CROSS COMPATIBILITY BETWEEN ABELMOSCHUS ESCULENTUS AND ABELMOSCHUS MANIHOT AND HYBRID STERILITY

BY

PRABHA P.

THESIS
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DECLARATION

I hereby declare that this thesis entitled "Cross Compatibility between *Abelmoschus esculentus* and *Abelmoschus manihot* and Hybrid Sterility" is a *bonafide* record of research work done by me during the course of research and that the thesis has not formed previously the basis for the award to me of any Degree, Diploma, Associateship, Fellowship or other similar title, of any other University or Society.

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Vellayani

5.10.'86
PRABHA.P.

CERTIFICATE

Certified that this thesis entitled "Cross Compatibility between *Abelmoschus esculentus* and *Abelmoschus manihot* and Hybrid Sterility" is a record of research work done independently by kum.PRABHA.P. under my guidance and supervision and that it has not formed previously the basis for the award of any Degree, Fellowship or Associateship to her.

K. Gopakumar
5-10-1986

K.GOPAKUMAR
Professor
Department of Agricultural Botany
CHAIRMAN
ADVISORY COMMITTEE

College of Horticulture
Vellanikkara

APPROVED BY

CHAIRMAN

Prof. K.GOPAKUMAR

MEMBERS

1. Achamma Oommen

2. SMT. P. SOUDAMINI.

3. DR. C.T. ABRAHAM

EXTERNAL EXAMINER

DR. S. PALANISAMY.

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CONTENTS

			Page
INTRODUCTION	...	...	1
REVIEW OF LITERATURE	...	...	5
MATERIALS AND METHODS	...	...	21
RESULTS AND DISCUSSIONS	...	...	33
SUMMARY	...	...	50
REFERENCES	...	...	i - vii

LIST OF TABLES

		Page
Table 1.	Particulars of attribute expression in 5 cultivated stocks of *Abelmoschus esculentus* and the wild *Abelmoschus manihot* studied.	22
Table 2.	Mean value and variablewise variance difference for 17 variables, mating compatibility and host reaction to virus infection in 16 treatments in the genus *Abelmoschus*	34
Table 3.	Mean value for net photosynthetic area, fruit yield, plant height, viable seed recovery and days for blooming initiation in 16 treatments of genus *Abelmoschus*, species, *esculentus* (5 varieties) and *manihot* and interspecific hybrids inclusive of reciprocals.	42

LIST OF PLATES(PHOTOGRAPHS)

1. Healthy plant of *Abelmoschus esculentus*
2. A diseased plant of *Abelmoschus esculentus* by YVM virus
3. Healthy plant graft inoculated to YVM diseased stock
4. T_1 plant - *Abelmoschus esculentus*, Var.Anakomban
5. T_2 plant - *Abelmoschus esculentus*, Var.MDU-1
6. T_3 plant - *Abelmoschus esculentus*, var.Pilicode local
7. T_4 plant - *Abelmoschus esculentus*, var.Pusa Sawani
8. T_5 plant - *Abelmoschus esculentus*, var. Sevan Dhari
9. T_6 plant - *Abelmoschus manihot*.
10. C 1.6 plant - Cross T_1 X T_6
11. C 2.6 plant - Cross T_2 X T_6
12. C 3.6 plant - Cross T_3 X T_6
13. C 4.6 plant - Cross T_4 X T_6
14. C 5.6 plant - Cross T_5 X T_6
15. R 1.6 plant - Cross T_6 X T_1
16. R 2.6 plant - Cross T_6 X T_2
17. R 3.6 plant - Cross T_6 X T_3
18. R 4.6 plant - Cross T_6 X T_4
19. R 5.6 plant - Cross T_6 X T_5

LIST OF CHARTS

1. Legend of indications shown in Charts 2 to 6

2. Plants T_1 , T_6 , C 1.6 and R 1.6

3. Plants T_2 , T_6 , C 2.6 and R 2.6

4. Plants T_3 , T_6 , C 3.6 and R 3.6

5. Plants T_4 , T_6 , C 4.6 and R 4.6

6. Plants T_5 , T_6 , C 5.6 and R 5.6

LIST OF DIAGRAMS

1. Leaf characteristics of T_1 T_6 and C 1.6
2. do. -do- T_1, T_6 and R 1.6
3. do. -do- T_2, T_6 and C 2.6
4. do. -do- T_2, T_6 and R 2.6
5. do. -do- T_3, T_6 and C 3.6
6. do. -do- T_3, T_6 and C 3.6
7. do. -do- T_4, T_6 and C 4.6
8. do. -do- T_4, T_6 and R 4.6
9. do. -do- T_5, T_6 and C 5.6
10. do. -do- T_5, T_6 and R 5.6

INTRODUCTION

INTRODUCTION

Serious production loss in okra/ bhindi/ lady's finger (Family, MALVACEAE: Genus Abelmoschus ; Species esculentus), the popular vegetable crop cultivated extensively for the edible tender fruits in parts of India and countries outside, is caused by the Yellow Vein Mosaic(YVM) disease. Uppal et al.(1940) suggested that the disease was caused by some virus. According to Capoor and Varma (1950) the viral transmission is effected by the insect vector, the white fly (Family ALEYRODIDAE;Genus Bemisia; Species tabaci).

Photographs of healthy and diseased plants are shown under Plate I and II respectively. The disease makes the plant characteristically deficient in chlorophyll, as a result of which the biomass production is drastically minimised and eventually the economic yield becomes low.

Since pathogens are identified as major biotic agencies causing severe production loss in crops, research for effective means to combat them has always been an important activity of the crop scientist. When several of the bacterial and fungal disease could be satisfactorily controlled with chemicals, it is not so in the case of viruses. Though cultivated varieties of bhindi could be saved from the YVM disease to a remarkable extent through chemical control of the insect


5


5

PLATE - ii

vector, the approach is not advisable on grounds of harmfully toxic residual effect, especially where the duration of the crop is brief and the fresh fruits are preferred for consumption. Hence, the search for alternate measures to prevent either totally or minimise satisfactorily, the possible loss in production in diseased plants. It is in this context that the prospect of inducing genetic improvement through breeding for built-in-resistance is thought of.

Many methods of breeding are known. In the breeding for built-in-resistance, genetic control of resistance to the damaging agency is to be established initially. Identification of the right donor source is important. In addition, the practicability of successful transference of resistance into desired stocks through crossing has to be assessed. Then only the screening of resistant varieties becomes possible.

Dhillion and Sharma (1982) reviewed the attempts made on developing bhindi varieties resistant to the YVM disease. According to them, since most of the cultivated varieties are variedly susceptible to the disease, few attempts were made to evolve resistant stocks through intervarietal hybridization. Wild species related to the cultivated one are found to possess genetic resistance worthy of transference through crossing. Among them, Abelmoschus manihot is identified as the most competent donor(Nariani and Seth,1958; Arumugham et al.,1975; Chelliah and Sreenivasan, 1983). During subsequent years many cultivated varieties of the species, esculentus were crossed to the species manihot with resolution of encouraging success(Jambhale and Nerkar, 1982 a & b; Dhillon and Sharma, 1982; Pillai, 1984).

Though interspecific crossings promise scope in certain instances, problems are not scarce. From the taxonomic point of view, 'Species' represent groups of individuals that are similar in morphology and performance. They maintain their identity through generations by virtue of reproductive isolation from other species. Occasional compatible matings do occur in nature and could also be effected by the breeder. Yet, many of these hybrids remain sterile preventing the generation of later segregatidng populations to facilitate screening, through appropriate methods of types with desired resistance.

This experiment in bhindi was undertaken as part of a major research project of the Department of Plant Breeding at the College of Agriculture, Vellayani,'Breeding for Resistance in Vegetables' under the Kerala Agricultural University. It was carried out to assess:

REVIEW OF LITERATURE

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Taxonomically the bhindi crop is located by Bailey(1949) and Purseglove (1982).

MALVACEAE is an important family under the dicotyledons. Commercial cotton (*Gossypium* spp.) is extensively cultivated. Others include species under genera *Hibiscus*, *Cannabinus*(Deccan hemp) and *Subdariffa* (Jamaican sorrel) that are less extensively grown for fibre.

Abelmoschus esculentus (L) Moench (*Hibiscus esculentus* (L), commonly referred to as bhindi, lady's finger or okra, is a popular vegetable crop cultivated for edible fruits.

The family MALVACEAE consists of about 50 genera with 1000 species and the genus *Hibiscus*/*Abelmoschus* alone has 200 species.

Bhindi, though now cultivated throughout countries in the tropics and to some extent in the subtropics originated in tropical Africa, where genetically diverse but related wild and semi-wild species occur still(Purseglove, 1982).The crop has quite a number of named cultivars. Some are naturally formed and others cultivator developed or breeder evolved.

Fruit Production Loss in Bhindi.

As in other crops grown for the produce, in bhindi too loss in fruit yield does occur.

Purseglove (1982) reports that the Yellow Vein virus is responsible for a major disease in this crop causing considerable detriment in production.

The initial report on the disease in India was made by Kulkarni (1924). Diseased plants were observed in parts of the erstwhile Bombay State.

The viral involvement of the disease is established by Uppal et al.(1940)

Currently in no part of the country the crop is free from this disease. Though cultivars differ in the degree of host resistance response to the virus, none is wholly resistant or tolerant (Jha and Misra, 1955; Varma and Mukherjee, 1955).

Nariani and Seth (1958) describe that the leaves in diseased plants following initial thickening / clearing of the veins and veinlets, turn yellow, curled and twisted. Such plants eventually become stunted in growth and produce only fewer number of characteristically short pale yellow malformed fruits.

It is not at all desirable to combat severity of damage in vegetable crops due to diseases and pests with chemicals because of the hazarduously toxic residual effects they leave. Hence breeding for built-in-resistance is vital.

Breeding for Built-in-Resistance.

Since cultivated varieties of bhindi are differently susceptible to the YVM disease and the transferable source of genetic resistance is localised generally in wild species, breeding for built-in-resistance necessitates crossing at interspecific level.

Dhillon and Sharma (1982) review the search for transferable genetic resistance in species of Abelmoschus other than esculentus. These species include angulosus, cannabinus, crinitus, subdariffa, panduraeformis, (Nariani and Seth, 1958), ficulneus (Gadwal et al.,1968; Hossain and Chattopadhpadhyay, 1976), moschatus (Gadwal et al.,1968), tuberculatus (Pal et al., 1952), tetraphyllus (Nair and Kuriachan, 1976; Ugale et al.,1976) and manihot(Teshima, 1935; Chizaki, 1934; Skovsted, 1935; Ustinova, 1937 and 1949 and Singh et al., 1938). Crosses of species esculentus with these speciess appear to be variedly compatible to incompatible. Further in the hybrids, whenever could be developed, the seed sterility manifested predominantly.

1. how far interspecific crosses in the Genus Abelmoschus are compatible, and
2. how far the hybrids produce viable seeds to enable breeding of varieties resistant to the YVM disease.

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The host range covers almost all the cultivated varieties, but in varying degree (Capoor and Varma, 1950). According to them, the virus is transmitted from diseased to healthy plants by an insect vector, the white fly (Bemisia tabaci). Based on the results of studies on virus vector relatinship conducted, they report that though a single fly can cause infection in quite a number of plants, a larger population is required to induce widespread damage.

According to Sangappa (1966), the white fly by itself is not a serious pest of bhindi. However, the presence of a few number of virulent flies is more than enough to cause substantial loss.

Costa (1976) reports that there is hardly any insecticide suited to kill totally the vector fly rapidly enough to exclude absolutely the viral inoculation.

Shastry and Singh (1974) and Chelliah and Murugesan (1975) estimated production loss in YVM diseased bhindi cultivars at different phases of the plant's growth and development under varied conditions in the environment and fly population size. Based on the findings, the unquestioned severity of loss in India for almost all the named cultivars due to the disease is well justified.

It is not at all desirable to combat severity of damage in vegetable crops due to diseases and pests with chemicals because of the hazarduously toxic residual effects they leave. Hence breeding for built-in-resistance is vital.

Breeding for Built-in-Resistance.

Since cultivated varieties of bhindi are differently susceptible to the YVM disease and the transferable source of genetic resistance is localised generally in wild species, breeding for built-in-resistance necessitates crossing at interspecific level.

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On the basis of the results of screening carried out by Arumugham et al.(1975), the species manihot, compared to the other species mentioned to above, is desirably resistant and promises scope for successful transference of genetic resistance to susceptible stocks under species esculentus through hybridization.

Accessions of this species are derived from various parts, tropical Africa and Japan. Singh et al.(1975) found accessions from Africa, particularly those from Ghana, highly immune to the disease.

Particulars of interspecific crosses attempted in cultivars of Abelmoschus esculentus to certain wild species are furnished below:-

1. Cross A.esculentus X A.manihot.

The earliest report is made by Kuwada(1961). He found the hybrids partially sterile

Arumugham and Muthukrishnan (1978 b and 1979) developed interspecific hybrid progenies from two cultivars of A.esculentus crossed to A.manihot. According to them the seed fertile hybrid recovery is readily possible and hence could be made useful in breeding programmes.

Mamidwar et al.(1979) while studying crosses between cultivars of A.esculentus and A.manihot found that fruit set was higher when A.esculentus was used as the female parent with 83.33 as the mean value for percentage fruit set.

Dhillon and Sharma (1982) produced interspecific hybrids of A.esculentus cultivars and a Ghanian accession of A.manihot (sub species manihot). They could realise appreciably good recovery of hybrids.

Pillai (1984) produced interspecific hybrids from A.manihot and four YVM susceptible A.esculentus cultivars. Though the hybrids produced fruits, the per fruit seed count was very much low (8 to 12) as against that of the parents (50 to 90). Further, the hybrids were found to be resistant to the YVM disease. A decrease in percentage pollen fertility in the hybrids (28.7 - 57.4) as against the parents (98 - 99) is presumably the reason for scanty hybrid seed recovery.

Jambhale and Nerkar (1982 b) recorded low rating for pollen fertility (55.7 %) in A.esculentus X A.manihot hybrids. They observed reduced seed fertility (7.1%) in the hybrids against the parents (90%). They identify the reasons for the lowering of percentage values for pollen and seed fertility in the hybrids in abberant meiotic behaviour during sporogenesis.

2. Crosses A.esculentus X species other than A.manihot

(a) A.esculentus X A.tetraphyllus.

Nair and Kuriachan (1976) studied a spontaneous interspecific hybrid presumably between A.tetraphyllus and A.esculentus that was totally seed sterile and in which selfing, open pollination and back crossing to both parents produced only fruits empty of seeds.

Ugale et al.(1976) found hybrids of H.esculentus and H.tetraphyllus intermediate between the parents for several morphological characters. They report that these hybrids could be developed not so readily as A.esculentus X A.manihot hybrids.

Jambhale and Nerkar (1981) studied a spontaneous seed fertile amphidiploid of A.esculentus X A.tetraphyllus hybrid. They believe that the amphidiploid originated as a result of fusion of unreduced gametes of the Fl. Later they developed successfully colchicine induced fertile amphidiploids of A.esculentus with A.tetraphyllus (Jambhale and Nerkar, 1982 a and b)

(b) A.esculents X A.tuberculatus.

Pal et al.(1952) could develop interspecific hybrids of the genus Abelmoschus by crossing species tuber culatus to species esculentus.

Joshi and Hardas (1956) made cytogenetic investigations in A.esculentus X A.tuberculatus hybrids. They established that A.esculentus has an allopolyploid origin with two genomes of which one genome is derived from A.tuberculatus.

(c) A.esculentus X A.ficulneus.

Gadwal et al.(1968) recovered A.esculentus X A.ficulneus hybrids through ovule and embryo culture techniques. Straight crossing has always been incompatible.

Hossain and Chattopadhyay (1976) studied hybrids of H.esculentus and H.ficulneus and found them totally sterile. These hybrids were found to be bearing a close resemblance to the wild parent for several morphological characters and the fruits invaiably carried no seeds.

(d) A.esculentus X A.moschatus.

Gadwal et al.(1968) reported that A.esculentus X A. moschatus hybrids could be produced only through ovule and embryo culture.

From the review of the attempts on interspecific hybridization tried by authors mentioned to above, it is seen that when hybrids of A.esculentus against A.manibot could be readily developed through controlled crossing, producing esculentus hybrids against other species is not that simple.

Controlled Pollination

This includes selfing and crossing. The Techniques for both have been standardised by Giriraj and Rao(1973).

Selfing

Flowers of plants in the different species of the genus Abelmoschus are bisexual and predominantly self pollinated. In order to confirm that self pollination alone does occur, precautions are to be exercised against pollen contamination. Flower buds are to be protected inside butter paper bags from the evening hours of the day prior to the opening of petals. The protective envelope is removed later only when signs of fruit set as evidenced by enlargement of ovary is confirmed. Relevant labels furnish information for future reference.

Crossing

Mature flower buds in the proposed seed parent that are to open on the subsequent day are chosen. Emasculation is done in the evening hours. A shallow circular incision is made at the base of the fused calyx-corolla complement to facilitate gradual withdrawal of it in the form of a hollow conical hood to expose the stigma with the surrounding staminal column. The staminal tube is sliced longitudinally taking care that accidental bursting of the intact anthers does not take place and also that the style, stigma and ovary are not injured or damaged. The calyx-corolla hood is then replaced to protect the vital organs of the emasculated flower against undesirable pollen. No protective paper envelope is used in this method.

The flower bud from the chosen pollen parent too has to be protected inside butter paper bags from the evening prior to the day on which the flower opens and the envelope is removed only at the time of the transference of the pollen to the receptive stigma of the emasculated flower of the proposed seed parent. Pollination is done during morning hours on the day next to the one on which emasculation is done, generally between 7.00 and 9.00 hours after removing the calyx-corolla hood which is then repositioned on the pollinated flower. The sepals and petal eventually gets dried and drops off by themselves with the initiation of fruit development. Proper labelling facilitates later knowing of particulars.

Screening for Resistance Against Yellow Vein Mosaic Disease

This is a vital step in breeding programmes for built-in-resistance. Testing of adequately varying germ plasm is necessitated to identify and choose the right source of resistance that can be used in breeding. It is also required to assess whether the genetic resistance is inherited desirably in the progeny population.

Screening of a germplasm consisting of 100 cultivated varieties and intervarietal hybrids in bhindi conducted at the Division of Botany, IARI, New Delhi, revealed that without exception all were susceptible to the YVM disease (Nariani and Seth, 1958).

Varma and Mukherjee (~~1958~~ 1955) screened 48 varieties of bhindi in West Bengal and reported that types with pink pigmentation appeared to be relatively tolerant to the disease, but no scientific justification is seen to be attributed.

Nariani and Seth (1958) studied the host reaction to YVM virus in 8 species of *Abelmoschus* and 4 species of *Hibiscus*. Viruliferous white flies reared on diseased plants were liberated to feed on the test stocks and it was found that *A. manihot* var. *pungens*, *A. Crinitus*, *H. vitifolius* *H. panduraeformis* were immune to infection. The other species tested by them showed variation in disease symptoms ranging from extremely severe to very much mild. *A. tuberc-*

ulatus, A.angulosus, H. cannabinus and A.subdariffa, though showed absence of viral chlorosis, had vein swellings on the undersurface of the leaf blade. Species esculentus, moschatus and ficulneus were observed to be highly susceptible. Accessions of A.manihot seemed absolutely resistant always. These findings were confirmed by graft inoculation technique of screening.Diseased scions were wedge grafted on healthy stocks and symptoms of disease were searched once the stionic union has established on sprouts developing from the stock region.

Resistance in Species esculentus

Within 267 indigenous cultivars of species esculentus, resistance was noticed at IIHR, Bangalore only in 2 - IHR-20-1 and IHR-15-1 (Premnath, 1970).

Sandhu et al.(1974) screened 49 lines belonging to A.esculentus for field resistance to YVM disease under conditions of heavy natural infection. They identified only three A.esculentus lines resistant.

Coupled Screening for High Yield and Resistance.

Rao and Bidari (1976) recommended Coupled Yield high disease resistance selection in cultivars of A.esculentus in the light of effectiveness expressed in experiments conducted.

46 strains of *A.esculentus* inclusive of the proven high yielding Pusa Sawani were assessed for yield and virus infection under unsprayed field conditions by Chauhan et. al.(1981). They found strains showing resistance had a mean infection rate 78.8%. The lowest mean value of infection, 17.8% was shown by IC-9213 which had a mean yield of 82g/ plant while the highest yield of 176g/plant given by IC-1342 had a mean infection as high as 98.3%. It appears that in bhindi,as the fruit yield becomes more, there is tendency for increased susceptibility.

Some cultivars of *A.esculentus* selected by Atiri(1983) yielded high and remained resistant to the YVM disease.

Pillai(1984) confirmed resistance of *A.manihot* using graft inoculation technique.When *A.manihot* was crossed to 4 cultivars of *A.esculentus*, the resultant hybrids, inclusive of reciprocals, were found to be resistant to the YVM virus under natural field conditions favourable for infection as well as under artificial graft inoculation. But the hybrid seed recovery has always been scarce compared to the parents.

Symptomless Carrier.

The concept of symptomless carrier in the context of understanding host resistance / susceptible reaction to pathogens of infectious diseases is proposed by Russel(1978). In this an apparently healthy plant harbouring the pathogen in a potentially favourable state for transmission among disease free host is referred. Such plants if left undetected, and unremoved can cause ready spread of the disease among healthy individuals. These carriers can be detected only through graft inoculation technique.

In bhindi, Singh et al.(1962) identified accession IC-1542 as a symptomless carrier of YVM virus based on results of application of the technique mentioned to as above.

Singh and Thaker(1979) suspected certain accessions of *A.manihot* Sub.*manihot* as symptomless carriers of the virus, but the required justification is yet to be made.

Incompatibility in Mating.

Failure of viable seed production as a result of mating under selfing or crossing, natural or induced is often attributed to sterility which is distinctly different from incompatibility. When sterility is the consequence of defective development during the reproductive phase, development of gametes is absolutely normal in incompatibility. The failure of viable seed production in this is not due to the developmental defect but it is due to functional reasons, often governed by specifically identiable incompatibility genes (Poehlman and Borthakur, 1969) Two types of incompatibility are recognised - self incompatibility and cross incompatibility. When latter is at the specific level, it is referred to as interspecific incompatibility(Lewis, 1956).

Hybrid Sterility

A hybrid is identified as the progeny of genetically dissimilar parents. When this progeny fails to produce viable seeds, it is described as hybrid sterility/hybrid seed sterility. In hybrids, meiotic abnormalities during sporogenesis is common and consequently the development of gametes becomes defective(Riley, 1951). These defective gametes are defective in fuction also irrespective of mating whether self or cross. The genetic diversity of the parents in a hybrid could be at the varietal or specific levels. More diverse the parents are, more will be the sterility and *vice versa*(Altenburg, 1961). The reason for viable seed production in hybrids, whether in small number or in profusion, can only be due to the compatible genetic similarity prevailing in the parents of the hybrids concerned.

Scanty Hybrid Seed Recovery and Pollen Sterility.

Due to reasons furnished above one can readily conceive that viable seed production in hybrids, intervarietal or interspecific, is scarce as compared to the parents. Often the reason can be pointed to sterility prevalent at the pollen and ovular levels. The methods to detect the sterility at the pollen level are less complex and hence employed as the overall indicator in related studies often.

For the study of pollen sterility, the acetocarmine staining technique has been in use since long. Zirkle(1937) introduced a method for testing the viability of pollen grains by acetocarmine staining method. Pollen grains are dusted on a slide on which are taken one or two drops of 2% acetocarmine stain. Then the coverslip is mounted. It is then examined after a few minutes under the microscope. Filled pollen grains that took the stain are considered viable. This attribute is expressed in percentage value.

MATERIALS AND METHODS

MATERIALS AND METHODS

MATERIAL

The experiment was carried out under the Kerala Agricultural University in the Department of Plant Breeding, College of Agriculture, Vellayani, during May 1985-Dec.1985. The plant material used was chosen from the collection maintained in the department. It consisted of 5 locally adapted high fruit yielding varieties of *Abelmoschus esculentus* and a stock from species, *manihot* reported by Pillai (1984) and recommended to be the most ideal source for breeding bhindi for built-in-resistance to the Yellow Vein Mosaic (YVM) disease.

METHODS

A. Initially plants were raised in pots from seeds of these six stocks. Preliminary aspects on important morphological and performance attributes were studied. In addition, the crop was used to generate adequate seed material for use in the major experiment.

Morphological and performance attributes of the material as noticed in the preliminary study are furnished in Table (I)

B. Major Experiment.

Both pot culture and field level experiments were

TABLE - I

Particulars of attribute expression in 5 stocks of *A. esculentus* and the wild *A. manihot* studied.

Attributes	Varieties/Stocks of *A. esculentus*					Accession of *A. manihot*
	1 Anakomban (S1)	2 MDU-1(S_2)	3 Pilicode local(S3)	4 Pusa Sawani	5 Sevan Dhari(S_5)	(S6)
1. Plant ht. at full maturity	Tall	Medium	Medium	Tall	Medium	Short
2. Length of petiole	Medium	Medium	Medium	Low	Medium	Low
3. Size of leaf blade	High	Medium	Medium	Medium	Low	High
4. Final fruit Harvest	Early	Early	Early	Early	Early	Late
5. Per plantfruit yield	Average	High	High	Average	Average	Low
6. Per plant fruit No.	High	High	High	Average	High	Low
7. Fruit length	Long	Average	Average	Long	Average	Short
8. Per plant seed recovery	High	High	Medium	Medium	Medium	Low
9. Edible quality of fruit	good	good	good	good	good	poor
10. Blooming initiation	Early	Early	Early	Early	Early	Late
11. Fruit girth	Average	High	Average	Average	Average	High
12. Per Plant No. of leaves	High	Average	Average	Low	Low	High
13. Per plant Relative photosynthetic area	High	Low	Low	Low	Low	High
14. Mean test seed weight	Average	Average	High	High	Average	Average
15. Germinability of seeds	High	High	High	High	High	High
16. Pollen fertility	High	High	High	High	High	High

TABLE - I (Contd...)

Attributes	Varieties/Stocks of *A.esculentus*					Accession of *A.manihot*(S6)
	1 Anakomban (S2)	2 MDU-1(S_2)	3 Pilicode Local(S3)	4 Pusa Sawani(S4)	Sevan Dhari(S5)	
17. Percentage seed set	High	High	High	High	High	High
18. Host reaction to graft virus inoculation	Susceptible	Susceptible	Susceptible	Susceptible	Susceptible	Resistant
19. Viable seed recovery	High	High	High	High	High	average

conducted.

Phase I Experiment - (Pot culture)

The experiment was arranged to carry out controlled mating as follows:

1. Selfing
2. Crossing: Crosses and reciprocals.

Total Number of treatments - 6

Number of Replications - 5

Total Pots -30

Treatments	Stocks
T_1	- *Abelmoschus esculentus*, var.Anakomban
T_2	- " " var.MDU-1
T_3	- " " var.Pilicode-local
T_4	- " " var.Pusa=Sawani
T_5	- " " Var.Sevan-Dhari.
T_6	- *Abelmoschus manihot*.

The six stocks as mentioned ~~to~~ above were grown with each replicated five times. Altogether 30 pots were used. The plants were used to generate seeds through controlled mating that included selfing and crossing. Since one of the stocks out of the six (*A.manihot*) was noticed during the preliminary trial to initiate blooming on a date later as against the remaining five, in order to synchronise blooming to facilitate controlled mating, its seeds were sown a fortnight in advance. With the initiation of blooming, controlled pollination was practiced as according to scheme furnished below:

Pollen Parents

		T_1	T_2	T_3	T_4	T_5	T_6
	T_1	⊗1					C1.6
	T_2		⊗2				C2.6
Seed Parents	T_3			⊗3			C3.6
	T_4				⊗4		C4.6
	T_5					⊗5	C5.6
	T_6	R1.6	R2.6	R3.6	R4.6	R5.6	⊗6

⊗ series represent selfed catergories of T_1 - T_6

C and R represent straight and reciprocal cross combinations respectively.

The techniqus of selfing and crossing in bhindi has been standardised earlier by Giriraj and Rao (1973). The proceedures recommended by them as detailed under review of literature were followed in this experiment. The fruits developed from flowers subjected to controlled pollination were individually harvested, kept inside properly labelled brown paper bags, let to sun drying for three days and stored safely. The fruits, when became dry dehised by themselves liberating the seeds within the envelope. The seeds were cleaned of debris and stored in separate butter paper envelopes with relevant particulars suitably labelled.

Phase II Experiment (Field level layout)

This part of the main experiment was arranged in the field level.

Design experiment	-	RBD
No.of Replications	-	3
No.of blocks	-	3
No.of plots/block	-	16
Total No.of plots	-	16x3 = 48
Individual Plot size	-	$400 \times 560\ cm^2$
Spacing	-	100 cm between columns and 80 cm between plants in each column
No.of plants per plot	-	28 (4 columns with 7 plants in each including border)
Plot sample size	-	10

Particulars of treatments

Treatment	Particulars	Parents		
T_1	⊗1	*A. esculentus*	var Anakomban	(Selfed)
T_2	⊗2	"	MDU-1	"
T_3	⊗3	"	Pilicode local	"
T_4	⊗4	"	Pusa Sawani	"

Treatment	Particulars	Parents
T_5	⊗5	*A.esculentus* Sevan Dhari (Selfed)
T_6	⊗6	*A.manihot* (Selfed)
T_7	C 1.6	Anakomban X A.manihot
T_8	C 2.6	MDU-1 X *A.manihot*
T_9	C.3.6	Pilicode Local X *A.manihot*
T_{10}	C 4.6	Pusa Sawani X *A.manihot*
T_{11}	C 5.6	Sevan Dhari X *A.manihot*
T_{12}	R 1.6	*A.manihot* X Anakomban
T_{13}	R 2.6	*A.manihot* X MDU-1
T_{14}	R 3.6	*A.manihot* X Pilicode local
T_{15}	R 4.6	*A.manihot* X Pusa Sawani
T_{16}	R 6.5	*A.manihot* X Sevan Dhari

The seeds representing the 16 treatments were sown on suitably prepared seedbed in the experimental plots. Throughout the duration of stand of the crop in the field, management care was given according to recommendations of The KAU Package of Practices (Anon.1982).

Observations were made and recorded for the following characters.

1. Height of Plant.

This was measured twice, initially on the 40th day following seed sowing and later on the date of final fruit harvest, the values expressed in cm.

2. Per Plant number of leaves.

This was estimated by counting the number of nodes on the main axis and the branches. The counting was done on the 20th day áfter blooming initiation.

3. Per plant mean leaf area.

A sample of ten leaves collected from the middle most part of the plant was used. The leaf outline was marked on graph paper and the area read out directly and recorded in cm^2 and the mean value was then estimated.

4. Per plant net photosynthetic area.

This value was computed by multiplying the plants' corresponding values for categories 2 and 3 above.The value was expressed as cm^2

5. Length of the petiole.

For taking this measurement, sampling as mentioned under category 3 was resorted to. Values were recorded in cm.

6. Per plant fresh fruit yield.

Fruits from plants were harvested on different days as and when they become ripe. The fresh fruit weight was noted on daywise harvest and the per plant total fruit yield was computed by adding the values. The value for this character was recorded in g.

7. Per plant number of fruits.

This was referred to the total number of fruits harvested from each plant.

8. Per plant mean fruit length.

This was computed from individual measurements on lengfth of fresh fruits harvested from the same plant and the mean value was expressed in cm.

9. Per plant mean fruit girth.

Measurement of this attribute was made by using a thread wound around the middlemost length of the individual fruit. The mean value worked out was expressed in cm.

10. Per plant mean number of ridges on the fruit.

Direct counting and computing the mean thensforth facilitated recording of data.

11. Per treatment mean test seed weight.

100 well dried seeds were chosen at random, weighed, the mean worked out and expressed in g.

12. Germinability of seeds.

Well dried seeds arranged on moist filter paper kept in petri-dishes were examined for signs of sprouting at day's intervel for a period of a week. Number of seeds germinated in this duration was expressed in %. Three petri-dishes were kept per treatment with 100 seeds in each to work out this information.

Two sets of germination trials were conducted- the first with seeds collected from the plants grown in the (pots) Phase I experiment that were subjected to selfing and crossing. In the second instance the germination was assessed for seeds from the F_1's alone that were grown in the Phase II experiment (field layout)

13. Pollen Sterility.

This was assessed for all the 16 treatments mentioned to already (T_1....../..T_{16}). The acetocarmine staining technique of Zirkle (1937), the details of which have been presented earlier under review of literature, was adopted. The percentage value for pollen fertility was computed treatmentwise.

14. Pre-fertilization ovular analysis.

Flower buds ready to open on the following day were chosen. From the cross section, the number of locules was counted. Further examination was made to confirm whether the ovules were arranged within the locule in a single row or not. From the longitudinal section, seeds arranged along the length of the locules were counted. By multiplying these two counts (Number of ovules perlocule X Number of locules), the total number of ovules in the pre-fertilized ovary was calculated.

15. Percentage seed set.

This was computed using the relationship:

$$\text{Percentage seed set} = \frac{\text{per plant mean number of seeds per fruit} \times 100}{\text{Per plant mean number of ovules in pre-fertilized ovary.}}$$

16. Number of days for blooming initiation.

Days were counted from sowing till the date of first flower opening.

17. Viable seed recovery.

This was calculated from the relationship:

Viable seed recovery = Treatment wise per plant mean number of seeds recovered X germination percentage.

Mean number of seeds recovered = Mean number of seeds per fruit X per plant mean number of fruits.

18. Compatibility of parents in the cross.

Matings that yielded viable seeds as characterised by morphologically normal sprout was considered compatible as against incompatible.

19. Host reaction to graft viral inoculation

The procedure developed by Nariani and Seth (1958) was tried. For this, seeds representing the 16 treatments were sown in pots in three replications. Two to three plants were accommodated in the same pot.The stem in 30 to 40 day old seedlings about 10 cm above the soil level were as thick as a pencil. Scion having similar stem thickness collected from YVM diseased plants were used in wedge grafting. After confirming that stionic union was fully established, the new shoot portions developed from the stock region were examined for manifested disease symptoms. Cases were symptoms were seen were classed as susceptible and those that remained healthy as resistant.

RESULTS AND DISCUSSION

RESULT AND DISCUSSION

The conduct of the experiment resolves important information that are being discussed hereunder:

Reference is being made to table II, where particulars on 19 attributes corresponding to the 16 treatments studied in the experiment are given. The significance of variance at 5% level of probability as read from the corresponding variablewise ANOVA for 17 variables is indicated additionally.

From the table it is evident:

i) Matings, irrespective of selfing or crossing inclusive of reciprocals, prove themselves to be compatible. Compatibility in mating between species esculentus and manihot in the genus was noticed by Kuwada (1961), Arumugham and Muthukrishnan (1978) and (1979), Mamidwar et al. (1979), Dhillion and Sharma (1982), Jambhale and Nerkar (1982 b) and Pillai (1984). The selfed and hybrid progenies grew to maturity and produced fruits containing viable seeds (V_6, V_{15} and V_{17}).

From the observations that none of the interspecific hybrids exhibited incompatibility in varied parental matings, it is evident that serious absence of harmony at the chromosomal level did not exist between the species _escu-lentus_ and _manihot_ at least in the crosses studied here.

ii) When the 5 parental cultivated varieties belonging to _Abelmoschus_ _esculentus_ remained susceptible to the YVM disease, the ten hybrids representing the crosses and their reciprocals were resistant like the wild parent _Abelmoschus_ _manihot_ as seen from graft inoculation technique (Photograph 3). This finding confirms the presence of transferable genetic resistance to the YVM virus in the _manihot_ species.

An examination of significance of variablewise variance in the 5 treatments (T1 to T5) for the 17 variables (V_1 to V_{17}) suggests that the treatments differed significantly for these variables without exception. This indicates that differentiation has established itself in the species _esculentus_ to the extent of adequate varietal identity at morphological and performance levels.

Similar type of significant variance difference prevails between the two species, _esculentus_ and _manihot_. The trend is manifested through the interspecific hybrid progenies, inclusive of reciprocal parental combinations.

It seemed justifiable that union of gametes from

the two parental species took place during the formation of hybrids.The hybrid progenies differed in several morphological and performance attributes compared to the parents. All the hybrids inherited resistance to the YVM virus from the manihot parent. They also differed in plant height and number of days to blooming initiation. Difference in the leaf characters particularly on the number, shape and size were observed. Diagrams 1 to 10 enable comparison of these characters in the parent and hybrid progeny for the different parental combinations. Petiole length varied considerably in families consisting of parents and their progeny. The esculentus parents had longer petioles than the manihot, and their hybrids had petioles still longer. Regarding fruit characters, though not much of difference was noticed for length and girth, there was a considerable reduction in the number of seeds per fruit. The hybrids were seen to have inherited increased number of longitudinal ridges on the fruit, presumably from the manihot parent. The seeds of parents and hybrids did not differ markedly for test weight, but the per fruit yield of seeds had always been relatively few in the hybrids. Viable seeds were recovered from esculentus X manihot hybrids by Kuwada (1961),Arumugham and Muthukrishnan (1978 b and 1979), Dhillion and Sharma (1982), Jambhale and Nerkar (1982 b) and Pillai(1984) and always the quantity had been less compared to the parents.

DIAGRAMS

Diagrams showing Leaf Characteristics of Parents, Crosses and reciprocals. The wild parent leaf outline shown in red, cultivated parent(*A. esculentus*) leaf outline in blue and the hybrid leaf outline in black. The diagrams are superimposed for comparison.

The number of ovules in the hybrid flowers was more when compared to the parents but the seed set was low. Further, the germination rating for hybrid seeds appeared to be low. This seems to have affected adversely the quantity of viable seed recovered from the hybrids.

Reference is made to values displayed in row corresponding to VI7 in Table II. This gives idea on the numerically expressed viable seed recovery in the 5 varieties of A.esculentus, the wild A.manihot, individually and in their interspecific hybrids of all possible combinations including the reciprocals. When the parents, irrespective of the variety or the species to which they belong, yielded viable seeds in profusion, there was a drastic decrease in the values in all hybrids.The finding appears to indicate that though the differentiation at specific levels is more than what it is for between the cultivated varieties, at least an amount of genetic homology prevails between the species that made it possible the recovery from interspecific hybrids of viable seeds, though in comparatively fewer numbers.

As in any other genera under the Angiosperms, in Abelmoschus too differentiation at species and variety levels got itself established sufficiently. Though these stabilised diverse forms possess and maintain morphological and performance standards of identity through generations, an absolute barrier of mating at intervarietal and interspecific levels do not exist as is evidenced by the hybrids yielding viable seeds. This is an advantage to the breeder contemplating on the genetic improvement of stocks through transference of genes from one species to another. Hence in the context of the study the practical scope of evolving economically desirable cultivated varieties of bhindi with built-in-resistance to the widely prevalent YVM disease is substantiated.

The very reason that the first generation interspecific hybrid progenies yield viable seeds, if not in profusion, is again a sign of encouragement because the possibility of generating subsequent segregating progeny populations that can eventually facilitate coupled screening of variants and evolution of varieties for performance superiority and built-in-resistance to the disease is made clear.

Photographs of the parents and hybrid progenies of different parental combinations are furnished under Plates 4 through 19. Plates 4,5,6,7 and 8 belong to the cultivated Abelmoschus esculentus varieties Anakomban(T_1),

Photograph of T1 plant - Abelmoschus esculentus, var. Anakomban.

Photograph of T2 plant - Abelmoschus esculentus, var.MDU-1.

PLATE - vi

Photograph of T3 plant-Abelmoschus esculentus, var.Pilicode Local.

Photograph of T4 plant - *Abelmoschus esculentus*, var. Pusa Sawani.

PLATE - viii

Photograph of T5 plant - Abelmoschus esculentus, var. Sevan Dhari.

PLATE - ix


1X6


3X6


4X6

Photograph of C 5.6 plant - Cross T5 x T6

Photograph of R 1.6 plant - Cross T6 x T1

Photograph of R 2.6 plant - Cross T6 x T2

PLATE - xvii

PLATE - xviii

Photograph of R 4.6 plant - Cross T6 x T4

Photograph of R 5.6 plant - Cross T6 x T5

MDU-I (T_2) Pilicode local (T_3), Pusa sawani (T_4) and Sevan Dhari (T_5) respectively. The wild Abelmoschus manihot is shown in Plate.9,Plates 10 to 14 represent crosses of the 5 varieties of the cultivated species esculentus used as seed parents against the wild YVM virus resistant donor species manihot. The reciprocals of these 5 parental combinations are given under Plates 15 to 19.

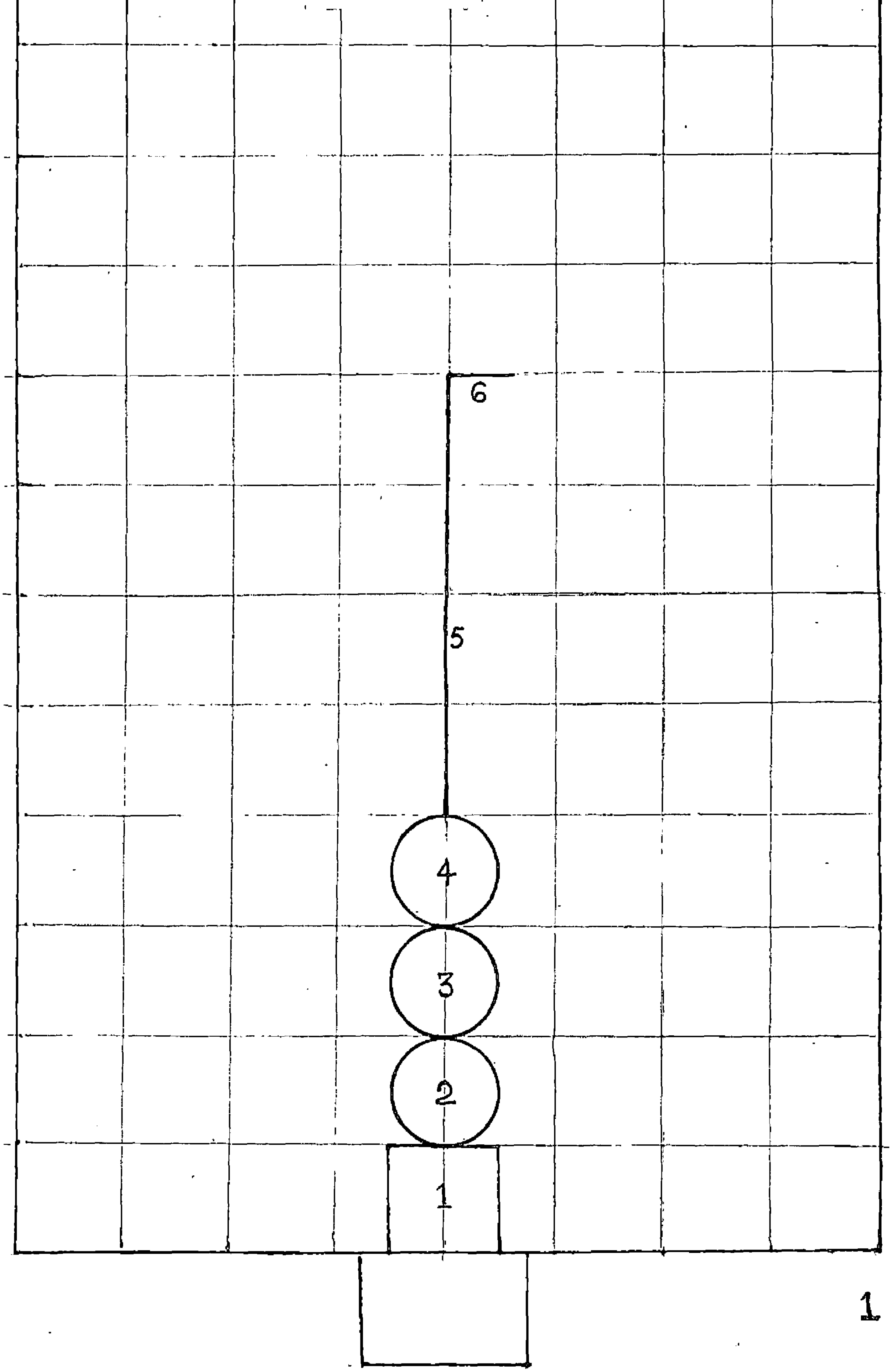
Presented in charts 1-6 are diagramatic representations of salient features of observations made during the experiment on interspecific hybridisation in the genus Abelmoschus.

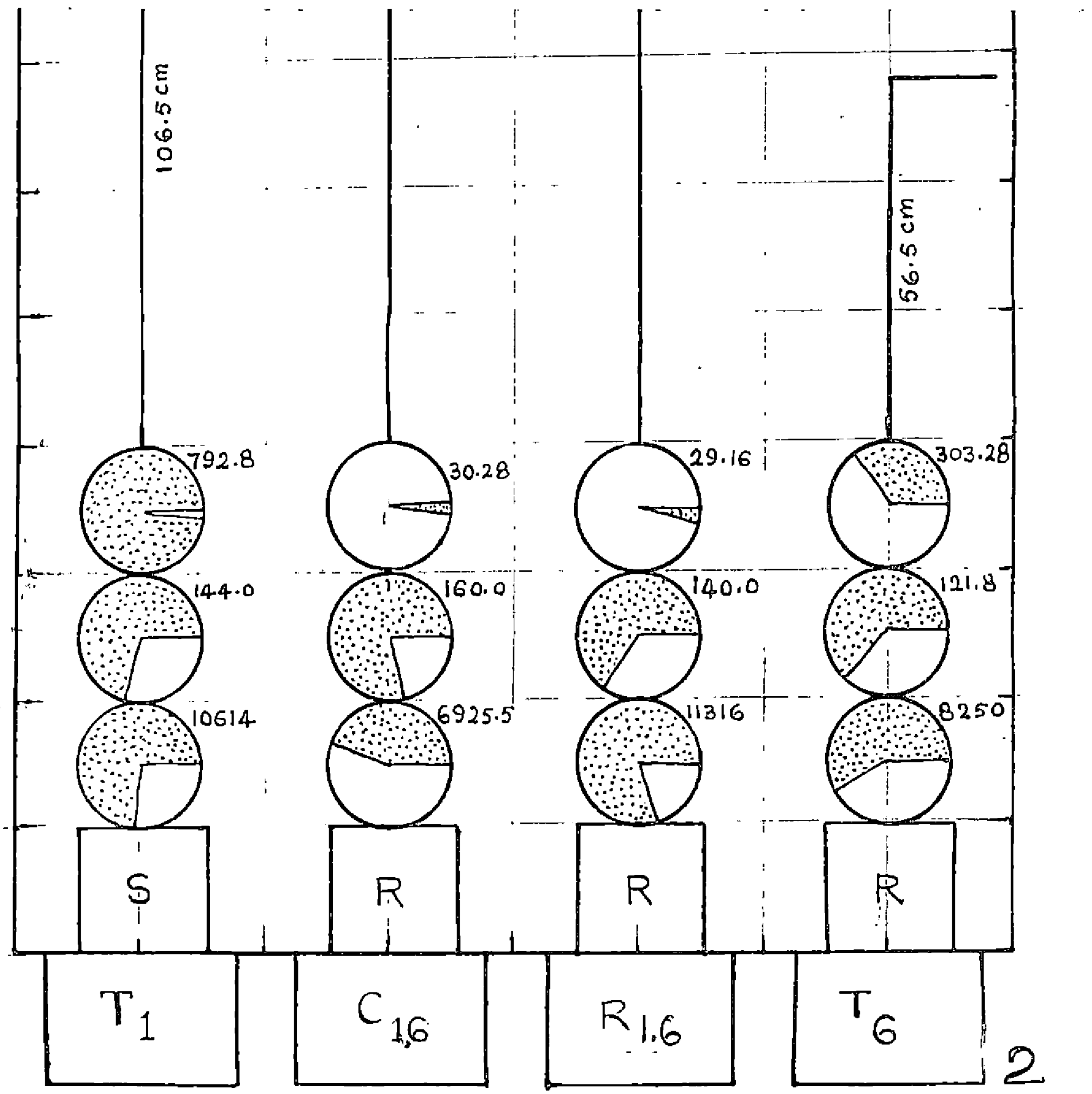
Chart 1 furnishes the relevant legend of indications shown in the remaining 5 charts (Chart 2,3,4,5 and 6). 5 variables are indicated in these charts.

		Marked as
i)	Plant height at final fruit harvest.	(5 in legend)
ii)	Number of days for blooming initiation	(6 " ")
iii)	Relative photosynthetic area	(2 " ")
iv)	Relative fruit yield, and	(3 " ")
v)	Relative viable seed recovery	(4 " ")

In addition, the host response to the viral infection is also indicated (Resistant/susceptible),(1 in legend)

CHART - I





106.5 cm
792.8
144.0
10614
30.28
160.0
6925.5
29.16
140.0
11316
56.5 cm
303.28
121.8
8250
S
R
R
R
T_1
$C_{1,6}$
$R_{1.6}$
T_6

2

CHART - iii

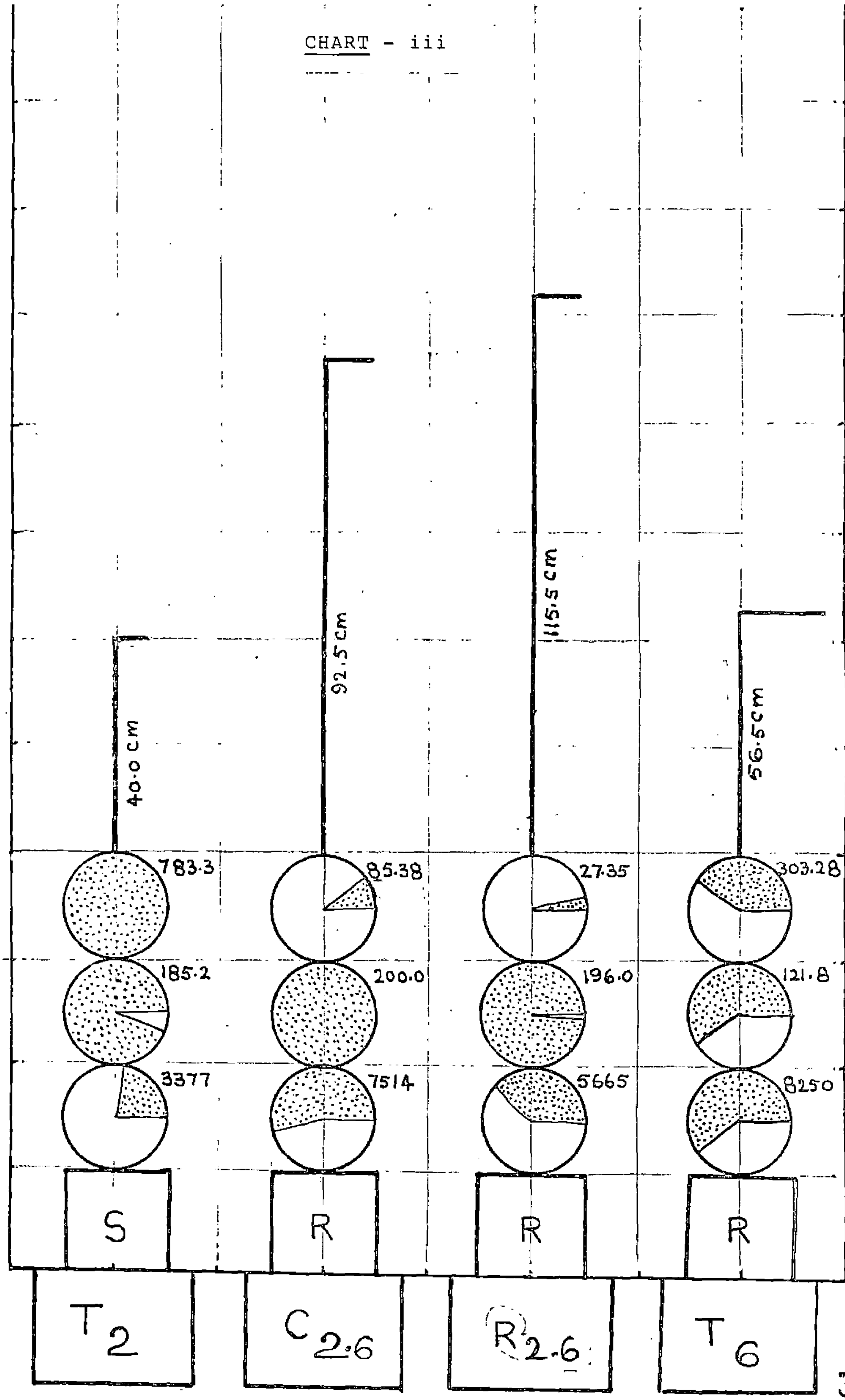
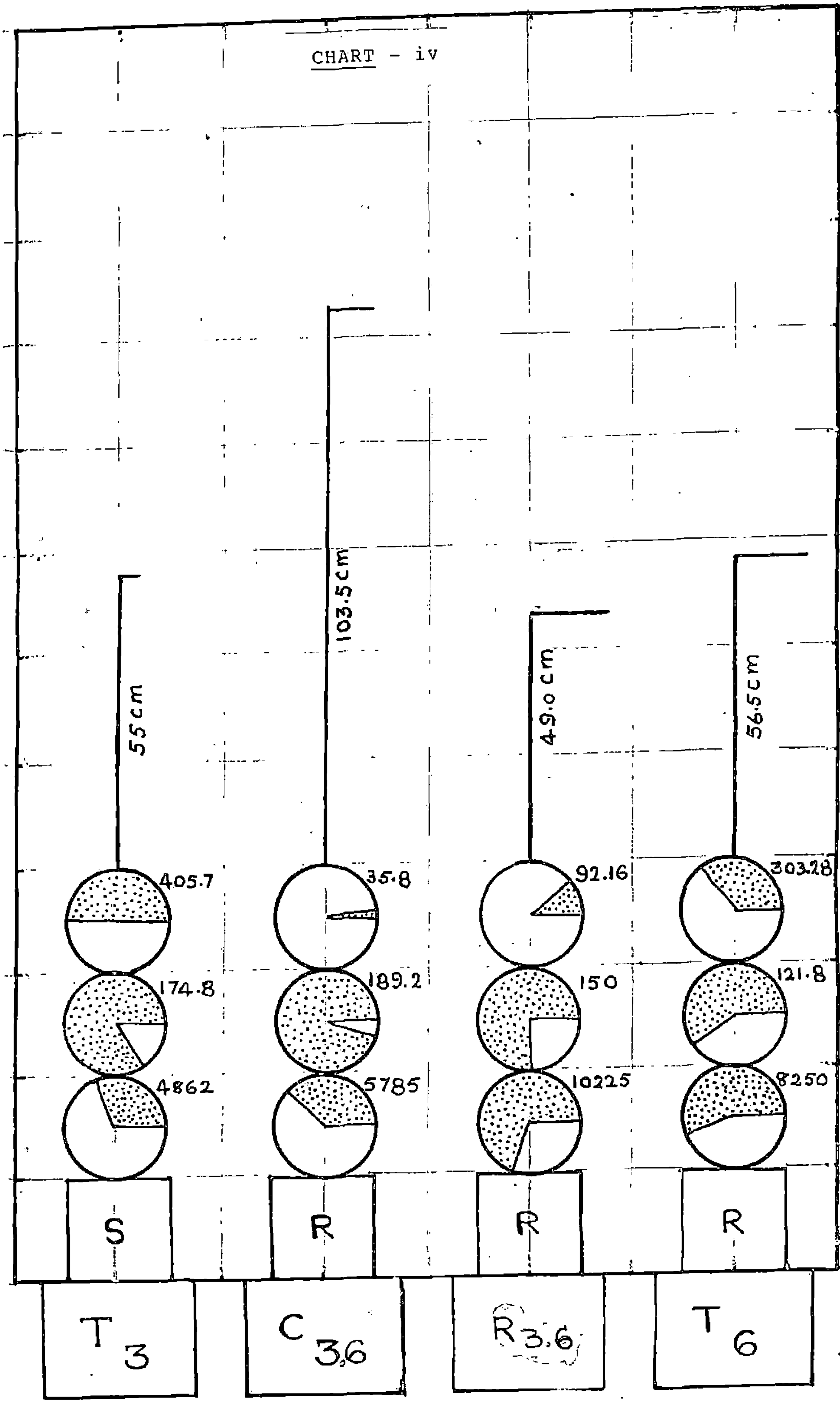

40.0 cm
92.5 cm
115.5 cm
56.5 cm
783.3
185.2
3377
85.38
200.0
7514
27.35
196.0
5665
303.28
121.8
8250
S
R
R
R
T2
C2.6
R2.6
T6

CHART - iv


55 cm
103.5 cm
49.0 cm
56.5 cm
405.7
174.8
4862
35.8
189.2
5785
92.16
150
10225
303.28
121.8
8250
S
R
R
R
T3
C3.6
R3.6
T6

4

<u>CHART</u> – V

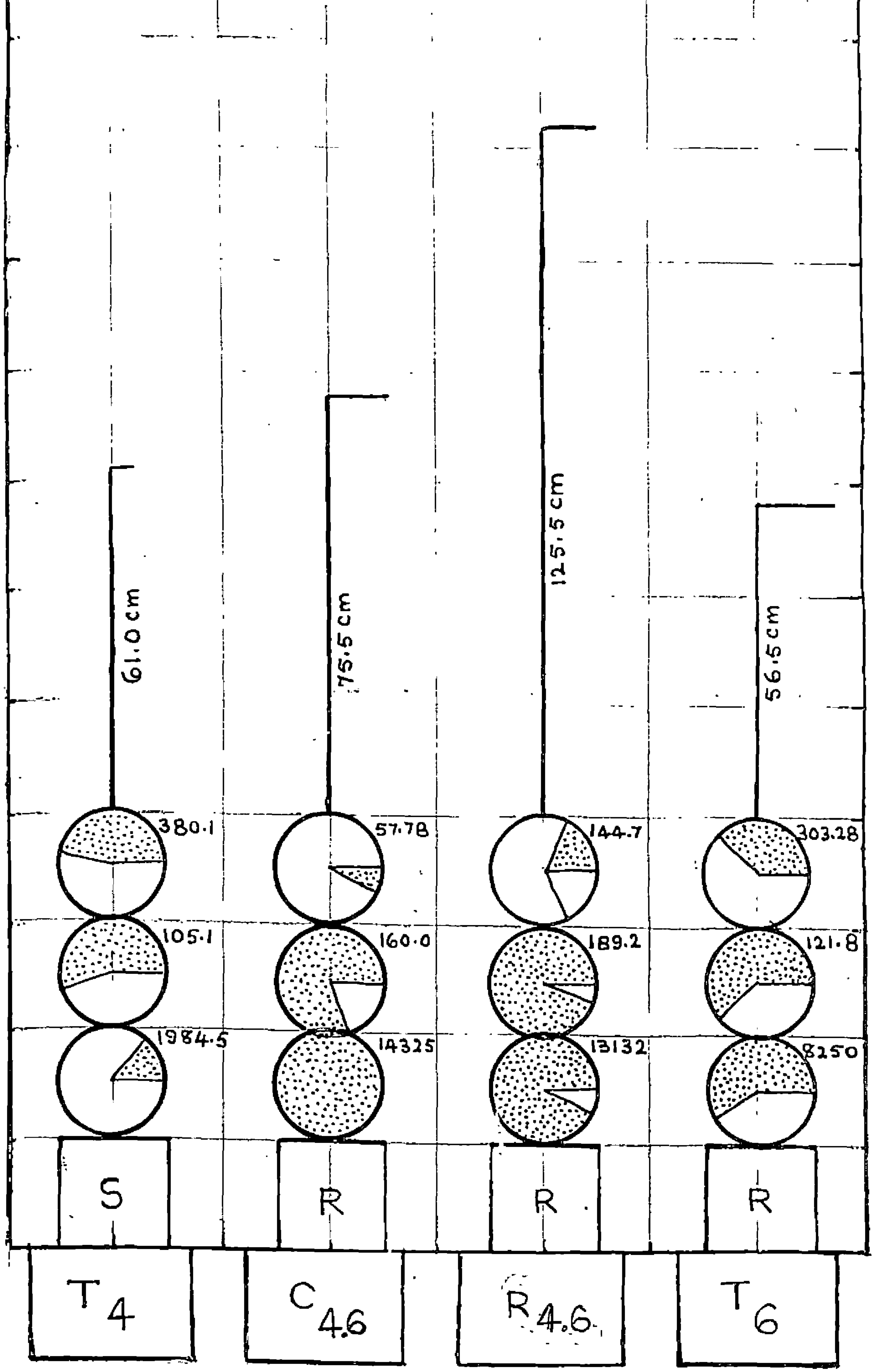
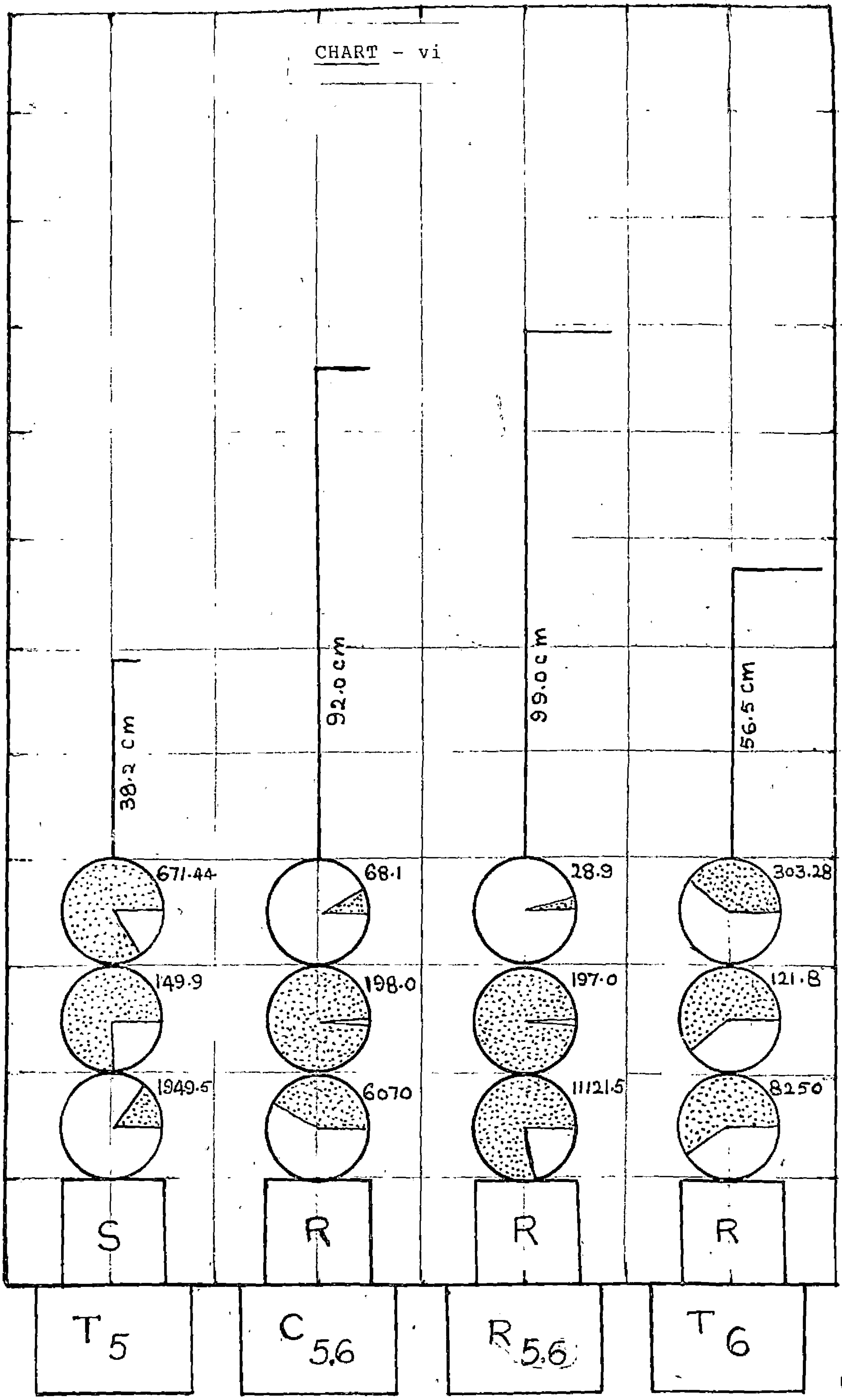

61.0 cm
75.5 cm
125.5 cm
56.5 cm
380.1
105.1
1984.5
57.78
160.0
14325
144.7
189.2
13132
303.28
121.8
8250
S
R
R
R
T_4
$C_{4.6}$
$R_{4.6}$
T_6

CHART - vi


38.2 cm
92.0 cm
99.0 cm
56.5 cm
671.44
149.9
1949.5
68.1
198.0
6070
28.9
197.0
11121.5
303.28
121.8
8250
S
R
R
R
T 5
C 5.6
R 5.6
T 6

When the variables (i) and (ii) are shown in linear scales, (iii), (iv) and (v) are indicated in pie diagram.

This diagramatic representation facilitates comparison of parents and corresponding interspecific hybrid progenies inclusive of reciprocal matings not only within the 5 sets of parental combinations in matings (Chart 2,3, 4,5 and 6), but also between sets.

Table III appended alongwith facilitate ready interpretation of these charts.

Days to blooming initiation.

In charts 2,3,4,5 and 6, T_6 represents A.manihot, the wild donor source of genetic resistance to the YVM virus. Plants belonging to this species took compartively more number of days to blooming initiation compared to the 5 varieties of the cultivated species esculentus indicated as T_1, T_2, T_3, T_4 and T_5 in charts 2,3,4,5 and 6 respectively. The mean value for this attribute for the cultivated varieties taken together was 46 with the exception of T_1 (Anakomban) which took the longest duration (57 days). In the cross where the cultivated variety (T_1) was used as the seed parent, no change in duration was noticed,though blooming initiated later in the cross where the variety was

TABLE - 3

Mean value for net photosynthetic area, Fruit yield, Plant height, viable seed recovery and days for blooming initiation in 16 treatments of Genus Abelmoschus species esculentus (5 varieties) and manihot and interspecific hybrids inclusive of reciprocals.

	Relative Photosynthetic Area(CM^2)	Fruit yield (g.)	Plant height(cm)	viable seed recovery	No.of days for blooming initiation.
T_1	10614.00	144.00	106.50	792.88	57.00
T_2	3377.00	185.20	40.00	798.33	92.00
T_3	4862.00	174.80	55.00	405.72	43.00
T_4	1984.00	105.14	61.00	380.12	44.00
T_5	1949.50	149.96	38.25	671,44	44.00
T_6	8250.00	121.80	56.50	303.28	68.00
C16	6925.50	160.00	195.50	30.28	51.00
C26	7514.00	200.00	92.50	85.38	54.00
C36	5795.00	189.20	103.50	35.80	55.00
C46	14325.00	160.00	75.00	57.78	49 00
C56	6070.00	198.00	92.00	96.83	55.00
R16	11316.00	140.00	173.00	29.16	64.00
R26	5665.00	196.00	115.50	27.35	57.00
R36	10225.00	150.00	49.00	92.16	72.00
R46	13132.00	189.20	125.50	144.70	56.00
R56	11121.50	197.00	99.00	28.94	62.00
Mean of Parents (Cultivated)	4557.40	151.82	60.15	609.70	46.00
Mean of wild parent	8250.00	121.80	56.50	303.28	68.00
Mean of Straight crosses	8125.90	181.44	111.80	61.21	54.00
Mean of Reciprocal crosses	10291.90	174.44	112.40	64.46	62.20
Mean of hybrids.	9208.90	177.90	112.10	62.83	58.10

used as the pollen parent.

In instances where T_2, T_3, T_4 and T_5 were used as the seed parents, blooming initiation was delayed, but never to the extent of the wild parent. In the reciprocals also, the delay in this regard was manifested, but to a greater extent than what it was for in cases of reversed parentage. A generalisation can therefore be made that though blooming initiation was delayed in interspecific hybrid progenies, and though not in every case to the extent of the wild species parent, the reason for the delay can be due to the prevailing chromosomal diversity in the parental species that caused disturbances sufficient to retard the rate of reproductive phase attainment in the hybrids.

<u>Plant Height</u>:

The value for the attribute ranged from 38.25(T_5) to 106.5-(T1) among the cultivated species <u>esculentus</u> with the mean at 60.15. The wild parent recorded a measure of 56.5. Crosses in which varieties of the cultivated species were employed as the seed parents, the hybrids exhibited increased vigour. Similar was the general observation among the reciprocal except in the instance (T_6X T_3) where the progeny was shorter than the wild parent probably due to chance reasons. Height of plant is established as a polygenically governed character where the manifestation of hybrid vigour in the first generation hybrid progeny is in no way a rare phenomenon. The finding exposes the scope of searching for worthy segregants of several economically desirable quantitative characters in genetic improvement of bhindi through hybridization.

Net Photosynthetic area.

The mean values of the attribute in the varieties of the cultivated species, wild species and the hybrids are given in Table III and corresponding charts. There are instances where the net photosynthetic area in the hybrids are more, as well as less compared to the parents. An examination of mean of this value when the varieties of the cultivated species are taken together against the value for the wild species and that for the hybrids, where a particular variety of the cultivated species was used as the seed or pollen parent, reveals that the value for the attribute had always increased in the hybrids as against that for the cultivated variety, but generally approximated the value of the wild parent. Strangely enough, in the reciprocals the trend indicated a substantial increase in the photosynthetic area. The reason for difference in value in the reciprocals, though cannot be attributed conclusively to any particular phenomenon, there is always justification to conceive that increase in net photosynthetic area makes the system more resistant to the disease caused by the virus. Probably with this accomplishment, the plant is able to synthesise relativelymore biomass, an adequate proportion of which gets transformed itself either to structures or factors that provide the system with the desired resistance to the stress of the viral infection.

Fruit Yield.

The varieties of the cultivated species used in the study were chosen from among high yielders. Though fruit yield in the wild species was not very much low, the presence of desirable qualities from the cultivator's point of view was not satisfactory. The hybrids appear to record higher yield than the parents. On an earlier occasion, it was suggested that genetic transference for resistance could be effected from the wild species. The present observation indicates that ready transference of this character can be effected without detriment to the fruit yield potential in the hybrids. From the breeder's point of view it is a clear plus point for developing quality higher yielding bhindi varieties resistant to the YVM disease.

During the course of study, it was noticed that interspecific hybrids, irrespective of the seed parent, though initiated blooming later than the parents, could be retained in the field in apparently healthy condition for a larger duration of time. They were also found to yield fruits, though not in profusion through their advanced age. But in the cultivation of bhindi as a vegetable an unduly longer duration crop variety is not desirable, because often advancement in age is negatively associated with economically desirable per plant production of fruits.

Viable Seed Recovery.

In any programme of breeding through hybridization and selection as what is proposed to be done in the case of bhindi in this experiment, the viable seed recovery from the first generation hybrid progeny is vital.

Total cessation of viable seed production had never been noticed against the hybrids. Four cross combinations (R4.6(144.7). C5.6(96.83), R3.6(92.16) and C2.6(85.38)) however yielded relatively more number of viable seeds, appear worthy of special attention. These, specifically pointed out parental combinations though individually did not produce seeds in profusion as the parents, promise scope of advancement through crop improvement technique as mentioned to above.

Since the hybrids responded favourably to selfing as evidenced by their ability to yield fruits and since these fruits in turn yielded relatively fewer number of viable seeds, it is recommended to practice self pollination in sufficiently large number of first generation hybrid flowers to generate adequate seed material to raise the subsequent progeny generation of the required size.

It was noticed that the ovaries in the pre-fertilized flowers of these hybrids contained more number of ovules than the corresponding parents. This is suspected to be due to an expression of heterotic vigour in this regard. Further, it was seen that the pollen fertility in the hybrids was drastically low. This could be the result of disturbances brought about by cytogenetically not so similar gametes made to be close together through interspecific hybridization during different phases of the meiotic division that precede sporogenesis in the hybrids. 7

Fruit set in hybrids occur remarkably well. These fruits though carried only smaller number of seeds, their test weight did not differ much from that of the parents. When the percentage germination of these seeds was considered, to assess their viability, these seeds were found to correspond to a lower value. Presumably these could probably be the reasons for the low value rating against viable seed recovery from the hybrids.

It had been pointed out earlier that certain parental combination yielded relatively more viable seeds. Mainstreaming the breeding programme with such parental combinations could be of greater advantage. Repeated backcrossing to the esculentus parent of the YVM resistant hybrid derivative through a few generations could probably help in restoring progressively the lost prolific viable seed recovery.

To conclude, it is emphasised that the observations made during the course of the experiment on bhindi, yield information of valuable practical utility.

Majority of the desirably accomplished varieties of the crop is deleteriously susceptible to the virus caused YVM disease. These stocks could be transformed into resistant varieties through a programme of breeding involving interspecific hybridization. The wild / semi-wild species, manihot is established to hold transferable genetic resistance to the disease. This species cross readily with the cultivated species esculentus indicating abscence of mating incompatibility at interspecific level. This condition is of advantage to the breeder. The hybrids manifested absolute resistance like the wild parent. Hybrid sterility too was not encountered. The hybrids yielded viable seeds, though not in profusion like the wild parental species, enabled generation of subsequent progeny populations that facilitated screening out and development of improved varieties of the crop with resistance.

The results enabled furnishing recommendation on the prospects of identifying particular interspecific parental combinations to yield greater quantity of viable seed recovery from the hybrids. Practicing selfing on more number of flowers in hybrids of such combinations is also recommended to realise higher proportion of viable seed recovery.

SUMMARY

SUMMARY

1. A breeding experiment on interspecific hybridization in the genus Abelmoschus under the family MALVACEAE was conducted as a Post-Graduate research programme of the Kerala Agricultural University during May - December 1985 at the Department of Plant Breeding, College of Agriculture, Vellayani.

2. The popular vegetable crop bhindi/okra/lady's finger cultivated for the fruits belongs to species esculentus of the genus. Majority of the known cultivars are susceptible to the vector transmitted virus causing Yellow Vein Mosaic disease. The fruit production in the diseased plant is drastically low, and being a crop cultivated for the fresh edible fruits, there are limitations in the usage of insecticides against the vector, the white fly because of the residual toxic effects they leave on the produce.

3. A search of genetic resistance enabled the identification of the wild/semi-wild manihot as the potentially ideal source of transferable genetic resistance to the disease into varieties of the cultivated species esculentus.

4. Plants of the species manihot cross readily with plants of varieties under species esculentus. This is basically the reason why breeding for built-in-resistance in cultivated bhindi varieties through combination breeding

method is thought of.

5. This particular experiment was undertaken with a view to assess how far crosses of A.manihot against varieties of A.esculentus are compatible. It was also envisaged to test the first generation hybrid progeny for seed fertility so as to assess their being useful in developing subsequent segregating generations to enable selection in favour of economically desirable attributes coupled with built-in-resistance to the disease can be exercised.

6. The material was chosen from the collection that is being maintained at the Department of Plant Breeding, College of Agriculture, Vellayani and consisted of 5 locally adapted popular high yieldidng varieties - Anakomban, MDU-1, Pilicode local, Pusa Sawani and Seven Dhari and an accession of wild manihot species.

7. In the initial pot culture experiment, the morphological and performance aspects of these 5 esculentus varieties and the manihot species were studied and adequate seed material was generated for conducting the more elaborate later trial.

8. Crosses were made in all possible interspecific parental combination. The crossed flowers developed into fruits containing viable seeds.

9. An elaborate field experiment accommodating 16 treatments in a thrice replicated Randomized Block Design was arranged systematically when observations were made on 19 attributes.

Treatments			Particulars
T_1	..	..	*A. esculentus* var. Anakomban.
T_2	..	..	" " " MDU-1
T_3	..	..	" " " Pilicode Local
T_4	..	..	" " " Pusa Sawani
T_5	..	..	" " " Seven Dhari
T_6	..	..	*A. manihot*.
T_7	..	..	T_1 X T_6
T_8	..	..	T_2 X T_6
T_9	..	..	T_3 X T_6
T_{10}	..	..	T_4 X T_6
T_{11}	..	..	T_5 X T_6
T_{12}	..	..	Reciprocal of T_7
T_{13}	..	..	" T_8
T_{14}	..	..	" T_9
T_{15}	..		" T_{10}
T_{16}	..	..	" T_{11}

.Attributes

V_1 Plant height at final fruit harvest

V_2 Per plant number of leaves

V_3 Per plant leaf area

V_4 Per plant net photosynthetic area

V_5 Length of petiole

V_6 Per plant fresh fruit yield

V_7 Per plant number of fruits

V_8 Per plant mean fruit length

V_9 Per plant mean fruit ~~length~~ Girth

V_{10} Per plant mean no.of ridges on fruit

V_{11} Per plant mean test seed weight

V_{12} Germinability of seeds

V_{13} Pollen fertility

V_{14} No.of ovules per pre-fertilized ovary

V_{15} Percentage seed set

V_{16} Number of days for blooming initiation

V_{17} Viable seed recovery

V_{18} Compatibility of parents in the cross

V_{19} Host reaction to graft virus inoculation

10. From the observations made it is seen that:

a) all the crosses inclusive of reciprocals were compatible and produced sprouts that grew and developed to represent the first generation hybrid progeny.

b) these hybrid progenies were self fertile and enabled generation of the subsequent progeny generation through selfing The viable seed recovery from the hybrids was low compared to that of the parents, presumably because of prevailing chromosomal differences that got established during speciation in the genus.

c) the manihot parent possessed transferable genetic resistance to the YVM disease and without exception hybrids were resistant after viral inoculation.

d) the hybrids exhibited character and performance difference in contrast to the parents confirming the successful union of gametes from the two species. The hybirds, though exhibited vigour for several of the polygenically controlled characters, produced only fewer number of viable seeds probably the result of certain degree of meiotic disturbances that would have preceded sporogenesis.

e) The question of total hybrid sterility was ruled out since the hybrids were seen to produce viable seeds, though not in profusion as the parents. This presumably suggests the presence of certain degree of residual chromosome homology maintained by representative members of the two species after speciation and varietal edifferentiation had established fully.

f) Certain parental combinations yielded more number of viable seeds on per fruit basis, than certain others.

11. In the light of the above findings, it is proposed that there is positive scope for varietal improvement in bhindi possessing buit-in-resistance to YVM disease through combination breeding.

12. Recommendations are also being made in favour of identifying particular interspecific parental combination yielding viable seeds in comparatively greater profusion and practicing selfisng in more number of flowers of the hybrids developed to enable raising adequately larger progeny population to facilitate selection for economically desirable characters and resistance to the disease in the crop.

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*Original not seen

CROSS COMPATIBILITY BETWEEN ABELMOSCHUS ESCULENTUS AND ABELMOSCHUS MANIHOT AND HYBRID STERILITY

BY

PRABHA P.

ABSTRACT OF THE THESIS
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COLLEGE OF AGRICULTURE
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ABSTRACT

Observations made during 1985, while conducting a breeding experiment on interspecific hybridization in the genus *Abelmoschus* of family MALVACEAE, reveal that the virus caused Yellow Vein Mosaic disease susceptible bhindi varieties of the cultivated species *esculentus* cross readily with the resistant wild / semi-wild species *manihot*. Absence of interspecific mating incompatibility is of advantage in programmes of breeding for evolving improved varieties of the crop with built-in-resistance. The first generation hybrids though do not produce viable seeds in profusion, are not totally sterile. The scanty viable seed recovery from the hybrids against the parents is suspected to be due to chromosomal differentiation that could have taken place during speciation in the genus. The quantity of viable hybrid seeds recovered differs in different parental combinations. Recomendations are made in favour of identifying specifically advantageous interspecific parental combinations and practicing controlled selfing on relatively more number of flowers in the hybrids to yield adequate seeds to generate subsequent progeny populations to enable selection for economic desirability and disease resistance.