in size, which showed a close relationship to Indian cassava mosaic bigemini virus.

The loss in yield due to the virus ranged from 50 to 90 per cent depending on the stage of crop at which infection occurs. (Sastry and Singh, 1974). If the plants were affected in the early stages of growth, there was a total loss so far as yield and quality were concerned. Plants infected 50 and 65 days after germination, suffered a loss of 80 and 60 per cent respectively. Chelliah *et al.* (1975) reported that infection by virus in 30 days old crop resulted in 88 per cent loss in yield. Sinha and Chakraborti (1976) confirmed that the disease had an adverse effect on plant height, number of branches, number and size of fruits and seed yield. Atiri and Ibidapo (1989) reported that combined infection by okra mosaic virus and okra leaf curl virus reduced growth of okra more than when plants were affected singly by either virus.

2.4. Sources of resistance

Attempts to locate resistant sources to yellow vein mosaic disease were made by many scientists. The variability in the genus *Abelmoschus* in respect of mosaic resistance has been studied extensively at the IARI, New Delhi in 1948. Varietal resistance to yellow vein mosaic in *A. esculentus* was reported as rare.

Pal *et al.* (1952) reported that *A. tuberculatus* closely related to *A. esculentus*, was resistant to yellow vein mosaic virus and their hybrids were seedless or with empty seeds.

Nariani and Seth (1958) reported that *A. manihot* var. *pungens*, *A. crinitus*, *H. vitifolius* and *H. panduriformis* were immune to YVM virus.

Singh *et al.* (1962) reported that a line IC 1542 which consistently showed freedom from disease under field conditions was found to be a symptomless carrier of virus.

Sandhu *et al.* (1974) reported that resistance to YVM virus was confined to wild species, viz., *A. manihot*, *A. crinitus*, *A. moschatus* and *A. pungens*.

According to Arumugam *et al.* (1975) the two accessions of *Abelmoschus manihot* introduced from Africa and Japan, were highly resistant to yellow vein mosaic disease. The crosses made between *A. esculentus* and *A. manihot* yielded viable F_1 seeds. But there was 40 per cent sterility in the F_2 generation.

A. manihot ssp. *tetraphyllus* of okra was reported to be a promising source of resistance to yellow vein mosaic virus by Ugale *et al.* (1976) and Mamidwar *et al.* (1979).

Chelliah and Sreenivasan (1983) reported that *A. manihot* ssp. *tetraphyllus* and *A. manihot* were resistant to YVM virus.

Preliminary evaluation of okra types under research project on maintenance and evaluation of germplasm of crop plants in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani have revealed that a semi wild species *A. manihot* is completely resistant to yellow vein mosaic disease while twenty other cultivars in the germplasm were severely affected by the disease (KAU, 1983).

Dutta (1984) reported that *A. manihot* ssp. *tetraphyllus* was successfully used in the development of yellow vein mosaic resistant lines Sel-4 and Sel-10.

Rajamony *et al.* (1995) reported that *A. tetraphyllus, A. manihot* ssp. *tetraphyllus, A. ficulneus, A. moschatus* and a new collection, *Hibiscus huegelii* were resistant to the virus in the hot spot condition of the southern region of Kerala.

2.5. Interspecific hybridisation in okra

Okra is essentially a self pollinated crop. However due to its showy corolla, the possibility of cross pollination cannot be ruled out. The rate of

cross pollination has been reported to vary from 4 to 19 per cent (Purewal and Randhawa, 1947); 4 to 31.7 per cent (Venkitaramani, 1953); 20 per cent (Joshi and Hardas, 1956); 42.2 per cent (Mitidiery and Vencovsky, 1974) and 63 per cent (Martin, 1983). Engels and Chandel (1990) reported that depending on the species or variety, season and location, varying degrees of out crossing, upto 60 per cent occurs in okra.

Interspecific hybridisation has been carried out in this genus as early as 1930's. Teshima (1933) reported a successful cross between *A. esculentus* and *A. manihot*. Later, Chizaki (1934), Skovsted (1935), Ustinova (1937) and Singh *et al.* (1938) reported success of the same cross.

Pal *et al.* (1952) attempted to transfer the true resistance against the yellow vein mosaic disease of *A. manihot* var. *pungens* and symptomless type of resistance of *A. tuberculatus* to cultivated okra variety, Pusa Makhmali. In the case of crosses with *A. tuberculatus*, the F_1 hybrids were completely sterile and no viable seeds were obtained even from back crosses. They succeeded in overcoming seed sterility through the production of amphidiploids from F_1 hybrids, but were not free from yellow vein mosaic disease. Similarly the *A. manihot* var. *pungens* x *A. esculentus* hybrids also exhibited very high degree of sterility. The F_1 hybrids were vigorous but mostly sterile as most of the meiotic chromosomes remained as univalents.

Joshi and Hardas (1956) obtained a fertile plant from a colchicine treated sterile F_1 hybrid between *A. esculentus* (2n = 130) and *A. tuberculatus*. There

were 29 bivalents and 36 univalents in the F_1 hybrid. The cross was successful in both directions and produced vigorous but sterile F_1 hybrids. Thus it was postulated that *A. esculentus* (2n = 130) evolved through hybridisation between one species with n = 29 and another with n = 36 followed by doubling the chromosome number. The constant presence of the genome of *A. tuberculatus* in *A. esculentus* was noted.

Kuwada (1961) reported that the hybrid between *A. esculentus* and *A. manihot* was particularly sterile. Later, Kuwada (1966) found that the crosses between *A. esculentus* and *A. tuberculatus* were successful in both directions but the hybrids were completely sterile.

Gadwal *et al.* (1968) through embryo and ovule culture of hybrid embryos, obtained viable hybrids from cross combinations of *A. esculentus* x *A. moschatus*, *A. esculentus* x *A. ficulneus*, *A. tuberculatus* x *A. moschatus* and *A. ficulneus* x *A. moschatus*.

Joshi *et al.* (1974) reported that the F_1 hybrid between *A. esculentus* (n = 65) and *A. moschatus* (n = 36) through *in vitro* culture showed very little genomic affinity.

Kuwada (1974) reported that the hybridisation between *A. tuberculatus* and *A. manihot* was successful only when *A. tuberculatus* was used as 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 this accession and *A. tetraphyllus* were completely sterile.

Hossain and Chattopadhyay (1976) reported that the interspecific hybrids of *A. esculentus* and *A. ficulneus* were resistant to yellow vein mosaic but were self sterile and produced many fruits without seeds or with only rudimentary seeds and resembled their wild parent in several morphological characters.

A successful cross between *A. esculentus* and *A. tetraphyllus* was reported by Ugale *et al.* (1976). Almost perfect pairing of the genome of *A. esculentus* with the chromosomes of the other species was observed in the meiosis of the hybrid. One of its genomes manifested a good homology with *A. esculentus* and behaved like an amphidiploid.

Thakur (1976) reported that YVM resistance in an interspecific cross involving *A. esculentus* cv. Pusa Sawani and *A. manihot* ssp. *manihot* cv. Ghana was conditioned by two dominant complementary genes.

Arumugam and Muthukrishnan (1978) reported that F_1s of crosses involving two wild forms of *A. manihot* and two susceptible cultivars of *A. esculentus* namely Pusa Sawani and Co-1 were resistant to yellow vein mosaic virus. They also obtained good recombinants from F_2 and F_3 generations.

Mamidwar *et al.* (1979) observed reciprocal differences in crosses between *A. esculentus* and wild forms of *A. manihot* and *A. tetraphyllus*. The fruit set was highest when *A. esculentus* was used as the female parent. The hybrids produced seedless fruits or fruits with shrivelled seeds.

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

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

Jambhale and Nerkar (1982) induced amphidiploidy in the F_1 hybrid between *A. esculentus* (n = 65) and *A. tetraphyllus* (n = 69) to overcome sterility. They also reported colchicine induced amphidiploidy in the cross *A. esculentus* (2n = 130) x *A. manihot* ssp. *manihot* (2n = 194).

Martin (1982) reported interspecific hybrids between unnamed West African species of *Abelmoschus* and *A. esculentus*. The F_1 hybrids were comparatively sterile but a few produced germinable seeds. Back crosses were more fertile with almost complete fertility in BC_2.

Siemonsma (1982) reported two distinct types of okra called Soudanien and Guineen type. Soudanien corresponded to botanical descriptions and previously reported chromosome numbers of *A. esculentus*. Guineen was

thought to be a natural amphidiploid of *A. esculentus* (2n = 130 to 144) and *A. manihot* (2n = 60 to 68) and had 2n = 185 to 199. Soudanien and Guineen types crossed readily in both directions and the progenies were intermediate in character.

Jambhale and Nerkar (1983) identified some plants resistant to yellow vein mosaic virus which were obtained from back crosses of *A. esculentus* x *A. manihot* to *A. esculentus* cv. Pusa Sawani. Seed fertility in the plants was 58 to 88 per cent.

Sharma and Dhillon (1983) reported that YVM virus was controlled by two dominant complementary genes with additive effects based on their studies on the genetics of resistance to YVM from the segregation of back crosses of *A. esculentus* x *A. manihot*. They also suggested that genes responsible for resistance to virus were sensitive to environmental changes. Therefore the possibility that resistance to YVM virus in *A. manihot* ssp. *manihot* is conditioned by polygenes cannot be ruled out.

In an interspecific breeding programme between *A. esculentus* and *A. manihot*, Sujatha (1983) observed high degree of pollen fertility (33.4 to 64.5 per cent) in the hybrids but there was hardly any seed set. The seeds if at all formed were shrivelled and small in size.

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 KS-17. But none outyielded the highest yielding parent KS-17.

Nerkar and Jambhale (1985) crossed *A. tetraphyllus*, *A. manihot* and *A. manihot* ssp. *manihot* with the cultivated okra *A. esculentus* cv. Pusa Sawani. Approaches of growing straight generation, back crossing and use of amphidiploidy were followed. They developed nine resistant lines with good agronomic traits and consumer qualities.

Cheriyan (1986) found that *A. manihot* and *A. manihot* ssp. *tetraphyllus* were cross compatible with *A. esculentus*. But the F_1 plants did not bear normal seeds and the pollen fertility of the hybrids was much lower than the parents. There was preponderance of characters of wild species in the interspecific hybrids.

Mathews (1986) observed preponderance of low yielding YVM resistant plants similar to semiwild parent among the F_2 population of the interspecific hybrids between the YVM susceptible cultivars of *A. esculentus* and YVM resistant semi wild species of *A. manihot*. Varying degrees of sterility were observed in the F_2 progenies. He also reported high phenotypic and genotypic coefficients of variation for weight of fruits per plant, number of leaves per plant and height of plant.

Prabha (1986) found that the interspecific crosses between the two species mentioned above were cross compatible with absence of total hybrid

sterility. The hybrids also inherited YVM disease resistance. But viable seed recovery was low in hybrids, because of cytogenetic disturbances arising out of chromosomal differentiation that has taken place during speciation.

Fatokun (1987) reported successful crosses between two cultivars from each of the *A. esculentus* varietal groups Soudanien and Guineen. The hybrids showed meiotic abnormalities which resulted in production of microspores of variable size. Pollen viability was low (35.8 and 39.4 per cent) and only few seeds were produced.

Sureshbabu (1987) reported vigorous F_1 hybrid between *A. esculentus* and *A. manihot* ssp. *tetraphyllus* var. *tetraphyllus*. Sterility in the hybrid was attributed to the failure of development of female gamete.

Bhargava (1989) reported embryo deterioration in ovules resulting from crosses between *A. manihot* and *A. esculentus* and that it started five days after pollination and was accompanied by reduction in ovule weight.

Kondaiah *et al.* (1990) made reciprocal crosses between *A. manihot* ssp. *manihot* and *A. tetraphyllus* and also between *A. manihot* ssp. *manihot* and induced amphidiploid of (1) *A. esculentus* x *A. tetraphyllus* and (2) *A. esculentus* x *A. manihot*. The study revealed that *A. manihot* ssp. *manihot* (hexaploid) contained two genomes from *A. tetraphyllus* and a third from *A. manihot*.

Swamy and Khanna (1991) studied pollen grain formation and pollen tube growth following interspecific pollination and reported that failure of seed

formation might be due to slowness of pollen tube growth, abnormal pollen tube, collapse of fertilised ovules or sparsity of pollen grains.

Sheela (1994) attempted to transfer YVM resistance from wild relatives namely *A. caillei* Stevels and *A. manihot* ssp. *tetraphyllus* to the cultivated varieties. She observed preponderance of low yielding YVM resistant plants similar to the donor parents among F_2 and F_2M_2 populations indicating the presence of powerful genetic mechanisms preventing recombination. Proportion of recombinants was higher in F_2M_2 populations indicating breakage of undesirable linkages through irradiation.

In interspecific crosses between the cultivated species *A. esculentus* and wild types viz., *A. moschatus, A. tetraphyllus* and *A. manihot*, Chandran and Rajamony (1997) observed that fruit set was higher when the cultivated type was used as the female parent. Percentage of viable seeds was low in all crossed fruits than parents except in the cross *A. esculentus* cv. Kiran x *A. manihot* which might be due to complete or partial failure of endosperm development.

2.6. Achievements

Varietal resistance to YVM in *A. esculentus* is rare. The earliest 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 okra.

However, the widely cultivated variety has lost this resistant reaction due to various genetic and agroclimatic factors.

The lack of varietal resistance to YVM prompted scientists to evolve resistant varieties through interspecific hybridisation. Punjab Padmini, an yellow vein mosaic disease resistant variety had been evolved as a result of interspecific hybridisation between *A. esculentus* and *A. manihot* ssp. *manihot* (Sharma, 1982).

Maharashtra State Seed Committee released another YVM disease resistant variety 'Parbhani Kranti' in 1985 which was derived from the backcrosses of *A. manihot* to *A. esculentus* cv. Pusa Sawani (Jambhale and Nerkar, 1986).

An YVM virus resistant variety P-7 was evolved from a cross between *A. esculentus* cv. Pusa Sawani and *A. manihot* ssp. *manihot*. The F_1 was backcrossed to Pusa Sawani four times and selection was followed in the selfing generations upto F_8 (Thakur and Arora, 1988).

Selections from IIHR, Bangalore viz., Selection-4, Selection-7, Selection-9, Selection-10 and Selection-12 possessed YVM disease resistance and was derived from a wild species *A. manihot* var. *tetraphyllus* (Marckose and Peter, 1990). Two varieties namely Arka Anamika and Arka Abhay resistant to YVM disease was evolved at IIHR, through interspecific hybridisation using *A. manihot* ssp. *tetraphyllus*. These varieties have been recommended for release

at National Level (Arka Anamika) and State Level (Arka Abhay) cultivation (IIHR, 1991).

2.7. Variability through induced mutation in okra

The effect of irradiation in inducing recombination through the breakage of undesirable linkages has been reported by several workers.

Kuwada (1967) induced resistance to phytophthora in *A. manihot* by irradiating seeds with ^{60}Co gamma rays and X-rays. Variability induced by X-ray mutation in okra has also been reported by Kuwada (1970).

Nandapuri *et al.* (1971) reported increased variation in plant height, number of days to flowering and yield on gamma irradiation of seeds of okra. One bushy mutant was also isolated.

Rao and Giriraj (1975) reported the effect of irradiation on seedling characters in okra (*A. esculentus*). He noticed low germination as well as shorter seedlings with thicker and darker leaves in M_2.

Thandapani *et al.* (1978) released a mutant variety, MDU-2 produced by treating seeds of Pusa Sawani with diethyl sulphoxide. The mutant showed a higher level of resistance to yellow vein mosaic than Pusa Sawani, under field conditions during winter season. The mutant was shorter than Pusa Sawani due to reduction in internodal length. More number of fruits per plant as well as increased weight of fruit contributed to increased yield.

Jambhale and Nerkar (1980) isolated an induced leaf mutant in M_2 following gamma irradiation of *A. esculentus* cultivar Pusa Sawani characterised by the presence of three to five leaflets on most of the leaves, small leaves and flowers, basal branching, dwarf habit and small fruits with six to seven ridges.

Nirmala (1982) induced variability in wild species of *Abelmoschus manihot* using 10, 15 and 20 kR gamma radiation. Vigour due to irradiation for plant height, internodal length and length of leaves was significant irrespective of the doses of radiation. Maximum variability was observed for fruit yield per plant.

Abraham and Bhatia (1984) reported that highest mutation rates in okra occured with 60 to 80 kR gamma rays.

Jambhale and Nerkar (1984) identified a mutant with fruits bearing stiff prickly trichomes in the *H. esculentus* variety Vaishali Vadhu by treatment of seeds with 40 kR gamma rays. Crosses of M_3 mutant with normal plants of Vaishali Vadhu indicated that presence of trichomes is controlled by a single incompletely dominant gene designated as sf.

Abraham (1985) isolated a mutant having the characteristics of *A. tetraphyllus* showing resistance to yellow vein mosaic disease from the M_2 generation of irradiated *A. esculentus* varieties and observed that the hybrids were more sensitive to mutation compared to varietal seeds.

Krishna (1985) treated okra seeds with 10, 20, 30, 40, 50 and 60 kR gamma rays to induce variability. In M_2 there was a progressive decline in mean values for most of the characters depending on doses. Pollen and seed sterility were high in higher doses of mutagen treatments.

Cheriyan (1986) reported considerable variability in interspecific hybrids involving *A. esculentus* and *A. manihot* by gamma irradiation. Irradiation produced considerable changes in dominant characters like branched habit, pubescence and pigmentation of vegetative parts. Gamma irradiation enhanced pollen fertility of interspecific hybrids and suggested that higher doses above 25 kr should be used to create wider variability in interspecific hybrids.

Regina (1986) reported higher variability in okra through gamma irradiation in M_4 generation than in M_2 generation. The irradiated hybrids showed maximum positive variability.

Jeevanandam *et al.* (1987) irradiated seeds of strain AE-7 of *A. esculentus* with gamma rays at 10, 20, 30, 40, 50 and 60 kR. The seeds of M_1 generation were either forwarded to M_2 or again exposed to 20 kR of gamma rays or presoaked in water for four hours and treated with 0.05 per cent EMS. The effectiveness of treatment and number of viable mutants increased with increasing doses of gamma rays upto 40 kr in all the three treatments.

Kulkarni and Nerkar (1992) identified an induced mutant 'Parbhani Tillu' suitable for fruit processing by gamma irradiation of seeds of okra (*A.*

esculentus) with a dose of 40 kR. The short fruit mutant was isolated from M_2 generation. The fruits do not break and retain acceptable fruit texture after freezing. The mutant was also characterised by short stature and small leaves with shallow leaf lobules.

Sheela (1994) studied the effect of radiation on the hybrid seeds of interspecific crosses between *A. caillei* and *A. tetraphyllus* with *A. esculentus*. She reported that a radiation dose of 60 kR was optimum for inducing breaks in closely linked genes so as to release the variability present in the interspecific hybrids for effecting selection of resistant types. The segregants resembled wild parents with regard to yellow vein mosaic resistance. Majority of the segregants showed complete resistance under heavy epidemic condition. She suggested the selection of early flowering types with increased fruit weight for enhancing the level of YVM disease resistance. She also observed a general reduction in the mean values of the important yield components like number of flowers, number of fruits and average fruit weight in the segregating generations due to the presence of sterile weak plants in the progeny. Maximum number of recombinants were identified in the irradiated crosses of *A. caillei* and cultivated parent *A. esculentus* (Anakkompan and Eanivenda).

Animon (1996) reported that the irradiated interspecific hybrid between *A. esculentus* x *A. manihot* represented more towards the semi wild parent for most economic characters. Not much difference was noticed among irradiated and unirradiated hybrids with respect to yield contributing characters like number

of flowers per plant, number of fruits per plant and fruit weight. All the hybrid treatments were found to be giving high yields and had resistance to YVM disease. Increase in radiation dose decreased germination percentage and survival rate. Delayed formation of flowers and fruits was noticed on irradiation of the hybrids.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study was undertaken in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 1996-97 to estimate the variability generated by hybridisation and hybrid irradiation in the F_2, F_2M_2, F_3 and F_3M_3 generations of okra (*Abelmoschus* spp.) and to isolate high yielding yellow vein mosaic disease resistant lines from among the segregating generations.

3.1. Materials

The present study was undertaken as a continuation of a previous investigation conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani wherein the parents, Kiran - a high yielding locally adapted *Abelmoschus esculentus* cultivar and *A. manihot*, a YVM disease resistant semi wild species were crossed, the hybrid seeds irradiated and F_1 studied. The selfed seeds obtained from the parents, F_1 and F_1M_1 plants of the above experiment were used to raise the F_2 and F_2M_2 generations in the present study. Recombinants of high fruit yield and YVM disease resistance from the F_2 and F_2M_2 generations were selected, selfed and the seeds used to raise the F_3 and F_3M_3 generation along with the parents.

3.2. Methods

3.2.1. Evaluation of the F_2 and F_2M_2 progenies

A field experiment was laid out in a Compact Family Block Design with seven treatments, five replications and ten progeny rows per treatment. Each progeny row consisted ten plants. The purpose of the experiment was to evaluate the F_2 (unirradiated) and F_2M_2 progenies from the four radiation treatments (10 kR, 20 kR, 30 kR and 40 kR) along with the parents. The details are furnished below

Treatment	Progeny rows
0 kR	1 to 10
10 kR	11 to 20
20 kR	21 to 30
30 kR	31 to 40
40 kR	41 to 50
Kiran (P_1)	51 to 60
A. manihot (P_2)	61 to 70

3.2.2. Evaluation of F_3 and F_3M_3 progenies

Plants with high fruit yield and YVM disease resistance were selected from the F_2 and F_2M_2 generation and selfed. The selfed seeds collected from

the F_2 and F_2M_2 progenies as well as from the two parents were utilised to raise the F_3 and F_3M_3 progenies. A field experiment was laid out in Compact Family Block Design with seven treatments, five replications, ten progeny rows per treatment and each progeny row consisting of ten plants inorder to evaluate the F_3 and F_3M_3 progenies. The details are furnished below.

Treatment	Progeny rows
0 kR	1-3, 2-4, 4-1, 4-4, 5-3, 6-3, 6-4, 7-2, 9-3, 10-2
10 kR	15-3, 15-4, 16-2, 16-3, 17-4, 17-5, 19-1, 19-2, 19-3, 19-4
20 kR	22-4, 23-1, 23-7, 24-6, 26-1, 27-4, 27-5, 29-4, 30-3, 30-6
30 kR	32-1, 33-4, 33-5, 35-1, 35-2, 35-3, 35-4, 35-8, 36-1, 40-6
40 kR	41-2, 42-4, 43-1, 43-2, 43-4, 44-3, 45-1, 46-2, 46-3, 46-4
Kiran (P_1)	51-3, 53-4, 53-6, 54-2, 55-4, 55-5, 56-2, 57-4, 58-3, 58-5
A. manihot (P_2)	61-1, 61-3, 62-4, 63-3, 64-3, 64-4, 65-4, 66-2, 67-3, 68-2

The crop was raised under insecticide free condition and susceptible check Kilichundan was grown as border plants for both the experiments. All agronomic practices except insecticidal sprays were followed as per the Package of Practices Recommendations (1993) of Kerala Agricultural University.

plants each were selected at random in each progeny row per replication for recording the observations.

3.3.1. Days to first flowering

The number of days taken from sowing to the first flower opening was recorded.

3.3.2. Leaf axil bearing the first flower

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

3.3.3. Leaf number

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

3.3.4. Leaf area

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

3.3.5. Number of branches per plant

The total number of primary branches in each plant was counted at final harvest and recorded.

3.3.6. Number of flowers per plant

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

3.3.7. Pollen sterility

Stainability with 1:1 glycerine acetocarmine was used as the criterion to assess pollen sterility. Mature flower buds produced during early part of flowering period were selected. Unstained, undersized, partially stained and shrivelled pollen grains were scored as sterile and uniformly stained properly filled pollen as fertile. In each of the slides, ten microscopic fields were scored and data recorded. Pollen sterility of each plant was estimated as percentage of the number of sterile pollen grains to the total number of pollen grains scored.

3.3.8. First fruiting node

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

3.3.9. Number of fruits per plant

The total number of fruits produced from each plant was counted and recorded.

3.3.10. Average fruit weight

Weight of each fruit was taken at the time of harvest and mean expressed in grams.

3.3.11. Weight of fruits per plant

Weight of fruits per plant was calculated from the product of average fruit weight and number of fruits per plant and expressed in grams.

3.3.12. Length of fruit

Length of fruit was measured from the base to the tip on the third, sixth and ninth node in each plant and expressed in centimetres.

3.3.13. Girth of fruit

The fruits used for recording the length were used for recording the girth. The girth was measured at the middle portion of the fruit and mean expressed in centimetres.

3.3.14. Number of seeds per fruit

Seeds were extracted from each of the fruits of which length and girth were measured and mean number of seeds recorded.

3.3.15. Number of ridges per fruit

The number of ridges per fruit was counted and recorded.

3.3.16. Fruiting phase

The duration between the first harvest and the final harvest in each treatment was recorded in days.

3.3.17. Height of the plant

Height of the plant from the ground level to the tip was measured after the last harvest and expressed in centimetres.

3.3.18. Incidence of YVM disease

The rating scale by Arumugam *et al.* (1975) was used for scoring yellow vein mosaic intensity. The scoring was done according to the characteristic symptoms appearing on the leaves or the fruits of each observational plant. The disease rating mean of each treatment in a replication was calculated as follows :

$$\text{Mean disease Rating} = \frac{\text{Sum of disease scores in the observational plants}}{\text{Number of plants}}$$

Table 1. Yellow vein mosaic disease rating scale

Sl. No.	Symptom	Grade	Rating scale
1.	No visible symptom characteristic of the disease	Highly resistant	1
2.	Very mild symptoms, basal half of 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
3.	Veins and veinlets turn completely yellow	Moderately resistant	3
4.	Pronounced yellowing of veins and veinlets. 50 % of leaf lamina turn yellow, fruits exhibit slight yellowing	Susceptible	4
5.	Petioles, veins, veinlets and interveinal area turn yellow in colour. Leaves start drying from margin. Fruits turn yellow in colour	Highly susceptible	5

3.3.19. Incidence of fruit and shoot borer

Infestation on the fruit and shoot by fruit and shoot borer (*Earias vitella* F.) in the observational plants was recorded, averaged and expressed in percentage.

3.3.20. Duration of the plant

The number of days taken from the day of sowing till the last harvest was recorded.

3.4. Statistical analysis

The data collected from the experiments were recorded separately for all the main items of study and subjected to statistical analysis.

3.4.1. Analysis of variance

Analysis of variance was done as per the design (Panse and Sukhatme, 1957) for the comparison among the different treatments, among the progenies within the treatments and to estimate variance components.

Table 2. ANOVA for the Compact Family Block Design

Source of variation	Between families (treatments)		Between progenies within families (treatments)			
	df	MS	df			MS
				1	2	*f*
Blocks	(r-1)	S^2b	(r-1)	S^2b_1	S^2b_2	S^2b_f
Families (treatments)	(*f*-1)	S^2f	(p-1)	S^2p_1	S^2p_2	S^2p_f
Error	(r-1) (*f*-1)	S^2e	(r-1) (p-1)	S^2e_1	S^2e_2	S^2e_f

When the error variances were found homogenous, the following pooled ANOVA was done.

Table 3. Pooled ANOVA for the Compact Family Block Design

Source of variation	df	MS
Blocks	(r-1)	S^2b
Families (treatments)	(f-1)	S^2f
Error (a)	(r-1) (f-1)	S^2ea
Progeny within families (treatments)	f (p-1)	S^2p
Error (b)	f (r-1) (p-1)	S^2eb
Total	f pr-1	

For different comparisons, the standard errors were computed as follows :

1. SE of difference between family means $= \sqrt{\frac{2S^2_{ea}}{rp}}$

2. SE of difference between two progeny means in the same family

$$= \sqrt{\frac{2S^2_{eb}}{r}}$$

3. SE of difference between two progeny means belonging to different families

$$= \sqrt{\frac{2\,[\,S^2_{ea} + (p-1)\,S^2_{eb}\,]}{pr}}$$

3.4.1. Estimation of variance components

Genotypic variance $(\hat{\sigma^2 g_i}) = \dfrac{SP^2_i - SP^2_{ei}}{r}$

Environmental variance $(\hat{\sigma^2 e_i}) = S^2_{ei}$

Phenotypic variance $(\hat{\sigma^2 p_i}) = \sigma^2 g_i + \sigma^2 e_i$

3.4.2. Coefficient of variation

Phenotypic and genotypic coefficients of variation (PCV and GCV) were estimated as

$$GCV = \frac{\sigma g_i}{\bar{x}_i} \times 100$$

$$PCV = \frac{\sigma p_i}{\bar{x}_i} \times 100$$

where σg_i = genotypic standard deviation of the variable x_i

σp_i = phenotypic standard deviation of the variable x_i

$\bar{x}_i$ = mean of the character x_i

3.4.3. Heritability (Broad sense)

$$H^2 = \frac{\sigma^2 g_i}{\sigma^2 p_i} \times 100$$

where H^2 is the heritability expressed in percentage (Jain, 1982).

3.4.4. Genetic advance under selection

$$GA = k H^2 \sigma p_i \text{ (Allard, 1960)}$$

where GA = Genetic advance

k = Selection differential

= 2.06 at 5 per cent selection in large samples

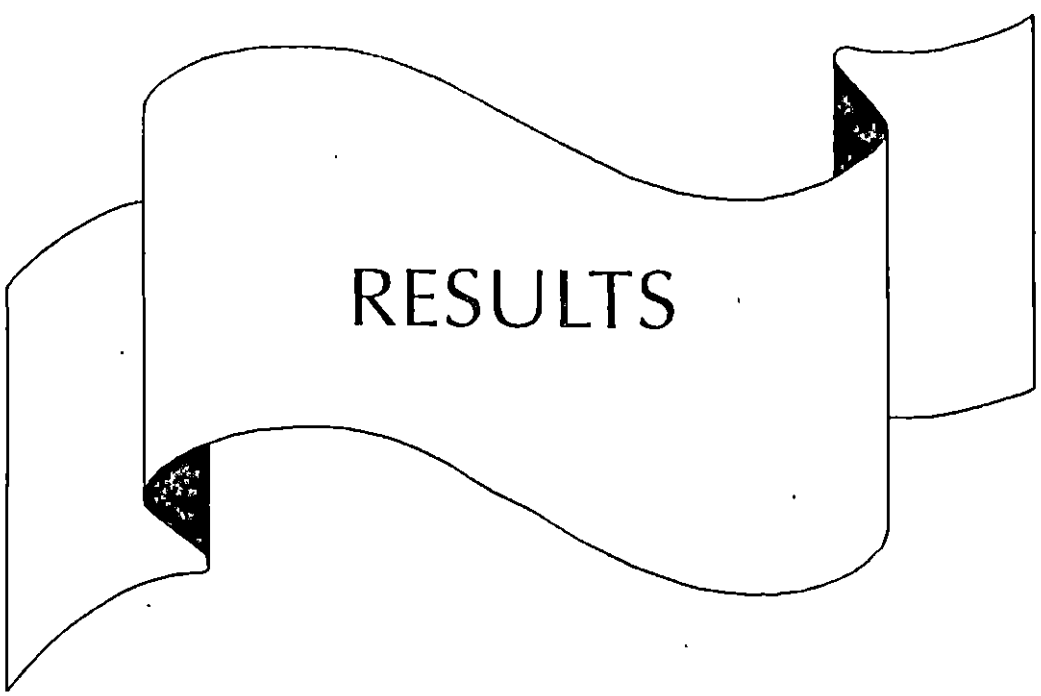
3.4.5. Correlation

$$\text{Phenotypic correlation } (r_{pxy}) = \frac{\sigma_{pxy}}{\sigma_{px} \times \sigma_{py}}$$

where σ_{pxy} = phenotypic covariance of characters x and y

σ_{px} = phenotypic standard deviation of character x

σ_{py} = phenotypic standard deviation of character y


RESULTS

4. RESULTS

The data collected from the experiments were tabulated and were subjected to statistical analysis. Phenotypic and genotypic coefficients of variation, heritability in the broad sense, genetic advance and correlation were computed for the different characters under study. The results obtained are presented below.

4.1. Evaluation of the F_2M_2 generation

Analysis of variance of the different characters studied showed that the treatments differed significantly among themselves for all the characters (Table 4). The mean values of the different treatments as well as the progenies with respect to each character are presented in tables 5 to 24. The variability observed for the plant characters are presented in figures 1 to 10.

4.1.1. Days to first flowering

Significant difference in the number of days to first flowering was observed among the treatments. The mean number of days taken for first flowering was minimum for the cultivated parent Kiran (44.35) and maximum in 30 kR (54.12). Progeny differences were significant within the treatments 20 kR and 30 kR.

Table 4. Pooled ANOVA of 20 characters for the seven treatments in F_2M_2

Sl. No.	Character	Mean Square			
		Replication df = 4	Family df = 6	Error df = 24	$F_{6,24}$
1.	Days to first flowering	5.45	622.53	7.03	88.87**
2.	Leaf axil bearing first flower	0.30	41.72	1.35	30.91**
3.	Leaf number	85.78	2489.08	28.20	88.27**
4.	Leaf area	728.50	116638.70	1504.17	77.54**
5.	Number of branches per plant	1.26	8.84	0.29	30.61**
6.	Number of flowers per plant	39.98	1652.51	11.98	137.96**
7.	Pollen sterility	60.04	7502.31	12.29	610.49**
8.	First fruiting node	2.08	87.63	1.36	64.63**
9.	Number of fruits per plant	8.07	1255.43	9.59	130.87**
10.	Average fruit weight	34.43	250.18	8.68	28.83**
11.	Weight of fruits per plant	5645.50	151376.00	5449.71	27.78**
12.	Length of fruit	4.49	168.07	1.84	91.32**
13.	Girth of fruit	1.31	62.94	0.69	91.08**
14.	Number of seeds per fruit	91.93	22012.18	58.66	375.26**
15.	Number of ridges per fruit	0.14	47.70	0.29	160.08**
16.	Fruiting phase	41.00	7515.21	41.40	181.55**
17.	Height of plant	225.88	7296.75	253.10	28.83**
18.	Incidence of YVM disease	0.04	1.41	0.06	24.95**
19.	Incidence of fruit and shoot borer	0.06	18.80	0.06	326.37**
20.	Duration of plant	9.88	9177.75	40.10	228.84**

** Significant at 1 percent level

In 20 kR the mean number of days taken to first flowering ranged from 49.54 to 57.10 and in 30 kR, it ranged from 45.88 to 59.50 (Table 5).

4.1.2. Leaf axil bearing the first flower

Leaf axil bearing the first flower varied significantly among the treatments (Table 6). The mean values ranged from 4.73 in the cultivated parent to 7.32 in 10 kR and the semi wild parent. The unirradiated treatment, 0 kR (6.08) was on par with 20 kR (6.46), which in turn was found to be on par with 40 kR (6.73) also. Progeny differences were significant within treatments 20 kR, 30 kR and P_1. The mean values ranged from 5.68 to 7.32 in 20 kR, 4.52 to 7.32 in 30 kR and 4.24 to 5.28 in the parent Kiran.

4.1.3. Leaf number

Significant variation in the number of leaves per plants was observed among the treatments (Table 7). The average number of leaves ranged from 19.81 (0 kR) to 40.64 (20 kR). The treatments 10 kR (27.02) and 30 kR (28.71) were on par, while 40 kR (24.13) was on par with P_2 (23.85). Progeny differences were observed within the treatments 10 kR, 20 kR, 30 kR and P_1. Maximum variability was observed among the progenies in 20 kR where the average number of leaves ranged from 16.52 to 167.88. The mean values ranged from 19.08 to 32.60 in 10 kR, 20.28 to 67.04 in 30 kR, 19.12 to 21.96 in P_1.

Table 5. Days to first flowering in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	49.88	48.76	51.62	59.50	52.73	43.98	53.26
2.	48.60	50.98	49.54	54.40	53.20	43.86	54.80
3.	49.20	53.28	52.76	50.98	54.08	43.68	51.30
4.	50.58	53.82	52.20	56.70	53.78	44.54	50.40
5.	48.48	52.02	52.54	45.88	55.00	45.00	56.28
6.	48.30	52.20	57.10	48.92	52.00	43.80	52.36
7.	47.48	53.32	54.48	58.08	53.80	44.14	54.42
8.	45.06	49.40	49.72	57.66	53.88	44.36	52.14
9.	50.56	51.84	52.84	53.46	55.36	43.44	52.28
10.	46.72	53.06	50.98	55.62	53.30	46.08	53.88
Mean	48.49	51.87	52.38	54.12	53.72	44.35	53.12
$F_{9,36}$	1.71	1.62	2.37*	15.95**	0.74	0.62	1.91
SE							
Progenies	1.872	1.886	2.048	1.544	1.632	1.542	1.795
Treatments	0.530						
Bartlett's X^2_6 for error variances	5.17						

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 6. Leaf axil bearing the first flower in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	5.72	7.36	6.80	7.32	6.32	4.28	7.20
2.	5.88	7.76	7.32	6.88	6.72	4.60	7.72
3.	6.52	7.32	5.68	4.96	6.40	4.84	7.12
4.	6.32	7.32	6.36	6.00	6.52	4.24	7.76
5.	6.52	7.80	7.12	5.84	6.96	4.92	7.28
6.	6.12	7.52	6.04	5.52	7.18	4.40	6.76
7.	6.24	6.88	6.48	5.80	7.08	4.80	7.80
8.	6.08	7.16	6.48	5.56	6.80	5.28	6.84
9.	6.04	7.00	5.96	5.88	6.72	5.00	7.40
10.	5.36	7.08	6.36	4.52	6.64	4.98	7.36
Mean	6.08	7.32	6.46	5.83	6.73	4.73	7.32
$F_{9,36}$	1.42	0.88	4.23**	11.70**	0.45	2.32*	2.07
SE							
Progenies	0.426	0.462	0.351	0.338	0.595	0.318	0.357
Treatments	0.232						
Bartlett's X^2_6 for error variances	23.26**						

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 7. Leaf number in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	22.92	30.48	25.22	22.21	31.44	20.00	24.08
2.	19.56	28.84	26.52	22.16	21.92	21.02	25.70
3.	19.76	19.08	24.36	23.68	24.96	20.16	26.20
4.	20.60	21.95	22.32	31.60	22.00	19.12	24.20
5.	19.52	32.60	27.08	21.32	23.36	19.28	23.40
6.	19.60	27.84	167.88	20.28	22.08	20.08	24.32
7.	19.88	28.52	16.96	23.96	21.44	20.48	23.00
8.	19.52	23.32	60.58	67.04	24.36	21.00	23.46
9.	19.04	28.40	19.00	28.56	21.88	21.76	21.72
10.	17.68	29.16	16.52	26.28	28.28	21.96	22.40
Mean	19.81	27.02	40.64	28.71	24.13	20.49	23.85
$F_{9,36}$	1.03	4.39**	359.04**	29.67**	1.50	3.12**	1.47
SE							
Progenies	1.845	2.831	3.467	3.608	3.798	0.763	1.605
Treatments	1.062						
Bartlett's X^2_6 for error variances	103.50**						

** Significant at 1 per cent level

4.1.4. Leaf area

Significant differences in leaf area were observed among the treatments (Table 8). The leaf area was highest in 40 kR (335.01 cm^2) and least in 0 kR (214.62 cm^2). The treatment 10 kR (290.39 cm^2) was on par with 30 kR (283.50 cm^2) while 40 kR (335.01 cm^2) was on par with P_2 (328.63 cm^2). Significant differences among the progenies were also observed within the treatments 0 kR, 10 kR, 20 kR, 30 kR and 40 kR. The average leaf area ranged from 161.76 to 246.80 cm^2 in 0 kR, 180.32 to 483.50 cm^2 in 10 kR, 86.60 to 340.16 cm^2 in 20 kR, 105.60 to 486.20 cm^2 in 30 kR and 239.88 to 424.52 cm^2 in 40 kR.

4.1.5. Number of branches per plant

Table 9 showed that the number of branches per plant was significantly different among the treatments. The average number of branches per plant ranged from 0.23 in the parent Kiran to 1.27 in 30 kR. The treatments 20 kR and 30 kR were on par, while the treatments 0 kR, 10 kR, and P_2 were also found to be on par. Progeny differences were observed within the irradiated treatments. The mean values ranged from 0.09 to 1.16 in 10 kR, 0.20 to 7.92 in 20 kR, 0.12 to 6.23 in 30 kR and 0.12 to 3.90 in 40 kR.

4.1.6. Number of flowers per plant

Table 10 showed that the number of flowers per plant varied significantly among the treatments. It was highest for 20 kR (30.79) and lowest for 0 kR (13.72).

Table 8. Leaf area (cm^2) in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	246.80	238.36	250.77	289.96	384.22	235.36	325.04
2.	244.56	180.32	252.56	255.48	424.52	213.12	341.92
3.	222.88	239.12	242.52	364.96	327.04	232.20	329.36
4.	246.24	254.26	229.00	201.04	293.52	216.80	309.32
5.	161.76	246.68	305.78	255.62	330.04	190.32	341.28
6.	208.60	461.66	86.60	154.52	421.28	223.64	317.92
7.	221.00	276.84	340.16	382.56	326.92	224.62	310.12
8.	177.36	483.50	128.33	105.60	239.88	230.36	321.20
9.	230.00	287.72	311.41	342.08	285.04	245.80	343.80
10.	186.96	235.40	287.76	486.20	317.60	230.28	346.32
Mean	214.62	290.39	243.49	283.50	335.01	224.25	328.63
$F_{9,36}$	6.38**	43.17**	54.23**	63.61**	27.88**	1.15	0.41
SE							
Progenies	16.965	21.580	15.418	20.272	15.871	19.903	31.048
Treatments	7.888						
Bartlett's X^2_6 for error variances	28.04**						

** Significant at 1 per cent level

Table 9. Number of branches per plant in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	0.72	0.20	0.48	0.35	3.90	0.16	0.24
2.	0.20	0.20	0.24	0.12	0.52	0.26	0.44
3.	0.56	0.16	0.36	0.40	0.40	0.48	0.34
4.	0.28	0.09	0.20	0.28	0.32	0.20	0.44
5.	0.60	1.16	0.20	0.60	0.24	0.36	0.40
6.	0.96	0.20	7.92	1.00	0.24	0.12	0.54
7.	0.16	0.68	0.36	0.43	0.12	0.24	0.52
8.	0.24	0.20	2.07	6.23	0.24	0.00	0.20
9.	0.16	0.24	0.33	1.02	0.12	0.16	0.42
10.	0.80	0.56	0.20	2.25	0.12	0.30	0.84
Mean	0.47	0.37	1.24	1.27	0.62	0.23	0.44
$F_{9,36}$	2.07	12.08**	173.16**	38.35**	34.65**	1.62	1.03
SE							
Progenies	0.291	0.136	0.259	0.422	0.278	0.148	0.247
Treatments	0.108						
Bartlett's. X^2_6 for error variances	61.31**						

** Significant at 1 per cent level

Table 10. Number of flowers per plant in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	15.64	17.36	16.04	14.33	22.48	14.68	16.24
2.	13.40	22.00	17.92	15.00	15.80	15.22	17.18
3.	13.08	14.04	16.92	16.84	16.40	13.94	18.52
4.	12.74	13.92	14.00	20.08	14.96	13.72	15.84
5.	12.92	24.68	18.12	15.16	13.72	13.20	16.60
6.	13.92	20.12	143.48	14.20	16.64	14.80	16.52
7.	14.08	20.44	10.72	16.44	14.64	15.12	16.24
8.	14.88	17.36	48.68	51.39	17.92	15.16	16.12
9.	13.92	17.96	11.84	17.04	14.48	15.40	14.40
10.	12.64	19.76	10.16	18.72	20.72	16.08	13.92
Mean	13.72	18.76	30.79	19.92	16.78	14.73	16.16
$F_{9,36}$	1.05	3.45**	268.69**	28.46**	2.83*	2.29*	1.41
SE							
Progenies	1.342	2.556	3.549	2.974	2.396	0.814	1.545
Treatments	0.704						
Bartlett's X^2_6 for error variances	92.15**						

** Significant at 1 per cent level

Progeny differences were observed within the irradiated treatments and the cultivated parent. In 10 kR the average number of flowers ranged from 13.92 to 24.68, while in 20 kR the range was from 10.16 to 143.48. The mean values ranged from 14.20 to 51.39 in 30 kR, 13.72 to 22.48 in 40 kR and in P_1 the range was from 13.20 to 16.08.

4.1.7. Pollen sterility

There was significant difference among the treatments with respect to pollen sterility (Table 11). The pollen sterility was minimum for the cultivated parent (3.59 per cent) while it was maximum for 10 kR (54.04 per cent). Progeny differences were significant in all the treatments except the cultivated parent. Maximum progeny differences were observed in 20 kR and 30 kR. In 20 kR the pollen sterility ranged from 2.40 to 52.92 per cent while in 30 kR it ranged from 5.42 to 79.00 per cent.

4.1.8. First fruiting node

Table 12 showed that first fruiting node differed significantly among the treatments ranging from 5.38 in the cultivated parent Kiran to 9.16 in the highest irradiation treatment 40 kR. The treatments 10 kR and 40kr were found to be on par. Significant progeny differences were observed within the treatments 20 kR, 30 kR and P_1. In 20 kR the mean values ranged from 6.96 to 8.96, while it was 5.00 to 8.40 in 30 kR and 4.84 to 6.24 in P_1.

Table 11. Pollen sterility (%) in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	14.86 (22.63)	57.05 (49.07)	38.48 (38.30)	36.68 (37.18)	24.04 (29.28)	3.24 (10.30)	33.15 (35.11)
2.	18.32 (25.20)	41.82 (40.22)	52.92 (46.66)	37.26 (37.55)	26.86 (31.16)	7.04 (15.36)	26.48 (30.81)
3.	14.76 (22.57)	77.06 (61.51)	43.24 (41.08)	79.00 (63.07)	64.68 (53.59)	3.60 (9.74)	25.12 (29.85)
4.	16.00 (23.55)	57.93 (49.58)	22.48 (28.05)	77.60 (61.93)	42.52 (40.64)	3.40 (10.50)	21.36 (27.43)
5.	19.48 (26.12)	51.58 (45.90)	15.68 (23.23)	5.42 (13.05)	39.20 (38.70)	3.50 (10.63)	41.62 (40.14)
6.	19.68 (26.27)	64.08 (53.24)	2.40 (8.82)	28.62 (32.26)	43.40 (41.12)	2.88 (8.73)	13.60 (21.61)
7.	16.64 (24.06)	61.30 (51.62)	51.00 (45.57)	30.90 (33.59)	27.40 (31.48)	1.84 (6.78)	17.56 (24.71)
8.	18.12 (25.15)	38.20 (38.12)	18.44 (25.15)	56.34 (48.79)	50.60 (45.33)	3.40 (10.60)	25.56 (30.06)
9.	15.88 (23.45)	45.40 (38.76)	39.24 (38.76)	23.84 (29.11)	44.08 (41.57)	4.16 (10.44)	34.32 (35.57)
10.	17.28 (24.53)	45.96 (32.39)	28.80 (32.39)	53.20 (46.82)	45.00 (42.02)	2.84 (8.55)	32.30 (34.52)
Mean	17.10 (24.35)	54.04 (47.43)	31.27 (32.80)	42.89 (40.34)	40.78 (39.49)	3.59 (10.16)	27.11 (30.98)
$F_{9,36}$	2.41*	3.09**	62.59**	34.36**	14.65**	1.56*	7.72**
SE							
Progenies	1.211	4.649	3.184	5.927	4.588	2.498	4.397
Treatments	0.702						
Bartlett's X^2_6 for error variances	121.32**						

Figures in parenthesis are values after angular transformation

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 12. First fruiting node in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	7.04	8.24	8.08	8.40	10.12	4.92	8.00
2.	7.56	10.56	8.96	7.76	8.16	5.12	8.08
3.	7.16	8.92	7.88	6.00	9.52	5.56	8.76
4.	7.52	8.96	8.40	6.88	9.08	4.84	8.48
5.	7.64	10.72	8.68	6.56	9.28	5.32	8.16
6.	7.64	9.08	7.72	6.72	8.96	5.12	7.52
7.	7.48	8.44	7.76	6.08	9.56	5.44	8.12
8.	7.24	8.68	7.36	6.72	10.04	5.60	7.16
9.	6.96	7.88	6.96	6.76	8.40	5.68	7.76
10.	7.12	8.64	7.92	5.00	8.52	6.24	7.72
Mean	7.34	9.01	7.97	6.69	9.16	5.38	7.98
$F_{9,36}$	1.42	0.88	4.23**	11.70**	0.45	2.32*	2.07
SE							
Progenies	0.336	0.408	0.342	0.213	0.720	0.357	
Treatments	0.233						
Bartlett's X^2_6 for error variances	58.62**						

* Significant at 5 per cent level ** Significant at 1 per cent level

4.1.9. Number of fruits per plant

Significant difference in the number of fruits per plant was observed among the treatments. The average number of fruits ranged from 11.08 in the unirradiated treatment to 26.40 in 20 kR. The treatments 10 kR, 40 kR, P_1 and P_2 were on par. Significant progeny differences were noticed within the treatments 20 kR, 30 kR, 40 kR and P_1. The number of fruits per plant ranged from 12.28 to 15.00 in the cultivated parent P_1. In 20 kR, the mean values ranged from 8.88 to 125.40 while in 30 kR the progeny mean values ranged from 12.16 to 44.44. In 40 kR, the mean values ranged from 10.56 to 17.62. (Table 13).

4.1.10. Average fruit weight

Significant differences existed among the treatments with respect to average fruit weight (Table 14). The highest fruit weight was for the semi wild parent (18.13 g) while 0 kR recorded the lowest (11.59 g). The parent Kiran (14.37 g) was on par with 40 kR (13.61 g). The unirradiated treatment 0 kR was on par with 10 kR which in turn was on par with 30 kR and 40 kR. Significant differences among the progenies were noticed within the treatments 20 kR, 30 kR and 40 kR. The average fruit weight ranged from 6.08 to 20.20 g in 20 kR, 7.18 to15.04 g in 30 kR and 10.44 to 17.44 g in 40 kR.

4.1.11. Weight of fruits per plant

The results showed that all the treatments differed significantly among themselves with respect to the weight of fruits per plant (Table 15).

Table 13. Number of fruits per plant in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	11.77	14.72	13.36	12.37	17.62	13.44	14.24
2.	11.68	14.36	13.28	12.56	12.96	13.72	15.24
3.	10.86	12.20	13.88	13.36	13.20	13.40	15.96
4.	9.28	13.52	10.88	17.79	13.00	13.04	13.96
5.	10.44	13.72	11.64	13.12	10.56	12.28	14.68
6.	10.16	13.48	12.40	13.20	13.76	14.08	15.84
7.	11.04	12.56	9.46	12.16	12.88	14.20	14.92
8.	12.64	13.36	45.23	44.44	14.86	14.28	14.36
9.	12.06	13.44	9.96	14.36	12.48	14.32	13.32
10.	10.86	13.50	8.88	14.12	15.80	15.00	14.00
Mean	11.08	13.49	26.19	16.75	13.68	13.78	14.65
$F_{9,36}$	0.75	0.32	463.01**	46.40**	2.56*	2.29*	0.51
SE							
Progenies	1.612	1.848	2.391	2.047	1.714	0.722	1.676
Treatments	0.619						
Bartlett's X^2_6 for error variances	45.33**						

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 14. Average fruit weight (g) in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	11.90	11.16	16.92	12.65	10.44	13.56	18.88
2.	12.04	12.26	18.28	13.50	17.44	14.14	18.16
3.	13.48	11.42	15.18	14.68	14.24	13.24	18.20
4.	10.78	12.04	19.74	13.08	13.08	14.32	18.28
	10.80	9.58	19.00	14.74	12.44	14.08	18.56
6.	11.56	13.16	6.08	12.64	14.36	15.00	17.16
7.	10.94	11.58	16.68	14.20	13.80	14.36	18.72
8.	11.20	14.60	8.30	7.18	13.16	14.68	19.12
9.	11.82	13.82	20.20	15.04	13.52	15.24	17.40
10.	11.36	14.50	18.24	12.26	13.62	15.04	16.80
Mean	11.59	12.41	15.86	13.00	13.61	14.37	18.13
$F_{9,36}$	1.10	1.65	9.08**	5.70**	9.14**	1.72	0.38
SE							
Progenies	1.084	1.766	2.269	1.345	0.819	0.699	1.771
Treatments	0.589						
Bartlett's X^2_6 for error variances	73.04**						

** Significant at 1 per cent level

Table 15. Weight of fruits per plant (g) in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	144.26	158.00	230.64	197.62	181.22	182.50	301.94
2.	143.37	176.56	242.84	192.20	224.94	194.16	335.60
3.	151.81	140.74	208.60	196.72	191.08	177.36	295.08
4.	115.76	152.18	211.89	233.39	170.18	185.98	277.28
5.	115.34	125.48	216.58	193.36	131.76	173.04	271.80
6.	124.13	165.38	684.88	178.64	198.46	211.76	271.80
7.	133.88	146.82	184.84	173.44	177.84	203.00	275.76
8.	140.26	192.50	354.94	320.94	192.30	209.60	276.60
9.	144.25	188.14	197.72	219.16	166.16	218.32	231.98
10.	123.56	210.92	278.98	170.36	215.82	229.38	240.44
Mean	133.66	165.67	281.19	207.88	184.98	198.51	277.82
$F_{9,36}$	0.80	1.32	14.65**	2.54*	2.75*	3.16**	0.48
SE							
Progenies	20.695	32.320	55.479	39.069	22.529	14.984	60.166
Treatments	14.767						
Bartlett's X^2_6 for error variances	105.61**						

* Significant at 5 per cent level ** Significant at 1 per cent level

The maximum fruit weight of plant was observed in the treatment 20 kR (281.19 g) and the least in the unirradiated treatment (133.66 g). The treatments 30 kR, 40 kR, and P_1 were on par. Progeny differences were significant within the treatments 20 kR, 30 kR, 40 kR and P_1. The mean values ranged from 184.84 to 684.88 g in 20 kR, while in 30 kR, the fruit weight per plant ranged from 170.30 to 320.94 g where all the progenies except one were on par. The fruit yield per plant ranged from 131.76 to 224.94 g in 40 kR and 173.04 to 229.38 g in P_1.

4.1.12. Length of fruit

Fruit length differed significantly among the treatments. Average fruit length ranged from 10.03 cm in 10 kR to 14.70 cm in the case of cultivated parent P_1. The lower doses of irradiation 10 kR and 20 kR were on par, while 30 kR and 40 kR were on par. The cultivated parent (14.70) was on par with the semi wild parent (14.18) with respect to this character. Progeny differences were significant within the irradiated treatments and the cultivated parent. In 10 kR, the fruit length ranged from 6.36 to 13.24 cm while in 20 kR, the range was from 4.70 to 12.40 cm. Fruit length ranged from 8.52 to 14.04 cm in 30 kR and 10.08 to 13.60 cm in 40 kR. In the cultivated parent the average fruit length varied from 13.88 to 15.88cm (Table 16 and Fig. 3).

4.1.13. Girth of the fruit

Significant differences were noticed among the treatments for fruit girth. The mean values ranged from 4.92 cm (10 kR) to 8.36 cm (P_2).

Table 16. Length of fruit (cm) in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	11.12	7.92	12.40	12.88	11.52	15.64	13.92
2.	10.68	7.80	11.00	12.96	13.60	15.04	14.12
3.	10.92	10.44	11.52	14.04	12.94	14.52	14.72
4.	10.90	10.88	11.68	12.92	12.36	13.88	13.80
5.	10.48	6.36	11.04	12.82	12.36	14.12	14.24
6.	10.44	8.44	4.70	11.00	10.72	14.60	14.72
7.	10.84	10.64	12.12	10.60	11.72	14.12	14.00
8.	10.76	13.24	9.96	8.52	11.60	14.72	14.44
9.	10.72	11.84	8.04	11.92	12.36	14.52	13.52
10.	10.80	12.72	11.24	11.08	10.08	15.88	14.56
Mean	10.77	10.03	10.37	11.87	11.93	14.70	14.18
$F_{9,36}$	0.15	30.91**	25.34**	21.78**	3.93**	2.47*	0.90
SE							
Progenies	0.735	0.584	0.659	0.486	0.736	0.585	0.581
Families	0.271						
Bartlett's X^2_6 for error variances	9.31						

* Significant at 1 per cent level ** Significant at 5 per cent level

The treatments 0 kR, 20 kR, 30 kR and P_1 were on par. The progenies of the treatments 0 kR, 20 kR, 30 kR and 40 kR differed significantly. The average fruit girth ranged from 5.00 to 6.32 cm in 0 kR, 3.80 to 6.64 cm in 20 kR, 5.12 to 8.00 cm in 30 kR and 5.56 to 7.78 cm in 40 kR (Table 17 and Fig. 3).

4.1.14. Number of seeds per fruit

Table 18 showed that there was considerable difference among the treatments with respect to mean number of seeds per fruit. It was highest for the semi wild parent (56.46) and lowest for 10 kR (4.22). The treatments 10 kR and 20 kR were on par while 0 kR was on par with 30 kR and 40 kR. Considerable differences were present among progenies of treatments 0 kR, the irradiated treatments and the semi wild parent. The mean number of seeds per fruit ranged from 6.92 to 12.16 in 0 kR, 1.92 to 7.60 in 10 kR, 1.36 to 26.52 in 20 kR, 2.65 to 29.04 in 30 kR, 2.36 to 15.44 in 40 kR and 48.76 to 64.28 in the semi wild parent.

4.1.15. Number of ridges per fruit

Significant differences in number of ridges per fruit were observed among the treatments (Table 19). The average number of ridges per fruit ranged from 5.02 in the cultivated parent to 7.89 in the semi wild parent. Progeny differences within the treatments 10 kR, 20 kR and 30 kR were significant. The number of ridges per fruit ranged from 5.32 to 6.96 in 10 kR, 5.00 to 6.96 in 20 kR and 5.00 to 5.96 in 30 kR (Fig. 3).

Table 17. Girth of fruit (cm) in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	5.14	4.69	6.12	5.68	6.22	5.40	8.06
2.	5.88	4.81	6.64	5.76	5.56	5.64	8.36
3.	5.78	4.80	5.88	5.28	7.78	5.48	8.68
4.	5.80	4.64	5.06	8.00	6.16	5.54	8.28
5.	6.16	4.86	5.20	5.52	6.32	5.32	8.44
6.	6.32	5.12	3.80	5.34	6.28	5.56	8.52
7.	5.08	5.34	5.60	5.60	6.60	5.84	8.28
8.	5.00	4.76	5.36	5.28	6.12	5.72	8.88
9.	5.48	5.04	5.30	5.12	5.81	5.40	7.98
10.	5.44	5.12	5.32	5.94	6.16	5.64	8.08
Mean	5.61	4.92	5.43	5.75	6.30	5.55	8.36
$F_{9,36}$	3.35**	1.83	4.50**	41.63**	10.67**	1.52	1.30
SE							
Progenies	0.352	0.236	0.344	0.182	0.256	0.179	0.353
Treatments	0.166						
Bartlett's X^2_6 for error variances	361.33**						

** Significant at 1 per cent level

Table 18. Number of seeds per fruit in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	8.76	5.76	1.36	10.04	5.72	41.36	54.32
2.	9.28	2.08	2.56	2.65	4.80	39.88	51.56
3.	8.68	2.36	2.60	4.80	11.22	39.72	48.76
4.	6.92	4.44	2.12	3.20	15.44	38.84	64.28
5.	11.32	3.40	3.44	29.04	13.88	50.52	59.10
6.	12.16	7.28	26.52	20.22	4.78	46.92	59.76
7.	12.08	1.92	1.68	3.03	2.36	36.16	53.44
8.	9.60	7.60	1.37	4.39	7.26	44.84	54.28
9.	10.60	4.00	10.76	5.28	4.00	42.56	56.76
10.	10.04	3.36	7.20	4.48	6.78	40.12	62.32
Mean	9.94	4.22	5.96	8.71	7.62	42.09	56.46
$F_{9,36}$	4.33**	18.67**	189.75**	74.85**	21.09**	1.97	3.15**
SE							
Progenies	1.121	0.673	0.804	1.452	1.356	4.289	3.897
Treatments	1.532						
Bartlett's X^2_6 for error variances	222.90**						

** Significant at 1 per cent level

Table 19. Number of ridges per fruit in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	5.52	5.86	6.96	5.32	6.20	5.04	7.96
2.	5.08	5.70	5.12	5.60	5.99	5.00	7.00
3.	5.12	5.68	5.84	5.00	5.84	5.00	7.64
4.	5.00	5.32	5.24	5.12	5.64	5.08	7.68
5.	5.36	6.04	6.12	5.00	5.80	5.04	7.68
6.	5.20	6.56	5.00	5.00	6.40	5.00	8.00
7.	5.22	5.80	6.12	5.96	6.48	5.00	8.04
8.	5.32	6.96	5.00	5.00	6.56	5.00	8.00
9.	5.00	5.88	5.28	5.28	6.12	5.00	7.96
10.	5.30	6.52	5.60	5.76	6.16	5.00	8.08
Mean	5.20	6.03	5.63	5.30	6.12	5.02	7.89
$F_{9,36}$	1.59	2.23*	7.17**	2.40*	1.07	1.00	1.50
SE							
Progenies	0.188	0.472	0.335	0.323	0.417	0.039	0.180
Treatments	0.109						
Bartlett's X^2_6 for error variances	166.91**						

* Significant at 5 per cent level ** Significant at 1 per cent level

4.1.16. Fruiting phase

Fruiting phase was significantly different among the treatments (Table 20). It was highest for the treatment 40 kR (108.80 days) and lowest for P_1 (73.03 days). Progeny differences were significant within 10 kR, 20 kR and 30 kR. The fruiting phase ranged from 70.72 to 83.84 days in 10 kR, 84.04 to 110.08 days in 20 kR and 73.94 to 115.86 days in 30 kR.

4.1.17. Height of the plant

Significant differences in plant height were noted among the treatments. The plant height ranged from 110.06 cm in 10 kR to 145.81 cm in 30 kR. The treatments 20 kR, 40 kR, P_1 and P_2 were on par, whereas 0 kR was on par with 30 kR. Progenies differed significantly within the treatments 0 kR, 10 kR, 20 kR, 30 kR and 40 kR. The mean height ranged from 131.44 to 156.90 cm in 0 kR, 56.00 to 161.60 cm in 10 kR, 70.20 to 159.30 cm in 20 kR, 114.60 to 238.16 cm in 30 kR and 100.84 to 149.50 cm in 40 kR (Table 21).

4.1.18. Incidence of YVM disease

The treatments differed significantly with respect to YVM disease incidence. The mean disease scores ranged from 1.12 in the semi wild parent to 2.43 in the treatment 30 kR. The treatment 0 kR was on par with 10 kR while the treatments 20 kR and 40 kR were also found to be on par.

Table 20. Fruiting phase in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	83.18	70.72	89.24	87.96	98.60	74.02	108.10
2.	76.70	79.82	89.60	88.78	101.48	72.24	106.96
3.	80.94	81.36	87.86	94.02	101.08	71.50	100.98
4.	82.52	81.96	98.32	74.86	103.28	73.74	104.40
5.	82.50	80.78	84.04	73.94	105.10	72.80	104.82
6.	82.54	81.72	110.08	79.88	111.68	72.68	106.82
7.	79.28	80.54	98.58	84.58	101.96	73.36	102.98
8.	76.30	81.34	0.44	115.86	104.94	74.36	105.62
9.	82.06	83.84	95 02	88.24	106.52	73.86	106.20
10.	82.12	78.32	84.92	91.74	103.36	71.78	105.94
Mean	80.81	80.04	92.81	87.99	108.80	73.03	105.28
$F_{9,36}$	1.75	3.16**	3.89**	21.46**	0.89	0.88	1.19
SE							
Progenies	2.695	2.844	5.651	3.634	5.389	1.488	2.708
Treatments	1.287						
Bartlett's X^2_6 for error variances	81.95**						

** Significant at 1 per cent level

Table 23. Height of the plant (cm) in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	137.74	72.31	137.40	130.20	138.42	113.52	119.86
2.	141.86	78.00	159.30	162.60	100.84	121.12	118.92
3.	149.70	56.00	109.20	128.60	141.92	124.62	126.42
4.	131.44	92.80	132.40	133.00	127.98	126.40	129.88
5.	134.78	153.54	146.62	114.56	113.70	123.74	130.12
6.	156.90	111.20	158.16	129.38	130.96	133.30	129.28
7.	148.38	125.20	132.74	123.20	149.50	121.54	127.44
8.	136.20	161.60	123.40	238.16	126.78	126.60	126.00
9.	154.00	113.04	70.20	156.60	142.22	125.40	124.76
10.	135.00	136.90	83.80	141.80	114.60	121.00	129.20
Mean	142.60	110.06	125.32	145.81	128.69	123.74	126.19
$F_{9,36}$	2.60*	22.49**	33.02**	29.25**	6.00**	1.01	1.69
SE							
Progenies	7.878	10.511	7.320	9.309	8.809	7.189	4.359
Treatments	3.225						
Bartlett's X^2_6 for error variances	120.65**						

* Significant at 5 per cent level ** Significant at 1 per cent level

Fig. 1 - 10. Variability in plant characters in F_2M_2

Fig.1. A. esculentus

Fig.2. A. manihot

Fig.3. 0 kR

Fig.4. 10 kR

Fig.5. 20 kR

Fig.6. 20 kR

Fig.9. 40 kR

Fig.10.

Progeny differences were significant within treatments 10 kR and the cultivated parent. It ranged from 1.04 to 1.47 in 10 kR and 1.29 to 2.04 in P_1 (Table 22).

4.1.19. Incidence of fruit and shoot borer

Significant differences among the treatments were observed with respect to incidence of fruit and shoot borer (Table 23). The mean values for fruit and shoot borer incidence ranged from 6.15 per cent in the semi wild parent to 19.45 per cent in the cultivated parent. Significant differences were observed within the treatments 30 kR and P_1. It ranged from 6.94 to 21.27 per cent in 30 kR and 14.79 to 23.68 per cent in P_1.

4.1.20. Duration of the plant

Duration of the plant varied significantly among the treatments. The duration was shortest for the cultivated parent (126.30 days) and maximum for the treatment 40 kR (161.04 days). Progeny differences were significant within the treatments 0 kR, 10 kR, 30 kR and the semi wild parent. Plant duration ranged from 129.24 to 142.06 days in 0 kR, 123.50 to 139.80 days in 10 kR 122.40 to 167.14 days in 30 kR and 152.76 to 167.36 days in the semi wild parent (Table 24).

Table 21. Incidence of YVM disease in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	1.17 (1.08)	1.47 (1.21)	1.66 (1.29)	2.38 (1.54)	1.39 (1.18)	1.61 (1.27)	1.11 (1.06)
2.	1.35 (1.25)	1.38 (1.18)	1.61 (1.27)	2.34 (1.53)	1.78 (1.34)	1.29 (1.13)	1.12 (1.06)
3.	1.17 (1.08)	1.43 (1.19)	1.26 (1.12)	2.38 (1.54)	1.15 (1.07)	1.56 (1.25)	1.15 (1.07)
4.	1.36 (1.17)	1.26 (1.12)	1.45 (1.20)	2.43 (1.56)	1.16 (1.08)	1.61 (1.27)	1.11 (1.06)
5.	1.16 (1.08)	1.12 (1.06)	1.21 (1.10)	2.34 (1.53)	1.55 (1.25)	2.04 (1.43)	1.08 (1.04)
6.	1.26 (1.12)	1.26 (1.12)	1.33 (1.15)	2.34 (1.53)	1.35 (1.16)	1.91 (1.38)	1.08 (1.04)
7.	1.09 (1.05)	1.04 (1.02)	1.40 (1.18)	2.09 (1.45)	1.34 (1.16)	1.95 (1.39)	1.04 (1.02)
8.	1.15 (1.07)	1.34 (1.16)	1.35 (1.17)	2.49 (1.58)	1.19 (1.09)	1.61 (1.26)	1.12 (1.06)
9.	1.47 (1.21)	1.08 (1.04)	1.07 (1.04)	2.70 (1.04)	1.39 (1.18)	1.37 (1.17)	1.12 (1.06)
10.	1.45 (1.20)	1.08 (1.04)	1.23 (1.11)	2.75 (1.66)	1.41 (1.19)	1.63 (1.28)	1.20 (1.10)
Mean	1.28 (1.13)	1.23 (1.11)	1.34 (1.16)	2.43 (1.56)	1.37 (1.17)	1.66 (1.29)	1.12 (1.06)
$F_{9,36}$	1.06	2.40*	1.11	0.80	1.72	3.75**	0.49
SE							
Progenies	0.096	0.065	0.103	0.094	0.086	0.069	0.041
Treatments	0.045						
Bartlett's X^2_6 for error variances	10.25						

Figures in parenthesis are values after angular transformation

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 22. Incidence of fruit and shoot borer in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	13.15 (3.63)	16.73 (4.09)	15.37 (3.92)	18.94 (4.35)	16.54 (4.07)	17.14 (4.14)	5.17 (2.27)
2.	12.58 (3.55)	14.78 (3.84)	16.17 (4.02)	17.78 (4.22)	16.57 (4.07)	14.79 (3.85)	5.91 (2.43)
3.	12.55 (3.54)	14.32 (3.78)	15.98 (3.99)	17.78 (4.22)	16.94 (4.12)	19.31 (4.39)	6.55 (2.56)
4.	13.18 (3.63)	14.58 (3.81)	16.59 (4.07)	16.24 (4.03)	14.58 (3.81)	19.38 (4.40)	6.59 (2.57)
5.	12.75 (3.57)	14.98 (3.87)	15.14 (3.89)	21.27 (4.61)	15.51 (3.94)	20.17 (4.49)	6.16 (2.48)
6.	14.34 (3.78)	15.39 (3.92)	16.18 (4.02)	16.17 (4.02)	15.16 (3.89)	20.18 (4.49)	5.77 (2.40)
7.	14.34 (3.78)	13.86 (3.72)	15.78 (3.97)	16.56 (4.07)	16.57 (4.07)	18.78 (4.33)	5.98 (2.45)
8.	14.78 (3.84)	14.95 (3.87)	14.97 (3.87)	17.56 (4.19)	15.95 (3.99)	23.68 (4.86)	6.97 (2.64)
9.	13.38 (3.66)	15.77 (3.97)	16.38 (4.05)	6.94 (2.63)	16.98 (4.12)	18.56 (4.31)	6.33 (2.52)
10.	15.17 (3.85)	15.38 (3.92)	15.39 (3.92)	16.74 (4.09)	15.37 (3.92)	22.94 (4.79)	6.16 (2.49)
Mean	13.54 (3.68)	15.05 (3.88)	15.76 (3.97)	16.32 (4.04)	16.00 (4.00)	19.45 (4.41)	6.15 (2.48)
$F_{9,36}$	2.00	1.03	0.82	10.77**	1.18	7.46**	1.10
SE							
Progenies	0.129	0.143	0.109	0.171	0.135	0.156	0.137
Treatments	0.048						
Bartlett's X^2_6 for error variances	15.23*						

Figures in parenthesis are values after angular transformation

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 24. Duration of the plant in F_2M_2

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	142.06	123.50	146.08	141.96	157.76	126.90	165.12
2.	129.26	129.76	146.00	139.32	163.80	123.96	167.36
3.	131.72	134.96	147.04	147.56	161.08	125.28	159.08
4.	133.96	137.14	144.40	133.40	160.52	125.66	157.38
5.	133.52	139.80	150.28	124.84	161.60	125.12	152.76
6.	135.16	127.84	147.76	122.40	163.04	129.36	154.56
7.	131.92	129.48	148.70	133.76	159.00	124.92	156.28
8.	133.22	132.88	149.94	167.14	159.76	123.88	155.28
9.	129.24	132.78	149.16	141.04	162.12	129.72	156.44
10.	133.88	134.28	148.32	152.32	161.68	128.22	166.40
Mean	133.39	132.24	147.77	140.37	161.04	126.30	159.11
$F_{9,36}$	3.14**	5.13**	1.06	25.27**	0.69	1.36	6.72**
SE							
Progenies	2.891	2.966	2.592	3.717	3.132	2.591	2.975
Treatments	1.266						
Bartlett's X^2_6 for error variances	6.89						

** Significant at 1 per cent level

4.2. Genetic variability in the F_2M_2 generation

Genetic parameters viz., phenotypic and genotypic coefficients of variation, heritability and genetic advance of the 20 characters pertaining to the seven treatments are presented in Tables 25 and 26.

4.2.1. 0 kR

Phenotypic and genotypic coefficients of variation were highest for number of branches per plant (108.49 per cent and 47.58 per cent respectively). Both phenotypic and genotypic coefficients of variation were low for all the other characters. Heritability estimate was highest for leaf area (52.00 per cent) but the genetic advance was comparatively low (19.29 per cent). Similar trend in heritability and genetic advance was noticed for number of seeds per fruit, girth of fruit, duration of plant, height of plant and pollen sterility. Heritability and genetic advance were low for all other characters except for number of branches per plant which had a genetic advance of 40.22 per cent. Genotypic coefficient of variation, heritability and genetic advance were not estimable for number of fruits per plant, weight of fruits per plant and length of fruit (Fig. 11).

4.2.2. 10 kR

Phenotypic and genotypic coefficients of variation were highest for number of branches per plant (104.68 and 85.47 per cent respectively)

Table 25. Phenotypic and genotypic coefficients of variation in F_2M_2

Sl. No.	Plant characters	0 kR		10 kR		20 kR		30 kR		40 kR		P_1		P_2	
		PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV
1.	Days to first flowering	6.53	2.31	6.09	2.03	6.90	3.20	9.01	7.81	4.67	ne	2.25	ne	5.81	2.28
2.	Leaf axil bearing first flower	11.51	3.29	9.85	ne	11.05	6.92	16.18	13.40	13.21	ne	11.96	5.59	8.50	3.60
3.	Leaf numbers	14.77	1.01	21.46	13.64	114.94	114.14	51.62	47.64	26.10	7.87	7.02	3.84	11.13	3.27
4.	Leaf area	18.01	12.96	36.10	34.13	34.17	32.67	41.57	40.00	18.90	7.37	14.24	2.45	14.03	ne
5.	No. of branches per plant	108.49	47.58	104.68	85.47	197.05	194.22	153.09	143.69	197.54	183.90	106.50	43.40	88.02	0.00
6.	No. of flowers per plant	15.55	1.63	26.30	15.09	134.57	133.33	60.14	55.31	26.38	13.64	9.81	4.45	15.73	4.33
7.	Pollen sterility	8.90	4.17	16.97	14.27	36.88	35.46	39.97	37.27	21.00	17.96	41.00	13.02	22.03	16.69
8.	First fruiting node	7.94	0.00	12.16	9.80	9.64	6.87	14.65	13.78	13.33	4.76	12.19	6.16	9.71	4.34
9.	No. of fruits per plant	22.44	ne	20.12	ne	138.41	137.66	61.36	58.24	22.68	11.06	9.29	4.23	17.19	ne
10.	Average fruit weight	4.94	2.11	23.92	8.09	36.59	28.76	22.78	15.80	15.43	12.14	8.23	2.87	14.44	ne

Contd...

(Table 25. Contd...)

Sl. No.	Plant characters	0 kR		10 kR		20 kR		30 kR		40 kR		P_1		P_2	
		PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV
11.	Weight of fruits per plant	23.99	ne	31.83	7.85	60.25	51.55	34.00	16.52	22.38	11.41	14.28	7.84	32.41	ne
12.	Length of fruit	9.83	ne	24.34	22.54	24.36	22.18	14.69	13.19	12.29	7.45	7.17	3.40	6.42	ne
13.	Girth of fruit	12.09	6.90	8.13	2.87	16.47	13.02	15.06	14.24	10.99	8.98	5.40	1.80	6.87	1.67
14.	Number of seeds per fruit	23.03	14.54	53.67	47.39	132.75	131.02	104.70	101.33	63.03	56.40	17.60	7.08	13.05	9.60
15.	Number of ridges per fruit	6.08	1.92	13.78	6.21	14.10	10.51	10.84	4.99	10.84	1.63	0.00	0.00	3.80	1.27
16.	Fruiting phase	8.60	2.04	6.72	3.69	12.69	7.32	14.73	13.21	7.74	ne	3.18	ne	4.14	0.79
17.	Height of plant	10.04	4.94	34.76	31.30	25.13	23.27	26.03	23.99	15.37	10.82	9.19	0.30	5.82	2.63
18.	Incidence of YVM disease	12.50	0.00	8.98	0.00	14.88	0.00	9.07	ne	12.08	0.00	11.01	7.78	0.00	ne
19.	Incidence of fruit and shoot borer	6.06	2.71	5.76	0.00	4.36	ne	15.24	12.36	5.59	0.00	8.18	6.00	9.02	0.00
20.	Duration of plant	4.10	2.24	4.79	3.22	2.73	0.30	10.13	9.23	2.98	ne	3.36	0.87	4.23	3.02

ne - not estimable

Table 26. Heritability and genetic advance in F_2M_2

Sl. No.	Plant characters	0 kR		10 kR		20 kR		30 kR		40 kR		P_1		P_2	
		H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA
1.	Days to first flowering	12.00	1.16	11.00	1.38	22.00	3.16	75.00	13.93	ne	ne	ne	ne	15.00	9.29
2.	Leaf axil bearing first flower	8.00	1.90	ne	ne	39.00	8.88	68.00	22.67	ne	ne	21.00	5.17	18.00	3.16
3.	Leaf numbers	1.00	0.30	40.00	17.68	99.00	234.40	85.00	90.39	9.00	4.83	30.00	4.34	9.00	2.06
4.	Leaf area	52.00	19.29	89.00	66.18	91.00	64.05	93.00	79.65	84.00	32.73	3.00	0.88	ne	ne
5.	No. of branches per plant	18.00	40.22	69.00	148.79	97.00	393.14	88.00	277.52	87.00	354.03	11.00	24.13	1.00	1.81
6.	No. of flowers per plant	1.00	0.32	33.00	17.88	98.00	271.67	85.00	105.31	27.00	14.67	21.00	4.25	8.00	2.59
7.	Pollen stenlity	22.00	4.03	71.00	24.82	92.00	69.89	87.00	71.63	73.00	31.57	10.00	8.45	57.00	25.87
8.	First fruiting node	0.00	0.00	65.00	16.28	50.00	9.93	88.00	26.55	13.00	3.57	25.00	6.28	19.00	3.80
9.	No. of fruits per plant	ne	ne	ne	ne	99.00	282.27	90.00	113.78	24.00	11.22	20.00	3.82	ne	ne
10.	Average fruit weight	2.00	0.62	11.00	5.42	62.00	46.73	48.00	22.53	62.00	19.71	13.00	2.21	ne	ne

Contd...

(Table 26. Contd...)

Sl. No.	Plant characters	0 kR		10 kR		20 kR		30 kR		40 kR		P_1		P_2	
		H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA
11.	Weight of fruits per plant	ne	ne	6.00	3.93	73.00	90.61	24.00	16.81	26.00	11.99	30.00	8.83	ne	ne
12.	Length of fruit	ne	ne	86.00	43.12	83.00	41.64	81.00	24.51	37.00	9.37	23.00	3.40	ne	ne
13.	Girth of fruit	32.00	7.97	14.00	2.34	63.00	21.38	89.00	27.61	66.00	14.95	9.00	1.00	6.00	0.85
14.	Number of seeds per fruit	40.00	18.98	78.00	86.24	97.00	265.26	94.00	202.74	80.00	103.88	16.00	5.80	30.00	8.07
15.	Number of ridges per fruit	11.00	1.37	20.00	5.68	55.00	15.97	22.00	4.90	1.00	0.22	0.00	0.00	9.00	0.70
16.	Fruiting phase	13.00	1.50	30.00	4.16	37.00	9.22	80.00	24.28	ne	ne	ne	ne	40.00	3.40
17.	Height of plant	24.00	4.96	81.00	57.99	86.00	44.53	85.00	45.58	50.00	15.76	0.00	0.00	12.00	1.44
18.	Incidence of YVM disease	1.00	0.26	22.00	4.06	2.00	0.61	ne	ne	13.00	3.24	35.00	7.94	ne	ne
19.	Incidence of fruit and shoot borer	17.00	2.12	1.00	0.12	ne	ne	66.00	20.72	3.00	0.35	56.50	9.44	2.00	0.37
20.	Duration of plant	30.00	2.53	45.00	4.44	1.00	0.06	83.00	145.16	ne	ne	7.00	0.48	51.00	4.44

ne - not estimable

(Fig. 12). Phenotypic and genotypic coefficients of variation were moderately high for number of seeds per fruit, leaf area and height of plant. All other characters had low phenotypic and genotypic coefficients of variation. Heritability estimate was highest for leaf area (89 per cent) which also had a moderately high genetic advance (66.18 per cent). Similar trends in heritability and genetic advance were noticed for plant height and length of fruit. Highest genetic advance was noticed for number of branches per plant (148.79 per cent) which had high heritability also (69.00 per cent). Similar trend was noticed for number of seeds per fruit. Genotypic coefficient of variation, heritability and genetic advance were not estimable for leaf axil bearing the first flower and number of fruits per plant.

4.2.3. 20 kR

Number of branches per plant recorded the highest phenotypic and genotypic coefficients of variation (197.05 and 194.22 per cent respectively). Phenotypic and genotypic coefficients of variation were also high for number of flowers per plant, number of seeds per fruit, leaf number and number of fruits per plant. Duration of the plant showed lowest phenotypic and genotypic coefficients of variation. Heritability estimate was highest for leaf number and number of fruits per plant (99 per cent). Highest genetic advance was recorded for number of branches per plant (393.14 per cent) which had high heritability (97 per cent) also. Similar trends were also noted for leaf number, number of fruits per plant, number of flowers per plant, number of seeds per fruit and weight of fruits per plant. Very low heritability and genetic advance

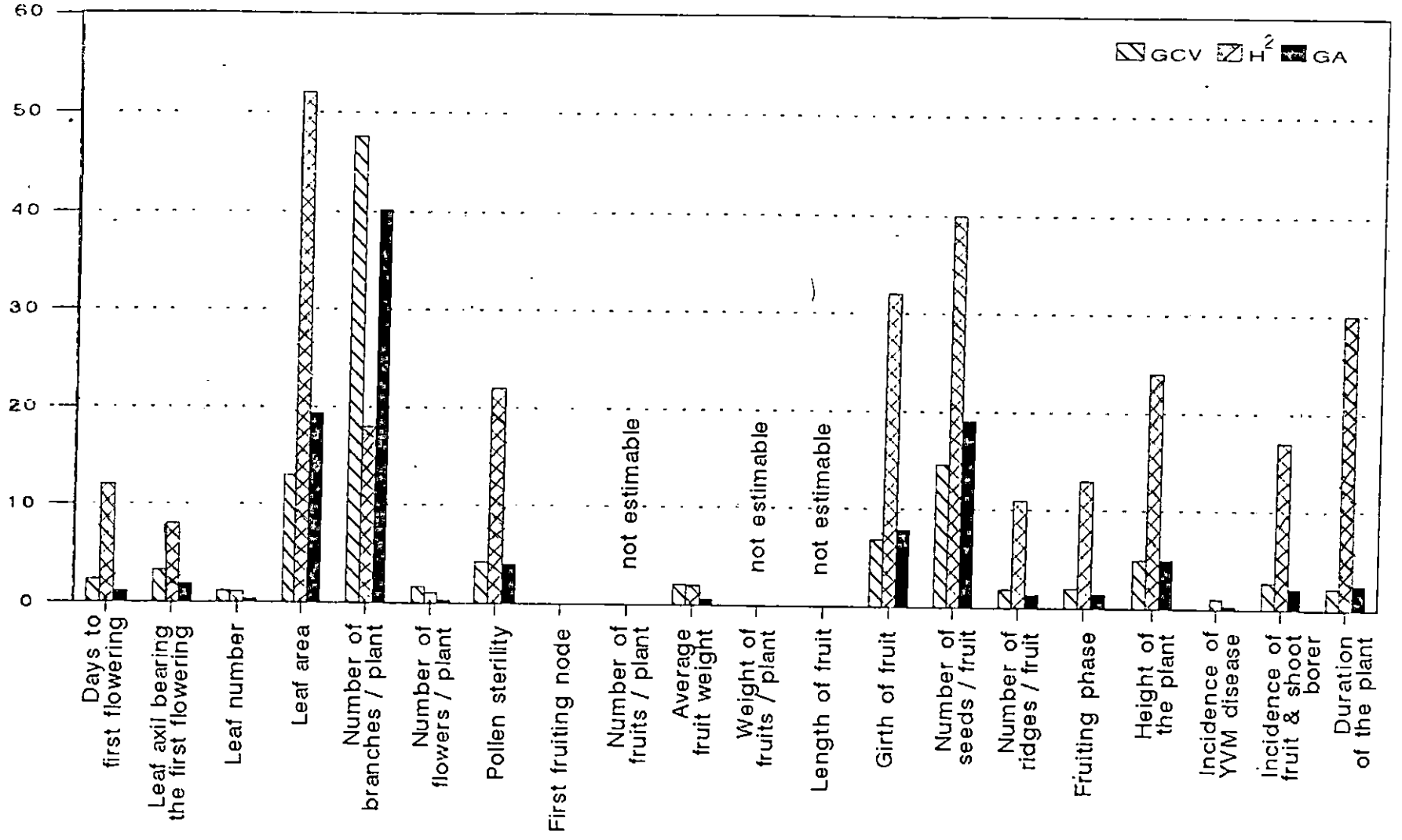


Fig. 11. Genetic variability in F_2M_2 - 0 kR

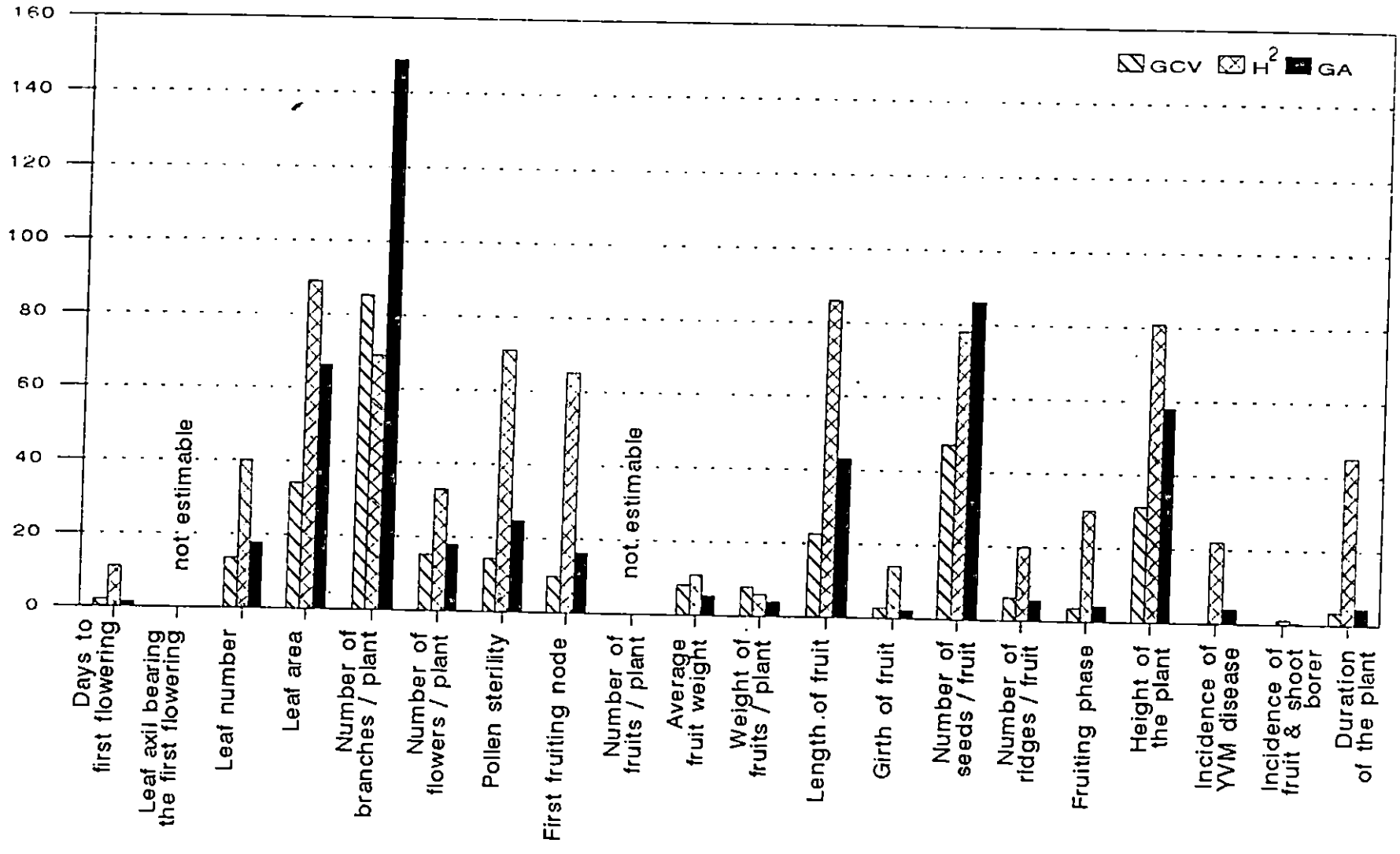


Fig. 12. Genetic variability in F_2M_2 - 10 kR

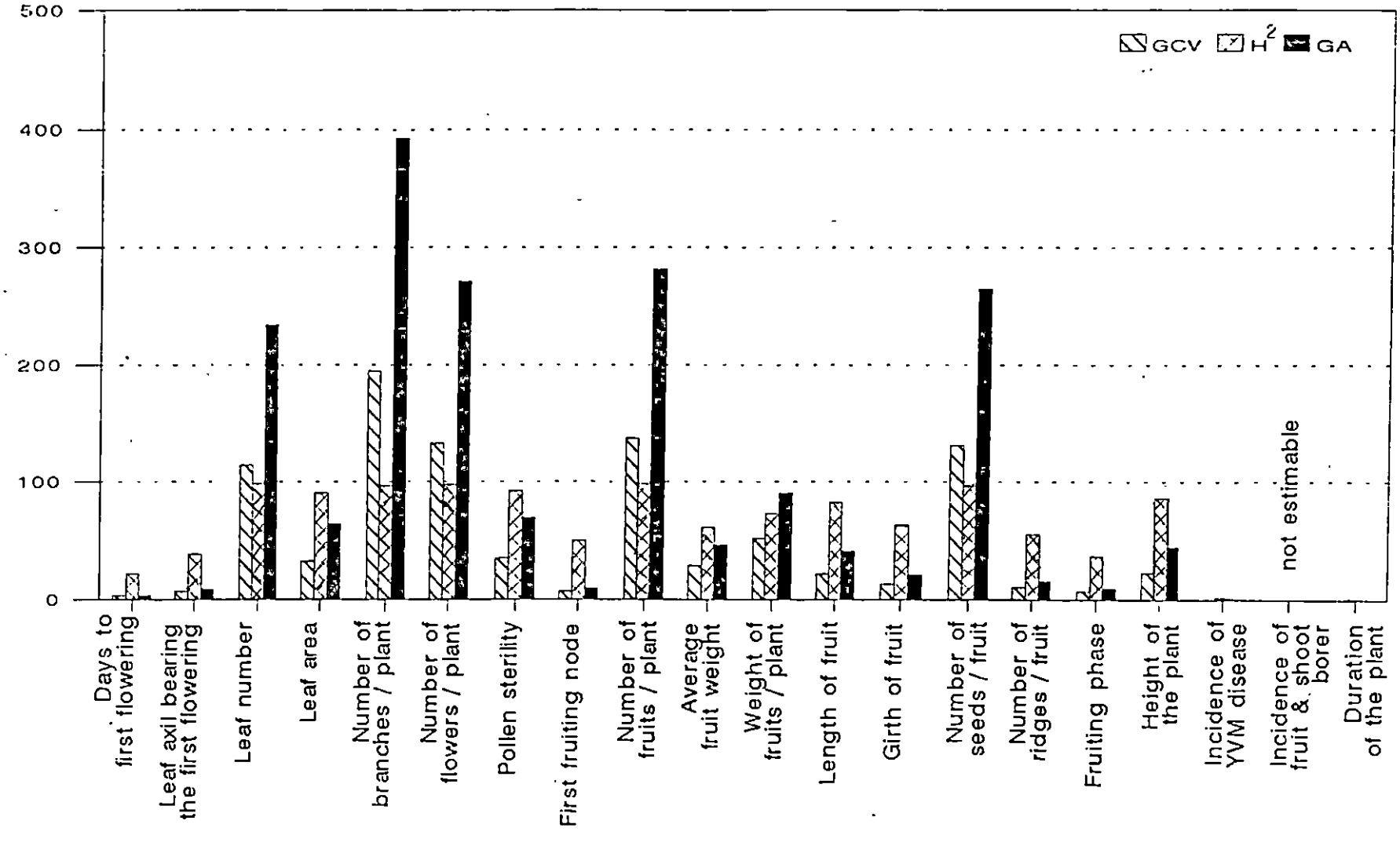


Fig. 13. Genetic variability in F_2M_2 - 20 kR

were recorded for duration of plant (1.00 and 0.06 per cent respectively) and yellow vein mosaic disease incidence (2.00 and 0.61 per cent respectively). Genotypic coefficient of variation, heritability and genetic advance were not estimable for incidence of fruit and shoot borer (Fig. 13).

4.2.4. 30 kR

Highest phenotypic and genotypic coefficients of variation were recorded for number of branches per plant (153.09 and 143.69 per cent respectively). Number of seeds per fruit also had high phenotypic and genotypic coefficients of variation. Number of fruits per plant, number of flowers per plant and leaf number recorded moderately high phenotypic and genotypic coefficients of variation. The lowest values were recorded for days to first flowering (9.01 per cent and 7.81 per cent respectively). Number of seeds per fruit, number of branches per plant, number of flowers per plant, number of fruits per plant and duration of plant recorded high heritability and very high genetic advance. Low heritability and genetic advance were recorded for number of ridges per fruit and for weight of fruits per plant (22.0 and 4.90 per cent respectively). Genotypic coefficient of variation, heritability and genetic advance was not estimable for incidence of YVM disease incidence (Fig. 14).

4.2.5. 40 kR

Number of branches per plant recorded the highest phenotypic (197.54 per cent) and genotypic (183.90 per cent) coefficients of variation (Fig. 15).

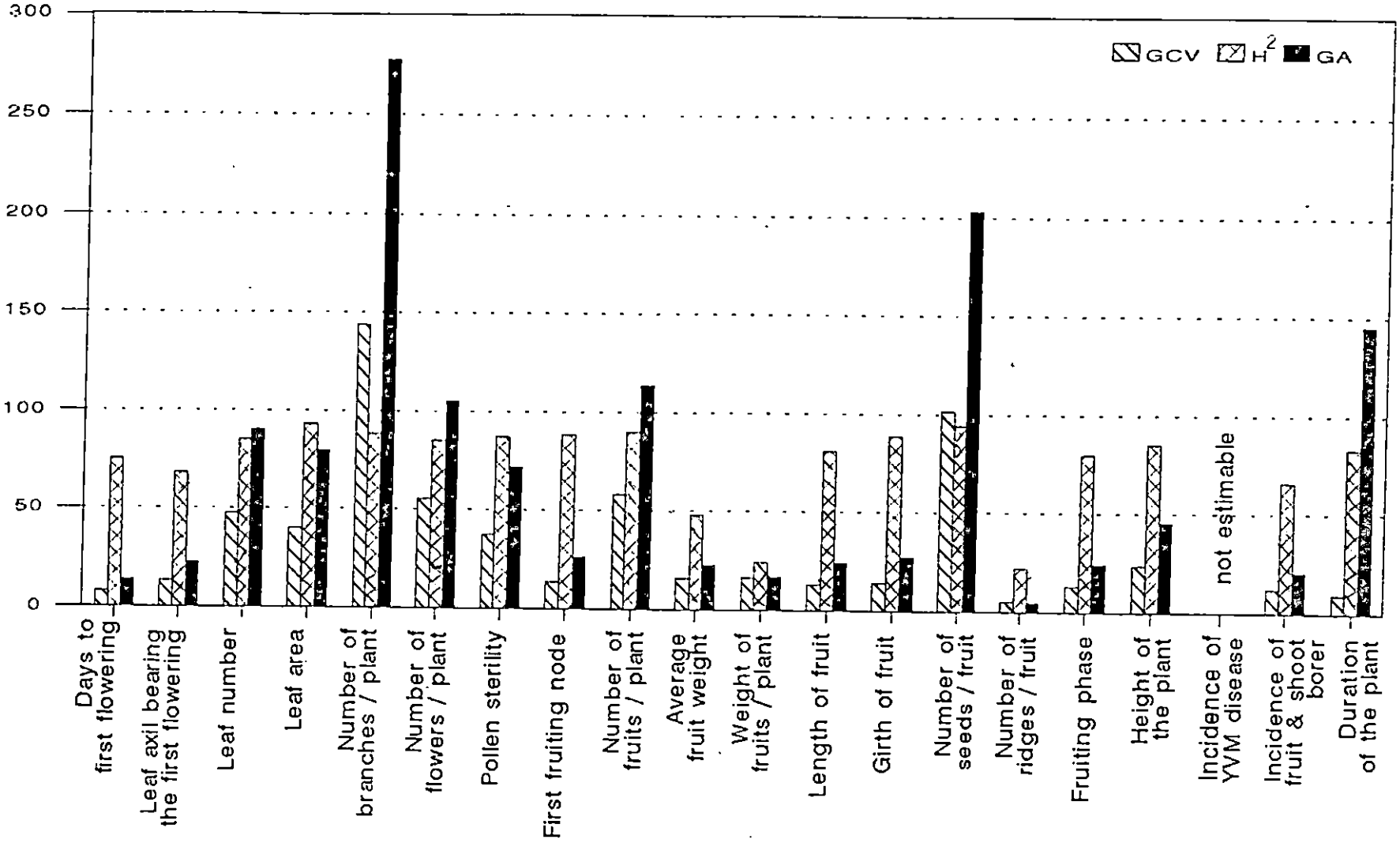


Fig. 14. Genetic variability in F_2M_2 - 30 kR

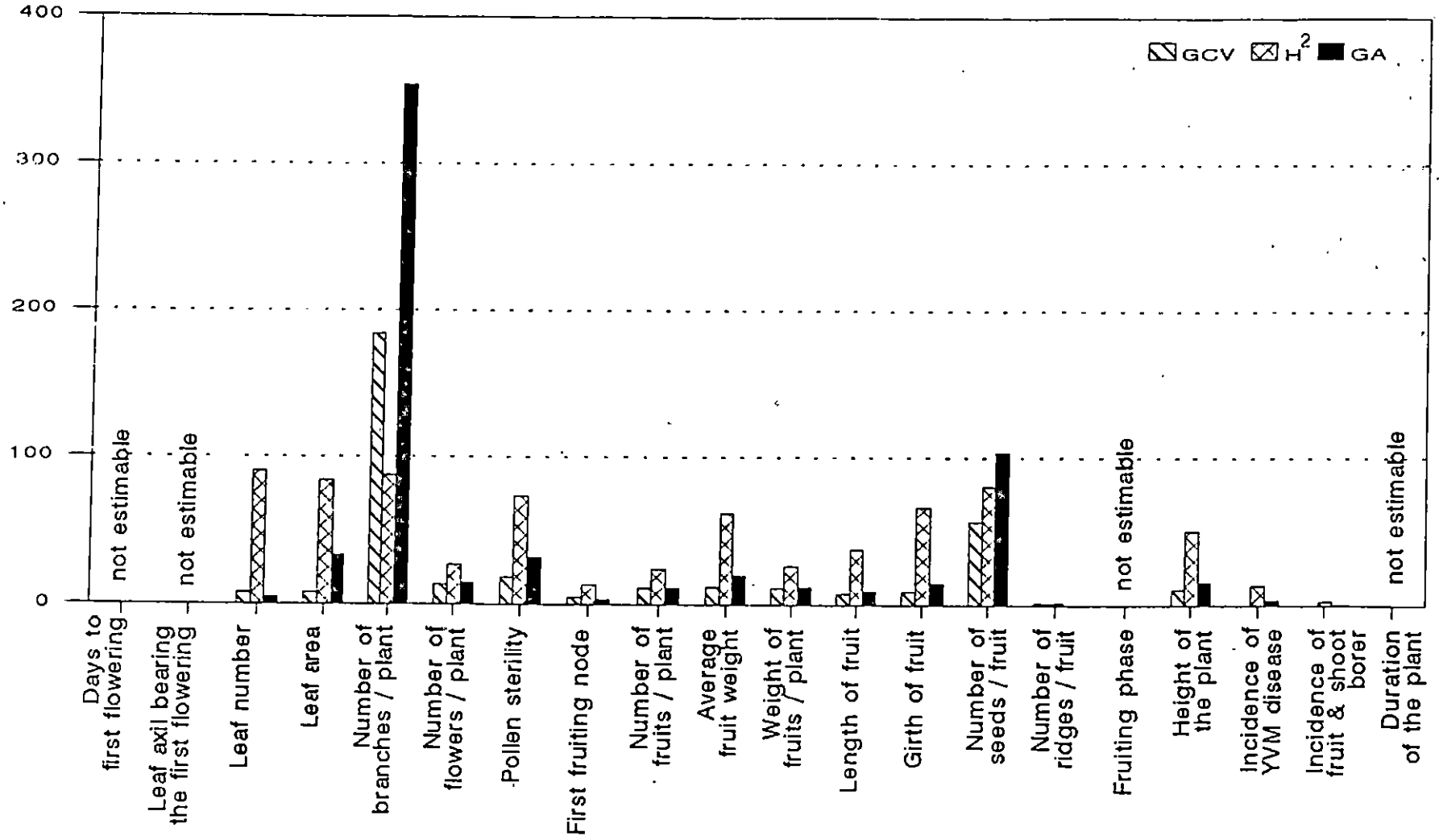


Fig. 15. Genetic variability in F_2M_2 - 40 kR

All other characters recorded low values except number of seeds per fruits which had moderately high phenotypic and genotypic coefficients of variation (63.03 and 56.40 per cent respectively). Lowest heritability and genetic advance estimates were for number of ridges per fruit (1.00 and 0.22 per cent respectively). Highest heritability and genetic advance were for number of branches per plant (87.00 and 354.03 per cent respectively). Similar trend was noticed for number of seeds per fruit (80.00 and 103.88 per cent respectively). Heritability estimates were high for leaf area, pollen sterility, girth of fruit and average fruit weight, but had low to moderately low genetic advance. Genotypic coefficient of variation, heritability and genetic advance were not estimable for days to first flowering, leaf axil bearing first flower, duration of plant and fruiting phase.

4.2.6. P_1

Highest phenotypic and genotypic coefficients of variation were noticed for number of branches per plant (106.50 and 43.40 per cent respectively) (Fig 16). All other characters had low values except pollen sterility which exhibited moderately high phenotypic coefficient of variation. Heritability estimate was highest for incidence of fruit and shoot borer (56.50 per cent) but had low genetic advance (9.44 per cent). All other characters had low heritability and genetic advance, the lowest being noticed for plant height and number of ridges per fruit. Genotypic coefficient of variation, heritability and genetic advance were not estimable for days to first flowering and fruiting phase.

4.2.7. P_2

Number of branches per plant had the highest phenotypic coefficient of variation (88.02 per cent) and the lowest genotypic coefficient of variation. Moderately high phenotypic coefficient of variation was noticed for weight of fruits per plant (32.41 per cent). Heritability (57.00 per cent) and genetic advance (25.87 per cent) were highest for pollen sterility. Heritability was moderately high for duration of plant, fruiting phase and number of seeds per fruit (51, 40 and 30 per cent respectively), but had low genetic advance. All the other characters had low heritability and genetic advance. Genotypic coefficient of variation, heritability and genetic advance were not estimable for leaf area, number of fruits per plant, average fruit weight, weight of fruits per plant, length of fruit and incidence of YVM disease (Fig.17).

4.3. Correlation in the F_2M_2 generation

Phenotypic correlation among the 18 characters are presented below

4.3.1. 0 kR

In the unirradiated treatment, leaf axil bearing first flower was significantly and positively correlated with first fruiting node and girth of fruit while it was significantly and negatively correlated with number of ridges per fruit. Number of leaves per plant, flowers per plant and fruits per plant were significantly and positively correlated with weight of fruits per plant

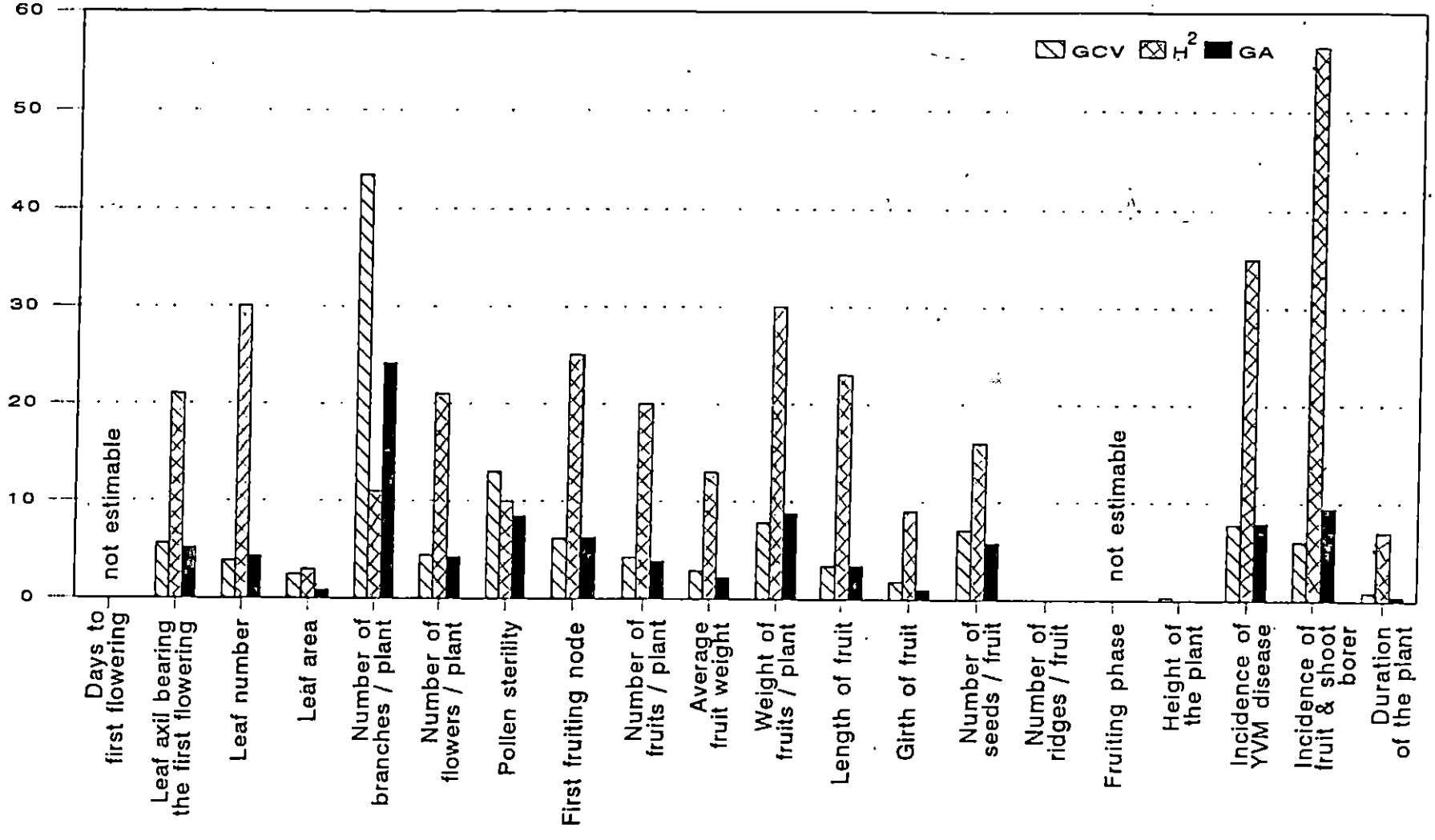


Fig. 16. Genetic variability in F_2M_2 - A. esculentus (P_1)

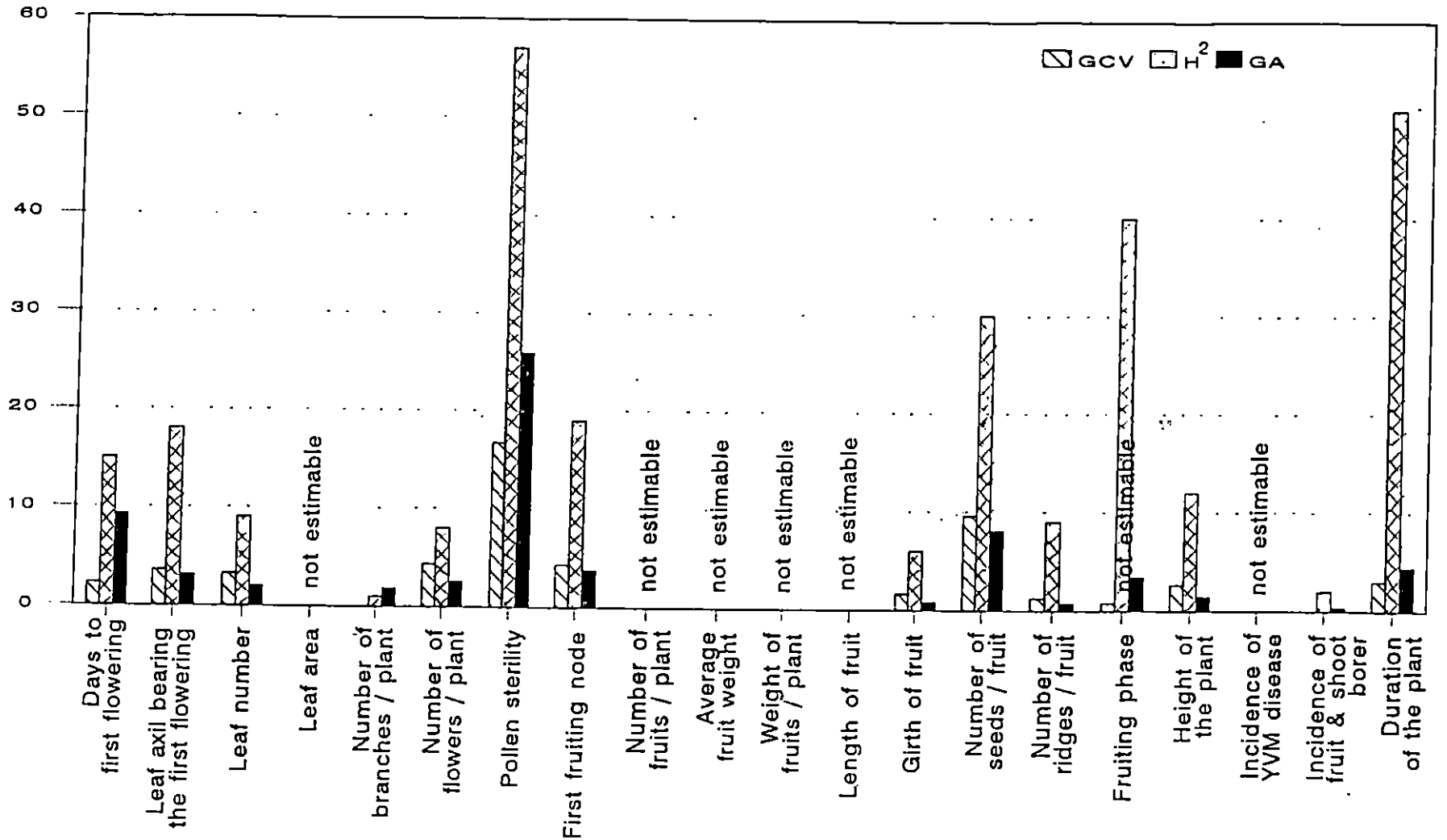


Fig. 17. Genetic variability in F_2M_2 - A. manihot (P_2)

and also among themselves. Leaf area was positively correlated with pollen sterility and negatively correlated with number of seeds per fruit. Number of branches per plant was significantly and negatively correlated with weight of fruits per plant. Pollen sterility exhibited significant positive correlation with number of seeds per fruit. Average fruit weight had significant positive correlation with weight of fruits per plant. First fruiting node was significantly and negatively correlated with weight of fruits per plant and length of fruit. Duration of plant was significantly and positively correlated with number of flowers per plant (Table 27).

4.3.2. 10 kR

In the treatment 10 kR, days to first flowering was significantly and negatively correlated with number of seeds per fruit while it was significantly and positively correlated with duration of the plant. Leaf axil bearing first flower was negatively correlated with length of fruit. Leaf number had significant positive correlation with number of branches per plant, flowers per plant and fruits per plant. Leaf area and number of branches per plant were significantly and positively correlated with number of flowers per plant, first fruiting node and plant height. Leaf area also had significant negative correlation with length of fruit and positive correlation with number of seeds per fruit and ridges per fruit whereas number of branches per plant and number of seeds per fruit were negatively correlated with each other. Number of flowers per plant was positively correlated with first fruiting node and negatively correlated with fruit length.

Table 27. Correlationin F_2M_2 – 0 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.0016	–																
X_3	Leaf number	0.2741	-0.0803	–															
X_4	Leaf area	0.1958	-0.1028	0.1701	–														
X_5	No of branches per plant	0.1020	0.2039	-0.1029	-0.0423	–													
X_6	No of flowers per plant	0.1122	-0.0198	0.5372**	-0.0289	-0.0981	–												
X_7	Pollen sterility	-0.0750	0.0748	-0.1606	0.4278**	0.0192	0.0727	–											
X_8	First fruiting node	-0.0727	0.5446**	-0.1876	-0.1458	0.1713	-0.1819	0.1840	–										
X_9	No of fruits per plant	0.1072	-0.1386	0.5302**	-0.0300	-0.2334	0.7745**	-0.0475	-0.1905	–									
X_{10}	Average fruit weight	0.1278	0.0123	0.0987	0.0986	-0.1190	-0.0247	0.0338	-0.2356	-0.0445	–								
X_{11}	Weight of fruits per plant	0.1031	-0.1286	0.4306**	0.0249	-0.3374*	0.5963**	-0.0727	-0.3100*	0.7558**	0.4539**	–							
X_{12}	Length of fruit	-0.2245	-0.1127	0.0279	0.1914	-0.2429	-0.0544	-0.2421	-0.3420*	0.1394	0.2639	0.2639	–						
X_{13}	Girth of fruit	0.0909	0.3001*	0.0987	-0.0021	0.1091	-0.1537	0.1853	0.2156	-0.2363	-0.0803	-0.0803	-0.1073	–					
X_{14}	No of seeds per fruit	0.0410	0.0287	-0.2183	-0.3462*	0.1163	0.0728	0.2957*	0.0722	0.0103	-0.0155	-0.0566	-0.0446	0.1078	–				
X_{15}	No. of ridges per fruit	-0.1876	-0.3418*	0.0824	-0.1748	0.1023	0.1273	0.0943	-0.2441	0.0924	-0.1786	-0.0141	-0.0050	-0.1986	0.0430	–			
X_{16}	Fruiting phase	0.2080	-0.1135	0.0101	0.0229	0.0783	-0.0327	-0.0042	-0.2585	-0.0947	-0.0415	-0.0471	-0.0983	0.0206	0.0752	0.1417	–		
X_{17}	Height of plant	-0.0287	0.0253	0.0822	0.0956	0.0602	0.1260	-0.1006	-0.0583	0.0472	0.0953	0.1153	0.0482	0.0919	0.1353	0.1010	-0.2046	–	
X_{18}	Duration of the plant	0.2013	0.0507	0.1878	-0.0500	0.2787	0.3591*	-0.0135	0.1336	0.1855	-0.2367	0.0032	-0.1285	-0.2212	0.1283	0.2659	0.2288	-0.2736	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Number of fruits per plant and average fruit weight had significant positive correlation with fruit yield per plant. Length of fruit was significantly and negatively correlated with first fruiting node while it was significantly and positively correlated with average fruit weight. Number of ridges per fruit had significant positive correlation with girth of fruit, number of seeds per fruit and plant height. Pollen sterility exhibited significant negative correlation with plant height (Table 28).

4.3.3. 20 kR

Days to first flowering had significant positive correlation with leaf number, number of branches per plant, flowers per plant, fruits per plant, seeds per fruit and fruiting phase while it had significant negative correlation with fruit length (Table 29). Leaf axil bearing first flower was significantly and positively correlated with first fruiting node, girth of fruit and plant height while it was significantly and negatively correlated with number of seeds per fruit and fruiting phase. Number of leaves per plant, flowers per plant and fruits per plant were significantly and positively correlated with all characters and among themselves except plant duration while they were significantly and negatively correlated with leaf area, pollen sterility, average fruit weight, length of fruit, girth of fruit and number of ridges per fruit. Leaf area was negatively correlated with number of branches per plant, weight of fruits per plant, number of seeds per fruit, fruiting phase and plant height while it had significant positive correlation with pollen sterility, average fruit weight, length and girth of fruit and number of ridges per fruit.

Table 23. Correlation in F_2M_2 – 10 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	-0.2618	–																
X_3	Leaf number	-0.0494	-0.0559	–															
X_4	Leaf area	-0.0591	-0.0335	-0.1357	–														
X_5	No. of branches per plant	0.0741	-0.1083	0.6072**	-0.1562	–													
X_6	No.of flowers per plant	-0.1672	0.0175	0.7682**	0.6702**	0.6702**	–												
X_7	Pollen sterility	0.1417	-0.0582	-0.2636	-0.2239	-0.0087	-0.2239	–											
X_8	First fruiting node	-0.0012	-0.0559	0.2729	0.4421**	0.4386**	0.4421**	-0.1029	–										
X_9	No. of fruits per plant	-0.2158	-0.0175	0.3087*	0.1603	0.1638	0.2380	-0.0154	0.1337	–									
X_{10}	Average fruit weight	0.0875	-0.2208	0.0454	-0.0331	-0.0424	-0.0331	-0.1798	-0.1205	0.1355	–								
X_{11}	Weight of fruits per plant	-0.0196	-0.0335	0.2298	0.1329	0.0737	0.1329	-0.1577	-0.0457	0.5449**	0.8675**	–							
X_{12}	Length of fruit	0.1576	-0.3595*	-0.2771	-0.2968*	-0.1727	-0.3064*	-0.1731	-0.5292**	-0.0835	0.3235*	0.2568	–						
X_{13}	Girth of fruit	0.1314	-0.1015	-0.0248	-0.0891	-0.0035	0.1069	0.0806	-0.1541	-0.1690	-0.0801	-0.1106	0.0587	–					
X_{14}	No. of seeds per fruit	-0.3078*	-0.1391	-0.1442	0.7207**	-0.3473*	-0.1490	-0.1464	-0.2323	-0.0779	0.0796	-0.0222	0.1090	-0.0237	–				
X_{15}	No. of ridges per fruit	-0.1168	-0.2618	0.0197	0.4130**	-0.0633	0.1372	-0.1114	-0.0118	0.1289	0.2325	0.2362	0.1223	0.3278*	0.3251*	–			
X_{16}	Fruiting crease	0.1204	0.0168	0.0221	0.1541	0.1259	0.1880	-0.0077	0.1392	0.0773	0.1053	0.0921	0.1274	0.1005	-0.1509	-0.0498	–		
X_{17}	Height of plant	-0.0474	-0.1182	0.1647	0.3893**	0.3290*	0.2454	-0.4579**	0.0118	0.0772	0.0671	0.0708	0.2408	0.1643	0.2060	0.4140**	0.1213	–	
X_{18}	Duration of the plant	0.3808**	-0.0878	-0.1808	-0.0585	0.1313	-0.1387	0.1223	0.2008	-0.0302	-0.0271	0.0088	0.1128	0.1164	-0.1698	0.1643	0.2009	0.2009	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 29. Correlation in F_2M_2 – 20 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.2503	–																
X_3	Leaf number	0.3858**	-0.1472	–															
X_4	Leaf area	-0.0387	0.1560	-0.7891**	–														
X_5	No. of branches per plant	0.3873**	-0.2238	0.9729**	-0.7883**	–													
X_6	No of flowers per plant	0.3792**	-0.1390	0.9967**	-0.7848**	0.9733**	–												
X_7	Pollen sterility	-0.2334	0.0898	-0.6611**	0.6258**	-0.6359**	-0.6548**	–											
X_8	First fruiting node	-0.1518	0.5552**	-0.1197	0.0988	-0.1279	-0.1278	0.0812	–										
X_9	No of fruits per plant	0.3647**	-0.1798	0.9872**	-0.7950**	0.9854**	0.9994**	-0.6485**	-0.1528	–									
X_{10}	Average fruit weight	-0.1587	0.1790	-0.6768**	0.7004**	-0.6914**	-0.5950**	0.4577**	0.2384	-0.7143**	–								
X_{11}	Weight of fruits per plant	0.2225	-0.1160	0.8533**	-0.6995**	0.8336**	0.8417**	-0.6058**	-0.0898	0.8608**	-0.5550**	–							
X_{12}	Length of fruit	-0.3473*	0.2462	-0.7831**	0.5164**	-0.7846**	-0.7936**	0.5166**	0.2885*	-0.7846**	0.5025**	-0.6612**	–						
X_{13}	Girth of fruit	-0.2755	0.3294*	-0.6205**	0.4144**	-0.6095**	-0.6152**	0.6964**	0.2649	-0.6196**	0.3135*	-0.5222**	0.5999**	–					
X_{14}	No. of seeds per fruit	0.4100**	-0.2890*	0.8325**	-0.4918**	0.8549**	0.8274**	-0.5427**	-0.2154	0.8209**	-0.4171**	0.7475**	-0.8510**	-0.6483**	–				
X_{15}	No of ridges per fruit	0.0842	0.2210	-0.3150*	0.3718**	-0.3370*	-0.3204*	0.2431	0.3253*	-0.3380*	0.3165*	-0.3509*	0.3941**	0.2980**	-0.3265*	–			
X_{16}	Fruiting phase	0.3530*	-0.3493*	0.4772**	-0.2906*	0.4945**	0.4792**	-0.2234	-0.1146	0.5162**	-0.3812**	0.4335**	-0.4375**	-0.4004**	0.4581**	-0.2309	–		
X_{17}	Height of plant	0.1075	0.3698**	0.3975**	-0.3480*	0.3589*	0.3944**	-0.1899	0.3495*	0.3761**	-0.3177*	0.2762	-0.0526	-0.0353	0.0403	-0.0451	0.2122	–	
X_{18}	Duration of the plant	0.0405	-0.1468	0.0306	0.0543	0.0257	0.0286	-0.0878	-0.2161	0.0524	-0.0707	0.0663	-0.1340	-0.1981	0.0434	-0.0307	-0.1379	-0.1986	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Number of branches per plant and fruit yield per plant had significant positive correlation with number of seeds per fruit, fruiting phase, plant height and also between themselves whereas they were significantly and negatively correlated with pollen sterility, average fruit weight, length and girth of fruit and number of ridges per fruit. Average fruit weight was positively correlated with pollen sterility, length and girth of fruits, and number of ridges per fruit and negatively correlated with number of seeds per fruit, fruiting phase and plant height. Length and girth of fruits were significantly and positively correlated with pollen sterility, number of ridges per fruit and also between themselves and significantly and negatively correlated with number of seeds per fruit and fruiting phase. Number of seeds per fruit exhibited significant negative correlation with number of ridges per fruit and positive correlation with fruiting phase.

4.3.4. 30 kR

Table 30 showed that, in this treatment, days to first flowering exhibited significant positive correlation with pollen sterility, fruit girth, fruiting phase, plant height and plant duration, while it had significant negative correlation with average fruit weight, length of fruit and number of seeds per fruit. Leaf number, number of branches per plant and number of flowers per plant had significant positive correlation with all characters except pollen sterility and days to first flowering while they were significantly and negatively correlated with leaf area, average fruit weight and length of fruit.

Table 30. Correlation in F_2M_2 – 30 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.1653	–																
X_3	Leaf number	0.2773	-0.1337	–															
X_4	Leaf area	0.0860	-0.2953*	-0.4604**	–														
X_5	No. of branches per plant	0.2628	-0.3079*	0.8168**	-0.3280*	–													
X_6	No.of flowers per plant	0.2558	-0.1377	0.9634**	-0.4655**	0.8188**	–												
X_7	Pollen sterility	0.3107*	-0 2695	0.2738	0.0213	0.1787	0.2495	–											
X_8	First fruiting node	0.1827	0 8363**	-0.0190	-0.4724**	-0.1835	-0.0410	-0.1930	–										
X_9	No. of fruits per plant	0.2193	-0.1062	0.9397**	-0.5294**	0.8123**	0.9478**	0.2367	0.0028	–									
X_{10}	Average fruit weight	-0.2802*	0 0865	-0.5718**	0.3937**	-0.6257**	-0.5661**	-0.2002	0.0239	-0.6090**	–								
X_{11}	Weight of fruits per plant	0.1472	0.1051	0.6386**	-0.3790**	-0.1503	0.6567**	0.1684	0.1554	0.7021**	-0.0342	–							
X_{12}	Length of fruit	-0.2948*	0.2621	-0.8252**	0.2347	-0.7202**	-0.6173**	0.0978	0.2180	-0.5914**	0.4543**	-0.3081*	–						
X_{13}	Girth of fruit	0.2955*	0.0507	-0.0699	-0.0971	-0.2051	-0.0909	0.4365**	0.0466	-0.0814	0.0292	-0.0109	0.1946	–					
X_{14}	No. of seeds per fruit	-0.6771**	0 0104	-0.2655	-0.2738	-0.1546	-0.2173	-0.5969**	0.0629	-0.1842	0.1255	-0.1503	0.1070	-0.2515	–				
X_{15}	No. of ridges per fruit	0.1613	0 0987	-0.0716	0.4002**	-0.0723	-0.0536	-0.0229	-0.0398	-0.1786	0.2841*	0.0721	-0.0962	0.0266	0.0342	–			
X_{16}	Fruiting phase	0.3247*	-0.1715	0.6881**	-0.1125	0.6838**	0.7263**	0.2662	-0.0743	0.7061**	-0.5348**	0.3982**	-0.4831**	-0.3665**	-0.4054**	-0.0343	–		
X_{17}	Height of plant	0.3508*	-0 0534	0.8011**	-0.4274**	0.8242**	0.7898**	0.1824	0.1066	0.7807**	-0.5252**	0.5075**	-0.5574**	-0.1677	-0.3641**	-0.0723	-0.6838**	–	
X_{18}	Duration of the plant	0.4479**	0.2074	0.6401**	0.0566	0.6438**	0.6601**	0.4208**	-0.1480	0.6238**	-0 4759**	0.3716*	-0.3345*	-0.1272	-0.5444**	0.0168	0.8963**	0.6503**	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Leaf area exhibited significant negative correlation with first fruiting node, weight of fruits per plant and plant height and had significant positive correlation with average fruit weight and number of ridges per fruit. Pollen sterility was positively correlated with fruit girth and plant duration, and negatively correlated with number of seeds per fruit. Average fruit weight had significant positive correlation with fruit length and number of ridges per fruit and had significant negative correlation with fruiting phase, plant height and plant duration. Fruit yield per plant, fruiting phase, plant height and plant duration were significantly and negatively correlated with fruit length and were significantly and positively correlated with one another. Number of seeds per fruit had significant negative correlation with fruiting phase, plant height and duration of plant.

4.3.5. 40 kR

In this treatment, leaf axil bearing first flower and first fruiting node were significantly and positively correlated. Number of leaves per plant, flowers per plant and fruits per plant were significantly and positively correlated with weight of fruits per plant, number of branches per plant and also among themselves but they were significantly and negatively correlated with plant duration. Leaf area was positively correlated with average fruit weight and plant duration but negatively correlated with pollen sterility. Number of branches per plant exhibited significant negative correlation with pollen sterility and average fruit weight. First fruiting node was negatively correlated with average fruit weight and positively correlated with fruit girth.

Number of fruits per plant and weight of fruits per plant were positively correlated where as significant negative correlation between number of fruits per plant and plant duration was observed. Average fruit weight was positively correlated with fruit yield per plant, length of fruit, and plant duration but negatively correlated with plant height. Weight of fruits per plant and number of seeds per fruit were negatively correlated. Girth of fruit exhibited significant positive correlation with pollen sterility and plant height while number of seeds per fruit and number of ridges per fruit were significantly and negatively correlated (Table 31).

4.3.6. P_1

In the cultivated parent, leaf axil bearing the first flower was significantly and positively correlated with first fruiting node. Leaf number, number of flowers per plant and fruits per plant were positively correlated with leaf area, first fruiting node, fruit yield per plant and also among themselves. Leaf number was found to be positively correlated with average fruit weight and negatively correlated with fruiting phase. Leaf area had significant positive correlation with fruit yield and length of fruit, but had negative correlation with number of branches per plant. Number of flowers per plant and pollen sterility were negatively correlated with number of seeds per fruit. Significant positive correlation between first fruiting node and weight of fruits per plant was noticed. Average fruit weight was found to be positively correlated with fruit yield per plant and negatively correlated with number of ridges per fruit. Girth of fruit had significant negative correlation with number of ridges per fruit (Table 32).

Table 31. Correlation in F_2M_2 – 40 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	-0.0786	–																
X_3	Leaf number	-0.1215	-0.1727	–															
X_4	Leaf area	-0.2393	0.0608	0.1148	–														
X_5	No. of branches per plant	-0.1274	0.1994	0.3475*	0.2762	–													
X_6	No.of flowers per plant	0.0716	-0.2029	0.9070**	-0.0204	0.4423**	–												
X_7	Pollen sterility	0.0782	-0.0650	-0.0112	-0.3408*	-0.3524*	-0.0204	–											
X_8	First fruiting node	0.0239	0.3933**	0.1207	-0.0961	0.1463	0.1094	0.0362	–										
X_9	No. of fruits per plant	-0.1930	-0.2002	0.8096**	0.1377	0.3831**	0.8713**	0.0049	0.1463	–									
X_{10}	Average fruit weight	0.0062	0.0317	-0.2462	0.2821*	-0.4500**	-0.2050	0.0095	-0.3175*	-0.2070	–								
X_{11}	Weight of fruits per plant	-0.1618	-0.1667	0.4855**	0.2729	-0.0121	0.5841**	0.0575	-0.0839	0.7221**	0.4990**	–							
X_{12}	Length of fruit	0.0716	-0.0625	-0.2198	0.0395	-0.0193	-0.2487	-0.0317	-0.0779	-0.2674	0.3417*	-0.0521	–						
X_{13}	Girth of fruit	0.0856	0.0281	0.0961	-0.0322	-0.0455	-0.0127	0.4386**	0.2883*	-0.0088	0.0148	0.0209	0.0305	–					
X_{14}	No. of seeds per fruit	0.0812	0.0030	-0.0241	-0.2039	-0.1109	-0.1774	0.3328*	0.0747	-0.1691	-0.1874	-0.2917*	0.1959	0.2147	–				
X_{15}	No. of ridges per fruit	-0.0718	0.0310	0.0102	-0.0171	0.0322	0.0299	-0.0971	-0.0594	-0.0167	0.0246	-0.0071	-0.1517	0.0451	-0.3286*	–			
X_{16}	Fruiting phase	0.0373	0.1843	-0.1825	-0.1062	-0.1274	-0.1062	0.0561	-0.0245	-0.0524	0.0681	-0.0079	0.0944	-0.2448	-0.0227	-0.1617	–		
X_{17}	Height of plant	0.1663	-0.0787	-0.0927	-0.1800	0.0910	-0.0946	0.0129	0.1966	0.0497	-0.3501*	-0.1767	-0.1404	0.3674**	-0.1927	0.1364	0.0815	–	
X_{18}	Duration of the plant	0.0822	0.1315	-0.3661**	0.2995*	-0.1289	-0.2995*	-0.0116	-0.1482	-0.5091**	0.3028*	-0.2325	0.1284	0.0018	-0.0211	0.0573	0.1332	-0.0379	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 32. Correlation in $F_2M_2 - P_1$

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.0520	–																
X_3	Leaf number	-0.3321*	0.1704	–															
X_4	Leaf area	-0.2783	-0.0358	0.3734**	–														
X_5	No. of branches per plant	-0.0226	0.2001	0.0530	-0.2872*	–													
X_6	No.of flowers per plant	-0.1974	-0.0680	0.8450**	0.4176**	-0.0122	–												
X_7	Pollen sterility	-0.0555	-0.0078	0.0785	-0.0184	0.0278	0.1346	–											
X_8	First fruiting node	-0.0787	0.6499**	0.4571**	0.1397	0.2030	0.3217*	0.0465	–										
X_9	No. of fruits per plant	-0.1700	-0.0420	0.7423**	0.4729**	-0.1780	0.8475**	-0.0250	0.3872**	–									
X_{10}	Average fruit weight	-0.0873	-0.0920	0.3013*	0.2196	-0.1046	0.2552	-0.0342	0.0771	0.2588	–								
X_{11}	Weight of fruits per plant	-0.1651	-0.0652	0.6755**	0.4447**	-0.1784	0.7063**	-0.0506	0.3187*	0.8114**	0.7703**	–							
X_{12}	Length of fruit	-0.1527	0.0109	0.2347	0.3195*	-0.0870	0.2312	-0.0033	0.2072	0.1658	0.1187	0.2101	–						
X_{13}	Girth of fruit	-0.0731	0.1890	0.2030	0.0430	0.0394	0.1963	-0.0827	0.2514	0.2623	0.0975	0.2106	-0.1094	–					
X_{14}	No. of seeds per fruit	-0.0428	-0.0240	-0.1938	-0.2023	-0.2085	-0.3522*	-0.3352*	-0.2238	-0.2473	0.1299	-0.0694	0.1777	-0.2287	–				
X_{15}	No. of ridges per fruit	-0.0467	0.0721	-0.1331	-0.0998	-0.0710	-0.1554	-0.1268	-0.1077	-0.0875	-0.3668**	-0.2687	-0.0825	-0.3330*	0.1980	–			
X_{16}	Fruiting phase	0.0743	0.0083	-0.3219*	-0.1881	0.2463	-0.2565	-0.0265	-0.0498	-0.2782	-0.0752	-0.2244	-0.0071	-0.1619	0.0732	0.1620	–		
X_{17}	Height of plant	-0.1053	0.1054	0.1040	-0.2118	-0.0001	0.0354	-0.0150	0.1676	0.0727	-0.1533	-0.0534	-0.1788	0.1762	0.0702	-0.0169	0.0368	–	
X_{18}	Duration of the plant	0.1306	-0.0684	0.0972	0.0257	0.1005	0.1167	-0.2279	-0.0355	0.0263	0.0186	0.0248	-0.1174	0.0371	-0.0334	-0.1493	-0.0967	0.0520	–

* Significant at 5 per cent level ** Significant at 1 per cent level

4.3.7. P_2

In the semi wild parent, days to first flowering was found to be positively correlated with leaf area. Leaf axil bearing the first flower had significant positive correlation with first fruiting node and negative correlation with girth of fruit. Leaf number, number of flowers per plant and fruits per plant were significantly and positively correlated with fruit yield and also among themselves. Leaf number was found to be positively correlated with first fruiting node also. Number of branches per plant had significant positive correlation with girth of fruit while first fruiting node had significant negative correlation with fruiting phase. Average fruit weight exhibited significant positive correlation with fruit yield per plant and girth of fruit but negative correlation with number of ridges per fruit. Fruit yield per plant was also found to be positively correlated with girth of fruit and plant duration, but had negative correlation with plant height. Number of seeds per fruit was negatively correlated with plant height which in turn was negatively correlated with plant duration (Table 33).

4.4. Evaluation of the F_3M_3 generation

The analysis of variance of the 20 characters showed that the treatments differed significantly among themselves (Table 34).

The mean values of the different treatments and progenies with respect to each character are presented in Tables 35 to 54. High yielding yellow vein mosaic disease resistant lines in the treatment 30 kR are presented in figures 18 to 20.

Table 33. Correlation in $F_2M_2 - P_2$

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.1437	–																
X_3	Leaf number	-0.0567	0.1630	–															
X_4	Leaf area	0.4129**	-0.0459	-0.0420	–														
X_5	No. of branches per plant	-0.0778	-0.1818	0.0654	-0.0579	–													
X_6	No.of flowers per plant	-0.0034	0.0366	0.7929**	0.0561	-0.0350	–												
X_7	Pollen sterility	0.1837	0.0905	-0.1291	0.1294	-0.1573	-0.1208	–											
X_8	First fruiting node	0.0403	0.7710**	0.3269*	-0.1098	-0 2077	0.2342	0.0967	–										
X_9	No. of fruits per plant	-0.0334	-0.0480	0.5952**	0.0775	0.1884	0.7838**	-0.2183	0.0162	–									
X_{10}	Average fruit weight	0.1212	-0.1420	0.1551	-0.0005	0 0452	0.1618	-0.0618	-0.1755	0 1898	–								
X_{11}	Weight of fruits per plant	0.1505	-0.1631	0.4740**	-0.0469	0.2144	0.5732**	-0.1694	-0.1274	0.6290**	0.6745**	–							
X_{12}	Length of fruit	-0.0311	-0.2173	-0.0708	0.0835	0.0111	0.1255	0.1157	0.1418	0.0619	-0.1428	-0.0666	–						
X_{13}	Girth of fruit	-0.2173	-0.3031*	0.2627	-0.2016	0.2798*	0.2478	-0.0492	0.1587	0 1360	0.3824**	0.3025*	0.0953	–					
X_{14}	No. of seeds per fruit	-0.0875	0 0373	-0.1498	0.1626	0.1649	0.0238	0.0239	-0.1380	0 0111	-0.0863	-0.0640	0.0439	-0.0836	–				
X_{15}	No of ridges per fruit	-0.0932	0.1422	-0.0252	-0.2749	-0.1583	-0.0034	0.0174	0.0145	0.1210	-0.3267*	-0.1180	0.0207	-0.2561	-0.1504	–			
X_{16}	Fruiting phase	0.0861	-0 2110	-0.1031	0.2019	0.1714	-0.1752	-0.0430	-0.4229**	-0 0603	0.1291	0.2165	0.0257	0.0396	0.0618	-0.0146	–		
X_{17}	Height of plant	0.0657	0.0956	-0.1786	0.0749	-0.1383	-0.1698	-0.0650	-0.0272	-0.1537	0.0520	-0.2867*	0.1465	-0.0051	0.3080*	-0.0676	-0.2208	–	
X_{18}	Duration of the plant	0.1954	0.1361	0.1634	0.1068	0.1338	0.0303	0.1189	-0.0184	0.1939	0.1886	0.3955**	-0.1229	0.0459	-0.0507	-0.0318	0.2328	-0.4002**	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 34. Pooled ANOVA of 20 characters for the seven treatments in F_3M_3

Sl. No.	Character	Mean Square			
		Replication df = 4	Family df = 6	Error df = 24	$F_{6,24}$
1.	Days of first flowering	8.95	625.60	14.29	43.77**
2.	Leaf axil bearing first flower	0.24	44.32	1.28	34.51**
3.	Leaf number	46.70	30184.56	48.49	622.39**
4.	Leaf area	10671.50	126690.00	4309.25	29.39**
5.	Number of branches per plant	1.66	196.03	1.26	155.46**
6.	Number of flower per plant	29.08	25138.03	46.10	545.24**
7.	Pollen sterility (%)	28.59	3719.63	21.99	169.14**
8.	First flowering node	2.08	87.63	1.35	64.63**
9.	Number of fruits per plant	10.66	17715.39	43.80	404.40**
10.	Average fruit weight (g)	3.40	501.76	3.43	146.16**
11.	Weight of fruits per plant (g)	1854.00	641259.00	6345.50	101.06**
12.	Length of fruit (cm)	2.40	391.71	1.88	207.67**
13.	Girth of fruit	0.25	59.43	0.36	161.41**
14.	Number of seeds per fruit	25.35	16087.41	37.84	425.15**
15.	Number of ridges per fruit	0.11	47.97	0.06	743.37**
16.	Fruiting phase	78.25	8219.38	38.94	211.09**
17.	Height of plant	129.25	47972.00	273.66	175.29**
18.	Incidence of YVM disease	0.13	0.71	0.02	100.66**
19.	Incidence of fruit and shoot borer	0.18	27.17	0.09	279.84**
20.	Duration of plant	51.37	9156.66	25.52	358.79**

** Significant at 1 per cent level

4.4.1. Days to first flowering

Significant differences in number of days taken to first flowering were observed among the treatments. 20 kR took the maximum number of days for first flowering (54.08 days) and the cultivated parent the minimum number of days (45.28 days). The treatment 10 kR was on par with the treatments 20 kR, 40 kR and the semi wild parent. Significant progeny differences were observed within all the treatments excluding the semi wild parent. The mean number of days taken for first flowering ranged from 43.60 to 50.88 days in 0 kR, 48.12 to 61.56 days in 10 kR, 50.16 to 60.64 days in 20 kR, 46.82 to 55.68 days in 30 kR, 47.52 to 59.24 days in 40 kR and 42.28 to 50.72 days in P_1 (Table 35).

4.4.2. Leaf axil bearing the first flower

Treatment wise differences were observed with respect to leaf axil bearing the first flower (Table 36). It ranged from 4.83 in 30 kR to 7.39 in the semi wild parent. The treatments 0 kR (6.70) and 10 kR (6.75) were on par while 40 kR (5.52) was on par with P_1 (5.14). Progeny differences were observed within the treatments 0 kR, 10 kR, 30 kR, P_1 and P_2. Progeny differences ranged from 6.24 to 7.28 in 0 kR, 5.64 to 7.36 in 10 kR, 4.14 to 5.20 in 30 kR, 4.72 to 5.56 in P_1 and 6.60 to 8.12 in P_2.

Table 35. Days to first flowering in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	47.76	51.48	58.00	55.64	56.84	45.74	53.94
2.	46.12	56.20	60.64	51.84	59.24	46.16	51.78
3.	48.20	61.56	55.84	50.28	56.68	46.16	54.36
4.	44.28	56.68	51.96	54.88	55.16	46.46	52.68
5.	50.88	54.40	51.04	47.24	53.16	43.12	52.76
6.	47.80	50.96	56.08	51.36	55.00	46.60	51.72
7.	46.46	52.84	50.16	46.82	50.76	42.28	54.06
8.	43.60	49.00	51.84	48.60	47.52	50.72	52.40
9.	47.20	50.00	50.36	55.68	55.40	43.64	53.52
10.	47.20	48.12	54.96	47.76	48.64	43.92	52.40
Mean	46.95	53.12	54.08	51.01	53.86	45.28	52.92
$F_{9,36}$	3.06**	4.17**	2.43*	6.32**	2.59*	5.96**	0.48
SE							
Progenies	1.656	2.865	3.232	1.945	3.324	1.392	1.942
Treatments	0.756						
Bartlett's X^2_6 for error variances	48.55**						

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 36. . Leaf axil bearing the first flower in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	7.28	7.18	6.04	5.12	5.56	4.80	7.00
2.	6.80	7.36	5.82	4.90	6.04	5.12	6.60
3.	6.92	7.28	5.32	5.20	5.96	5.48	7.08
4.	6.40	6.68	7.16	4.36	4.88	5.40	7.32
5.	6.44	6.40	6.04	5.20	5.38	4.76	7.12
6.	7.12	7.08	5.48	5.08	5.00	5.10	7.88
7.	6.60	6.56	5.36	4.16	5.44	5.32	7.89
8.	6.24	5.64	6.68	4.14	5.12	4.72	7.00
9.	6.48	6.96	7.14	4.92	6.34	5.16	7.92
10.	6.76	6.32	5.60	5.20	5.44	5.56	8.12
Mean	6.70	6.75	6.06	4.83	5.52	5.14	7.39
$F_{9,36}$	2.54*	3.28**	1.34	2.31*	1.76	2.17*	7.90**
SE							
Progenies	0.296	0.417	0.856	0.407	0.503	0.291	0.260
Treatments	0.226						
Bartlett's X^2_6 for error variances	84.28**						

* Significant at 5 per cent level ** Significant at 1 per cent level

4.4.3. Leaf number

Significant differences in leaf number were observed among the treatments (Table 37). It ranged from 16.67 in 0 kR to 71.15 in 10 kR. Progeny differences were significant within the irradiated treatments. The mean number of leaves ranged from 30.24 to 135.42 in 10 kR, 27.60 to 128.00 in 20 kR, 10.32 to 136.40 in 30 kR and 13.76 to 156.72 in 40 kR.

4.4.4. Leaf area

The treatments were significantly different with respect to leaf area ranging from 210.41 cm^2 (P_1) to 343.54 cm^2 (10 kR) (Table 38). Significant progeny differences were observed within the irradiated treatments and the semi wild parent. The mean leaf area ranged from 214.84 to 478.38 cm^2 in 10 kR, 208.24 to 440.60 cm^2 in 20 kR, 188.78 to 344.54 cm^2 in 30 kR, 167.82 to 409.00 cm^2 in 40 kR and 288.24 to 393.28 cm^2 in P_2.

4.4.5. Number of branches per plant

Treatment wise differences were highly significant with respect to the number of branches per plant. Maximum number of branches were observed in 20 kR (5.05) and least in P_2 (0.36). P_1, P_2 and the unirradiated treatment were on par. Progeny differences were significant in the irradiated and unirradiated treatments and in the cultivated parent. In 0 kR the maximum number of branches was 1.36 and minimum 0.12 while in 10 kR, the range was from 1.20 to 10.54, in 20 kR from 3.14 to 7.82, in 30 kR from 0.44 to 9.10 and in 40 kR from 1.28 to 5.36. In the cultivated parent the number of branches ranged from 0.04 to 1.04 (Table 39).

Table 37. Leaf number in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	15.56	37.68	48.00	19.48	92.84	17.68	20.52
2.	17.56	30.24	83.40	22.20	29.72	16.76	21.80
3.	15.46	58.00	44.40	136.40	64.96	18.12	19.00
4.	15.36	52.00	49.80	16.84	36.88	17.60	17.40
5.	18.24	135.42	128.00	18.08	80.12	17.60	19.60
6.	16.24	54.40	72.40	24.08	49.80	17.40	19.74
7.	16.72	41.20	54.80	10.32	29.08	16.64	20.88
8.	16.92	132.60	49.00	14.48	156.72	18.56	19.72
9.	17.32	51.60	45.20	49.20	123.04	17.64	22.40
10.	17.32	118.36	27.60	13.68	13.76	19.52	22.84
Mean	16.67	71.15	60.26	32.48	67.69	17.75	20.39
$F_{9,36}$	1.52	128.18**	70.34**	495.99**	176.80**	0.84	1.47
SE							
Progenies	1.130	5.104	4.780	2.417	4.873	1.293	1.932
Treatments	1.392						
Bartlett's X^2_6 for error variances	147.38**						

** Significant at 1 per cent level

Table 38. Leaf area (cm^2) in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	270.26	305.54	242.48	254.24	409.00	204.16	393.28
2.	229.36	403.30	277.84	344.54	354.04	217.38	334.52
3.	217.46	270.32	208.24	340.92	329.24	195.70	375.60
4.	220.48	350.38	360.50	287.56	261.32	210.06	320.30
5.	233.80	455.76	289.00	211.14	274.94	220.82	288.24
6.	220.26	394.96	257.74	188.78	167.82	213.66	330.36
7.	214.64	478.38	245.52	241.16	268.40	218.10	333.18
8.	216.46	232.80	268.16	241.26	300.00	209.20	320.50
9.	216.04	214.84	440.60	215.12	244.32	210.98	310.66
10.	208.20	329.12	231.04	214.73	242.06	204.02	310.12
Mean	224.70	343.54	282.11	253.95	285.11	210.41	331.68
$F_{9,36}$	1.48	18.94**	7.97**	4.35**	8.69**	0.45	7.27**
SE							
Progenies	20.458	29.237	34.658	36.701	32.171	16.049	16.383
Treatments	13.129						
Bartlett's X^2_6 for error variances	48.41**						

** Significant at 1 per cent level

Table 39. Number of branches per plant in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	0.20	2.84	7.82	0.44	4.64	0.32	0.52
2.	0.28	1.20	5.52	2.52	2.54	0.64	0.52
3.	0.40	5.16	4.20	9.10	1.70	1.04	0.20
4.	0.16	3.24	3.88	1.86	3.16	0.60	0.68
5.	0.24	10.54	5.42	0.98	1.74	0.80	0.36
6.	0.12	4.88	5.52	0.60	2.18	0.04	0.36
7.	0.36	1.64	5.40	1.22	2.34	0.28	0.20
8.	0.84	4.88	5.12	1.42	5.36	0.40	0.24
9.	1.36	6.00	4.44	1.04	1.28	0.44	0.32
10.	1.12	6.06	3.14	0.84	2.22	0.32	0.24
Mean	0.51	4.64	5.05	2.00	2.72	0.49	0.36
$F_{9,36}$	6.24**	28.28**	7.35**	74.28**	27.98**	2.46*	0.62
SE							
Progenies	0.248	0.715	0.662	0.421	0.353	0.260	0.289
Treatments	0.224						
Bartlett's X^2_6 for error variances	83.50**						

* Significant at 5 per cent level ** Significant at 1 per cent level

4.4.6. Number of flowers per plant

Table 40 showed that significant differences among the treatments were noted with respect to number of flowers per plant. The maximum number of flowers was in 10 kR (60.67) which was on par with 40 kR (58.32) and the least was in 0 kR (10.29). The semi wild parent (14.25) and the cultivated parent (13.39) were on par for this character. Progeny differences were also significant within the unirradiated and the irradiated treatments. The mean number of flowers ranged from 9.16 to 11.64 in 0 kR, 22.02 to 121.68 in 10 kR, 19.60 to 116.20 in 20 kR, 5.92 to 122.20 in 30 kR and 9.28 to 138.20 in 40 kR.

4.4.7. Pollen sterility

The treatments differed significantly with respect to pollen sterility. It ranged from 4.16 per cent in the cultivated parent to 38.64 per cent in the unirradiated treatment. Progeny differences were significant within all the treatments excluding the parental treatments. It ranged from 15.98 to 55.72 per cent in 0 kR, 4.06 to 53.86 per cent in 10 kR, 4.56 to 74.16 per cent in 20 kR, 1.98 to 30.14 per cent in 30 kR, 3.74 to 34.80 per cent in 40 kR (Table 41).

4.4.8. First fruiting node

Significant treatment wise differences were noticed with respect to first fruiting node (Table 42). It ranged from 5.50 in P_1 to 8.30 in 0 kR.

Table 40. Number of flowers per plant in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	9.32	29.64	40.20	14.00	82.28	13.96	13.96
2.	11.12	22.02	71.00	16.20	22.40	13.16	15.64
3.	9.36	48.60	34.00	122.20	57.44	13.36	13.90
4.	9.16	44.40	39.80	12.28	29.56	13.48	13.52
5.	11.64	121.68	116.20	12.44	71.40	13.52	13.72
6.	9.32	46.00	62.00	18.52	42.48	13.54	16.04
7.	10.44	32.74	47.00	5.92	22.28	12.40	13.68
8.	10.84	118.00	39.60	10.04	138.20	14.20	13.04
9.	10.64	42.60	36.60	40.00	107.88	12.92	14.56
10.	11.04	101.00	19.60	8.52	9.28	13.32	14.40
Mean	10.29	60.67	50.60	26.01	58.32	13.39	14.25
$F_{9,36}$	2.22*	111.87**	64.75**	602.94**	196.60**	0.69	0.66
SE							
Progenies	0.869	5.047	4.773	2.021	4.206	0.857	1.654
Treatments	1.358						
Bartlett's X^2_6 for error variances	197.01**						

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 41. Pollen sterility in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	45.30 (42.18)	22.24 (27.98)	4.56 (11.65)	18.22 (25.12)	25.14 (30.02)	3.34 (9.90)	24.68 (29.29)
2.	55.72 (48.28)	29.16 (36.65)	26.22 (30.62)	17.40 (24.59)	25.90 (30.48)	3.08 (8.95)	34.70 (36.01)
3.	15.98 (23.47)	33.04 (35.04)	6.18 (14.07)	30.14 (33.17)	22.72 (28.40)	1.25 (6.22)	29.44 (32.83)
4.	25.44 (30.23)	53.86 (47.20)	74.16 (60.18)	21.16 (27.27)	34.80 (36.11)	3.44 (10.15)	24.88 (29.71)
5.	47.36 (43.46)	28.84 (32.44)	37.28 (37.57)	4.76 (12.40)	30.52 (33.27)	4.22 (11.77)	27.36 (31.44)
6.	35.68 (36.63)	4.06 (11.28)	18.92 (25.61)	18.96 (25.42)	16.94 (24.12)	6.16 (13.62)	23.06 (28.33)
7.	36.62 (37.19)	17.20 (24.33)	31.44 (34.05)	4.66 (11.99)	3.74 (10.87)	5.38 (12.98)	17.86 (24.84)
8.	36.20 (36.92)	5.40 (12.95)	5.78 (13.38)	9.36 (19.98)	16.62 (23.82)	4.50 (12.20)	24.86 (29.84)
9.	42.90 (40.88)	10.46 (18.68)	63.22 (52.70)	25.46 (30.23)	4.26 (11.36)	6.66 (14.01)	25.15 (29.97)
10.	45.22 (42.16)	15.60 (23.09)	44.52 (41.80)	1.98 (7.81)	24.14 (29.25)	3.56 (10.69)	26.36 (30.73)
Mean	38.64 (38.14)	21.99 (26.57)	31.23 (32.17)	15.21 (21.50)	20.48 (25.77)	4.16 (11.05)	25.84 (30.31)
$F_{9,36}$	13.85**	61.35**	66.28**	20.94**	20.34**	1.68	2.05
SE							
Progenies	2.571	2.081	2.894	2.491	2.369	2.466	2.883
Treatments	0.938						
Bartlett's X^2_6 for error variances	39.22**						

Figures in parenthesis are values after angular transformation

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 42. First fruiting node in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	9.42	8.48	6.82	6.12	6.56	5.72	7.28
2.	8.12	8.44	7.00	6.08	7.18	5.44	7.08
3.	8.46	8.48	6.62	6.56	6.64	5.60	7.28
4.	9.16	8.16	7.84	5.60	6.20	5.78	7.72
5.	7.40	7.24	7.12	5.54	6.36	5.12	7.44
6.	8.02	7.29	6.60	5.84	5.80	5.44	8.20
7.	8.08	7.54	6.18	5.10	6.46	5.64	8.36
8.	7.66	6.76	8.60	5.48	6.14	5.04	7.36
9.	8.10	8.52	8.22	5.38	7.40	5.52	8.20
10.	8.58	8.16	6.36	6.42	6.24	5.68	8.32
Mean	8.30	7.97	7.14	5.81	6.50	5.50	7.72
$F_{9,36}$	6.49**	7.03**	1.87	4.08**	1.61	1.91	15.24**
SE Progenies	0.347	0.323	0.843	0.332	0.538	0.254	0.179
Treatments	0.232						
Bartlett's X^2_6 for error variances	116.30**						

** Significant at 1 per cent level

The unirradiated treatment was on par with 10 kR whereas 30 kR was on par with P_1. Progeny differences were significant within treatments 0 kR, 10 kR, 30 kR and P_2. In 0 kR, the first fruiting node varied from 7.40 to 9.42, in 10 kR from 6.76 to 8.52, in 30 kR from 5.10 to 6.56 and in P_2 it ranged from 7.08 to 8.36.

4.4.9. Number of fruits per plant

The treatments varied significantly with respect to number of fruits per plant (Table 43). It ranged from 10.14 (0 kR) to 52.22 (10 kR). The cultivated parent (12.78) and the semi wild parent (13.52) were on par. The treatment 10 kR (52.22) was on par with 40 kR (50.55). Progeny differences were significant within the irradiated treatments. It ranged from 18.96 to 110.44 in 10 kR, 15.60 to 100.40 in 20 kR, 5.44 to 103.20 in 30 kR and 8.32 to 125.20 in 40 kR.

4.4.10. Average fruit weight

Average fruit weight varied significantly among the treatments. It ranged from 7.26 g in 10 kR to 16.14 g in the semi wild parent. The unirradiated treatment and 30 kR were on par (12.47 and 12.59 g respectively). Progeny differences within the irradiated treatments were significant. It ranged from 5.80 to 8.58g; 5.72 to 12.36 g; 9.48 to 18.32 g and 5.88 to 11.16 g in 10, 20, 30 and 40 kR respectively (Table 44).

Table 43. Number of fruits per plant in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	9.12	27.28	35.40	13.80	72.04	13.32	13.04
2.	10.64	18.96	65.20	15.06	17.64	12.72	14.60
3.	9.08	43.46	29.20	103.20	51.28	12.04	13.24
4.	10.16	38.64	33.60	12.20	24.00	12.72	13.00
5.	10.68	110.44	100.40	11.96	63.00	13.04	13.24
6.	9.24	41.20	54.40	16.16	34.60	13.08	15.36
7.	10.28	24.58	41.00	5.44	16.24	11.88	13.08
8.	10.60	101.20	36.40	9.20	125.20	13.80	12.44
9.	9.68	34.20	30.80	35.40	93.20	12.64	13.76
10.	10.96	82.20	15.60	8.36	8.32	12.60	13.48
Mean	10.14	52.22	44.20	23.08	50.55	12.78	13.52
$F_{9,36}$	1.30	72.82**	50.32**	564.00**	145.65**	0.95	0.74
SE							
Progenies	0.897	5.493	4.786	1.745	4.456	0.825	1.411
Treatments	1.324						
Bartlett's X^2_6 for error variances	226.01**						

** Significant at 1 per cent level

Table 44. Average fruit weight (g) in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	11.92	7.46	6.12	11.32	9.70	13.30	17.94
2.	11.96	8.34	10.40	16.24	10.68	14.36	15.66
3.	11.88	6.96	10.12	9.50	8.36	13.44	17.62
4.	12.92	6.04	6.54	11.18	10.68	12.56	15.32
5.	12.92	5.80	5.72	9.58	5.88	14.24	16.24
6.	12.84	7.70	6.08	14.60	11.16	13.84	14.80
7.	12.72	8.58	8.96	10.86	9.24	13.64	15.96
8.	12.40	6.80	8.56	14.80	8.48	13.44	16.00
9.	12.56	8.32	8.76	9.48	8.74	13.48	17.04
10.	12.56	6.62	12.36	18.32	10.58	13.28	14.80
Mean	12.47	7.26	8.36	12.59	9.35	13.56	16.14
$F_{9,36}$	0.79	8.48**	11.55**	17.82**	3.01**	0.80	1.34
SE							
Progenies	0.657	0.475	0.923	1.059	1.293	0.772	1.337
Treatments	0.371						
Bartlett's X^2_6 for error variances	53.28**						

** Significant at 1 per cent level

4.4.11. Weight of fruits per plant

Weight of fruits per plant differed significantly with respect to the treatments. It ranged from 126.95 g in 0 kR to 444.34 g in 40 kR. The lower doses of radiation viz., 10 kR and 20 kR were on par. Progeny differences were significant within the irradiated treatments. Weight of fruits per plant ranged from 158.50 to 688.48 g in 10 kR, 194.08 to 680.56 g in 20 kR, 58.12 to 980.20 g in 30 kR and 86.16 to 1059.04 g in 40 kR (Table 45).

4.4.12. Length of fruit

The treatments differed significantly with respect to fruit length. The length of fruit was maximum for the semi wild parent (14.92 cm) which was on par with the cultivated parent (14.54 cm). The fruit length was minimum in 10 kR (7.38cm). The treatments 0 kR (12.04 cm) and 40 kR (12.13 cm) were on par. Progeny differences were significant within the treatments 0 kR, 30 kR, 40 kR and P_2. The maximum fruit length was 13.88 cm and the minimum 10.12 cm in 0 kR, while it was 8.28 and 6.68 cm in 10 kR, 10.44 and 7.52 cm in 20 kR and 14.52 and 8.92 cm in 30 kR respectively (Table 46).

4.4.13. Girth of fruit

Girth of fruit differed significantly among the treatments. It was maximum for the fruits of the semi wild parent (8.32 cm) and minimum in 20 kR (5.20 cm). The treatments 10 kR, 20 kR, 30 kR and P_1 were on par. The unirradiated treatment was on par with 40 kR.

Table 45. Weight of fruits per plant in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	113.32	202.40	215.76	156.44	693.56	176.68	233.70
2.	128.12	158.50	680.56	249.18	187.94	184.24	228.86
3.	108.80	299.02	301.88	980.20	429.14	161.98	232.56
4.	132.08	237.66	218.44	136.56	257.12	159.98	199.42
5.	137.84	686.96	573.68	114.66	368.16	185.32	216.04
6.	117.76	314.42	339.52	236.52	396.52	178.18	227.46
7.	130.88	211.06	364.92	58.12	153.50	163.38	209.02
8.	131.68	688.48	313.92	136.64	1059.04	185.68	195.42
9.	133.40	285.84	255.64	430.96	812.26	170.32	239.74
10.	135.58	543.34	194.08	153.98	86.16	167.62	199.92
Mean	126.95	362.77	345.84	265.33	444.34	173.34	218.21
$F_{9,36}$	1.16	40.62**	18.53**	43.91**	47.67**	0.75	0.58
SE							
Progenies	13.124	44.515	52.706	57.900	64.679	16.364	30.392
Treatments	15.931						
Bartlett's X^2_6 for error variances	125.61**						

** Significant at 1 per cent level

Table 46. Length of fruit (cm) in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	11.36	7.52	8.80	10.92	11.98	15.10	15.86
2.	12.52	8.28	7.80	10.70	11.92	14.88	15.16
3.	12.32	7.44	7.52	9.48	11.72	15.02	15.38
4.	12.76	7.68	8.08	12.42	13.86	14.46	15.30
5.	13.36	7.64	8.92	14.52	11.72	14.62	15.16
6.	13.88	7.76	8.36	12.76	12.82	15.18	14.68
7.	12.88	6.88	10.44	13.04	14.10	14.74	15.08
8.	10.72	6.76	8.72	8.92	13.20	14.02	15.10
9.	10.12	6.68	8.62	12.32	8.92	13.40	13.56
10.	10.44	7.16	8.68	10.12	11.02	14.02	13.92
Mean	12.04	7.38	8.59	11.52	12.13	14.54	14.92
$F_{9,36}$	4.73**	1.55	2.00	8.75**	7.69**	1.37	3.20**
SE							
Progenies	0.843	0.576	0.795	0.847	0.768	0.692	0.548
Treatments	0.274						
Bartlett's X^2_6 for error variances	12.77*						

* Significant at 5 per cent level ** Significant at 1 per cent level

Progeny differences were significant within the treatments 0 kR, 30 kR, 40 kR and the two parents. Fruit girth ranged from 5.24 to 6.30 cm in 0 kR, 5.08 to 5.96 cm in 30 kR, 4.94 to 6.90 cm in 40 kR, 5.02 to 5.94 cm in P_1 and 6.90 to 9.32 cm in P_2 (Table 47).

4.4.14. Number of seeds per fruit

Treatments varied significantly with respect to number of seeds per fruit (Table 48). It ranged from 1.56 (10 kR) to 50.29 (P_2). The lower doses of radiation viz., 10 kR and 20 kR were on par (1.56 and 2.70 respectively). Progeny differences were significant within the treatments 0 kR, 20 kR, 30 kR, 40 kR, P_1 and P_2. The number of seeds per fruit varied from 8.08 to 12.24 in 0 kR, 0.32 to 10.36 in 20 kR, 8.36 to 35.76 in 30 kR, 1.00 to 15.64 in 40 kR, 23.74 to 41.04 in P_1 and 43.56 to 57.84 in P_2.

4.4.15. Number of ridges per fruit

Treatment differences were significant with respect to number of ridges per fruit (Table 49). The semi wild parent had fruits with maximum number of ridges (7.97) and the cultivated parent the lowest (5.00). All other treatments were on par. Significant progeny differences were noticed in all the treatments excluding the cultivated parent. The number of ridges per fruit ranged from 5.04 to 6.36 in 0 kR, 5.02 to 7.06 in 10 kR, 5.06 to 7.00 in 20 kR, 5.02 to 7.86 in 30 kR, 5.00 to 6.18 in 40 kR and 7.84 to 8.06 in P_2.

Table 47. Girth of fruit (cm) in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	5.48	5.64	5.16	5.22	6.90	5.02	7.40
2.	5.82	5.24	5.36	5.72	6.50	5.24	7.70
3.	5.86	5.04	5.40	5.08	6.64	5.22	9.32
4.	5.56	5.18	5.40	5.24	6.86	5.36	8.72
5.	6.00	5.52	5.24	5.94	5.10	5.42	9.30
6.	5.24	5.92	5.08	5.46	6.22	5.44	8.62
7.	6.12	5.16	5.12	5.96	5.24	5.36	9.24
8.	6.30	5.76	5.36	5.44	4.94	5.48	8.48
9.	6.08	5.24	4.92	5.14	5.08	5.94	6.90
10.	5.76	5.04	4.96	5.20	6.26	5.30	7.56
Mean	5.82	5.37	5.20	5.44	5.97	5.38	8.32
$F_{9,36}$	2.99**	1.02	0.84	2.94**	11.57**	2.25*	11.35**
SE							
Progenies	0.265	0.437	0.277	0.270	0.329	0.224	0.368
Treatments	0.120						
Bartlett's X^2_6 for error variances	23.15**						

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 48. Number of seeds per fruit in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	10.44	1.76	1.12	13.24	1.44	32.16	43.56
2.	8.28	1.92	0.92	28.24	4.72	23.74	55.24
3.	8.08	3.00	1.32	8.36	2.52	38.26	54.32
4.	10.00	2.56	0.96	16.36	12.16	41.04	57.84
5.	9.52	0.76	0.90	9.24	1.00	33.64	56.46
6.	12.08	1.60	0.32	16.64	15.64	35.14	48.36
7.	9.00	0.44	3.20	16.70	4.72	36.30	44.28
8.	12.24	1.32	4.16	29.10	2.48	23.82	47.06
9.	9.76	1.00	3.76	17.12	6.48	24.48	48.06
10.	9.52	1.28	10.36	35.76	10.32	25.50	47.72
Mean	9.89	1.56	2.70	19.08	6.15	31.41	50.29
$F_{9,36}$	5.59**	1.71	9.62**	14.11**	6.24**	5.64**	2.46*
SE							
Progenies	0.836	0.852	1.373	3.393	2.819	3.882	4.689
Treatments	1.244						
Bartlett's X^2_6 for error variances	170.79**						

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 49. Number of ridges per fruit in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	5.12	5.64	5.12	6.00	5.76	5.00	8.04
2.	6.36	7.06	5.10	7.86	5.28	5.00	8.06
3.	5.42	5.76	5.44	5.38	5.66	5.00	8.06
4.	5.04	5.58	5.12	5.06	6.00	5.00	7.84
5.	5.32	5.28	5.20	5.04	5.42	5.00	8.00
6.	5.28	5.48	5.34	5.02	5.00	5.00	7.84
7.	5.48	5.38	5.96	5.10	5.04	5.00	8.02
8.	5.86	5.08	6.26	5.10	5.34	5.00	8.00
9.	5.88	5.20	5.06	5.10	5.52	5.00	7.88
10.	5.08	5.02	7.00	5.32	6.18	5.00	8.00
Mean	5.48	5.55	5.56	5.50	5.52	5.00	7.97
$F_{9,36}$	17.98**	10.40**	12.71**	137.56**	15.17	—	2.54*
SE							
Progenies	0.142	0.256	0.256	0.106	0.139	—	0.077
Treatments	0.049						
Bartlett's X^2_6 for error variances	277.51**						

* Significant at 5 per cent level ** Significant at 1 per cent level

4.4.16. Fruiting phase

Fruiting phase exhibited significant difference between the treatments (Table 50). It was highest for the semi wild parent (109.97 days) and least for the cultivated parent (70.74 days). The treatment 10 kR (92.00 days) was on par with 40 kR (90.90 days) while 30 kR (83.64 days) was on par with 0 kR (81.93 days). Progenies also differed significantly in all the treatments excluding the parental treatments. Fruiting phase varied from 78.92 to 87.60 days in 0 kR, 86.84 to 99.26 days in 10 kR, 92.82 to 108.16 days in 20 kR, 71.96 to 102.72 days in 30 kR and 83.12 to 99.88 days in 40 kR respectively.

4.4.17. Height of the plant

Treatment differences were significant with respect to plant height. It ranged from 101.57 cm in the cultivated parent to 186.90 cm in 10 kR. The treatments 30 kR (133.87 cm) and 40 kR (139.52 cm) were on par. Significant progeny differences were noticed in all the treatments except in the semi wild parent. Plant height ranged from 135.46 to 161.12 cm in 0 kR, 155.08 to 252.48 cm in 10 kR, 128.86 to 226.44 cm in 20 kR, 57.54 to 226.70 cm in 30 kR, 75.56 to 188.06 cm in 40 kR and 94.16 to 118.92 cm in P_1 (Table 51).

4.4.18. Incidence of YVM disease

Significant differences among treatments were observed with respect to YVM disease incidence and it ranged from 1.17 for the semi wild parent to 2.40 for the cultivated parent (Table 52). Significant progeny differences were observed within treatments 10 kR, 20 kR and 30 kR and it ranged from 1.11 to 2.05 in 10 kR, 1.38 to 1.89 in 20 kR and 1.14 to 3.30 in 30 kR.

Table 50. Fruiting phase in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	87.60	87.82	104.92	102.72	97.84	73.02	110.72
2.	81.20	97.22	108.16	91.74	94.12	71.30	110.66
3.	78.92	99.26	98.88	99.46	99.88	72.02	107.28
4.	80.00	88.50	93.64	78.98	96.56	71.38	107.02
5.	82.24	89.92	92.82	72.42	86.84	70.78	111.24
6.	81.54	94.38	101.96	80.58	87.34	68.70	110.36
7.	82.26	93.70	102.28	84.50	86.82	72.30	112.42
8.	81.32	93.82	101.22	71.96	90.30	67.80	110.10
9.	80.60	88.54	98.24	74.20	86.14	70.80	113.78
10.	83.58	86.84	100.94	79.88	83.12	69.34	106.16
Mean	81.93	92.00	100.31	83.64	90.90	70.74	109.97
$F_{9,36}$	3.36**	5.43**	4.17**	35.13**	5.93**	1.43	1.45
SE							
Progenies	1.830	2.593	3.243	2.610	3.357	1.964	2.871
Treatments	2.575						
Bartlett's X^2_6 for error variances	21.68**						

** Significant at 1 per cent level

Table 51 Height of the plant (cm) in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	138.98	194.08	128.86	208.92	159.66	97.26	119.94
2.	145.88	179.32	139.86	226.70	159.48	104.14	118.24
3.	152.94	252.48	181.66	166.92	164.04	99.32	117.18
4.	143.28	155.08	220.44	123.92	188.06	94.16	114.04
5.	135.46	191.92	172.40	57.54	160.52	101.78	118.68
6.	158.34	162.84	182.40	110.42	128.94	98.42	117.18
7.	152.90	182.44	168.52	112.12	155.32	99.36	114.62
8.	150.34	185.73	217.46	103.06	80.38	106.56	120.28
9.	135.70	161.58	226.44	138.16	75.56	96.24	117.16
10.	161.12	203.56	154.54	90.92	123.20	118.92	111.38
Mean	147.49	186.90	179.29	133.87	139.52	101.57	116.87
$F_{9,36}$	5.72^{**}	16.20^{**}	39.76^{**}	94.45^{**}	52.78^{**}	4.50^{**}	1.48
SE							
Progenies	5.388	9.776	7.574	7.685	7.231	4.645	3.235
Treatments	3.308						
Bartlett's X^2_6 for error variances	51.85^{**}						

** Significant at 1 per cent level

Table 52. Incidence of YVM disease in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	1.27 (1.12)	2.05 (1.43)	1.85 (1.36)	2.03 (1.43)	2.38 (1.54)	2.60 (1.61)	1.13 (1.06)
2.	1.07 (1.04)	1.50 (1.22)	1.48 (1.22)	1.95 (1.40)	2.20 (1.48)	2.21 (1.49)	1.09 (1.05)
3.	1.34 (1.16)	1.19 (1.09)	1.52 (1.23)	1.14 (1.07)	2.13 (1.46)	2.39 (1.55)	1.25 (1.12)
4.	1.07 (1.04)	1.23 (1.11)	1.55 (1.25)	1.81 (1.35)	2.36 (1.54)	2.39 (1.55)	1.17 (1.08)
5.	1.30 (1.14)	1.49 (1.22)	1.43 (1.19)	2.41 (1.55)	2.15 (1.47)	2.47 (1.57)	1.26 (1.12)
6.	1.45 (1.20)	1.11 (1.05)	1.38 (1.17)	1.72 (1.31)	2.04 (1.43)	2.25 (1.50)	1.19 (1.09)
7.	1.21 (1.10)	1.25 (1.12)	1.40 (1.19)	3.30 (1.82)	2.27 (1.51)	2.39 (1.55)	1.18 (1.08)
8.	1.34 (0.15)	1.43 (1.19)	1.43 (1.20)	2.57 (1.61)	2.43 (1.56)	2.45 (1.57)	1.12 (1.05)
9.	1.51 (1.23)	1.61 (1.27)	1.89 (1.38)	1.37 (1.17)	2.52 (1.59)	2.45 (1.57)	1.20 (1.09)
10.	1.55 (1.07)	1.77 (1.33)	1.87 (1.36)	1.97 (1.40)	2.16 (1.47)	2.45 (1.57)	1.12 (1.05)
Mean	1.28 (1.13)	1.46 (1.21)	1.59 (1.26)	1.99 (1.41)	2.25 (1.50)	2.40 (1.55)	1.17 (1.08)
$F_{9,36}$	11.11	4.08*	2.70*	14.24**	2.10	1.06	0.77
SE							
Progenies	0.087	0.024	0.069	0.080	0.158	0.156	0.133
Treatments	0.026						
Bartlett's X^2_6 for error variances	18.38**						

Figures in parenthesis are values after square root transformation

* Significant at 5 per cent level ** Significant at 1 per cent level

Fig. 18 - 20. High yielding YVM resistant plants in F_3M_3

Fig. 18.

Fig. 19.

Fig. 20.

4.4.19. Incidence of fruit and shoot borer

There was significant difference among treatments with respect to fruit and shoot borer incidence and it ranged from 6.45 per cent for the semi wild parent to 25.10 per cent for the cultivated parent (Table 53). The treatments 0 kR and 40 kR were on par. Significant progeny differences were observed within all the treatments except 20 kR. It ranged from 12.80 to 14.99 per cent in 0 kR, 13.55 to 15.96 per cent in 10 kR, 8.71 to 22.34 per cent in 30 kR, 9.70 to 20.94 per cent in 40 kR, 20.68 to 30.37 per cent in P_1 and 4.74 to 7.38 per cent in P_2.

4.4.20. Duration of the plant

Duration of the plant varied significantly among the treatments. It ranged from 127.56 days in P_1 to 167.28 days in P_2. Progeny differences were significant in all the treatments except the cultivated parent. It ranged from 135.70 to 146.90 days in 0 kR, 142.64 to 164.12 days in 10 kR, 152.14 to 175.14 days in 20 kR, 119.12 to 161.62 days in 30 kR, 131.68 to 164.38 days in 40 kR and 162.60 to 171.54 days in the semi wild parent (Table 54).

4.5. Genetic variability in the F_3M_3 generation

Genetic parameters viz., phenotypic and genotypic coefficients of variation, heritability and genetic advance of the 20 characters are presented in Tables 55 and 56.

Table 53. Incidence of fruit and shoot borer in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	13.20 (3.63)	15.58 (3.94)	15.97 (3.99)	19.71 (4.44)	12.54 (3.54)	21.53 (4.64)	6.44 (2.54)
2.	13.23 (3.64)	15.79 (3.97)	14.98 (3.87)	14.47 (3.80)	13.96 (3.73)	20.68 (4.55)	5.72 (2.39)
3.	13.12 (3.62)	15.96 (3.99)	14.92 (3.86)	8.71 (2.95)	12.56 (3.54)	22.57 (4.75)	4.74 (2.17)
4.	13.04 (3.61)	14.78 (3.84)	15.58 (3.94)	21.55 (4.64)	14.17 (3.76)	27.55 (5.44)	6.36 (2.52)
5.	13.22 (3.63)	13.55 (3.68)	15.37 (3.92)	19.38 (4.40)	9.70 (3.12)	27.72 (5.26)	7.20 (2.68)
6.	12.80 (3.57)	13.78 (3.71)	15.79 (3.97)	13.35 (3.65)	12.72 (3.57)	27.52 (5.24)	6.55 (2.55)
7.	12.91 (3.59)	13.77 (3.71)	15.98 (3.99)	22.15 (4.71)	14.94 (3.87)	24.87 (4.99)	6.24 (2.50)
8.	13.91 (3.63)	13.78 (3.71)	16.59 (4.07)	22.34 (4.73)	10.71 (3.27)	24.36 (4.94)	7.38 (2.72)
9.	14.83 (3.85)	14.77 (3.84)	16.36 (4.05)	15.17 (3.89)	14.77 (3.84)	22.91 (4.79)	6.95 (2.49)
10.	14.99 (3.87)	13.58 (3.68)	15.58 (3.95)	21.54 (4.64)	20.94 (4.58)	30.37 (5.51)	6.97 (2.64)
Mean	13.47 (3.67)	14.52 (3.81)	15.68 (3.96)	17.47 (4.18)	13.54 (3.68)	25.10 (5.01)	6.45 (2.54)
$F_{9,36}$	11.28**	3.13**	0.76	18.99**	12.21**	6.47**	2.56*
SE							
Progenies	0.139	0.103	0.111	0.191	0.159	0.188	0.139
Treatments	0.063						
Bartlett's X^2_6 for error variances	28.54**						

Figures in parenthesis are values after square root transformation

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 54. Duration of the plant in F_3M_3

Progenies	Treatments						
	0 kR	10 kR	20 kR	30 kR	40 kR	P_1	P_2
1.	146.90	153.32	166.84	159.12	164.38	127.82	166.52
2.	139.76	159.26	175.14	157.62	157.20	128.02	171.54
3.	135.70	164.12	162.68	147.96	161.96	131.24	162.60
4.	137.88	154.98	155.62	139.86	162.26	126.20	168.74
5.	136.94	156.18	152.14	119.12	141.04	125.50	163.19
6.	136.58	150.40	162.74	152.10	152.08	127.56	170.46
7.	143.34	151.66	160.24	129.98	131.68	127.20	168.02
8.	135.80	154.48	168.34	132.56	136.36	123.86	167.60
9.	139.12	146.86	152.58	126.34	133.72	129.72	163.56
10.	138.74	142.64	155.16	161.62	137.42	158.50	170.60
Mean	139.08	153.39	161.15	142.63	147.81	127.56	167.28
$F_{9,36}$	4.70**	12.29**	15.53**	44.99**	61.53**	0.95	4.64**
SE							
Progenies	2.323	2.447	2.692	3.191	2.353	3.025	2.134
Treatments	1.010						
Bartlett's X^2_6 for error variances	9.59						

** Significant at 1 per cent level

Table 55. Phenotypic and genotypic coefficients of variation in F_3M_3

Sl. No.	Plant characters	0 kR		10 kR		20 kR		30 kR		40 kR		P_1		P_2	
		PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV
1.	Days to first flowering	6.63	3.58	10.90	6.80	10.72	5.05	8.67	6.22	11.20	5.50	6.86	4.84	5.49	ne
2.	Leaf axil bearing first flower	8.04	3.95	11.75	6.63	23.04	5.72	14.90	6.87	15.48	5.73	9.92	4.35	8.56	6.49
3.	Leaf number	11.27	3.50	58.32	57.21	48.36	46.71	117.69	117.09	68.45	67.50	11.34	ne	15.66	4.57
4.	Leaf area	15.07	4.46	28.83	25.49	30.06	22.93	29.52	18.70	28.43	22.13	11.38	ne	11.73	8.74
5.	No. of branches per plant	110.90	78.40	61.94	56.94	31.25	23.35	131.81	127.57	51.86	47.65	95.72	45.63	121.08	ne
6.	No. of flowers per plant	14.90	6.59	63.32	61.94	55.32	53.27	135.36	134.80	72.24	71.3	9.79	ne	17.71	ne
7.	Pollen sterility	20.92	17.87	42.50	40.65	53.14	51.20	43.20	39.12	35.65	32.56	38.21	14.65	16.52	6.83
8.	First fruiting node	9.56	6.92	9.47	6.99	20.24	7.79	11.42	7.09	13.85	4.62	7.93	3.15	6 21	7.21
9.	No. of fruits per plant	14.39	3.42	65.19	63.03	56.43	53.77	127.44	126.90	76.25	74.96	10.14	ne	16.06	ne
10.	Average fruit weight	8.18	ne	16.36	12.62	30.80	25.37	27.79	24.39	25.89	13.86	8.91	ne	13.55	3.45

Contd...

(Table 55. Contd...)

Sl. No.	Plant characters	0 kR		10 kR		20 kR		30 kR		40 kR		P_1		P_2	
		PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV
11.	Weight of fruits per plant	16.61	2.93	57.96	54.62	51.15	45.12	106.82	101.09	73.98	70.31	14.55	ne	21.07	ne
12.	Length of fruit (cm)	14.62	9.54	13.00	4.07	16.05	6.59	18.56	14.47	15.31	11.60	7.81	2.06	6.96	3.85
13.	Girth of fruit (cm)	8.59	4.55	12.90	0.00	8.38	ne	9.19	4.86	15.44	12.76	7.43	3.22	12.26	10.06
14.	Number of seeds per fruit	18.51	12.79	92.22	32.69	132.77	105.60	53.52	45.54	103.71	74.18	27.13	18.82	16.75	7.95
15.	Number of ridges per fruit	8.56	7.52	12.35	10.03	13.33	11.23	16.26	15.95	7.90	6.78	0.00	0.00	1.77	0.00
16.	Fruiting phase	4.29	2.43	6.12	4.20	6.54	4.07	13.81	12.89	8.23	5.80	4.57	1.28	4.30	1.24
17.	Height of plant	8.05	5.60	16.62	14.42	19.76	18.60	40.28	39.24	27.61	26.37	9.43	6.05	4.58	1.36
18.	Incidence of YVM disease	12.54	0.00	14.37	8.30	11.26	0.00	17.37	14.18	6.66	0.00	6.44	0.00	0.00	ne
19.	Incidence of fruit and shoot borer	2.72	2.72	14.46	2.62	4.36	ne	15.48	13.72	12.44	10.15	8.47	6.30	9.02	5.57
20.	Duration of plant	3.49	2.27	4.55	3.79	5.22	4.50	11.08	10.50	9.11	8.76	3.73	ne	2.65	1.72

ne - not estimable

Table 56. Heritability and genetic advance in F_3M_3

Sl. No.	Plant characters	0 kR		10 kR		20 kR		30 kR		40 kR		P_1		P_2	
		H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA
1.	Days to first flowering	29.00	3.96	39.00	8.76	22.00	4.86	52.00	9.28	24.00	5.54	50.00	7.07	ne	ne
2.	Leaf axil bearing first flower	24.00	3.97	31.00	7.51	6.00	2.56	21.00	6.46	13.00	4.15	19.00	3.88	58.00	10.23
3.	Leaf number	9.00	2.09	96.00	115.34	93.00	92.65	99.00	240.01	97.00	136.78	ne	ne	9.00	2.90
4.	Leaf area	9.00	2.79	78.00	46.32	58.00	35.91	40.00	24.33	61.00	35.72	ne	ne	56.00	13.53
5.	No. of branches per plant	51.00	116.50	85.00	108.46	56.00	36.05	94.00	257.96	84.00	89.74	23.00	45.35	ne	ne
6.	No. of flowers per plant	20.00	6.14	96.00	125.22	93.00	105.98	99.00	276.05	98.00	145.83	ne	ne	ne	ne
7.	Pollen sterility	74.00	31.88	92.00	80.54	93.00	101.80	82.00	72.97	83.00	60.96	15.00	11.81	17.00	5.79
8.	First fruiting node	52.00	10.24	55.00	10.73	15.00	6.26	38.00	8.94	11.00	3.14	15.00	2.44	74.00	10.29
9.	No. of fruits per plant	6.00	1.78	93.00	124.89	91.00	105.79	99.00	259.90	97.00	152.35	ne	ne	ne	ne
10.	Average fruit weight (g)	ne	ne	60.00	20.22	68.00	43.14	77.00	44.08	29.00	15.47	ne	ne	6.00	1.67

Contd...

(Table 56. Contd...)

Sl. No.	Plant characters	0 kR		10 kR		20 kR		30 kR		40 kR		P_1		P_2	
		H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA	H^2	GA
11.	Weight of fruits per plant (g)	3.00	1.03	89.00	106.26	78.00	82.19	90.00	198.04	90.00	173.17	ne	ne	ne	ne
12.	Length of fruit (cm)	43.00	28.13	10.00	2.68	17.00	5.62	61.00	23.32	57.00	17.98	7.00	1.13	31.00	4.45
13.	Girth of fruit (cm)	28.00	4.96	0.00	0.00	ne	ne	28.00	5.30	68.00	21.63	20.00	3.06	67.00	16.92
14.	Number of seeds per fruit	48.00	18.30	12.00	22.80	63.00	172.30	72.00	79.38	51.0	108.96	48.00	26.83	23.00	7.94
15.	Number of ridges per fruit	77.00	13.58	65.00	91.80	70.00	19.23	96.00	32.16	74.00	12.04	ne	ne	24.00	0.88
16.	Fruiting phase	32.00	2.83	47.00	5.93	39.00	5.25	87.00	24.74	50.00	8.47	8.00	0.75	8.00	0.71
17.	Height of plant	49.00	8.13	75.00	25.68	89.00	36.23	95.00	78.82	91.00	51.77	41.00	7.96	9.00	0.85
18.	Incidence of YVM disease	2.00	0.52	38.00	11.25	25.00	5.79	73.00	26.12	18.00	2.84	1.00	0.13	ne	ne
19.	Incidence of fruit and shoot borer	67.00	3.76	30.00	3.24	ne	ne	78.00	24.87	69.00	17.68	52.00	9.06	24.00	4.77
20.	Duration of plant	43.00	3.09	69.00	6.47	74.00	7.94	90.00	20.54	92.00	17.27	ne	ne	42.00	2.29

ne - not estimable

4.5.1. 0 kR

Phenotypic and genotypic coefficients of variation were maximum for number of branches per plant (110.09 and 78.40 per cent respectively). All other characters had low phenotypic and genotypic coefficients of variation. Heritability was highest for number of ridges per fruit (77.00 per cent) but genetic advance was low (13.58 per cent). Similar trend was noticed for pollen sterility, first fruiting node, plant height, plant duration and number of seds per fruit. Number of branches per plant had moderately high heritability of 51.00 per cent and recorded the maximum genetic advance of 116.50 per cent. Genotypic coefficient of variation, heritability and genetic advance were not estimable for average fruit weight (Fig. 21).

4.5.2. 10 kR

Highest phenotypic coefficient of variation was recorded for number of seeds per fruit (92.22 per cent) but genotypic coefficient of variation was low (32.69 per cent). Moderately high phenotypic and genotypic coefficients of variation were noticed for number of fruits per plant, number of flowers per plant, number of branches per plant, leaf number, weight of fruits per plant and pollen sterility. Heritability and genetic advance was maximum for number of flowers per plant (96.00 and 125.22 per cent respectively). Similar trend was noticed for leaf number, number of fruits per plant, weight of fruits per plant, number of branches per plant, number of ridges per fruit and pollen sterility. Heritability was moderately high for all the other characters except

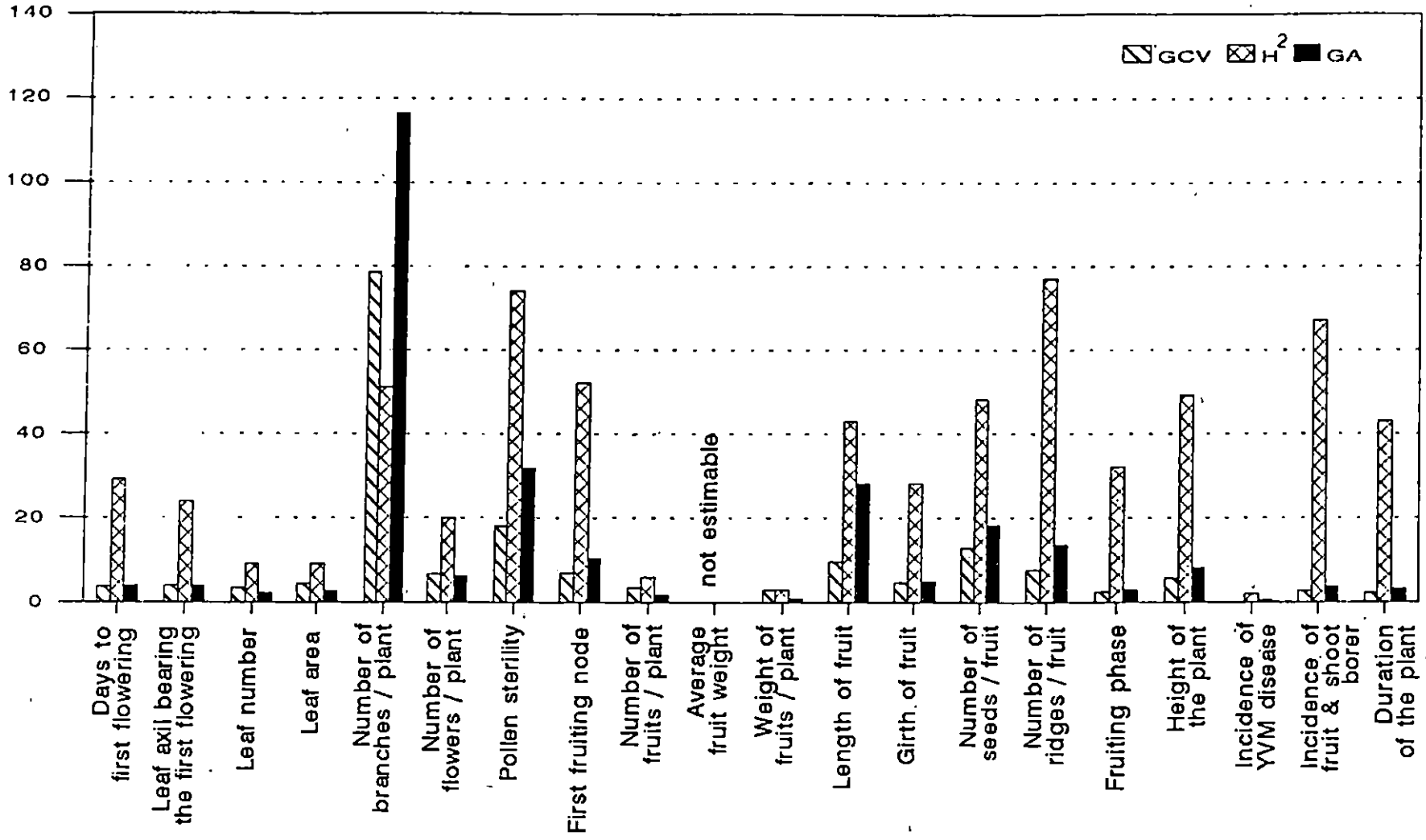


Fig. 21. Genetic variability in F_3M_3 - 0 kR

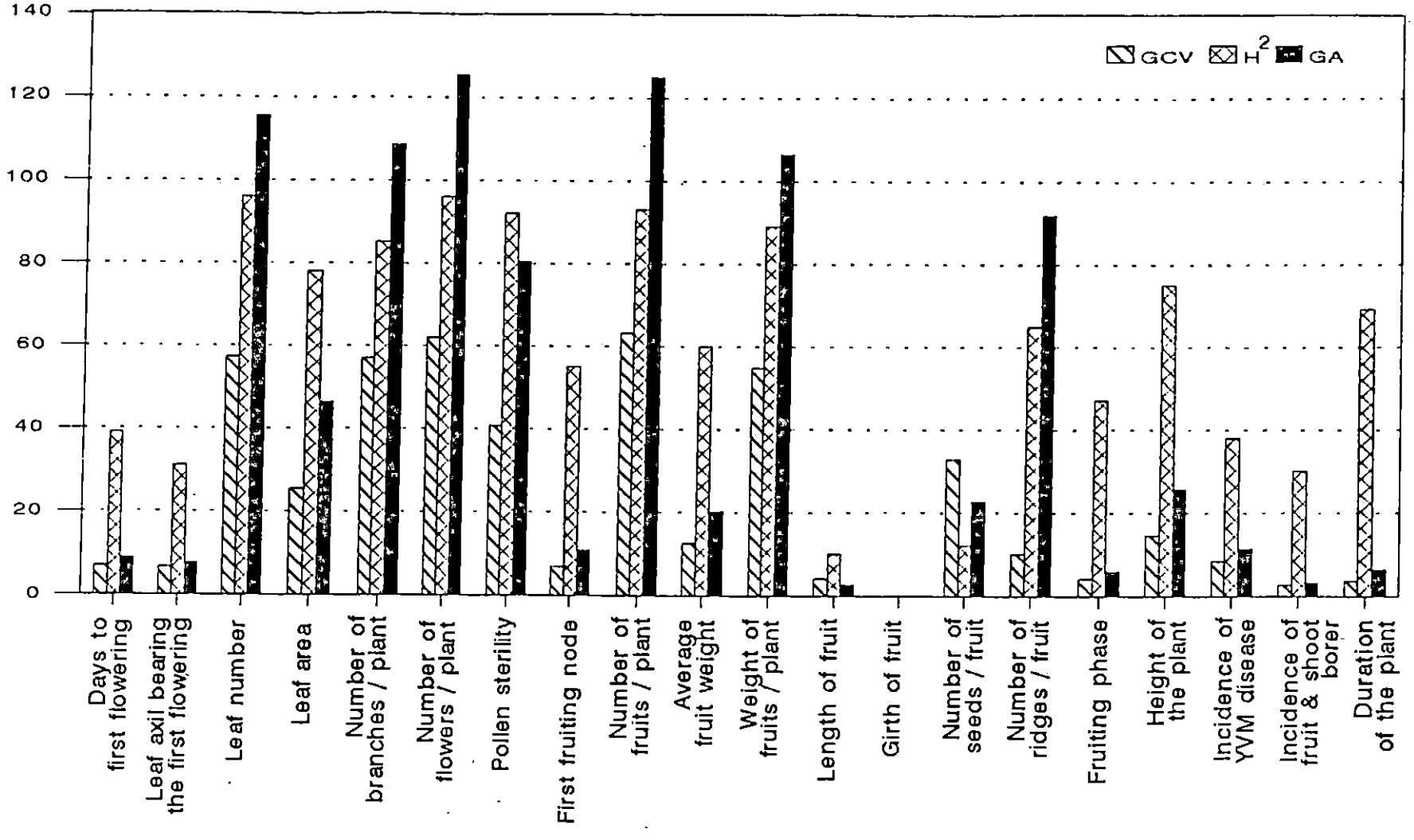


Fig. 22. Genetic variability in F_3M_3 - 10 kR

length of fruit, girth of fruit and number of seeds per fruit but genetic advance was low (Fig. 22).

4.5.3. 20 kR

Phenotypic and genotypic coefficients of variation were highest for number of seeds per fruit (132.77 and 105.60 per cent respectively) (Fig. 23). Moderately high phenotypic and genotypic coefficients of variation were noticed for number of fruits per plant, number of flowers per plant, pollen sterility, weight of fruits per plant and leaf number. Heritability was maximum for number of leaves per plant, flowers per plant and pollen sterility (93.00 per cent) and had high genetic advance also. Genetic advance was highest for number of seeds per fruit (172.30 per cent). Heritability was high to moderately high for all characters except leaf axil bearing first flower, first fruiting node, fruit length, days to first flowering and incidence of YVM disease. Genotypic coefficient of variation, heritability and genetic advance were not estimable for girth of fruit and incidence of fruit and shoot borer.

4.5.4. 30 kR

Number of flowers per plant recorded the highest phenotypic and genotypic coefficients of variation (135.36 and 134.80 per cent respectively). Similar trend was also noticed for number of branches per plant, leaf number, number of fruits per plant and weight of fruits per plant. Heritability and genetic advance were highest for number of flowers per plant (99.00 and

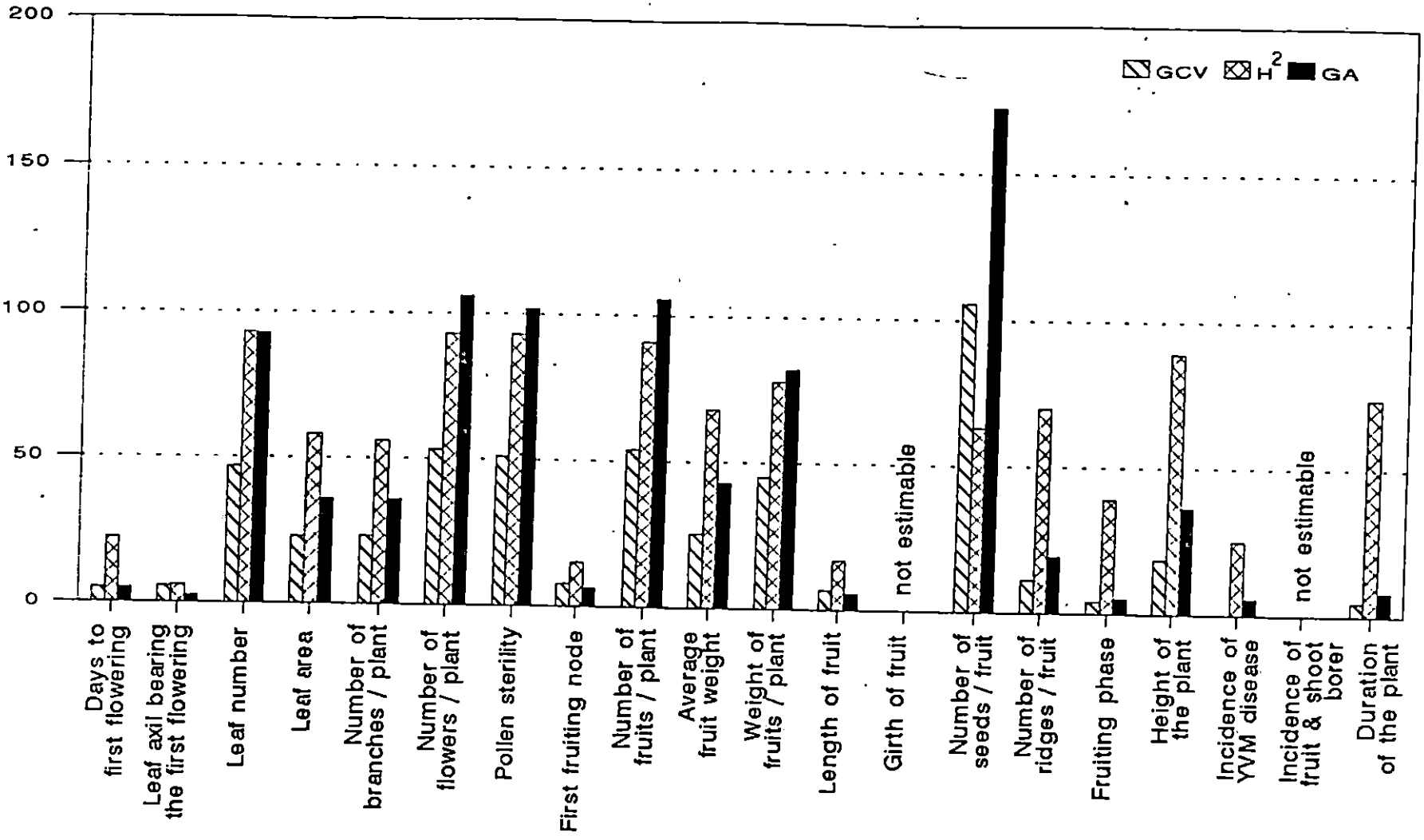


Fig. 23. Genetic variability in F_3M_3 - 20 kR

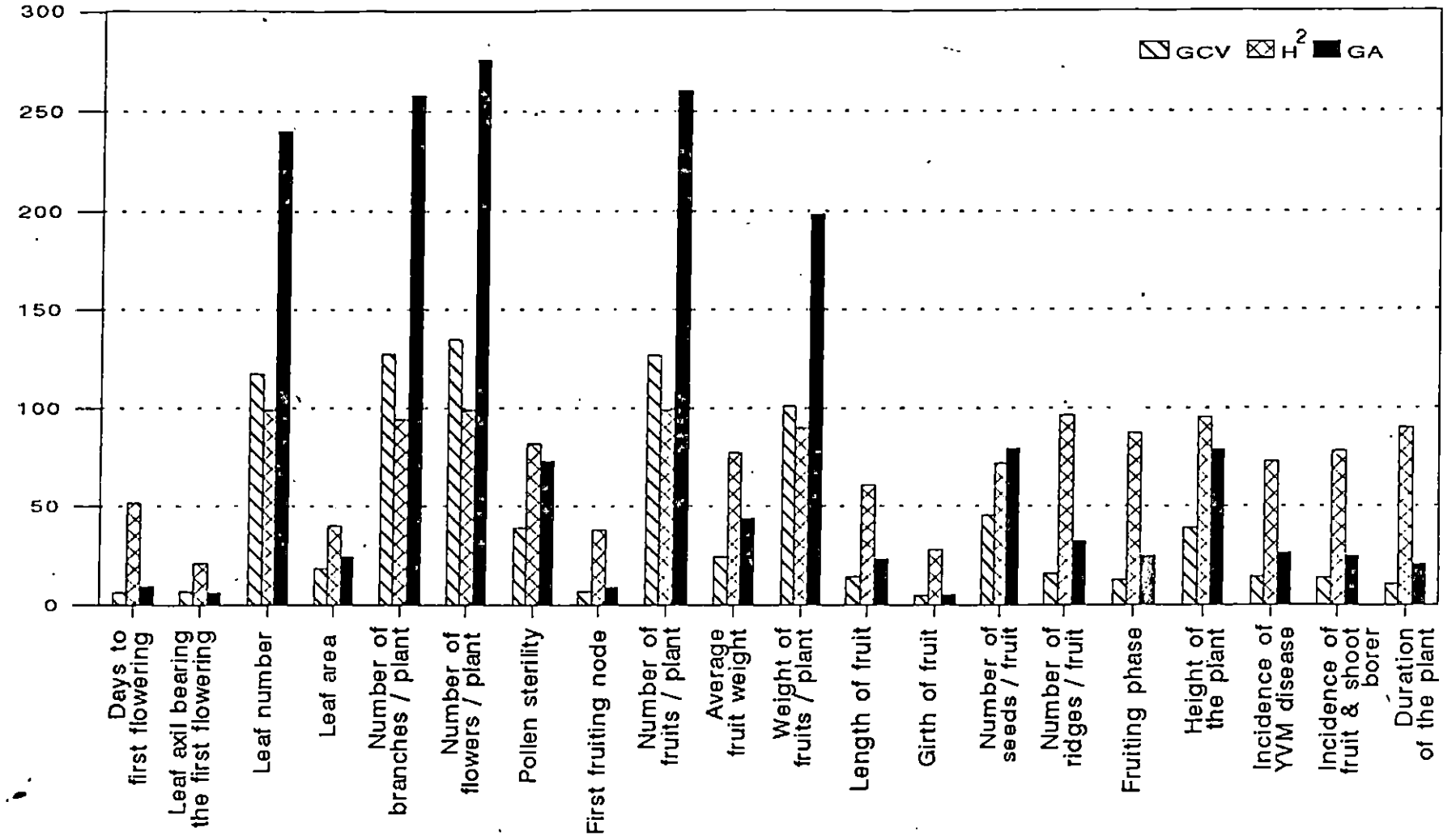


Fig. 24 Genetic variability in F_3M_3 - 30 kR

276.05 per cent). Similar trend was observed for leaf number, number of fruits per plant, number of branches per plant, weight of fruits per plant and number of seeds per fruit. Heritability was minimum for leaf axil bearing the first flower (21.00 per cent) while genetic advance was minimum for fruit girth (5.30 per cent) (Fig. 24).

4.5.5. 40 kR

Phenotypic coefficient of variation was maximum for number of seeds per fruit (103.71 per cent) while it had a genotypic coefficient of variation of 74.18 per cent (Fig. 25). Phenotypic and genotypic coefficients of variation were high for number of fruits per plant, weight of fruits per plant, number of flowers per plant and leaf number. Heritability and genetic advance were high for number of flowers per plant, leaf number, number of fruits per plant, weight of fruits per plant, number of seeds per fruit, number of branches per plant, pollen sterility and plant height. Heritability was lowest for first fruiting node (11.00 per cent) while genetic advance was least for incidence of YVM disease (2.84 per cent).

4.5.6. P_1

Phenotypic and genotypic coefficients of variation were maximum for number of branches per plant (95.72 and 45.63 per cent respectively). All other traits recorded low values. Heritability was moderately high for incidence of fruit and shoot borer, days to first flowering and number of seeds per fruit

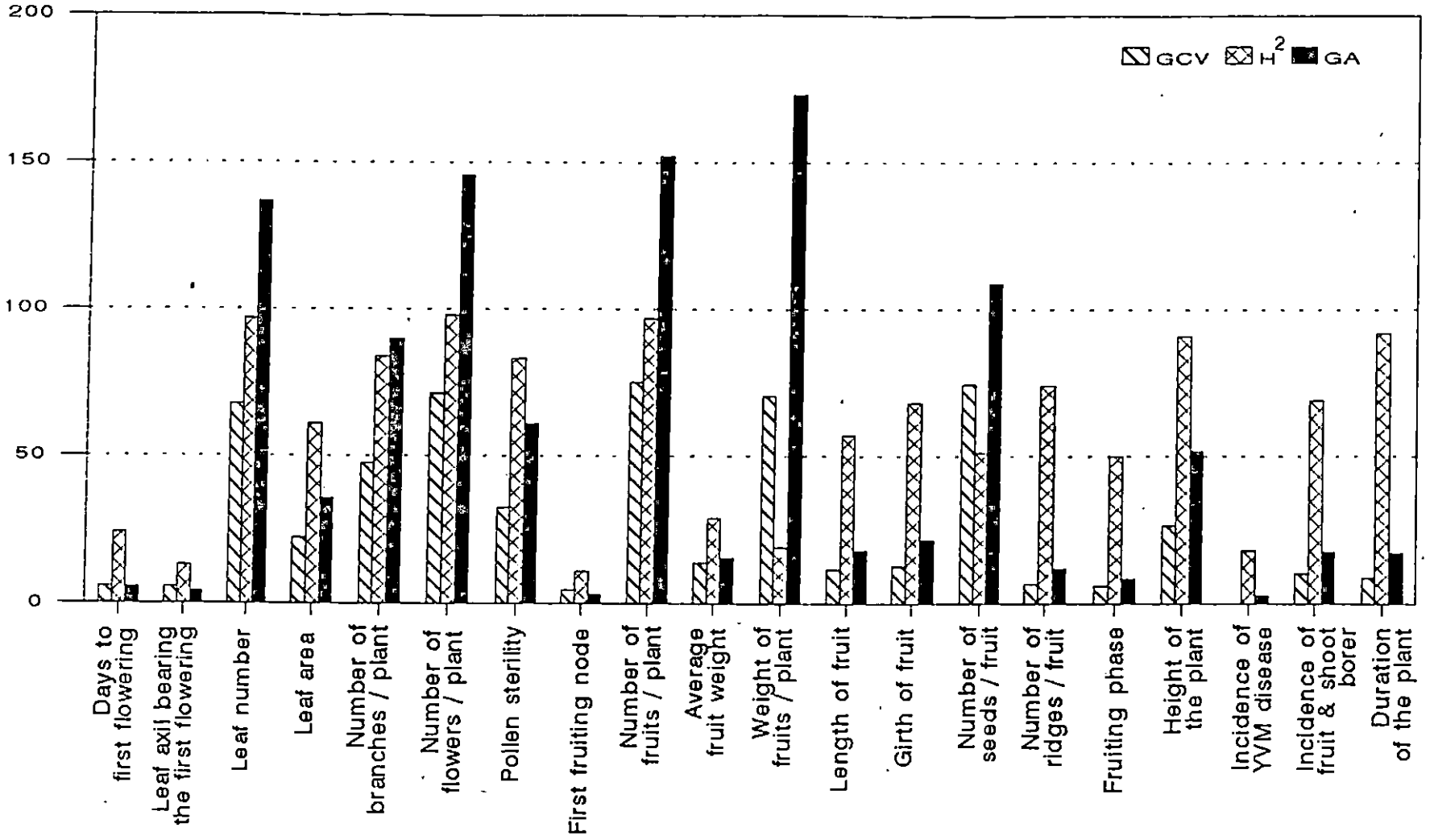


Fig. 25 Genetic variability in F_3M_3 - 40 kR

(52, 50 and 48 per cent respectively) but genetic advance was low (9.06, 7.07 and 26.83 per cent). Genotypic coefficient of variation, heritability and genetic advance were not estimable for characters like leaf number, leaf area, number of flowers per plant, average fruit weight, weight of fruits per plant, plant height and plant duration (Fig. 26).

4.5.7. P_2

Phenotypic coefficient of variation was highest for number of branches per plant (121.08 per cent). Both phenotypic and genotypic coefficients of variation were low for the other characters (Fig. 27). Heritability was highest for first fruiting node (74.00 per cent). High heritability was also noticed for girth of fruit, leaf axil bearing the first flower, leaf area and plant duration. But genetic advance was low for all these characters. Genotypic coefficient of variation, heritability and genetic advance were not estimable for days to first flowering, number of branches per plant, flowers per plant, fruits per plant, fruit yield per plant and incidence of YVM disease.

4.6. Correlation in the F_3M_3 generation

Phenotypic correlations among the 18 characters are presented in Tables 57 to 63.

4.6.1. 0 kR

In the unirradiated treatment leaf axil bearing first flower was significantly and positively correlated with first fruiting node, but had

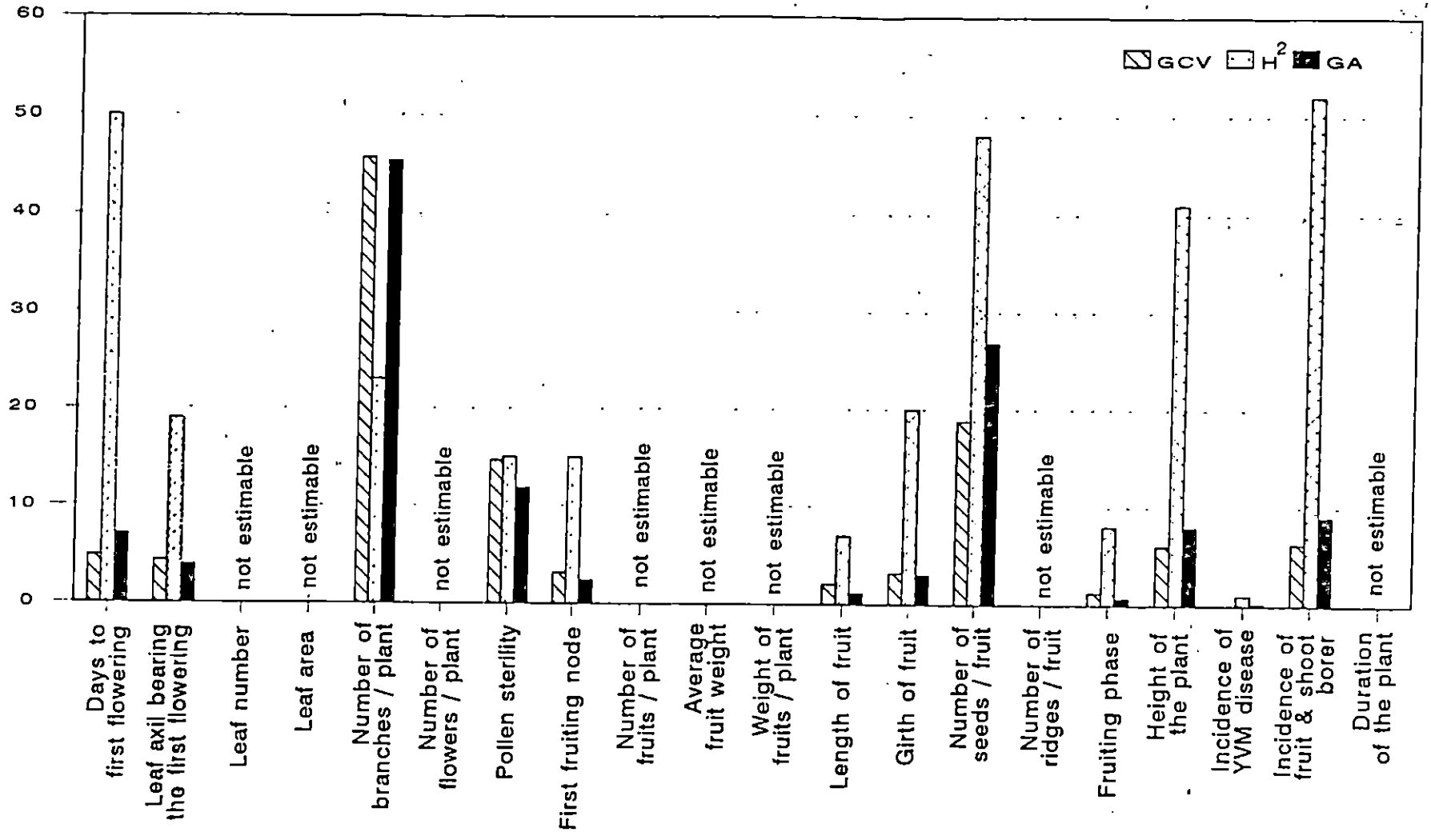


Fig. 26 Genetic variability in F_3M_3 - A. esculentus (P_1)

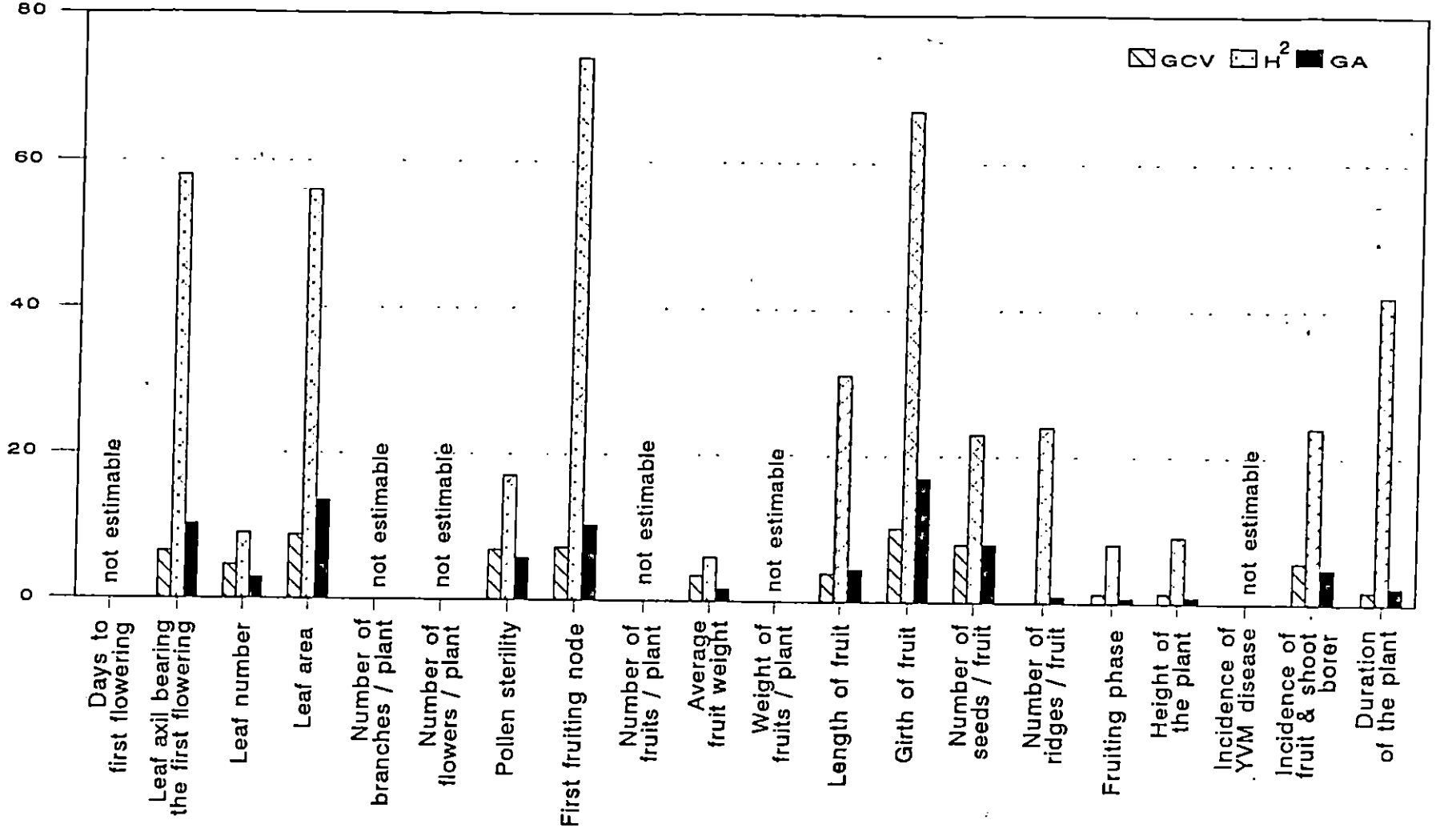


Fig. 27. Genetic variability in F_3M_3 - A. manihot (P_2)

significant negative correlation with average fruit weight, weight of fruits per plant and girth of fruit. Number of leaves per plant and number of flowers per plant had significant positive correlation with pollen sterility, number of fruits per plant, fruit yield per plant and also among themselves. Leaf area and pollen sterility were positively correlated with fruiting phase. Number of branches per plant had significant positive correlation with fruit girth and negative correlation with length of fruit. Number of flowers per plant as well as pollen sterility were found to be positively correlated with number of ridges per fruit. First fruiting node exhibited significant negative correlation with average fruit weight and plant duration. Significant positive correlation of fruit yield per plant with number of fruit per plant and average fruit weight was observed. Number of ridges per fruit was significantly and positively correlated with fruit girth and significantly and negatively correlated with fruiting phase (Table 57).

4.6.2. 10 kR

In 10 kR, days to first flowering was significantly and positively correlated with pollen sterility, length of fruit, fruiting phase and plant duration. Leaf axil bearing the first flower exhibited significant negative correlation with leaf number, number of flowers per plant, fruits per plant and fruit yield per plant but had significant positive correlation with first fruiting node and number of ridges per fruit. The characters like number of leaves per plant, flowers per plant and fruits per plant had significant positive correlation with number of branches per plant, weight of fruits per plant and among themselves but had significant negative correlation with first fruiting node, average fruit weight and number of ridges per fruit.

Table 57. Correlation in F_3M_3 – 0 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.0637	–																
X_3	Leaf number	0.2048	0.0087	–															
X_4	Leaf area	0.1084	0.0588	-0.0763	–														
X_5	No. of branches per plant	0.1171	0.1830	0.0733	-0.1427	–													
X_6	No.of flowers per plant	0.0801	-0.1467	0.8209**	-0.1271	0.1489	–												
X_7	Pollen sterility	0.1462	-0.1042	0.3205*	0.2189	0.1280	0.3220*	–											
X_8	First fruiting node	-0.0352	0.3415*	-0.2357	0.0997	0.0275	-0.2069	-0.1841	–										
X_9	No. of fruits per plant	-0.1307	-0.1243	0.6113**	-0.0832	0.2033	0.7716**	0.1833	-0.0912	–									
X_{10}	Average fruit weight	0.0534	-0.3187*	0.0582	-0.1435	0.0212	0.0187	0.1047	-0.3841*	0.0027	–								
X_{11}	Weight of fruits per plant	-0.1163	-0.2841*	0.4794**	-0.1045	0.1585	0.6308**	-0.2164	-0.2739	0.8133**	0.5544**	–							
X_{12}	Length of fruit	0.2484	-0.0984	-0 1384	-0.0977	-0.3955**	-0.1825	-0.0005	0.1717	-0.2327	0.2677	0.0879	–						
X_{13}	Girth of fruit	0.0785	-0.2845*	0.0385	-0.2146	0.3804**	0.1737	0.0488	-0.2098	0.0112	-0.0226	0.0143	-0.1479	–					
X_{14}	No. of seeds per fruit	-0.1506	-0.0393	-0.0519	0.0816	0.0423	-0.0327	0.0133	0.0567	-0.0127	-0.0796	-0.0347	-0.0074	-0.0590	–				
X_{15}	No. of ridges per fruit	-0.0855	-0.0963	0.2158	-0.1038	0.2716	0.3013*	0.3011*	-0.1867	0.1960	-0.1584	0.0643	-0.1323	0.2927*	-0.0954	–			
X_{16}	Fruiting phase	-0.0022	0.0545	-0.1625	0.3258*	-0.1357	-0.1396	0.2823*	-0.1648	-0.2459	0.1980	-0.0624	-0.0812	-0.1213	0.0286	-0.3088*	–		
X_{17}	Height of plant	-0.0448	0.2364	0.0022	-0.2651	-0.0812	-0.0515	-0.2517	-0.1894	0.0391	0.0873	0.0394	0.0869	-0.1228	0.0274	-0.2007	-0.0448	–	
X_{18}	Duration of the plant	-0.0073	0.2092	-0.0901	0.0766	-0.0250	-0.1193	0.1858	0.4066**	-0.0500	-0.0936	-0.0589	-0.0471	-0.1436	-0.0793	-0.1417	-0.0073	-0.0983	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Number of branches per plant was significantly and negatively correlated with average fruit weight and number of ridges per fruit and positively correlated with weight of fruits per plant. There was significant negative correlation for pollen sterility with average fruit weight and positive correlation with number of ridges per fruit and plant duration. First fruiting node was significantly and negatively correlated with weight of fruits per plant and significantly and positively correlated with number of ridges per fruit. Average fruit weight was negatively correlated with weight of fruits per plant which was in turn negatively correlated with number of ridges per fruit. Fruiting phase and plant duration were significantly and positively correlated among themselves and also with number of ridges per fruit and plant height (Table 58).

4.6.3. 20 kR

In this treatment, days to first flowering was positively correlated with fruiting phase and plant duration and negatively correlated with plant height, while leaf axil bearing first flower was positively correlated with pollen sterility first fruiting node and plant height. Leaf number, number of flowers per plant and fruits per plant were negatively and significantly correlated with average fruit weight, number of seeds per fruit and number of ridges per fruit but had significant positive correlation with weight of fruits per plant and also among themselves. Leaf area was positively correlated with pollen sterility and plant height but negatively correlated with fruiting phase and plant duration.

Table 58. Correlation in F_3M_3 – 10 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.0481	–																
X_3	Leaf number	-0.2716	-0.4712**	–															
X_4	Leaf area	-0.0521	-0.1893	0.0900	–														
X_5	No. of branches per plant	-0.1405	-0.2205	0.7100**	-0.0428	–													
X_6	No.of flowers per plant	-0.2556	-0.4729**	0.9970**	-0.0737	0.7172**	–												
X_7	Pollen sterility	0.4677**	0.1893	-0.2146	0.0765	-0.1306	-0.2046	–											
X_8	First fruiting node	-0.0008	0.6685**	-0.5028**	-0.0476	-0.1906	-0.5035**	0.2411	–										
X_9	No. of fruits per plant	-0.2321	-0.4200**	0.9846**	-0.0494	0.7470**	0.9902**	-0.1735	-0.4648**	–									
X_{10}	Average fruit weight	-0.0235	0.2190	-0.5329**	0.0077	-0.4539**	-0.5400**	-0.3923**	0.0652	-0.5628**	–								
X_{11}	Weight of fruits per plant	-0.2643	-0.4157**	0.9664**	-0.0958	0.7060**	0.9690**	0.2761	-0.5029**	0.9732**	-0.4227**	–							
X_{12}	Length of fruit	0.2977*	0.2372	-0.1410	0.2779	-0.0281	-0.1334	0.2462	0.1043	-0.1078	0.0123	-0.1418	–						
X_{13}	Girth of fruit	-0.0688	0.1475	0.0817	0.0691	0.0633	0.0861	-0.2074	0.0358	0.1324	-0.0843	0.1601	0.0113	–					
X_{14}	No. of seeds per fruit	0.2491	0.1444	-0.1529	-0.2682	-0.1350	-0.1526	0.2785	0.1174	-0.1435	0.0031	-0.1693	0.0211	-0.0575	–				
X_{15}	No. of ridges per fruit	0.2336	0.3897**	-0.4776**	0.1260	-0.4347**	-0.4790**	0.3082*	0.3471*	-0.4500**	0.2146	-0.4685**	0.2811	-0.0228	0.1954	–			
X_{16}	Fruiting phase	0.3374*	0.0962	-0.1468	0.0745	-0.1915	-0.1332	-0.0393	0.0126	-0.1049	0.1223	-0.0921	-0.1176	0.0951	0.1386	0.3261*	–		
X_{17}	Height of plant	0.2135	0.2130	0.1542	-0.0702	0.1428	0.1557	0.0765	0.1903	0.1694	-0.1520	0.1500	-0.1164	-0.0019	0.1475	-0.0606	0.3304*	–	
X_{18}	Duration of the plant	0.4782**	0.1274	-0.1631	0.0039	-0.0998	-0.1489	0.3811**	0.0282	-0.0948	-0.0998	-0.1316	-0.0345	0.0184	0.2667	0.4342**	0.5471**	0.3983**	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Number of branches per plant exhibited significant negative correlation with pollen sterility, average fruit weight, number of seeds per fruit, ridges per fruit and plant height but had significant positive correlation with girth of fruit and plant duration. Pollen sterility was negatively correlated with fruiting phase and plant duration but positively correlated with plant height. There was significant positive correlation between first fruiting node and plant height while average fruit weight had significant positive correlation with number of seeds per fruit and ridges per fruit. Significant negative correlation of weight of fruits per plant and fruit girth with number of seeds per fruit was observed which was in turn found to be positively correlated with number of ridges per fruit. Fruiting phase was found to be negatively correlated with plant height and positively correlated with plant duration while plant height was negatively correlated with plant duration (Table 59).

4.6.4. 30 kR

Table 60 showed that in this treatment, days to first flowering had significant positive correlation with pollen sterility and plant height. Leaf number, number of flowers per plant and fruits per plant were found to be positively correlated with all other characters and among themselves except days to first flowering, leaf axil bearing the first flower, plant height and plant duration but had significant negative correlation with average fruit weight, girth of fruit and number of seeds per fruit.

Table 59. Correlation in F_3M_3 – 20 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.0580	–																
X_3	Leaf number	0.0233	-0.0154	–															
X_4	Leaf area	-0.1591	0.2321	0.0656	–														
X_5	No. of branches per plant	0.2641	0.0482	0.1842	-0.0396	–													
X_6	No.of flowers per plant	0.0048	-0.0065	0.9954**	0.0608	0.1920	–												
X_7	Pollen sterility	-0.2243	0.3233*	-0.0230	0.5118**	-0.3870**	-0.0215	–											
X_8	First fruiting node	0.0873	0.8972**	-0.0184	0.1928	0.0482	-0.0198	0.1912	–										
X_9	No. of fruits per plant	0.0127	-0.0245	0.9844**	0.0593	0.2103	0.9876**	-0.0490	-0.0310	–									
X_{10}	Average fruit weight	0.0386	-0.2748	-0.4021**	-0.0663	-0.3845**	-0.4116**	-0.0053	-0.2472	-0.4059**	–								
X_{11}	Weight of fruits per plant	0.1257	-0.1502	0.7809**	0.0194	0.0473	0.7735**	-0.1079	-0.1436	0.8075**	0.1075	–							
X_{12}	Length of fruit	-0.2018	0.1348	0.0317	0.0820	-0.0411	0.0777	0.0162	0.0114	0.0704	-0.1228	0.0373	–						
X_{13}	Girth of fruit	-0.1239	0.0341	0.0635	-0.2289	0.2865*	0.0668	-0.0993	0.0201	0.0895	-0.0889	0.1174	0.2428	–					
X_{14}	No. of seeds per fruit	-0.1028	-0.2077	-0.4325**	0.0006	-0.2999*	-0.4286**	0.1454	-0.1675	-0.4673**	0.6376**	-0.2907*	0.0759	-0.2955*	–				
X_{15}	No. of ridges per fruit	0.0067	-0.1872	-0.3453*	-0.1961	-0.2841*	-0.3510*	-0.1079	-0.1747	-0.3641**	0.4892**	-0.2142	0.1582	-0.2460	0.7386**	–			
X_{16}	Fruiting phase	0.3916**	-0.1568	-0.1667	-0.3370*	0.2263	-0.1802	-0.2977*	-0.0755	-0.1201	0.1571	0.1300	0.0469	-0.0493	0.0206	0.1496	–		
X_{17}	Height of plant	-0.3726**	0.2943*	-0.1277	0.5114**	-0.2973*	-0.1346	0.4082*	0.3884*	-0.1695**	-0.0733	-0.2529	-0.0515	-0.0467	0.0657	-0.0323	-0.4557**	–	
X_{18}	Duration of the plant	0.4879**	-0.0532	-0.0487	-0.3447*	0.3661**	-0.0741	-0.5000**	0.0929	-0.0159	0.0551	0.2246	-0.1201	0.1128	-0.2374	-0.0144	0.6696**	-0.3799**	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 60. Correlation in F_3M_3 – 30 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.1516	–																
X_3	Leaf number	0.0954	0.2082	–															
X_4	Leaf area	0.0824	-0.1080	0.3605*	–														
X_5	No. of branches per plant	-0.0587	0.0981	0.8879**	0.4834**	–													
X_6	No.of flowers per plant	0.0863	0.1941	0.9985**	0.3609*	0.8956**	–												
X_7	Pollen sterility	0.5502**	0.1329	0.6173**	0.2765	0.4693**	0.6185**	–											
X_8	First fruiting node	0.0789	0.5698**	0.3316*	0.1808	0.3321*	0.3316*	0.2110	–										
X_9	No. of fruits per plant	0.0982	0.2039	0.9980**	0.3646**	0.8929**	0.9992**	0.6178**	0.3369*	–									
X_{10}	Average fruit weight	-0.1634	-0.0250	-0.3688**	-0.0387	-0.2647**	-0.3707**	-0.3371*	0.1143	-0.3728**	–								
X_{11}	Weight of fruits per plant	0.1591	0.1924	0.9618**	0.3929**	0.8206**	0.9610**	0.6007**	0.2770	0.9628**	-0.2635	–							
X_{12}	Length of fruit	0.0703	0.0616	-0.2738*	-0.2782*	-0.3351*	-0.2803*	-0.1154	-0.4117**	-0.2773*	-0.3078*	-0.3009*	–						
X_{13}	Girth of fruit	-0.1735	0.0118	-0.3101**	-0.0957	-0.2202	-0.3035*	-0.3350*	-0.0956	-0.3078*	-0.1057	-0.3356*	0.3026*	–					
X_{14}	No. of seeds per fruit	-0.1693	0.2113	-0.3834**	-0.0170	-0.2585*	-0.3815**	-0.3304*	-0.0196	-0.3897**	0.7266**	-0.2873*	-0.2947*	-0.0451	–				
X_{15}	No. of ridges per fruit	0.1326	0.1246	-0.0425	0.4254**	0 0826	-0.0455	0.1313	0.2831*	-0.0416	0.3072*	0.0159	-0.2394	0.0996	0.2592	–			
X_{16}	Fruiting phase	0.2364	0.1806	0.4252**	0.3656**	0.4406**	0.4224**	0.3936**	0.4074**	0.4244**	-0.1037	0.3889**	-0.2871*	-0.1518	0.2580	0.4821**	–		
X_{17}	Height of plant	0.3969**	0.0334	0.2616	0.0521	0.2869	0.2610	0.4897**	0.2796*	0.2687	0.0316	0.3096*	-0.3563*	-0.1818	-0.0088	0.7562**	0.7289**	–	
X_{18}	Duration of the plant	0.1866	0.2700	0.0571	0.2308	0.0967	0.0950	0.1428	0.6231**	0.0606	0.5474**	0.1028	-0.4135*	-0.2395	0.3145*	0.5036**	0.5715**	0.5384**	–

* Significant at 5 per cent level ** Significant at 1 per cent level

Significant negative correlation between number of flowers per plant and length of fruit was also observed. Leaf area was found to have significant positive correlation with number of branches per plant, weight of fruits per plant, number of ridges per fruit and fruiting phase. Number of branches per plant exhibited significant positive correlation with pollen sterility, first fruiting node, weight of fruits per plant, fruiting phase and plant height but had significant negative correlation with fruit length. Pollen sterility had significant negative correlation with average fruit weight, girth of fruit and number of seeds per fruit but had significant positive correlation with weight of fruits per plant, fruiting phase and plant height. Average fruit weight exhibited significant positive correlation with number of seeds per fruit, ridges per fruit and plant duration but had significant negative correlation with length of fruit. Fruit yield per plant had significant negative correlation with length of fruit, girth of fruit and number of seeds per fruit, but had significant positive correlation with fruiting phase and plant height. Length and girth of fruits were positively correlated with each other but length of fruit was also negatively correlated with number of seeds per fruit, fruiting phase, plant height and plant duration. Number of ridges per fruit, fruiting phase, plant height and plant duration were significantly and positively correlated with each other. Duration of plant was positively correlated with fruiting phase also.

4.6.5. 40 KR

In the treatment 40 kR, days to first flowering was positively correlated with leaf area and plant duration. Significant positive correlation of leaf axil bearing first flower with first fruiting node and negative correlation with number of branches per plant was observed. Number of leaves per plant, flowers per plant and fruits per plant had significant positive correlation with number of branches per plant, weight of fruits per plant and also among themselves but had significant negative correlation with average fruit weight, fruit girth, number of seeds per fruit and plant height. Leaf area exhibited significant positive correlation with number of branches per plant and fruiting phase but had significant negative correlation with number of seeds per fruit and plant duration. Number of branches per plant and weight of fruits per plant were significantly and positively correlated where as pollen sterility was significantly and positively correlated with girth of fruit, number of ridges per fruit, fruiting phase, plant height and plant duration. Average fruit weight was positively correlated with fruit girth and number of seeds per fruit while fruit yield per plant had significant negative correlation with plant height. Length of fruit was positively correlated with plant height. Girth of fruit exhibited significant positive correlation with number of ridges per fruit, fruiting phase, plant height and plant duration. Significant positive correlation existed among fruiting phase, plant height and plant duration (Table 61).

Table 61. Correlation in F_3M_3 – 40 kR

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.0919	–																
X_3	Leaf number	-0.0885	0.1008	–															
X_4	Leaf area	0.3043*	0.2167	0.1892	–														
X_5	No. of branches per plant	-0.2332	-0.3085*	0.3993**	0.3178*	–													
X_6	No.of flowers per plant	-0.0867	0.0889	0.9853**	0.1697	0.3923**	–												
X_7	Pollen sterility	0.1943	-0.1736	-0.2526	-0.1914	0.1140	-0.2341	–											
X_8	First fruiting node	0.0452	0.6828**	0.0956	0.1692	-0.2277	0.0608	-0.1272	–										
X_9	No. of fruits per plant	-0.0835	0.0649	0.9924**	0.1872	0.4075**	0.9965**	-0.2077	0.0608	–									
X_{10}	Average fruit weight	0.0370	-0.2171	-0.3111*	-0.1690	0.1582	-0.3191*	-0.0848	-0.2360	-0.3232*	–								
X_{11}	Weight of fruits per plant	-0.0582	0.0285	0.9424**	0.1574	0.4823**	0.9427**	-0.2600	-0.0102	0.9427**	-0.0408	–							
X_{12}	Length of fruit	0.0551	-0.1223	-0.1967	0.0056	0.2440	-0.2099	0.1237	-0.0741	-0.2165	0.0375	0.0056	–						
X_{13}	Girth of fruit	0.2170	-0.1059	-0.4317**	0.2685	0.1095	-0.4288**	0.4388**	-0.1089	-0.4174**	0.3730**	0.2685	0.0321	–					
X_{14}	No. of seeds per fruit	-0.0334	-0.1708	-0.3599**	-0.4935**	-0.2543	-0.3518*	0.0508	-0.2000	-0.3669**	0.4089**	-0.2715	0.0843	0.1903	–				
X_{15}	No. of ridges per fruit	-0.1868	-0.0545	-0.1479	0.0688	0.0712	-0.1542	0.4480**	-0.0405	-0.1307	0.1259	-0.1017	-0.2487	0.3471*	0.0887	–			
X_{16}	Fruiting phase	0.1979	-0.1370	-0.0186	0.3334*	0.2279	0.0016	0.4121**	-0.1845	0.0070	-0.0215	0.0361	0.0082	0.4013**	-0.0649	0.2345	–		
X_{17}	Height of plant	0.2534	-0.1014	-0.6082**	0.2319	-0.0976	-0.6048**	0.5258**	-0.0127	-0.6023**	0.0706	-0.5967**	0.4199**	0.5050**	0.0374	0.1649	0.3573*	–	
X_{18}	Duration of the plant	0.4253**	-0.0142	-02220	-0.3630**	0.1473	-0.2101	0.5948**	-0.0108	-0.2075	0.1752	0.1372	0.1823	0.7164**	0.0745	0.2278	0.6329**	0.6156**	–

* Significant at 5 per cent level ** Significant at 1 per cent level

4.6.6. P_1

In the cultivated parent, days to first flowering had significant negative correlation with leaf axil bearing the first flower and first fruiting node (Table 62) . Leaf number was positively correlated with number of flowers per plant, fruits per plant and weight of fruits per plant. Significant negative correlation of pollen sterility with number of branches per plant, length of fruit, fruiting phase and plant duration were observed. First fruiting node was significantly and positively correlated with leaf axil bearing first flower. Significant positive correlation between average fruit weight and weight of fruits per plant was noticed. Length of fruit had significant positive correlation with number of seeds per fruit and plant duration while number of seeds per fruit was significantly and positively correlated with fruiting phase and negatively correlated with plant height. Significant negative correlation between fruiting phase and plant height was also noticed.

4.6.7. P_2

In the semi wild parent, leaf axil bearing the first flower was significantly and positively correlated with leaf number and first fruiting node and negatively correlated with pollen sterility and fruit length. Leaf number, number of flowers per plant, fruits per plant as well as fruit yield per plant were positively correlated among themselves. Pollen sterility was positively correlated with number of fruits per plant, average fruit weight,. weight of fruits per plant and number of seeds per fruit.

Table 62. Correlation in $F_3M_3 - P_1$

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	-0.3460*	–																
X_3	Leaf number	-0.0011	-0.0064	–															
X_4	Leaf area	-0.0145	0.0320	-0.0334	–														
X_5	No. of branches per plant	-0.0721	0.0739	-0.1249	-0.2194	–													
X_6	No.of flowers per plant	0.1651	-0.0894	0.6570**	-0.1894	0.0129	–												
X_7	Pollen sterility	-0.0768	0.0320	-0.1945	0.2426	-0.2792*	-0.1946	–											
X_8	First fruiting node	-0.3861**	0.7488**	-0.0967	0.0768	-0.0092	-0.0621	0.0880	–										
X_9	No. of fruits per plant	0.2261	-0.0742	0.5254**	-0.1146	-0.0158	0.9101**	-0.0288	-0.0239	–									
X_{10}	Average fruit weight	0.0362	-0.1688	0.1053	0.1490	0.1623	0.1109	-0.1799	-0.2223	0.1537	–								
X_{11}	Weight of fruits per plant	0.1897	-0.1730	0.4511**	-0.0029	0.0917	0.7372**	-0.1379	-0.1623	0.8208**	0.6848**	–							
X_{12}	Length of fruit	0.1317	-0.0533	-0.1881	-0.0845	-0.0456	-0.0249	-0.3382*	-0.0558	-0.0056	-0.0414	-0.0354	–						
X_{13}	Girth of fruit	-0.1105	0.0578	-0.1718	0.0854	0.1100	-0.1566	-0.2107	-0.0818	-0.1235	-0.1392	-0.1762	-0.0933	–					
X_{14}	No. of seeds per fruit	-0.1967	0.1864	0.1716	0.0123	-0.2212	-0.1159	-0.1949	0.2145	-0.1866	-0.0536	-0.1793	0.3628**	-0.0854	–				
X_{15}	No. of ridges per fruit	ne	ne	ne	ne	ne	ne	ne	ne	ne	ne	ne	ne	ne	ne	–			
X_{16}	Fruiting phase	0.0018	-0.3061*	-0.0872	0.1024	0.0759	0.0799	-0.3436*	-0.1882	-0.1102	0.1548	0.0096	0.2497	0.0412	0.6190**	ns	–		
X_{17}	Height of plant	0.0171	0.2002	0.0102	-0.0625	-0.1584	-0.1683	-0.0095	0.1018	-0.1212	-0.0738	-0.1355	-0.0627	0.0525	-0.3535*	ns	-0.3535*	–	
X_{18}	Duration of the plant	0.0299	0.1357	0.0617	-0.1411	0.0713	-0.0875	-0.3213*	0.1073	-0.1376	0.0022	-0.1016	0.2902*	-0.0140	0.1001	ns	0.1900	-0.0170	–

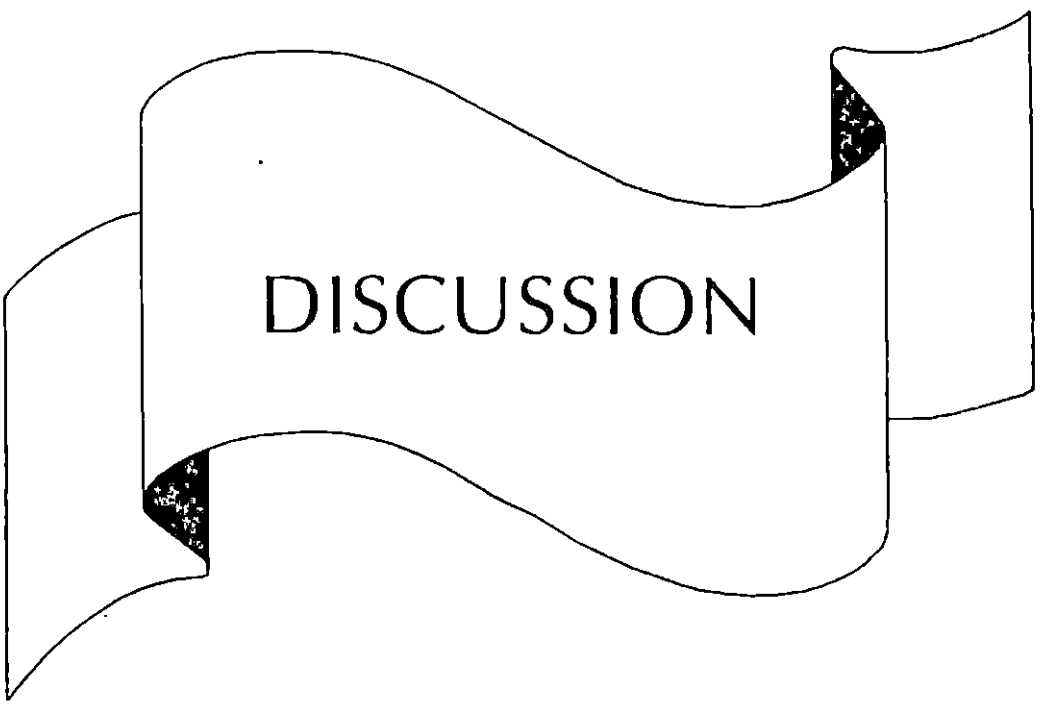
* Significant at 5 per cent level ** Significant at 1 per cent level ns - Not estimable

Table 63. Correlation in $F_3M_3 - P_2$

	Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}
X_1	Days to first flowering	–																	
X_2	Leaf axil bearing the first flower	0.1087	–																
X_3	Leaf number	0.0299	0.3430*	–															
X_4	Leaf area	0.1261	-0.1627	-0.1189	–														
X_5	No. of branches per plant	0.0373	-0.0462	-0.0062	0.0251	–													
X_6	No.of flowers per plant	-0.0612	0.1817	0.7685**	-0.0043	0.0025	–												
X_7	Pollen sterility	-0.1173	-0.2950*	-0.0142	0.1574	0.1160	0.0992	–											
X_8	First fruiting node	0.1654	0.8988**	0.2731	-0.2475	0.0182	0.1263	-0.0819	–										
X_9	No. of fruits per plant	-0.0909	0.1843	0.7008**	-0.0327	-0.0167	0.9782**	0.3195*	0.1076	–									
X_{10}	Average fruit weight	0.2349	-0.0171	0.1512	0.1436	-0.0926	0.0326	0.2934*	-0.0508	-0.0072	–								
X_{11}	Weight of fruits per plant	0.0678	0.1286	0.6270**	0.0526	-0.0785	0.7560**	0.4198**	0.0448	0.7493**	0.6469**	–							
X_{12}	Length of fruit	0.0434	-0.3236*	-0.1726	0.2383	0.2431	-0.0513	0.0957	-0.4630**	-0.0037	-0.0178	-0.0176	–						
X_{13}	Girth of fruit	0.0588	-0.1291	-0.2704	-0.0479	-0.0153	-0.1009	0.0128	-0.0771	-0.1079	-0.1507	-0.1507	0.1582	–					
X_{14}	No. of seeds per fruit	0.0144	-0.1076	-0.1399	-0.0909	-0.0271	0.1047	0.3073*	-0.1237	0.1229	-0.1475	0.0015	0.0400	0.1531	–				
X_{15}	No. of ridges per fruit	0.2009	-0.2463	0.2423	0.1682	0.0311	0.1342	-0.0240	-0.2944*	0.1119	0.0219	0.1000	0.2985*	-0.0404	0.0320	–			
X_{16}	Fruiting phase	0.0444	0.1412	0.2062	-0.1310	0.0886	0.1634	0.0352	0.1219	0.1940	0.2000	0.2987*	-0.1236	-0.1089	-0.0071	0.0601	–		
X_{17}	Height of plant	0.2357	-0.0710	0.1965	0.0613	0.0307	0.3130*	-0.0173	-0.0819	0.3195*	0.2934*	0.4198**	0.0957	0.0128	0.1204	-0.0612	0.1562	–	
X_{18}	Duration of the plant	-0.1149	0.2080	0.1311	-0.1185	0.0652	0.1385	-0.1430	0.2424	0.1009	-0.1094	-0.0101	0.0586	-0.1235	-0.0661	0.0244	-0.1469	-0.0122	–

* Significant at 5 per cent level ** Significant at 1 per cent level

First fruiting node exhibited significant negative correlation with fruit length and number of ridges per fruit. Average fruit weight had significant positive correlation with fruit yield per plant and plant height whereas fruit yield per plant was positively correlated with fruiting phase and plant height. Significant positive correlation was also observed between fruit length and number of ridges per fruit (Table 63).


DISCUSSION

5. DISCUSSION

Recombination breeding through interspecific hybridisation of chosen parents followed by selection in the segregating generations is a popular method of crop improvement to get desirable recombinants. But recovery of such recombinants is somewhat limited by the linkage between desirable and undesirable traits which reduces variability. In okra, interspecific hybridisation between cultivated species *A. esculentus* and semi wild species *A. manihot* did not yield useful recombinants due to strong linkage between YVM disease resistance and semi wild characters of *A. manihot* in the F_2 generation (Mathews, 1986). Variability can be induced by subjecting hybrid seeds of okra to mutation (Gregory, 1961; Cheriyan, 1986; Sheela, 1994 and Animon, 1996).

The present investigation aimed to study the variability generated by hybridisation and hybrid irradiation in F_2M_2 and F_3M_3 generations and thereby identify disease resistant high yielding plants from among the variable population. The results obtained are discussed in the following sections.

5.1. Evaluation of the F_2M_2 generation

The scope for selection in the breeding population depends on the extent of altered mean values and genetic variability present in the segregating

generations. The F_2 and F_2M_2 populations showed wide range of variability for majority of the characters studied.

Days to first flowering was least for the cultivated parent. All the irradiated treatments tended to resemble the semi wild parent for this character and took more number of days for flowering than the unirradiated treatment. Contrary to this Sheela (1994) reported that plants in F_2M_2 population took less number of days to flowering.

Leaf axil bearing first flower was lowest for the cultivated parent. All other treatments had higher mean values. There were several plants resembling the cultivated parent in 30 kR, which flowered at lower nodes and hence had a mean value closer to the cultivated parent when compared to other treatments.

Irradiation was found to increase the number of leaves per plant. The irradiated treatment 20 kR had the maximum number of leaves while the unirradiated treatment 0 kR had the minimum. Significant variation among the F_2M_2s was noticed for this character. Sheela (1994) reported that F_2 s and F_2M_2 s recorded significantly higher number of leaves than the parents.

Leaf area also was significantly higher in the irradiated treatments when compared to the unirradiated treatment and the cultivated parent. Maximum leaf area was observed in 40 kR. Significant variability was noticed within all the treatments except the parental treatments were noticed. Some plants with high number of leaves and small leaf area were noted especially

in 20 kR and 30 kR treatments. Sheela (1994) reported that F_2s and F_2M_2s showed marked increase in leaf area.

Number of branches per plant were high in the treatments 20 kR and 30 kR. 40 kR also recorded higher mean values when compared to 0 kR, 10 kR and the parents. Kuwada (1970) reported higher number of branches on irradiation in okra. Significant variation for number of branches in the F_2 and F_2M_2 generations of irradiated inter specific hybrids of okra has been reported by Sheela (1994).

Number of flowers per plant showed similar results like number of leaves per plant. Higher dose of radiation (40 kR) reduced the number of flowers per plant, when compared to the other irradiated treatments. The mean values were lower for the unirradiated treatment. This is in contrast to the results of Sheela (1994) who reported that F_2M_2s produced lesser number of flowers per plant as compared to parents and F_2s.

Pollen sterility was least for the cultivated parent. Irradiation was found to increase the pollen sterility. Krishna (1985) reported increased pollen sterility with increasing radiation dose. But these results are not in agreement with the findings of Cheriyan (1986) and Animon (1994) who reported that radiation induced pollen fertility.

The cultivated parent recorded the lowest mean value for first fruiting node. All other treatments had higher mean values and tended to resemble

the semi wild parent for this character. This is in agreement with the findings of Sheela (1994).

Number of fruits per plant showed significant variability among the treatments. Maximum number of fruits were observed in 20 kR, due to presence of certain plants with large number of small sized fruits with spines. The unirradiated treatment, 0 kR had the lowest mean value for this character. Higher doses of radiation viz., 30 kR and 40 kR reduced the number of fruits when compared to 20 kR. Reduction in number of fruits per plant on gamma irradiation of okra seeds was observed by Abraham (1985).

Fruit weight was maximum for the semi wild parent but it was minimum for the unirradiated treatment. Not much difference was noted among 0 kR and 10 kR with respect to this character. Many plants with very low average fruit weight were also observed in treatments 20 kR and 30 kR.

Irradiation was found to increase the fruit yield per plant and it was maximum for the 20 kR treatment. The unirradiated treatment had lowest fruit yield per plant when compared to all the other treatments. But Abraham (1985) reported lower fruit yield on gamma irradiation.

Significant differences among the treatments were observed with respect to fruit length. The cultivated parent had the maximum fruit length followed by the semi wild parent. The lower doses of radiation viz., 10 kR and 20 kR did not vary much with respect to this character but were smaller

than 30 kR and 40 kR which were on par. The progenies of the cultivated parent showed minimum variation for fruit length when compared to the progenies within the irradiated treatments. Animon (1996) observed that there was no significant difference among the 10 kR, 20 kR and 30 kR irradiated plants with respect to fruit length, but were smaller when compared to untreated hybrids.

Girth of fruits showed an increasing trend with respect to the irradiated treatments which was contrary to the findings of Animon (1996). The fruit girth was maximum for the semi wild parent.

Number of seeds per fruit were high for both the parental treatments. The unirradiated treatment had higher number of seeds per fruit when compared to the irradiated treatments. This radiation induced sterility might be due to detectable chromosomal aberrations and cryptic deficiencies (Gaul *et al.*, 1966) Radiation induced seed sterility has been reported by Abraham (1985), Cheriyan (1986) and Animon (1996) in okra.

Number of ridges per fruit was maximum for the semi wild parent and lowest for the cultivated parent. It was higher for the irradiated treatments when compared to the unirradiated treatment and was highest for 40 kR. The progenies in 30 kR showed lower values which might be due to presence of plants resembling the cultivated type with fruits having lower number of ridges.

There was not much difference between 0 kR and 10 kR with respect to fruiting phase. But in general fruiting phase showed an increasing trend with respect to irradiated treatments when compared to the unirradiated treatment. It was maximum for the 40 kR treated plants and least for the cultivated parent. These results are in agreement with the findings of Animon (1996).

Plant height varied significantly in all the treatments. It was lowest in 10 kR and maximum in 30 kR. All the irradiated treatments had lower plant height except 30 kR, when compared to the unirradiated treatment. Animon (1996) observed that there was no significant difference among 20, 30 and 40 kR treated plants with respect to plant height.

Yellow vein mosaic disease incidence did not differ much among the irradiation treatments viz., 10 kR, 20 kR and 40 kR, and had a lower level of incidence compared to 30 kR. However, a few recombinants with high yield resembling cultivated parent and with YVM disease resistance were also found in 30 kR. The semi wild parent was almost free from the disease, while the cultivated parent showed mild incidence of the disease. Animon (1996) reported that YVM disease incidence did not differ significantly among irradiated and unirradiated hybrids but cultivated parent recorded high incidence.

Fruit and shoot borer incidence was high in 30 kR and 40 kR treatments as well as the cultivated parent. It was very low in the semi wild parent.

The treatment 40 kR recorded the maximum duration and the cultivated parent the minimum. The plant duration showed in general, an increasing trend on irradiation. Not much difference was noticed between the unirradiated treatment and 10 kR with respect to this character.

5.2. Genetic variability in the F_2M_2 generation

The variability available in a population could be partitioned into heritable and non heritable components using the genetic parameters phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance based on which selection can be effectively carried out.

The highest phenotypic and genotypic coefficients of variation were observed for number of branches per plant in all the treatments except in the semi wild parent which recorded a low genotypic coefficient of variation. This is in agreement with the findings of Alex (1988) and Sheela (1994) who obtained high degree of genetic variability for number of branches per plant. All the irradiated treatments showed high phenotypic and genotypic coefficients of variation for number of seeds per fruit. Yadav (1986) and Alex (1988) observed moderately high genotypic coefficient of variation with respect to this character. Leaf number and number of flowers per plant and fruits per plant showed high to moderately high phenotypic and genotypic coefficients of variation in the treatments 20 kR and 30 kR. High phenotypic and genotypic coefficients of variation were noticed for number of flowers per plant by Mathews (1986) and Alex (1988). Moderately high values of phenotypic coefficient of variation and genotypic coefficient of variation were recorded

for weight of fruits per plant in 20 kR. Low phenotypic and genotypic coefficient of variation were observed for yellow vein mosaic disease incidence in all treatments which is in agreement with the findings of Mathews (1986). But Alex (1988) reported high genotypic coefficients of variation for this character.. The characters days to first flowering, leaf axil bearing first flower, first fruiting node, length and girth of fruit, number of ridges per fruit, fruiting phase, plant duration and incidence of fruit and shoot borer recorded low phenotypic and genotypic coefficients of variation in all the treatments. Except for 20 kR all other treatments had low phenotypic and genotypic coefficients of variation for average fruit weight which is in confirmity with the findings of Alex (1988). But Sheela (1994) reported moderate phenotypic and genotypic coefficients of variation for this trait.

Heritable variation may be effectively used with greater degree of accuracy when heritability is studied in conjunction with genetic advance (Majumdar *et al.*, 1974). A high genetic advance along with high heritability shows the most effective condition of selection. High heritability with very high genetic advance were noticed for number of branches per plant and number of seeds per fruit in all the irradiated treatments. High heritability with moderately high genetic advance was noticed for leaf area in the four radiation treatments. High heritability with high genetic advance was observed for leaf number, number of flowers per plant, number of fruits per plant and pollen sterility in the treatments 20 kR and 30 kR. However Mathews (1986) reported high heritability with low genetic advance for number of branches

per plant, number of flowers per plant and number of fruits per plant while low heritability and low genetic advance was reported by Alex (1988) for number of flowers per plant and number of fruits per plant. Sheela (1994) reported high heritability and low genetic advance for number of fruits per plant, which is not in conformity with the present findings. High heritability and high genetic advance were noticed for fruit yield per plant in 20 kR and plant duration in 30 kR but all other treatments recorded low values. Sheela (1994) also reported high heritability and genetic advance for fruit yield per plant. High heritability with moderately high genetic advance was observed for plant height in 10 kR, 20 kR and 30 kR. This is in conformity with the findings of Alex (1988) who reported high heritability and moderately high genetic advance indicating the low influence of environment and the scope for direct selection of these characters based on phenotypic performance. High heritability and moderately low genetic advance were noticed for length of fruit in the irradiated treatments 10 kR, 20 kR and 30 kR whereas for girth of fruit, high heritability and low genetic advance were noticed in 20 kR, 30 kR, and 40 kR. Fruiting phase also recorded high heritability and low genetic advance in 30 kR. Heritability and genetic advance were low for yellow vein mosaic incidence in all the treatments except 30 kR and the cultivated parent Kiran which had moderately high heritability and low genetic advance. Low heritability and genetic advance for yellow vein mosaic incidence was reported by Sheela (1994). However, Mishra and Chhonkar (1979) reported high heritability and genetic advance for this trait while Mathews (1986) and Alex

(1988) reported high heritability and low genetic advance. Low heritability and genetic advance suggest the predominant role of environment in the inheritance of YVM disease and it indicates lesser scope for improvement of this trait through selection. Low heritability and genetic advance were also observed for characters like days to first flowering and number of ridges per fruit in all the treatments.

5.3. Correlation in the F_2M_2 generation

Correlation provides information on the nature and extent of relationship among the various characters. In order to obtain information on the association of traits in the F_2M_2 generation, correlation coefficient was worked out among the eighteen characters.

Days to first flowering was significantly and positively correlated with plant duration in 10 kR, leaf number, number of branches per plant, flowers per plant, fruits per plant, seeds per fruit and fruiting phase in 20 kR, pollen sterility, girth of fruit, fruiting phase, plant height and plant duration in 30 kR and leaf area in P_2. However, there was significant negative association of days to first flowering with length of fruit in 20 kR, average fruit weight, length of fruit and number of seeds per fruit in 30 kR and leaf number in P_1. Alex (1988) reported that there was significant positive correlation of days to first flowering with fruiting phase, girth of fruit and number of seeds per fruit while significant negative association was noticed with number of flowers per plant, fruits per plant and length of fruit.

In all the treatments except in 10 kR, number of leaves per plant, flowers per plant and fruits per plant were positively correlated with weight of fruits per plant and also among themselves. Mathews (1986) and Sheela (1994) reported significant positive correlation of fruit yield per plant with leaf number, flowers per plant and fruits per plant. The importance of fruit number per plant as a selection criterion was stressed by Arumugam and Muthukrishnan (1981) and Balachandran (1984). Significant positive correlation of weight of fruits per plant with number of fruits per plant has been reported by Ariyo (1992). In all the irradiated treatments number of leaves and flowers were significantly and positively correlated with number of branches per plant while in the treatments 20 kR, 30 kR and 40 kR, fruit number per plant was also positively correlated with number of branches per plant. Number of flowers per plant and fruits per plant had significant negative correlation with average fruit weight in the treatments 20 kR and 30 kR. Alex (1988) reported that number of branches per plant was positively correlated with number of flowers per plant and fruits per plant which is in accordance with the present finding. He also observed that number of fruits per plant had significant positive correlation with average fruit weight which is not in agreement with the present results.

Pollen sterility was found to be positively correlated with leaf area and number of seeds per fruit in 0 kR, leaf area, average fruit weight and length and girth of fruit in 20 kR, girth of fruit and plant duration in 30 kR, girth of fruit and number of seeds per fruit in 40 kR whereas it was negatively correlated with plant height in 10 kR, number of leaves per plant, branches

per plant, flowers per plant, fruits per plant, fruit yield per plant and number of seeds per fruit in 20 kR, number of seeds per fruit in 30 kR, leaf area and number of branches per plant in 40 kR and with number of seeds per fruit in P_1.

Average fruit weight was found to be significantly and positively correlated with weight of fruits per plant in the treatments 0 kR, 10 kR, 40 kR, P_1 and P_2 while in 20 kR they were negatively correlated. Average fruit weight had significant positive correlation with fruit length in 10 kR, leaf area and length of fruit in 20 kR, 30 kR and 40 kR, number of ridges per fruit in 20 kR and 30 kR, fruit girth in 20 kR and P_2. Significant negative association of average fruit weight with number of branches per plant and plant height was observed in treatments 20 kR , 30 kR and 40 kR, fruiting phase in 20 kR and 30 kR and number of ridges per fruit in P_1 and P_2. Significant positive correlation of average fruit weight with length and girth of fruit and fruit weight per plant was observed by Alex (1988).

Fruit yield per plant was significantly and positively associated with number of branches per plant, number of seeds per fruit and fruiting phase in 20 kR, fruiting phase, plant height and plant duration in 30 kR while there was significant negative correlation with number of branches per plant in 0 kR, leaf area, length of fruit, girth of fruit and number of seeds per fruit in 20 kR, leaf area and length of fruit in 30 kR, number of seeds per fruit in 40 kR and plant height in P_2. Significant and positive association of yield with

number of branches per plant has been reported by Elangovan *et al.* (1980), Balachandran (1984), Mathews (1986), Alex (1988) and Sheela (1994). Significant positive correlation of yield with fruit girth as well as non-significant positive correlation between fruit yield and plant height was observed by Sheela (1994). Alex (1988) reported significant positive correlation of fruit yield per plant with length of fruit and positive yet non significant association with leaf area, girth of fruit and number of seeds per fruit.

Number of seeds per fruit was significantly and positively correlated with leaf area and number of ridges per fruit in 10 kR, number of leaves per plant, branches per plant, flowers per plant, fruitsper plant and fruiting phase in 20 kR and plant height in P_2 while significant negative association was noticed with leaf area in 0 kR, number of branches per plant in 10 kR, leaf area, length and girth of fruit and number of ridges per fruit in 20 kR, fruiting phase, plant height and plant duration in 30 kR, length of fruit and number of ridges per fruit in 40 kR and number of flowers per plant in P_1. Significant negative association between plant height and number of seeds per fruit was observed by Alex (1988).

Fruiting phase, plant height and plant duration was significantly and positively correlated among themselves in 30 kR, but plant duration and plant height were negatively correlated in P_2.

5.4. Evaluation of the F_3M_3 generation

F_3 and F_3M_3 populations showed wide range of variability for majority of the characters studied.

Days to first flowering was least in the cultivated parent. The irradiated treatments took more number of days for flowering than the unirradiated treatment and the cultivated parent. The maximum number of days to first flowering was taken by the treatment 20 kR. However, Sheela (1994) reported that the irradiated population took less number of days to first flowering when compared to unirradiated treatment.

Leaf axil bearing first flower was lowest for 30 kR. Several plants resembling the cultivated parent, with low flowering nodes were found to be present in 30 kR. The semi wild parent had the maximum value for this character. The treatments 0 kR and 10 kR did not vary much but differed significantly from the other treatments.

Leaf number varied significantly among the treatments. Irradiated treatments had more number of leaves per plant when compared to other treatments and it was maximum in 10 kR. The unirradiated treatment had least number of leaves per plant. Several plants which resembled the cultivated parent and with fewer number of leaves were found in 30 kR. Sheela (1994) reported higher number of leaves in F_2s as well as F_2M_2s than their parents. Animon (1996) reported that the 30 kR treated plants produced less number of leaves compared to other treated plants and untreated control.

Leaf area was least for the cultivated parent when compared to the other treatments and it was maximum in 10 kR. Irradiation was found to increase the leaf area. The treatments 10 kR and semi wild parent did not show significant variation among themselves while 0 kR resembled the cultivated parent with respect to this character. In general, the F_3M_3s resembled the semi wild parent with respect to leaf area.

Number of branches per plant was low in the unirradiated treatment and resembled the parents for this character. Irradiation increased the number of branches per plant. The maximum number of branches per plant was in 20 kR. It was also high in 10 kR and moderate with respect to 30 kR and 40 kR. Wide range of variability observed with respect to this character among the F_3M_3s might be due to release of variability on irradiation. Similar results were obtained in F_2M_2 generation also. But Animon (1996) observed a decrease in number of branches per plant on irradiation of the inter specific hybrids of okra.

Number of flowers per plant was maximum in the treatment 10 kR. The unirradiated treatment as well as the parents had lower number of flowers per plant when compared to the irradiated treatments. The number of flowers was low in 30 kR when compared to the other irradiated treatments due to presence of plants resembling cultivated parent with fewer number of flowers per plant. Sheela (1994) reported that the segregants produced lesser number of flowers.

Pollen sterility was lowest in the cultivated parent. The pollen sterility was maximum in the unirradiated treatment while the irradiated treatments had significantly lower pollen sterility when compared to 0 kR. This indicated the chance for the presence of fertile segregants among the irradiated population. These findings agree with the results of Cheriyan (1986) and Animon (1996). But Krishna (1985) reported higher pollen sterility at higher doses of mutagen treatments.

Cultivated parent recorded the lowest value with respect to the first fruiting node. Among the irradiated treatments, 30 kR had the lowest value for this character and resembled the cultivated parent. All other treatments resembled the semi wild parent. Sheela (1994) also reported that the segregants resembled the wild parent with respect to this character.

Number of fruits per plant was highest in 10 kR and least in the unirradiated treatment. In general, radiation increased the number of fruits per plant. The treatment 30 kR recorded lower values compared to other irradiated treatments, which might be due to presence of plants, resembling the cultivated parents in this treatment. Animon (1996) observed that there was no significant difference between the irradiated and unirradiated treatments with respect to this character.

Average fruit weight showed wide variation among the treatments. The semi wild parent had the maximum average fruit weight. Irradiation was found to decrease the average fruit weight. A reduction in the average fruit weight was observed among the segregants by Sheela (1994).

Weight of fruits per plant was high in the irradiated treatments when compared to the other treatments and it was highest in the treatment 40 kR. The unirradiated treatment had the lowest fruit yield per plant. However, Abraham (1985) reported decreased fruit yield on irradiation. Sheela (1994) reported general reduction in the mean values of segregants F_2s and F_2M_2s with respect to this character.

Length of fruit increased with increasing dose of radiation. 10 kR recorded the lowest fruit length while the semi wild parent had the maximum fruit length. Except for 40 kR, all the other irradiated treatments had smaller fruits than the unirradiated treatment which was in agreement with the findings of Animon (1996).

The semi wild parent had the maximum fruit girth. There was no significant difference among the irradiated treatments 10 kR, 20 kR and 30 kR with respect to this character and had lower mean values than the unirradiated treatment. Animon (1996) reported that plants in the treatment 40 kR produced fruits with lesser girth.

The treatment 30 kR had significantly higher number of seeds per fruit when compared to the other irradiated treatments as well as the unirradiated treatment. This might be due to the presence of plants resembling cultivated parent in 30 kR which had higher number of seeds per fruit. But in general irradiation was found to decrease number of seeds per fruit. Maximum number of seeds per fruit was for the semi wild parent. Radiation

induced sterility was observed among F_2M_2 s also. Animon (1996) also reported reduced number of seeds per fruit for the irradiated treatments.

The semi wild parent had the highest mean value for the number of ridges per fruit while the cultivated parent recorded the lowest value. Significant differences between irradiated and unirradiated treatments were not observed with respect to this character.

Irradiation of the interspecific hybrids increased the fruiting phase and resembled the semi wild parent for this character. The fruiting phase was lowest for the cultivated parent and maximum for the semi wild parent.

Significant differences were observed among the treatments with respect to plant height. The higher doses of radiation viz., 30 kR and 40 kR reduced the plant height when compared to 10 kR and 20 kR. Plant height was maximum in 10 kR and minimum in the cultivated parent. Not much difference between 0 kR and 10 kR and also among 20 kR, 30 kR and 40 kR irradiated treatments were observed by Animon (1996).

Incidence of yellow vein mosaic disease was more for the treatments 30 kR, 40 kR and the cultivated parent. However, a few plants which had resistance to YVM disease and resembling the cultivated parent were also observed in 30 kR. The semi wild parent had the lowest value for this character and had almost no incidence of this disease. According to Animon (1996) not much difference among irradiated and unirradiated treatments was

observed with respect to YVM incidence, but the incidence was high in the cultivated parent.

The cultivated parent and the treatment 30 kR had high incidence of fruit and shoot borer. The semi wild parent had the lowest incidence of fruit and shoot borer. All the other treatments did not vary very much with respect to this character. High incidence of fruit and shoot borer was observed in treatments 30 kR, 40 kR and the cultivated parent by Animon (1996).

Plant duration was higher in the irradiated treatments when compared to the unirradiated treatment as well as the cultivated parent. The plant duration was maximum for the semi wild parent. Among the irradiated treatments, 20 kR recorded the maximum mean value for this character.

5.5. Genetic variability in the F_3M_3 generation

High to moderately high genotypic coefficient of variation was observed for number of branches per plant in all the treatments which was in agreement with the findings of Balachandran (1984), Alex (1988) and Sheela (1994). The characters such as leaf number, number of flowers per plant, number of fruits per plant, weight of fruits per plant and number of seeds per fruit had moderately high phenotypic as well as genotypic coefficients of variation in all the irradiated treatments. High genotypic coefficient of variation for number of flowers per plant, fruits per plant, weight of fruits per plant and number of seeds per fruit has been reported by Alex (1988).

Moderately high phenotypic as well as genotypic coefficients of variation for number of fruits per plant as well as fruit yield per plant have been reported by Sheela (1994). Moderate genotypic coefficient of variation was observed for pollen sterility with respect to the irradiated treatments. All other characters had low phenotypic as well as genotypic coefficients of variation. The treatment 0 kR had low phenotypic and genotypic coefficients of variation for all characters except number of branches per plant.

Genotypic coefficient of variation as well as heritability estimate provide a better picture of the amount of genetic advance to be expected by phenotypic selection. Number of fruits per plant and weight of fruits per plant had high heritability and genetic advance for all the irradiated treatments. This finding was in consonance with the results of Sheela (1994) but contrary to the results of Balachandran (1984) and Alex (1988). Leaf number, number of branches per plant, flowers per plant and pollen sterility also recorded high heritability and genetic advance in all the irradiated treatments. High heritability and genetic advance for number of seeds per fruit was observed in the irradiated treatments 20 kR, 30 kR and 40 kR. Moderately high to high heritability was observed in the irradiated treatments as well as the unirradiated treatment with respect to number of ridges per fruit, plant height and plant duration. Heritability was moderately high in the irradiated treatments as well as the semi wild parent with respect to leaf area, but genetic advance was moderately low. Sheela (1994) reported high heritability coupled with high genetic advance for plant height and leaf area which are contrary to the

present findings. Moderately high heritability coupled with low genetic advance was observed for length of fruit and fruiting phase in the treatments 30 kR and 40 kR. The treatments 30 kR, 40 kR and P_1 had moderately high heritability and low genetic advance as far as fruit and shoot borer was concerned. All the other treatments except 30 kR had low heritability as well as genetic advance with respect to the incidence of YVM disease. Low heritability coupled with low genetic advance for yellow vein mosaic disease has also been reported by Sheela (1994). This suggests the predominant role of the environment in the spread of the disease. Sharma and Dhillon (1983) also reported that the genes responsible for resistance to virus are sensitive to environmental changes. This accounts for the low heritability recorded for the incidence of the YVM disease during the present investigation.

5.6. Correlation in the F_3M_3 generation

Correlation studies among the 18 characters in F_3M_3 were done to find the extend of association among them.

Days to first flowering was positively correlated with pollen sterility, fruit length, fruiting phase and plant duration in 10 kR, fruiting phase and plant duration in 20 kR, pollen sterility and plant height in 30 kR and leaf area and plant duration in 40 kR. Significant negative correlation was noticed with plant height in 20 kR and leaf axil bearing the first flower as well as first fruiting node in P_1. Alex (1988) reported significant positive correlation of days to flowering with fruiting phase and first flowering node.

Number of leaves per plant, flowers per plant and fruits per plant were positively correlated with fruit yield per plant in all the treatments. Similar results have been observed in the F_2M_2 generation also. Significant positive association was also noticed with number of branches per plant in 10 kR, 30 kR and 40 kR. Number of flowers per plant and fruits per plant were negatively correlated with average fruit weight in all the irradiated treatments. Significant negative association of number of flowers per plant and fruits per plant with number of seeds per fruit was observed in treatments 20 kR, 30 kR and 40 kR. Alex (1988) has reported significant positive correlation of number of fruits per plant with number of branches per plant and average fruit weight.

Pollen sterility was significantly and positively correlated with number of leaves per plant and flowers per plant in treatments 0 kR and 30 kR, number of fruits per plant and fruit yield in 30 kR and P_2, average fruit weight in P_2, number of ridges per fruit in 0 kR, 10 kR and 40 kR, fruiting phase in 0 kR and 30 kR, plant height in 20 kR, 30 kR and 40 kR, number of seeds per fruit in P_2 and plant duration in 10 kR and 40 kR. Significant negative association was noticed with average fruit weight in 10 kR and 30 kR.

Average fruit weight exhibited significant positive correlation with fruit yield per plant in 0 kR, P_1 and P_2 while significant negative association with fruit yield was noticed in 10 kR. Significant negative association was noticed with number of branches per plant in 10 kR and 20 kR, while positive

association was noticed with respect to number of seeds per fruit in treatments in 20 kR, 30 kR and 40 kR and number of ridges per fruit in 20 kR and 30 kR. Alex (1988) and Sheela (1994) observed significant positive association of fruit yield with average fruit weight. Significant negative correlation of average fruit weight with number of branches per plant and positive correlation with number of seeds per fruit was reported by Alex (1988).

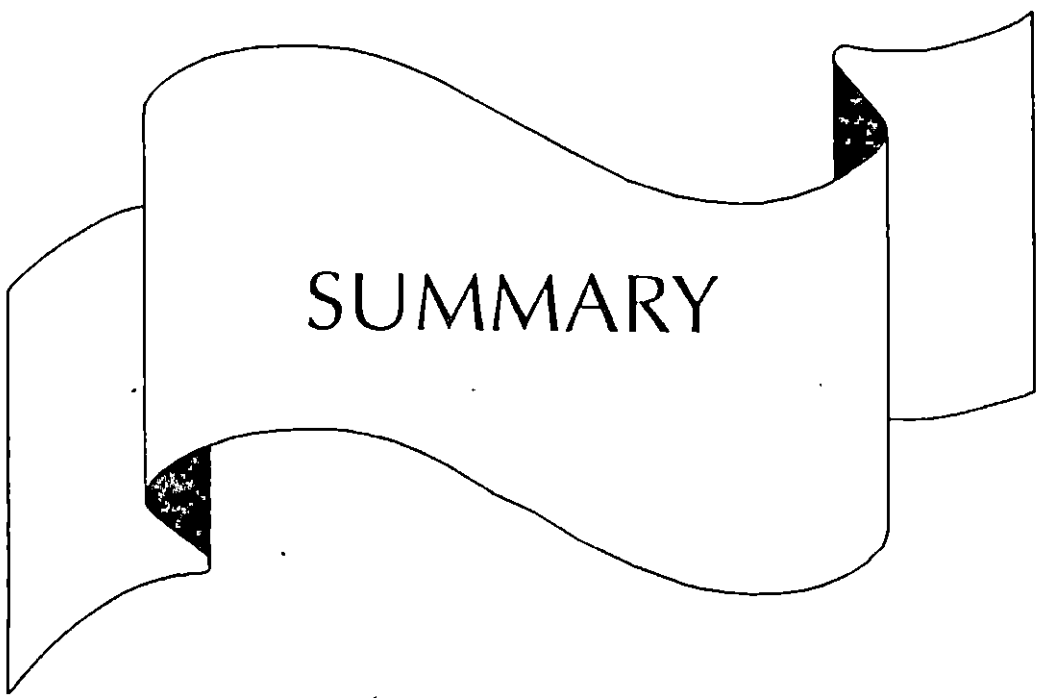
Fruit yield was found to have a significant positive correlation with number of branches per plant in 10 kR, 30 kR and 40 kR, fruiting phase and plant height in 30 kR and P_2 but had significant negative correlation with number of ridges per fruit in 10 kR, number of seeds per fruit in 20 kR and 30 kR and length and girth of fruit in 30 kR. Sheela (1994) reported significant positive association of fruit yield per plant with branches per plant and girth of fruit.

Significant positive correlation of number of seeds per fruit with number of ridges per fruit was observed in 20 kR and plant duration in 30 kR. Significant positive correlation between number of seeds per fruit and ridges per fruit was also observed by Alex (1988). Significant negative correlation of number of seeds per fruit with number of branches per plant and fruit girth was observed in 20 kR and fruit length in 30 kR. Alex (1988) reported significant negative association of number of seeds per fruit with number of branches per plant and positive association with girth of fruit.

Number of ridges per fruit was positively correlated with girth of fruit in 0 kR and 40 kR, fruiting phase and plant duration in 10 kR, leaf area, fruiting phase, plant height and duration in 30 kR, while there was significant negative correlation with fruiting phase in 0 kR and number of branches per plant in 10 kR and 20 kR.

Fruiting phase, plant height and plant duration were positively correlated among themselves in 10 kR, 30 kR and 40 kR. Significant negative correlation of fruiting phase and plant duration with plant height was noticed in 20 kR. Significant negative association between plant height and fruiting phase was observed by Alex (1988).

From the present study several plants resembling the cultivated parent having higher fruit yield and which showed tolerance or resistance to YVM disease were isolated from the 30 kR treatment. As a future line of work, these selected plants will be further evaluated for a few more generations and if found superior and resistant to the disease it will finally be developed into a YVM disease resistant variety.


SUMMARY

SUMMARY

Okra is one of the most important fruit vegetable crops cultivated in India. However the growth and yield of the crop is highly affected by the yellow vein mosaic disease. As part of the larger objective of evolving high yielding, YVM disease resistant varieties of okra, a study was undertaken in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, to estimate the extent of variability generated in the F_2M_2 and F_3M_3 generations on irradiation of the hybrid seeds of okra and also to isolate high yielding YVM disease resistant lines from among the segregating generations. Correlation studies were also conducted to find out the extent of association among the characters under study. The various findings obtained are given below.

Evaluation of the F_2M_2 generation

The irradiated treatments were found to be late flowering when compared to the unirradiated treatment and the cultivated parent.

Irradiation was found to increase the number of leaves per plant, flowers per plant and fruits per plant and it was maximum for the treatment 20 kR. The treatments 20 kR and 30 kR had the maximum number of branches compared to all other treatments.

Irradiation was found to increase pollen sterility and it was maximum for 10 kR. However seed set was lower for the irradiated treatments when compared to the unirradiated treatment and parental treatments.

Fruit weight was maximum for the semi wild parent. Among the irradiated treatments, the plants in 20 kR exhibited maximum fruit weight and weight of fruits per plant. However a few plants which resembled the cultivated parent with good yield could be observed in the treatment 30 kR. Fruit length and girth were found to increase with increasing radiation doses.

Number of ridges per fruit, fruiting phase and plant duration were higher for the irradiated treatments when compared to 0 kR and was maximum in the treatment 40 kR. Plant height was found to be maximum in 30 kR and least in 10 kR.

Irradiation was found to increase yellow vein mosaic disease incidence as well as fruit and shoot borer incidence and it was maximum in 30 kR among the irradiated treatments. However, a few high yielding YVM disease resistant plants resembling the cultivated parent were also observed in 30 kR.

Genotypic coefficient of variation was highest for number of branches per plant in all the treatments except the semi wild parent. High genotypic coefficient of variation was observed for the number of seeds per fruit in all the irradiated treatments as well as number of leaves per plant and flowers per plant in treatments 20 kR and 30 kR.

High heritability and very high to moderately high genetic advance were observed for number of branches per plant, seeds per fruit and leaf area in all the irradiation treatments. High heritability with high genetic advance were observed for leaf number, number of flowers per plant, fruits per plant and pollen sterility in treatments 20 kR and 30 kR, fruit yield per plant in 20 kR and plant duration in 30 kR. Heritability and genetic advance were low for yellow vein mosaic disease incidence in all the treatments.

Significant positive correlation of number of leaves per plant, flowers per plant and fruits per plant with weight of fruits per plant and also among themselves was observed in all the treatments except 10 kR. Average fruit weight and fruit yield per plant were positively correlated in treatments 0 kR, 10 kR, 40 kR, P_1 and P_2.

Evaluation of the F_3M_3 generation

The irradiated treatments were found to be late flowering but had more number of leaves, branches, flowers and fruits per plant.

The irradiated treatments had lower pollen sterility when compared to the unirradiated treatment and was lowest in 30 kR. However, the number of seeds per fruit was more in 30 kR compared to the other treatments excluding parental treatments.

Irradiation was found to decrease average fruit weight. However fruit yield per plant was more for the irradiated treatments due to the larger number

of fruits. Fruit yield per plant was maximum in 40 kR. Length of fruit increased with increasing radiation doses. There was not much difference among irradiated treatments 10 kR, 20 kR and 30 kR with respect to girth of fruit and had lower mean values than the unirradiated treatment. Significant differences among the irradiated treatments were not observed with respect to number of ridges per fruit.

Irradiation was found to increase the fruiting phase as well as plant duration but the semi wild parent recorded the maximum fruiting phase and plant duration when compared to all other treatments. Plant height was maximum in 10 kR when compared to other treatments.

Incidence of YVM disease was more in the treatments 30 kR, 40 kR and the cultivated parent. However, a few high yielding, YVM disease resistant plants resembling the cultivated parent were also observed in 30 kR. Fruit and shoot borer incidence were found to be high in the cultivated parent and 30 kR.

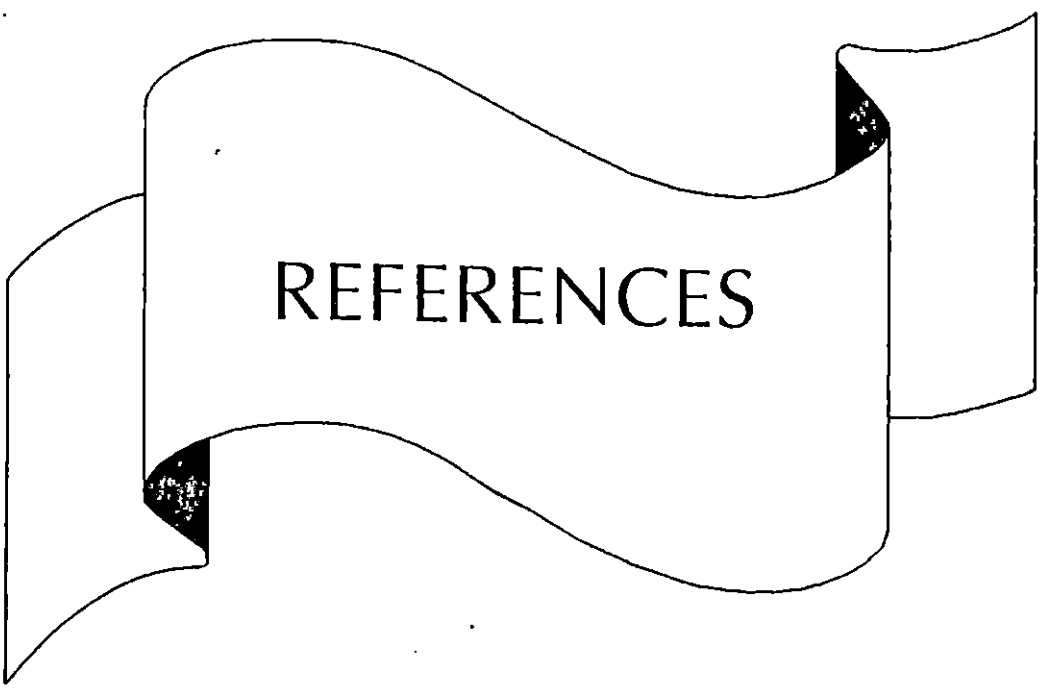
High to moderately high genotypic coefficient of variation was observed for number of branches per plant in all the treatments, as well as for number of leaves per plant, flowers per plant, fruits per plant, weight of fruits per plant and number of seeds per fruit in all the irradiated treatments.

High heritability and genetic advance were observed for number of fruits per plant, weight of fruits per plant, leaf number, number of branches

per plant, flowers per plant and pollen sterility in the irradiated treatments. The treatments 20 kR, 30 kR and 40 kR had high heritability and genetic advance for number of seeds per fruit. Moderately high to high heritability was observed for the irradiated treatments as well as the unirradiated treatment with respect to number of ridges per fruit, plant height and plant duration but genetic advance was low. All other treatments except 30 kR had low heritability as well as genetic advance with respect to yellow vein mosaic disease incidence.

Days to first flowering was positively correlated with plant duration in 10 kR, 20 kR and 40 kR. Number of leaves per plant, flowers per plant and fruits were plant were positively correlated with fruit yield per plant in all the treatments. Average fruit weight had significant positive correlation with fruit yield per plant in 0 kR, P_1 and P_2 while there was significant negative association with fruit yield in 10 kR. There was significant positive correlation between weight of fruits per plant and number of branches per plant in 10 kR, 30 kR and 40 kR. Fruiting phase, plant height and plant duration were positively correlated among themselves in 10 kR, 30 kR and 40 kR.

From the present study, several plants resembling the cultivated parent with high yield and YVM disease resistance were isolated from the treatment 30 kR. As a future line of work these plants will be further evaluated for a few more generations and if found superior and YVM disease resistant, it will finally be developed into a YVM disease resistant variety.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* Originals not seen

GENETIC ANALYSIS OF SEGREGATING GENERATIONS OF IRRADIATED INTERSPECIFIC HYBRIDS IN OKRA (*Abelmoschus* spp.)

By

SOPHIA JOHN

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COLLEGE OF AGRICULTURE
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ABSTRACT

A study was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 1996-'97 to estimate the extent of variability generated in the F_2M_2 and F_3M_3 generations as a result of hybridisation and hybrid irradiation of the interspecific hybrids between *A. esculentus* and *A. manihot* and also to isolate high yielding yellow vein mosaic disease resistant lines from among the segregating generations.

In the F_2M_2 generation, the irradiated treatments were found to be late flowering and had more number of leaves per plant, flowers per plant and fruits per plant. Irradiation was found to increase pollen sterility and was maximum in 10 kR. However seed set was lower for the irradiated treatments. Average fruit weight and weight of fruits per plant was maximum in plants belonging to the treatment 20 kR. Fruit length and girth were found to increase with increasing radiation doses. Number of ridges per fruit, fruiting phase and plant duration were higher in the irradiated treatments when compared to 0 kR and was maximum in 40 kR. Plant height was highest in the treatment 30 kR. Irradiation was found to increase YVM disease incidence and fruit and shoot borer incidence and it was maximum in 30 kR among the irradiated treatments. However a few high yielding YVM disease resistant plants resembling the cultivated parent were also observed in 30 kR.

Genotypic coefficient of variation, heritability and genetic advance were high for number of branches per plant and number of seeds per fruit in all the irradiated treatments in F_2M_2. High heritability with high genetic advance were observed for leaf number, number of flowers per plant, fruits per plant and pollen sterility in 20 kR and 30 kR. Significant positive correlation of number of leaves per plant, flowers per plant and fruits per plant with weight of fruits per plant and also among themselves was observed in all the irradiated treatments in F_2M_2. Average fruit weight and fruit yield per plant were positively correlated in treatments 0 kR, 10 kR, 40 kR, P_1 and P_2.

In F_3M_3 the irradiated treatments were found to be late flowering and had more number of leaves, branches, flowers and fruits per plant. Pollen sterility was lower for the irradiated treatments, when compared to the unirradiated treatment and was lowest in 30 kR. However the number of seeds per fruit was more in 30 kR compared to the other treatments excluding parental treatments. Irradiation was found to decrease average fruit weight but fruit yield per plant was more for the irradiated treatments due to the larger number of fruits and was maximum in 40 kR. Length of fruit increased with increasing radiation doses. Significant differences among the irradiated treatments were not observed with respect to number of ridges per fruit. Irradiation was found to increase the fruiting phase as well as plant duration. Plant height was maximum in 10 kR when compared to all the other treatments. Yellow vein mosaic disease incidence was high in the cultivated parent and the higher dose radiation treatments viz., 30 kR and 40 kR. From the present

study a few recombinants which resembled the cultivated parent, with high yield and YVM disease resistance could be isolated from 30 kR, which suggested that 30 kR could be ideal radiation dose for evolving high yielding YVM disease resistant lines in okra. Fruit and shoot borer incidence was highest in the cultivated parent and was also high in 30 kR.

High to moderately high genotypic coefficient of variation was observed for number of branches per plant, leaves per plant, flowers per plant, fruits per plant, weight of fruits per plant and number of seeds per fruit in all irradiated treatments in F_3M_3. High heritability and genetic advance were observed for number of fruits per plant, weight of fruits per plant, flowers per plant and pollen sterility in all the irradiated treatments. Number of leaves per plant, flowers per plant and fruits per plant were positively correlated with fruit yield per plant in all the treatments while average fruit weight had significant positive correlation with fruit yield per plant in 0 kR, P_1 and P_2 in the F_3M_3 generation.

As a future line of work, high yielding, YVM disease resistant plants assembling the cultivated parent which have been isolated from the treatment 30 kR will be further evaluated for a few more generations and if found superior and YVM disease resistant it will finally be developed into a YVM disease resistant variety.