STUDIES ON INTERVARIETAL HYBRIDS OF TOMATO

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THESIS

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C O N T E N T S

C E R T I F I C A T E

Certified that this thesis is a record of research work done independently by Smt. N. Rema Bai under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

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The tomato is one of the most important vegetable crops of India. Its adaptability to a wide range of soil and climatic conditions has made it very popular among the vegetables grown not only for commercial purposes but also in the kitchen gardens. However, tomato growing in India has not yet attained the status of an organized industry as in countries like the U.S.A. and Mexico. Tomato ranks second in value among vegetable crops next to potato. Tomato cultivation has increased rapidly in popularity from the mid nineteenth century to the present time and in respect to its climatic tolerances, it has proved to be one of the versatile of cultivated plants.

According to Chaudhary (1967), the area under tomato cultivation in India is estimated to be a little more than 36000 hectares. Research on this crop in India has been directed primarily towards the introduction and selection of choice varieties and their multiplication on a large scale. Selection of varieties resistant to fungal and virus diseases has been another objective in tomato breeding. Studies on this genetics of tomato has been

stimulated recently by organisation of tomato genetics co-operative which serves to co-ordinate and facilitate the activities of many workers. In recent years certain growth regulators and chemicals have been recorded and the practical application if such findings have also been put under way.

Hybridisation between varieties or strains have been used to develop several new varieties. By this method desirable characters from the parental strains may be combined into one strain or transgressive segregation for quantitative characters such as yield might be obtained. The success of intervarietal hybridization depends mostly on the correct selection of the parents.

Exploitation of hybrid vigour has proved to be a potential method of increasing yields in many of the crop plants. Attempts have been made by research workers, in the field of tomato breeding to utilize this tool for increasing the production of tomato fruits. Many authors have recorded significant heterosis in respect of various characters in crosses involving varieties and species of Lycopersicon.

In the present investigation five varieties of

Lycopersicon esculentum viz. Walter, VF_{36}, YRFH-3, $Mech_9$ and Local were selected for intercrossing with a view to make an assessment of the five varieties and to study the expression of resistance pattern of ~~inheritance~~ of some of the important economic characters and other attributes related to yield in the segregating population of intervarietal crosses of tomato in order to select the best plant type.

REVIEW OF LITERATURE

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Origin and history

The centres of domestication and the first cultivation of tomato have been evaluated by Jenkins (1948). With other contigens from the new world tomato was first introduced into Europe early in the period of the Spanish conquest some time before 1944. The tomato is scarcely mentioned in the accounts of the first explorations and practically nothing was written about its introduction and first cultivation in Europe. Only two areas viz. Peru and Mexico have received serious attention as potential sites of domestication of this crop.

As pointed out by Jenkins (1948) the attitude of most authorities in favour of Peru being the centre of origin was influenced by the names occurring in the literature of tomato - as "Mala peruvana" and "Pomidel peru". Taking into account the wide spread distribution in Mexico of Lycopersicon esculentum var cerasiforme, the diversity of forms, the variety of uses and the wealth of indigenous names applied to cultivated types and to the variety, "Cerasiforme" Jenkins concluded that "it is reasonably certain that Mexico and not Peru was the source of the cultivated tomotoes of the world and very probably the only centre of the domestication

of tomato".

In the seventeenth century tomato was grown in England as an ornamental plant, eventhough it was known to be edible in other parts of the world. Less than a hundred years ago it was thought to be the cause of cancer. It was presumed that tomato had been introduced to India as a result of Europian colonisation.

Classification and varieties

Tomato belongs to the genus Lycopersicon of solanaceae family. According to Muller (1940) and Luckwill (1943) the genus Lycopersicon is naturally divided into two subgenera on the basis of colour of fruits, position of stigma and other characters. The red fruited subgenus Eulycopersicon includes two species viz. Lycopersicon esculentum var. mill and Lycopersicon pimpinellifolium. The green fruited subgenus Eriopersicon includes the species Lycopersicon livinatum, Lycopersicon peruvianum, Lycopersicon chilense, Lycopersicon cheesmannie and Lycopersicon glandulsum.

Most authorities recognize two distinct species Lycopersicon esculentum and Lycopersicon pimpinellifolium with four or five botanical varieties like Carliana, Valiant, Bonney best, Marglobe, Sanmarzano etc. Baily (1949) classified

tomatos into two species, Lycopersicon pimpinellifolium and Lycopersicon esculentum with the following botanical varieties under the latter.

Var.	Commune	- Common tomato
,,	Grandifolium	- Large leaved tomato
,,	Validium	- Upright tomato
,,	Cerasiforme	- Cherry tomato
,,	Pyriforme	- Pear tomato

Anthesis and pollination

Since flowers of tomato are essential for hybridization work and production of seeds, artificial induction of flowering in late flowering varieties and synchronization of flowering are important. This is done by altering the photoperiod or day length. Anthesis is downward and centri-petal in tomato. Under normal conditions the pollen retains its viability for one or two days. It can be stored for about twelve days at 85 per cent relative humidity in an atmosphere of carbondioxide at a temperature of $5^{o}C$ to $13^{o}C$.

The relative merits of four different methods of pollination in the production of hybrid seeds of varieties 10 x Bison was tested by Kisimava (1964). The best method consisted in dusting the stigma with pollen collected on the

previous day. Fresh pollen as well as pollen stored for more than two days, showed lower germination capacity. A reduced seed set was obtained when unripe stigmas were used.

Sood and Saini (1971) working on tomato in Himachal Pradesh stated that anthesis in tomato flowers commenced at 6 A.M. with flowers opening between 7 and 8 A.M. Anther dehiscence reached a peak between 9 and 11 A.M. The stigma became receptive 16 hours before anthesis and remained so for five days.

Crossability studies

Intergeneric

Wallen (1965) studied the genetic segregation in some intergeneric and interspecific hybrids of Lycopersicon and Solanum. He stated that of the fourteen recessive mutant genes of Lycopersicon esculentum studied, md, nd and yg_6 gave abnormal single factor ratios in Lycopersicon esculentum x Lycopersicon hirsutum and in Lycopersicon esculentum x Solanum pennellie. The gene yg_6 was variable in transmission and this variability was correlated with germination rate. However md and nd were transmitted with a frequency of 20 to 25 per cent through the pollen in all backcrosses of heterozygotes with Lycopersicon hirsutum x

Solanum pennellie.

Chirilei (1968) conducted intergeneric crosses involving Lycopersicon and Capsicum. Fruits derived from this cross resembled those of the Capsicum in shape and colour. In the F_1 and F_2 plant growth was generally similar to that of the female parent and the fruits were similar to those of the male. In the F_1, 89 per cent and in the F_2, 86.3 per cent had the long shape and colour of Capsicum. Of the remaining fruits 10 per cent of F_1 and 10.7 per cent of F_2 were pear shaped and with colour of Capsicum and the rest of the fruits resembled tomato. The hybrids gave high yields of fruit which had the distinctive tomato flavour and ripened 10 to 15 days later than tomato but earlier than Capsicum. Photosynthesis was greater in hybrids than in parents and transpiration and respiration was less than in the female parent but greater than in male parent.

Interspecific

In order to transfer useful characters of Lycopersicon pimpinellifolium, a wild species, commonly known as "Currant tomato", the cross L.esculentum x L.pimpinellifolium, was studied by Pal and Singh (1945). The F_1 exhibited marked heterosis and fruiting was earlier than the parents. The characters for which selection had been made include earliness,

large number of clusters per plant, large number of fruits per cluster, smooth skinned, non-cracking fruits with bright skin colour and good flavour.

Interspecific crosses in tomato, L. esculentum x L. racemigerum, L. esculentum x L.hirsuitum, L. esculentum x L. pimpinellifolium were made by Daskalov and Ognganeva in 1967 at Bulgaria for studying heterosis. F_1 of L.esculentum x L.racemigerum manifested a higher degree of heterosis for plant height and dry plant weight than any of the other hybrids, with L.esculentum x L.hirsuitum showing the least heterosis. The F_1 of L.racemigerum x L.esculentum showed less heterosis initially than the reciprocal F_1 but almost made up the difference later on. In the F_1s of L.esculentum with L.pimpinellifolium and L.chilense, heterosis was also more noticeable in the later stages of development.

Majeed, Swaminathan and Iyer (1968) worked for the production of interspecific hybrids and its cytogenetic analysis in Lycopersicon. The single F_1 plant that resulted from the cross between L.esculentum x L. perruvianum was slow growing and less pubescent flowered and the inflorescence was similar to that of the female parent. Pollen fertility ranged upto 66 per cent. A single F_1 was obtained in L.esculentum x L. glandulosum. Meiosis was normal and about

68 per cent pollen fertility was seen. Seeds were similar to those of female parent. Meiosis in all hybrids studied was normal with 12 bivalents. The pairing was somewhat loose.

Sahrigy, Mallah and Sherif (1970) observed the inheritance of quantitative characters through interspecific hybridization in Lycopersicon. Six characters were studied in L.esculentum, L.pimpinellifolium, their hybrid and L. perruvianum. Dominance effects were important in the number of leaflets per leaf, earliness, yield per plant, number of fruits per plant and fruit size. Additive effects were more important than dominance effects for number of flowers per inflorescence. Heterosis was observed for number of small leaflets per leaf in the F_1 and F_2 of the cross.

Intervarietal

Observations were made by Chaberidise (1963) in the productivity and earliness of F_1, F_2 and F_3 of 8 inter-varietal crosses of tomato with three approved varieties being used as controls. The best results were shown by the F_1 of Krasnodareo x Light house and market wonder x dark red early. The F_3 of these hybrids were also substantially more productive than the controls.

Chaudhary and Khanna (1972) studied two varieties of tomato (L.esculentum Mill) with their F_1, F_2 and backcross generations for the inheritance of locule number and reported that there was no heterosis.

Gorbunov (1963) has stated that the hybrids of Majak x Zarja and the reciprocal hybrids of Antaba x Majak and Zarja x Antaba were early and had 20 - 30 per cent higher yields and 1 - 2 per cent higher dry matter content than their parents.

Stambera (1968) crossed the variety seelendia as seed parent with five other varieties of tomato. In most cases the yield and quality of the F_1 hybrids equalled or surpassed that of the parents. All the hybrids were earlier than seelendia. The earliest was seelendia x Early north. The highest yield came from seelendia x Cardine Red.

Grill and Bergis (1971) stated that the F_1 hybrids GCES 716 and GCES 717 of tomato were more uniform than the inbreds Homestead 24 and Atkinson for total number of fruits per plant. GCES 717 produced more fruits per plant and fruits were larger than in other lines.

Heterosis

Knight (1779) described hybrid vigour as a natural

sequence of crossing varieties of a species. Mendel (1866) observed hybrid vigour in his pea crosses. East (1908), Shull (1908, 1911) and Jones (1918, 1945) have reported superiority of hybrids in corn. Odland and Noll (1948) experimented with sixteen hybrid types and recorded that in every case, the hybrids were early bearers and outyielded their respective parents. The percentage of increase in yield ranged from 11 to 153 and the mean percentage of increase of all the sixteen hybrids over the mean of all the parents was 62.1. They observed that the parental lines were able to produce hybrids of excellent productivity.

A representative picture of the performance of tomato hybrids is given by Powers (1945). He has recorded that the grand mean of the total yield of the ripe fruit for all hybrids exceeded that of the parent lines by 59 per cent and the most outstanding hybrid outyielded the best available commercial variety.

The subject of tomato heterosis is re-evaluated particularly, in the light of very extensive study by Powers et al (1950), the nature of the inheritance of yield components in various generations being derived from the cross varieties porter x ponderosa.

Based on intervarietal hybridization of Capsicum, Popovova (1965) observed that the F_1 progenies were intermediate between the parents and uniform in habit and fruit form. Subsequent generation showed much variations.

From a detailed study of F_1 hybrids of eight crosses involving five parental varieties of brinjal, Viswanathan (1967) reported hybrid vigour in plant height, number of branches, earliness, number of flowers, number of fruits, size and weight of fruits, weight and number of seeds and pollen diameter.

Height of plants

Balya (1918) was probably the first to report the superiority of F_1 hybrids in height over their parents based on his studies of a cross between a native and foreign variety of brinjal.

Pal and Singh (1946) in their studies of six crosses of brinjal found that all except two crosses showed increase in height over the taller parent.

Mishra (1961) found that the hybrids were invariably superior to both parents except in a few cases showing intermediate plant height.

Rajki and Pal (1962) in a cross between L. esculentum Var commune 'Albeno' (AL) and Var Piriforme "Affasohetto" (AF) heterosis for plant height was observed and was greater in AL x AF than in AF x AL.

Chaudhary and Mishra (1966) reported an increase in height of fifteen day old seedlings in his studies inchillies.

Viswanathan (1967) reported that out of eight hybrids studied in brinjal, six were in comparison with mid parental value and three, as compared to better parental mean, showed significant increase in height.

Pillai (1973) has reported that out of seven hybrids studied in Capsicum, three showed intermediate position between the parents in seedling height; and five out of seven hybrids recorded heterosis over their respective parents in height of plants.

Uncini (1973) in a study of all crosses made among 50 varieties of tomato found that the F_1 hybrid G14 x Burbank was outstanding for rapidity of plant height.

Number of branches

Nagai and Kaida (1926) and Kakishaki (1928) had reported superiority of the hybrids with respect to the number

of branches in brinjal hybrids. Pal and Singh (1946) showed an increase in the number of branches in five out of eight hybrids, the increase ranging from 9 to 54 per cent.

Viswanathan (1967) has recorded that two out of eight crosses, in brinjal, showed their superiority in number of branches over the parental mean.

Nair (1970) and Pillai (1973) reported superiority of the hybrids with respect to the number of branches in Capsicum.

Number of leaves

Balya (1918) in his studies in brinjal found that the F_1 hybrids produced higher number of leaves than the parents. The intermediate nature of F_1 hybrids as compared to the parents in respect of number of leaves was reported by Venkitaramani (1946).

According to Peat and Whittington (1966) the increase in leaf number was followed in F_1, F_2 and F_3 generations in tomato.

Pillai (1973) reported that out of seven F_1s in Capsicum three showed superiority over their respective parents with respect to number of leaves.

Number of leaflets per leaf

Rajki and Pal (1964) reported that in a cross between tomato varieties AL x AF the number of leaflets per leaf was higher than the parents.

Six characters were studied by Sahrigy et al (1970) in L.esculentum, L.pimpinellifolium, their hybrid and L. perruvarinum. Dominance effects were important in the control of leaflets per leaf. Heterosis was observed for number of small leaflets per leaf in the F_1 and F_2 of the cross.

Leaf area

Doroshov and Iovva (1966) conducted experiments for studying the assimilatory area and photosynthetic intensity in the first generation of hybrids of tomato variety No.10. In all varietal hybrids, the assimilatory area was greater than in plants produced by intravarietal pollination. The assimilatory area was least in progeny from selfing. The most intensive photosynthesis was found in hybrids.

Nair (1970) found in two out of four crosses of chillies the area of leaves and number of leaves were higher than the parents.

Time of flowering and number of flowers

Lantican et al (1964) observed the performance of 33 single cross hybrids in brinjal and compared with that of the corresponding parental sources. Date of flowering of the hybrids tended towards that of the early parent.

Saakjan (1964) observed from all the five inter-varietal hybrids of tomato that all were earlier and had 20 to 25 per cent higher yield than the recommended variety majaak.

Culkov (1965) studied the biological features of tomato hybrids in the first generation. In the hybrids studied, the length of period from emergence of seedlings to flowering was directly related to the degree of earliness in the parents. An increase in number of inflorescences on the main stem and of flowers in the inflorescences was observed in the F_1 hybrids, compared with the parents.

A study of factors affecting earliness andmode of inheritance of this character in tomato was carried out by Young (1966). Of the nine F_1 hybrids grown, only one showed heterosis by exceeding the early production of the earlier parent. Both F_1 and F_2 were intermediate between parents for earliness.

Gopimony (1968) reported pronounced earliness in blooming and an increase in total number of flowers in hybrids of brinjal.

Stambera (1968) crossed seelandia, a variety of tomato with other five varieties and recorded that all the hybrids were earlier than the parents.

Nair (1970) and Pillai (1973) reported earliness of hybrids with respect to time of flowering in chillies hybrids.

Viswanathan (1967) reported heterosis in flowering time for eight intervarietal hybrids from crosses involving five parents of brinjal.

Pollen sterility

Majeed, Swaminathan and Iyer (1968) studied cytogenetic analysis of interspecific hybrids in Lycopersicon. They crossed L.esculentum var Meeruti x L.perruvianum E.C.492. Here pollen fertility which in the beginning was 33 to 34 per cent increased upto 65 to 66 per cent.

By crossing L.esculentum var. marglobe x L. perruvianum var. E.C.492, they observed normal pairing at meiosis in all the F_1 plants and pollen fertility ranged between 75 to 78 per cent.

By crossing L.esculentum var.marglobe x L. perruvianum var.E.C.492 they observed normal pairing at meiosis in all the F_1 plants and pollen fertility ranged between 75 to 78 per cent.

By crossing L.esculentum var.marglobe x L.perruvianum var. E.C.493 they observed normal meiosis. Pollen fertility ranged between 65 to 66 per cent.

In a cross between L.esculentum var. pusa ruby X L.glandulosum Majeed, Swaminathan and Iyer (1968) observed that meiosis was normal and pollen fertility reached upto 68 per cent.

Mallah, Sabrigy and Sherif (1970) crossed three species of Lycopersicon and they observed that pollen viability in L.perruvianum was higher than that of other species.

Nair (1970) and Pillai (1973) observed that in hybrids of chillies the percentage of pollen sterility surpassed that of parents.

Percentage of fruit set

Betlach (966) observed average fruit set of 39.7 per cent and 47.47 per cent in two hybrids of Capsicum.

Rao (1965) reported that percentage of fruit set in the case of interspecific F_1 hybrids of Solanum was greater

than that of parents.

Gopimony (1968) reported heterosis in hybrids of brinjal with regard to percentage of fruit set.

Kondrashova (1970) studied the intervarietal and intraplant pollination in tomato and recorded highest fruit setting in intervarietal pollination.

Crill and Burges (1970) made comparison of tomato varieties and F_1 hybrids for yield and uniformity. Two standard varieties of tomato were compared with two F_1 hybrids in the field. He found that the F_1 hybrids were more uniform than the standard inbred varieties for fruit set.

Nair (1970) and Pillai (1973) made comparison of varieties of Capsicum for percentage of fruit set and they found that the F_1 hybrids were superior to their parents for percentage of fruit set.

Number of fruits

Nagai and Kaida (1926) and Pal and Singh (1940, 1941) reported considerable increase in the number of fruits based on their studies on the manifestation of hybrid vigour in brinjal.

Venkitaramani (1940) reported intermediate nature of F_1 hybrids in brinjal.

Mishra (1961) recorded that the F_1 hybrids were superior to their parents with regard to the number of fruits.

Viswanathan (1967) reported an increase in the number of fruits per plant in five out of eight crosses of brinjal. Abrosimova (1970) crossed certain varieties of tomato and found that the crosses white juice x 171, Talalikhin x sever (North) and Talalikhin x 171 ripen early and yield a large number of fruits.

Crill and Burges (1971) made comparative studies of tomato varieties and F_1 hybrids for yield and uniformity in growth. They found that the F_1 hybrids GCES 716 and GCES 717 were more uniform than the inbreds Homestead 24 and Atkinson for total number of fruits per plant. GCES 717 produced more fruits per plant than other lines and the fruits were larger.

Pillai (1973) reported that two out of seven hybrids of Capsicum remained intermediate between that produced by the parents with respect to number of fruits.

Weight of fruits

Pal and Singh (1940, 1942) in their studies in six crosses of brinjal found that in respect of fruit weight, all crosses except one showed an increase up to 129.2 per cent.

Stavropol (1960) crossed varieties differing in earliness and reported that highest yields were obtained in F_1 hybrids from direct and reciprocal crosses.

Stambera (1965) crossed seelandia, a tomato variety as seed parent with five other varieties. In most cases the yield of the F_1 hybrids equalled or surpassed that of the parents.

Chaudhary and Sangha (1966) studied a number of hybrids in tomato from crosses between seven parental varieties. All of them out-yielded their parental average. The hybrids of crosses between improved meeruti x pusa ruby, pusa ruby x best of all and Improved meeruti x Local, produced significantly higher yields than their respective parents.

Torres and Fernandez (1966) conducted yield trial of 22 tomato varieties at the Pan American School of Agriculture and found that the hybrid N-57 was outstanding for yield.

Chaudhary and Mishra (1966) observed that out of fifteen hybrids studied by them, thirteen exhibited significant increase in total yield over their better parents.

Higher degree of heterosis for yield was observed in the hybrids of 10 x Bison and Comet x Zaja in tomato by

Dasklov *et al* in 1967.

Breshnev (1973) crossed tomatoes representing five geographical groups and various selected lines in different combinations and the number of hybrids displaying heterosis for yield were tabulated. One of the hybrids gave a higher yield than the standard and parental varieties.

Size of fruits

Observations were made on the inheritance of some characters in tomato, by Hosir (1965). His studies on the F_1 hybrids of *L. esculentum* Golden Jubilie x Violetta Carmine demonstrated heterosis on polar diameter of fruit.

Andronisescu and Enashescu (1966) noticed that the fruit characteristics like size, shape and appearance in *Capsicum* tended to be intermediate between those of the parents.

According to Douce (1969) the new variety of tomato 'Canabee' is a high yielder with very large fruits.

Oniscenko (1970) found that F_1 hybrids of tomato grown on highly fertilized soil were high yielders with larger fruits.

Abrusimova (1971) observed from the F_1 varieties of tomato that they gave a number of large fruits. Their yields

were 42 - 73 per cent higher than those of the parental and standard forms.

Nair (1970) and Pillai (1973) reported intermediate position of hybrids of Capsicum with respect to size of fruits.

Number of locules per fruit

In an experiment where two varieties of tomato were grown and crossed Alpatjev (1960) found that in the F_1 generation the indeterminate habit, round fruits with few locules of second parent was dominant over the determinate habit and multilocular fruits of the first.

Salib Mallah et al.(1970) during their studies on inheritance of tomatoes and genetic studies of some fruit characters involving five varieties showed that the small number of locules and the genome is controlled by one major dominant gene.

A genetic analysis of locule number by means of diallel analysis was performed by Ahuja (1968) using 11 inbred lines of tomato. Dominance estimates indicated that on the average there was a partial dominance of low locule number over high locule number.

Inheritance of locule number in a cross in tomato

was done by Chaudhary and Khanna (1972). Two varieties of tomato with their F_1, F_2 and backcross generations were studied for the inheritance of locule number and found that there was no heterosis. It was concluded that the selection for high locule number will be quite effective.

Number and weight of seeds

Kakishaki (1931) reported that the F_1 selfed seeds of brinjal showed an increase in weight over the selfed seeds of the embryo by heterosis. Increase in number of seeds was noted in three out of eight crosses by Viswanathan (1967).

Szwadiak (1965) made preliminary observations on number and weight of seeds in intervarietal hybrids of L. esculentum Mill. In diallel crosses of 182 combinations, the seed number varied with the direction of the crosses. Eight crosses gave more seeds than the respective parents. Measurements of 1000 seed weight showed that in 86.6 per cent of combinations the 1000 seed weight was greater than that of the controls.

Singh and Singh (1969) observed that the berry yield in chillies was significantly correlated with 1000 seed weight.

Popova and Mihajlov (1970) observed that in tomato plants three varieties pollinated with pollen from other plants

of the same variety were more vigorous and had a higher 1000 seed weight than plants self pollinated in the normal way.

Nair (1970) reported an increase in number of seeds in chillies hybrids. Pillai (1973) recorded an increase in number and weight of seeds in hybrids of Capsicum.

Sucrose content

Esipova et al (1964) studied about 20 hybrids of tomato and he noticed among them certain hybrids with higher sugar content.

Chulkova and Chulkov (1969) noticed in a study of 174 intraspecific hybrids of tomato heterosis for sugar content in whose maternal parent had a higher sugar content than the male parent.

Betlach (1967) could notice no marked difference between parents and F_1 progeny in the content of total sugars.

Nair (1970) reported that all the four hybrids of chillies studied by him exhibited heterosis in sucrose content.

Brezhenv (1973) crossed tomato representing five geographical groups and various selected lines in different combinations and found that the sugar content inherited independently and showed heterosis in certain combinations.

Cytogenetics

Chromosome number

Winkler was the first to discover that tomato has a somatic number of 24 and a haploid number of 12 chromosomes. Luckwill (1943) recorded no deviation from this number in any of the other investigated species of Lycopersicon. In metaphase of somatic tissue the chromosomes are relatively small varying from about 1.5 to 3 microns in dimension. The nucleolar pairing can be readily identified by the presence of secondary constriction and a satellite varying in size according to the strain of Lycopersicon.

Meiosis

Meiotic chromosome behaviour has been studied almost exclusively in pollen mother cells. The earlier studies of meiosis were made by Lesley (1928), Jorgenson (1928), Lindstran (1929), Afify (1933), Humphry (1934) and Lesley and Lesley (1935).

The following features of genetic interest were demonstrated by their early work. Pairing occurs prior to pachytene and fixation results in severe distortions at diplotene. Towards the end of diakynesis the pairs appear mostly as ring bivalents and a few as rods. Bivalent pairing is the rule in tomato.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study was undertaken in the Division of Agricultural Botany, College of Agriculture, Vellayani during the period 1974-'75. The experiment was spread over two seasons January-April and June-September.

During the first season five varieties of Lycopersicon esculentum viz. YRFN-3, $Mech_9$, VF_{36}, Walter and Local were grown in experimental field and selfing and crossing were done.

During the second season, an experiment was laid out using the five parents and the nine hybrids obtained therefrom.

A. Materials

Materials involved in the present investigation constituted the following five varieties of L. esculentum viz. YRFN-3, $Mech_9$, VF_{36}, Walter, Local and the nine hybrids obtained therefrom. Pure seeds for the first four varieties were obtained from Agricultural College, Richmond, Australia and the Local variety was obtained from the collection in the Division of Agricultural Botany, College of Agriculture, Vellayani.

B. Methods

The following method was adopted for hybridization. In the evening of the day before crossing the correct sized buds which would open on the next day were selected and with the help of a fine pointed needle, a longitudinal split was made on the corolla. Then using a pointed forceps the anthers were removed one after another, taking utmost care not to injure any other floral parts, including the removed anthers. After ensuring the stigma to be free from pollen, the emasculated flower buds were covered with a polythene bag and pinned the free end of the bag to prevent the contamination with foreign pollen. Some matured flower buds which would open on the next day were selected from the pollen parent and bagged in the same evening as a safeguard against admixing of pollen.

Next morning at about 9 A.M. the protected flower buds from the pollen parent were plucked and kept in a petridish in whichalittle water was sprinkled to keep up the humidity. Then a few anthers from these flower buds were taken out and a longitudinal split was made on them using a needle. The outcoming pollen grains were dusted gently over the stigma of the emasculated flower of seed parent, using a camel hair brush. Dusting was done between 9.30 and 10.30 A.M.

After pollination, the flower buds were again bagged and labelled. The bags were removed only after 9 days.

In order to get selfed seeds of the parental varieties in each case, fifteen well developed flower buds which would open on the next day were covered with polythene bags in the previous evening and labelled. The bag was allowed to remain for four to five days until all the flower parts except the ovary had fallen off. The bag was then removed after tying the label on the developing fruit.

The fruits of both selfed and crossed flowers were harvested when completely matured, the maturity being judged by the standard ripening colour of the variety concerned.

2. Field plot technique and the study of F_1 generation

The study of F_1 generation of plants along with their parents was conducted under the following major headings.

I. Morphological studies

II. Chemical studies

The methods adopted for each of the above studies are enumerated below.

I. Morphological studies

1. Lay out

The experiment was laid out in a Completely Randomised Design with fourteen treatments viz. the five parents and the nine hybrids. Single plants were planted in pots having height 30 cm and diameter at base 10 cm and diameter at top 15 cm. Since the number of seeds varied the treatments had unequal number of replications.

2. Treatments and replications

The fourteen treatments and their corresponding replications are given below.

S.No.	Notation	Description	Replication
1	P1	YRFN-3	8
2	P2	$Mech_9$	10
3	P3	VF_{36}	7
4	P4	Walter	10
5	P5	Local	10
6	C1	YRFN-3 x Local	10
7	C2	$Mech_9$ x VF_{36}	10
8	C3	VF_{36} x $Mech_9$	5
9	C4	$Mech_9$ x Walter	10
10	C5	Walter x $Mech_9$	10

11	C6	$Mech_9$ x Local	10
12	C7	Local x $Mech_9$	10
13	C8	VF_{36} x Local	10
14	C9	Walter x Local	10

3. Nursery

Well developed good seeds from the nine crosses and the five parents were sown in separate seed pans filled with standard pot mixture.

4. Transplanting

Twenty five days after sowing healthy seedlings of uniform growth were selected for transplanting. One seedling each was planted in pots filled with pot mixture and receiving farm yard manure as basal dressing. After planting, chemical fertilizers were applied twice and the crop was regularly watered in the morning and evening.

Observations on the following quantitative and qualitative characters were recorded for both the F_1 hybrids and the parents.

A. Quantitative characters

1. Number of seeds per fruit from parents and F_1
2. Germination capacity of F_1 and parental seeds

3. Height of seedlings
4. Height of plants
5. Number of branches per plant
6. Number of leaves per plant
7. Number of leaflets per leaf
8. Area of leaves
9. Time of flowering
10. Percentage of pollen sterility in parents and hybrids
11. Percentage of fruit set
12. Number of fruits per plant
13. Weight of fruits per plant
14. Size of fruits (volume of fruit)
15. Number of locules per fruit
16. Number of seeds per fruit from parents and F_2F_1
17. Weight of seeds (1000 seed weight)
18. Germination capacity of F_2 and parental seeds

The observations were taken from all the available F_1 progenies and parents. The following were the details of observations taken in each case.

(1) Number of seeds per fruit from parents and F_1

The number of seeds in the crossed and selfed fruits were counted.

(2) Germination capacity of F_1 and parental seeds

A random sample of 100 seeds from each parent and the available seeds of F_1 hybrids were taken into account.

(3) Height of seedlings

The height of seedlings at the time of transplanting was taken. For this purpose observations were recorded from all the available seedlings from parents and F_1 progenies.

(4) Height of plants

Height of plants were taken from the ground level to the top most leaf bud of all the plants by using a meter scale. The first observation was taken at the time of transplanting and the subsequent ones at an interval of 10 days. The ultimate height was measured on the 80th day. The mean height was recorded.

(5) Number of branches per plant

Primary, secondary and tertiary branches were taken into account. Observations were taken from the parental varieties and all the available F_1 progenies. The number of branches in each plant was noted.

(6) Number of leaves per plant

The total number of leaves of the plants from each treatment was counted at 10 days interval from the date of transplantation.

(7) Number of leaflets per leaf

Ten uniform leaves from each plant were taken and their leaflets were counted and the mean was taken.

(8) Leaf area per leaf

Ten leaves at maturity from each plant were taken and their outline was traced on a graph paper and measured the area. The mean area of 10 leaves was recorded.

(9) Time of flowering

The number of days taken for the first flower to bloom was observed and recorded for each treatment.

(10) Percentage of pollen sterility in parents and hybrids

Pollen grains collected from matured flower buds were utilised for the study of pollen sterility. The pollen grains were kept in a solution of 1:1 acetocarmine and glycerine for 2 hours on a slide, under a cover glass. Then counts were taken from thirty fields for each treatment. Well filled and well stained pollen grains were taken as the fertile and the rest as the sterile.

(11) Percentage of fruit set

The total number of flowers bloomed and the total number of fruit-set were observed and the percentage of fruit set was calculated.

(12) Number of fruits per plant

The total number of fruits in each plant was counted.

(13) Weight of fruits per plant

The total weight of fruits obtained from each plant was recorded.

(14) Size of fruits (Volume of fruit)

Ten random fruits from each plant were selected and their volume measured by water displacement method using a measuring cylinder.

(15) Number of locules per fruit

Ten random fruits from each plant were selected and their locules were counted.

(16) Number of seeds per fruit from parent and F_2 F_1

The number of seeds per fruit in the selfed F_1 progeny and the parents was counted.

(17) Weight of seeds (1000 seed weight)

The weight of 1000 seeds from each parent and F_2 materials was determined.

(18) Germination capacity of F_2 and parental seeds

A random sample of 100 seeds from each treatment was placed in petridishes containing moist blotting paper. The number of seeds germinated was counted daily for 15 days.

B. Qualitative characters

1. Structure
2. Spread
3. Stem pigmentation
4. Leaf size
5. Flower size
6. Petal colour
7. Colour of anther
8. Fruit size
9. Fruit shape
10. Fruit apex
11. Colour of mature fruit

C. Genetic parameters

Genetic parameters like range, general mean, SE_M, phenotypic variance, genotypic variance, heritability and genetic advance through selection of the best 5 per cent as percentage of mean were calculated for twelve characters.

II. Chemical studies

The percentage of sucrose in tomato fruits was determined according to the following procedure.

Twenty five grams of the fruit was crushed in a mixer and the seeds were removed by filtering. The filtered solution was treated with lead acetate to remove tannins. The solution was then filtered and made upto 250 cc.

100 cc of this solution was then taken and removed the lead by precipitation with potassium phosphate. This was filtered into a 250 cc volumetric flask and hydrolised with 5 cc of conc. hydrochloric acid for eight minutes at $80^{o}C$ in a water bath. Cooled the solution. Neutralised the excess acid with sodium carbonate and again made up to 250 cc. Titrated this solution against 10 cc of Fehlings solution and the percentage of sucrose of the fruit was calculated.

RESULTS

RESULTS

The morphological descriptions of the parents are summarised in Table I.

The details of crosses effected and the percentage of fruit set in each case are given in Table II. The maximum fruit set of 33.33 per cent was observed in the cross $Mech_9$ x VF_{36} followed by Walter x VF_{36} giving 13.16 per cent fruit set.

When YRFN-3 was used as female parent fruit setting was seen only in one cross viz. YRFN-3 x Local and percentage of fruit set was only 6.67, while as male parent, seeds could be obtained only in the cross Walter x YRFN-3 with 2.88 per-cent fruit set and the seeds were not viable.

$Mech_9$ as female parent succeeded in producing seeds in three crosses, except in the cross $Mech_9$ x YRFN-3. In the cross $Mech_9$ x VF_{36} the percentage of fruit set was comparatively high (33.33 per cent). By using $Mech_9$ as male parent there was seed setting except in the cross YRFN-3 x $Mech_9$. In all the above crosses the seeds were viable.

VF_{36} either as female or male parent could not produce successful crosses with YRFN-3. In two crosses involving VF_{36}, viz. Walter x VF_{36} and Local x VF_{36} eventhough

Table I

Morphological description of the parents

Sl. No.	Characters	YRFN-3	$Mech_9$	VF_{36}	Walter	Local
1.	Stature	Short	Medium	Tall	Tall	Medium
2.	Spread	Semi-compact	Semi-compact	Semi-compact	Compact	Semicompact
3.	Stem pigmentation	Green	Green	Green	Green	Green
4.	Leaf size	Large	Large	Medium	Large	Medium
5.	Flower size	Medium	Medium	Medium	Large	Small
6.	Petal colour	Yellow	Very pale yellow	Yellow	Very pale yellow	Yellow
7.	Anther colour	Yellow	Yellow	Yellow	Yellow	Yellow
8.	Fruit size	Small	Large	Small	Medium	Small
9.	Fruit shape	Elongated	Oval	Oval	Oval	Round
10.	Fruit apex	Pointed	Pointed	Pointed	Slightly pointed	Blunt
11.	Colour of mature fruit	Reddish yellow	Reddish yellow	Red	Red	Red

Table II

The details of crosses effected and percentage of fruit set

Sl. No.	Female parent	Male parent	No. of flowers crossed	No. of fruits obtained	Percentage of fruit set
1.	YRFN-3	$Mech_9$	11	0	0.00
2.	,,	VF_{36}	20	0	0.00
3.	,,	Walter	17	0	0.00
4.	,,	Local	30	2	6.67
5.	$Mech_9$	YRFN-3	10	0	0.00
6.	,,	VF_{36}	9	3	33.33
7.	,,	Walter	12	1	8.33
8.	,,	Local	43	3	6.98
9.	VF_{36}	YRFN-3	21	0	0.00
10.	,,	$Mech_9$	15	1	6.67
11.	,,	Walter	37	1	2.71*
12.	,,	Local	41	3	7.32
13.	Walter	YRFN-3	42	1	2.88*
14.	,,	$Mech_9$	37	3	8.11
15.	,,	VF_{36}	38	5	13.16
16.	,,	Local	28	2	7.14
17.	Local	YRFN-3	13	0	0.00
18.	,,	$Mech_9$	20	2	10.00
19.	,,	VF_{36}	12	1	8.33x
20.	,,	Walter	21	1	4.76x

*Seeds are not viable

xEventhough produced viable seeds seedlings failed to survive

seeds were viable seedlings failed to survive.

By using Walter as female parent there was fruit setting in all the four crosses but the cross Walter x YRFN-3 produced only non-viable seeds. Walter x VF_{36} produced seeds which were viable but the seedlings did not survive. When Walter was used as male parent fruit setting was noticed in three crosses except YRFN-3 x Walter. VF_{36} x Walter produced non-viable seeds. Although the seeds obtained from the cross Local x Walter were viable, the seedlings failed to survive.

When Local was used as female parent three crosses were successful, the only failure being with YRFN-3. The seedlings in the crosses Local x VF_{36} and Local x Walter failed to survive. When Local was used as male parent, all the four crosses were successful producing viable seeds and the seedlings survived.

Comparative study of parents and hybrids

I. Morphological studies

A. Quantitative characters

1. Number of seeds per fruit from parents and F_1

The seeds obtained from the selfed and crossed fruits were kept in a cool dry place for 15 days before sowing. The number of seeds per fruit in each treatment is given in Table III.

Table III

Number of seeds per fruit from parents and F_1

Sl. No.	Treatments	Mean	Parental mean	Percentage of deviation of F_1 mean from the	
				Better parent	Parental mean
1.	P1	16			
2.	P2	13			
3.	P3	20			
4.	P4	26			
5.	P5	45			
6.	P1 x P5	28	30.5	37.8(-)	8.2(-)
7.	P2 x P3	15	16.5	25.0(-)	9.1(-)
8.	P3 x P2	15	16.5	25.0(-)	9.1(-)
9.	P2 x P4	16	19.5	38.4(-)	17.9(-)
10.	P4 x P2	19	19.5	26.9(-)	2.5(-)
11.	P2 x P5	28	29.0	37.8(-)	3.5(-)
12.	P5 x P2	27	29.0	40.0(-)	6.9(-)
13.	P3 x P5	31	32.5	41.1(-)	4.6(-)
14.	P4 x P5	26	35.5	42.2(-)	26.7(-)
15.	P4 x P1	17	21.0	34.6(-)	14.3(-)
16.	P3 x P4	19	23.0	26.9(-)	17.4(-)
17.	P4 x P3	18	23.0	30.8(-)	21.7(-)
18.	P5 x P3	27	32.5	40.0(-)	16.9(-)
19.	P5 x P4	19	35.5	57.8(-)	46.5(-)

P1 - YRFN-3
P2 - $Mech_9$
P3 - VF_{36}
P4 - Walter
P5 - Local

As regards the number of seeds per fruit, all the hybrids did show a considerable reduction. They exhibited marked reduction from the better parent to the extent of 25 to 42.2 per cent. The maximum decrease from the better parent in seed number was noticed in Local x Walter, the percentage of decrease being 57.8. The minimum decrease in seed number was noticed in the crosses $Mech_9$ x VF_{36} and VF_{36} x $Mech_9$, the percentage of decrease being 25.0. All the crosses showed a considerable reduction in seed number with respect to their parental mean also.

2. Germination capacity of F_1 and parental seeds

Table IV shows the germination percentage of F_1 and parental seeds.

Among the five parents, Walter recorded the maximum germination percentage of 91 which is closely followed by YRFN-3, $Mech_9$, VF_{36} and Local. The variety Local showed the minimum germination of 66 per cent. As regards hybrids, all of them exhibited a better germination. The hybrid $Mech_9$ x Walter recorded the maximum germination of 93 per cent and the minimum of no germination was noticed in the crosses Walter x YRFN-3 and VF_{36} x Walter.

3. Height of seedlings

The results of analysis are given in Table V.

Table IV

Germination capacity of F_1 and parental seeds

Sl. No.	Treatments	No. of seeds sown	No. of seeds germinated	Percentage of germination
1.	P1	100	89	89
2.	P2	100	68	68
3.	P3	100	68	68
4.	P4	100	91	91
5.	P5	100	66	66
6.	P1 x P5	57	35	61
7.	P2 x P3	48	25	52
8.	P3 x P2	15	6	40
9.	P2 x P4	16	15	93
10.	P4 x P2	57	31	54
11.	P2 x P5	84	43	51
12.	P5 x P2	54	31	57
13.	P3 x P5	93	62	66
14.	P4 x P5	52	41	78
15.	P4 x P1	17	-	-
16.	P3 x P4	19	-	-
17.	P4 x P3	88	41	46
18.	P5 x P3	27	18	66
19.	P5 x P4	19	14	73

P1 - YRFN-3 P3 - VP_{36}
P2 - $Mech_9$ P4 - Walter P5 - Local

Table V

Height of seedlings in cm

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean (10.7)	Mean of parents	Better parent
1.	P1 x P5	9.8	10.5	10.1	10.6	4.1	0.7	-	0.5	0.1
2.	P2 x P3	10.3	10.1	10.2	10.4	1.7	0.4	-	0.2	0.1
3.	P3 x P2	10.1	10.3	10.2	7.6	-	-	-	-	-
4.	P2 x P4	10.3	12.3	11.3	14.2	26.0	16.1	34.1	3.5*	2.1
5.	P4 x P2	12.3	10.3	11.3	11.2	-	-	5.6	-	-
6.	P2 x P5	10.4	10.5	10.4	12.1	16.4	15.7	14.1	2.1	1.9
7.	P5 x P2	10.5	10.4	10.4	11.3	8.6	7.9	6.6	1.1	0.9
8.	P3 x P5	10.1	10.5	10.3	10.7	4.3	2.2	0.9	0.5	0.3
9.	P4 x P5	12.3	10.5	11.4	12.6	11.1	3.0	1.8	1.5	0.4
10.	P4 x P3	12.3	10.1	11.2	-	-	-	-	-	-
11.	P5 xP3	10.5	10.1	10.3	-	-	-	-	-	-
12.	P5 x P4	10.5	12.3	11.4	-	-	-	-	-	-

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

*Significant at 5 per cent level

Among the parents, Walter showed maximum seedling height.

As regards hybrids $Mech_9$ x Walter manifested the maximum seedling height of 14.2 cm followed by Walter x Local reaching a height of 12.6 cm. The hybrid $Mech_9$ x Walter showed significant heterosis in height over the parental mean. The crosses $Mech_9$ x Local, Walter x Local, VF_{36} x Local, Local x $Mech_9$ also showed heterosis over parental mean, better parent and general mean. The cross $Mech_9$ x VF_{36} showed heterosis over parental mean and better parent but its reciprocal cross showed heterosis over parental mean, better parent and general mean. The reciprocal cross of $Mech_9$ x Walter showed heterosis over general mean only. The cross $Mech_9$ x Walter showed significant heterosis when compared to parental mean.

4. Height of plants

The height of parents and hybrids were recorded at 10 days interval. The data pertaining to the growth pattern of parents and hybrids are graphically represented in Figure 1. The data relating to the final observations were analysed statistically and the results are furnished in Table VI.

Among the parents, maximum height of 148.6 cm was recorded by Walter and minimum of 112.0 cm by YRFN-3.

Table VI

Height of plants in cm

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean (135.9)	Mean of parents	Better parent
1.	C1 (P1xP5)	112.0	136.7	124.4	119.0	-	-	-	-	-
2.	C2 (P2xP3)	138.3	141.0	139.6	120.1	-	-	-	-	-
3.	C3 (P3xP2)	141.0	138.3	139.6	152.8	9.4	8.3	12.4	6.9**	5.4**
4.	C4 (P2xP4)	138.3	148.6	143.5	137.6	-	-	1.2	-	-
5.	C5 (P4xP2)	148.6	138.3	143.5	152.1	6.0	2.3	11.8	6.1**	2.1
6.	C6 (P2xP5)	138.3	136.7	137.5	132.1	-	-	-	-	-
7.	C7 (P5xP2)	136.7	138.3	137.5	140.6	2.2	1.6	3.4	2.1	0.8
8.	C8 (P3xP5)	141.0	136.7	138.9	142.2	2.4	0.8	4.6	2.3	0.7
9.	C9 (P4xP5)	148.6	136.7	142.7	151.5	6.2	1.9	11.4	6.1**	1.8

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

**Significant at both 5 and 1 per cent level

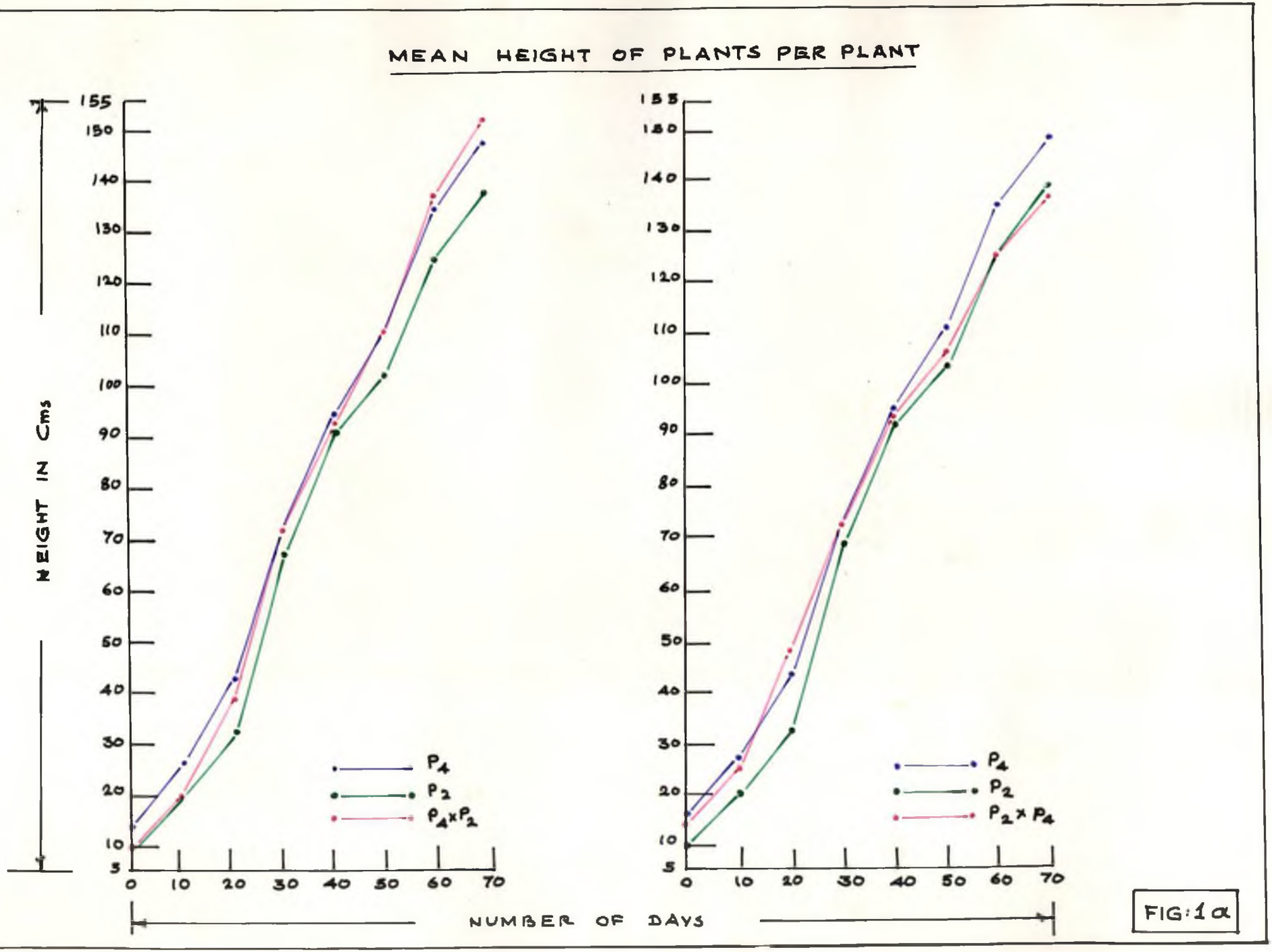
MEAN HEIGHT OF PLANTS PER PLANT
HEIGHT IN Cms
155
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
5
0
10
20
30
40
50
60
70
NUMBER OF DAYS
P4
P2
P4 x P2
P2 x P4

FIG: 1 a

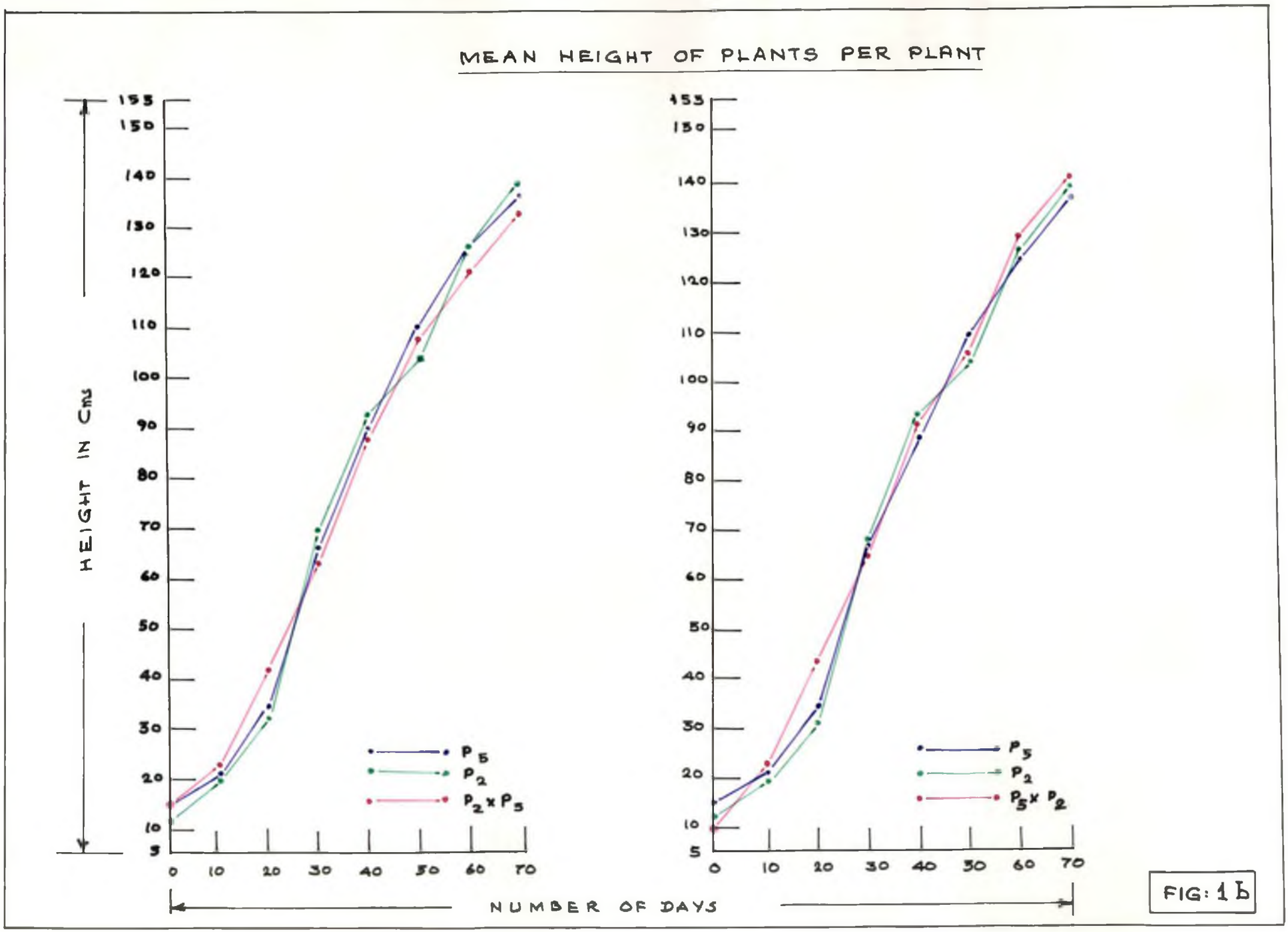
MEAN HEIGHT OF PLANTS PER PLANT
HEIGHT IN Cms
155
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
5
0
10
20
30
40
50
60
70
NUMBER OF DAYS
P5
P2
P2 x P5
P5
P2
P5 x P2

FIG: 1 b

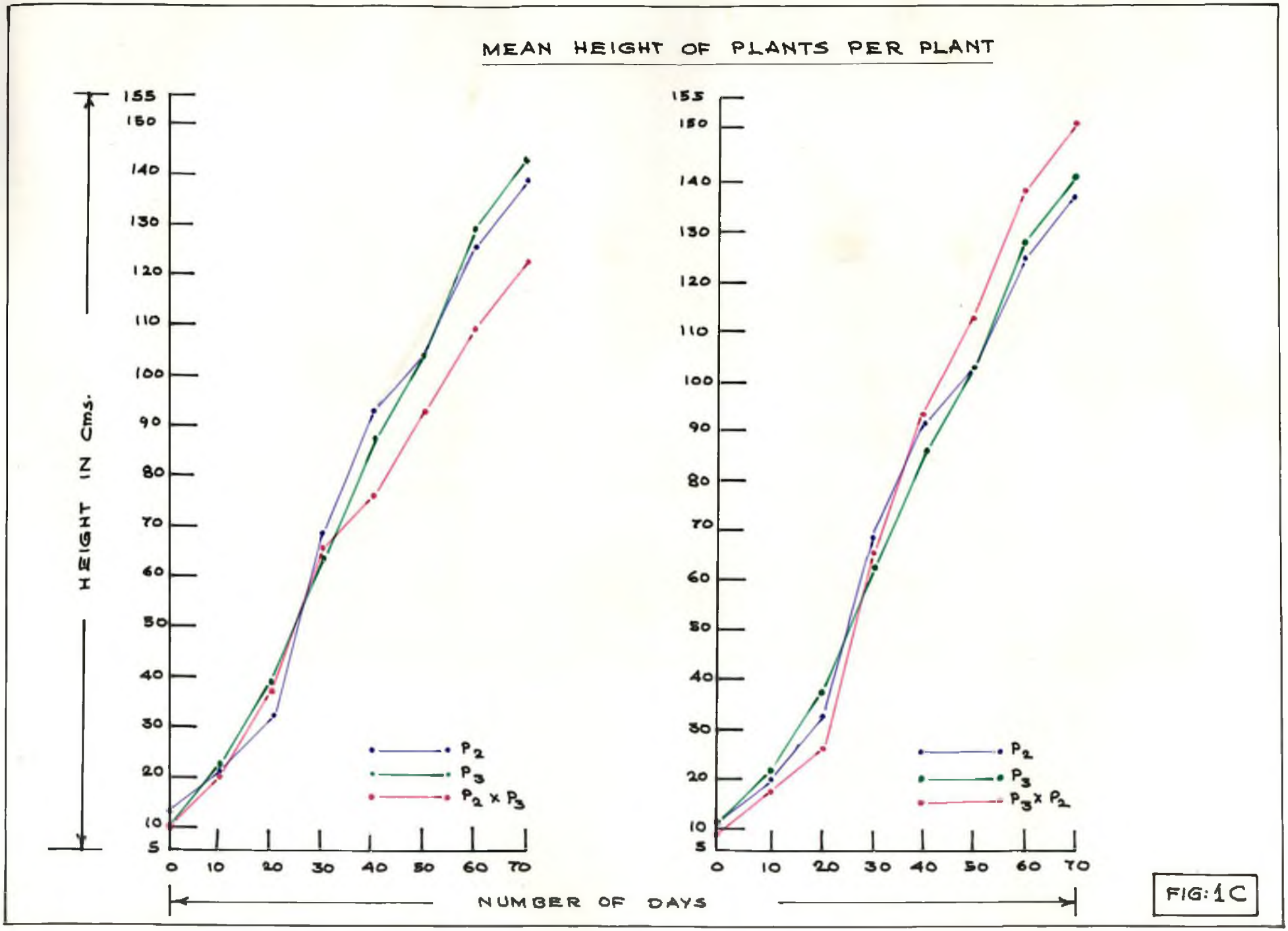
MEAN HEIGHT OF PLANTS PER PLANT
HEIGHT IN Cms.
155
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
5
0 10 20 30 40 50 60 70
NUMBER OF DAYS
P2
P3
P2 x P3
P3 x P2

FIG: 1C

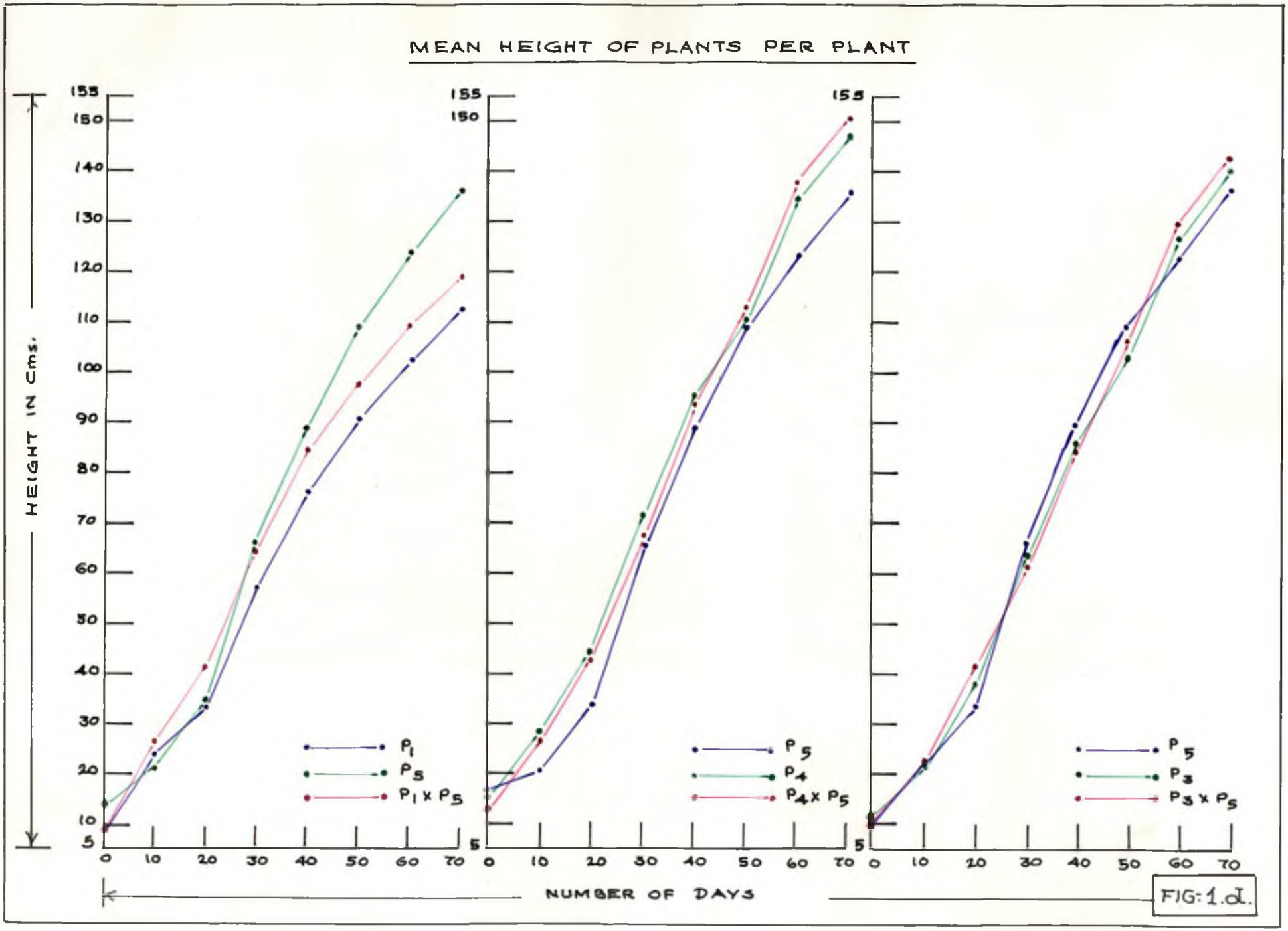
MEAN HEIGHT OF PLANTS PER PLANT
HEIGHT IN Cms.
155
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
5
0 10 20 30 40 50 60 70
P1
P5
P1 x P5
P5
P4
P4 x P5
P5
P3
P3 x P5
NUMBER OF DAYS

FIG: 1.d.

Among the hybrids VF_{36} x $Mech_9$ manifested the maximum plant height of 152.8 cm followed by Walter x $Mech_9$ and Walter x Local and the minimum plant height was observed in YRFN-3 x Local. The crosses VF_{36} x $Mech_9$, Walter x $Mech_9$ and Walter x Local exhibited significant heterosis when compared to their parental means. The cross VF_{36} x $Mech_9$ showed significant heterosis when compared to the better parent also. The crosses VF_{36} x $Mech_9$ and Walter x $Mech_9$ showed heterosis over their mean of parents, better parent and general mean but their respective reciprocal crosses showed no heterosis. The crosses VF_{36} x Local and Walter x Local also showed heterosis over mean of parents, better parents and general mean. The heights of hybrids $Mech_9$ x VF_{36}, $Mech_9$ x Walter and $Mech_9$ x Local were lower than that of the dwarf parents. The height of the hybrid YRFN-3 x Local was higher than that of the dwarf parent but lower than that of better parent and parental mean.

5. Number of branches

The results of analysis are given in Table VII. The mean number of branches of parents and hybrids are tabulated.

Among the parents, Walter exhibited the maximum number of branches, 17.5 followed by $Mech_9$, Local, VF_{36} and YRFN-3. YRFN-3 exhibited the minimum number of branches, 12.3.

Table VII

Number of branches per plant

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean (14.4)	Mean of parents	Better parent
1.	C1 (P1xP5)	12.3	13.7	13.0	13.1	0.8	-	-	0.3	-
2.	C2 (P2xP3)	14.5	13.2	13.9	14.4	3.9	-	-	0.2	-
3.	C3 (P3xP2)	13.2	14.5	13.9	17.0	2.3	17.2	18.1	6.9**	5.0**
4.	C4 (P2xP4)	14.5	17.5	16.0	16.7	4.4	-	15.9	2.0	-
5.	C5 (P4xP2)	17.5	14.5	16.0	17.8	11.2	1.7	2.3	6.0**	0.8
6.	C6 (P2xP5)	14.5	13.7	14.1	14.9	5.6	2.7	3.4	2.4*	1.0
7.	C7 (P5xP2)	13.7	14.5	14.1	16.3	15.6	12.4	13.1	6.2**	4.5**
8.	C8 (P3xP5)	13.2	13.7	13.5	14.7	9.3	7.1	2.1	3.5*	2.6*
9.	C9 (P4xP5)	17.5	13.7	15.6	17.9	14.7	2.2	24.3	6.5**	1.0

P1 - YREN-3 P3 - VP_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

**Significant at both 5 and 1 per cent level

*Significant at 5 per cent level

From the table it is evident that the hybrids VF_{36} x $Mech_9$, Local x $Mech_9$ and VF_{36} x Local show increase over their respective parents in the mean number of branches. The cross VF_{36} x $Mech_9$ showed heterosis percentage as 2.3, 17.2 and 18.1 over mean of parents, better parent and general mean respectively. The hybrid Local x $Mech_9$ showed 15.6, 12.4 and 13.1 as heterosis percentages over their mean of parents, better parents and general mean respectively. The hybrid VF_{36} x Local also showed heterosis over parental mean, better parent and general mean. The hybrids YRFN-3 x Local and $Mech_9$ x VF_{36} showed heterosis over their mean of parents. The hybrid $Mech_9$ x Walter showed heterosis over mean of parents and general mean. The cross Walter x $Mech_9$ showed heterosis over parental mean, better parent and general mean. The hybrids YRFN-3 x Local, $Mech_9$ x VF_{36} and $Mech_9$ x Walter were found to be intermediate to their parents. All the hybrids recorded an increase over their inferior parents.

It can be seen that significant heterosis was shown in all crosses with Local as the male parent except the cross YRFN-3 x Local. When $Mech_9$ was taken as female parent no significant heterosis was achieved in any of the crosses except $Mech_9$ x Local. When $Mech_9$ was taken as male parent there was significant heterosis in crosses VF_{36} x $Mech_9$,

Walter x $Mech_9$ and Local x $Mech_9$. VF_{36} and Walter as female parents gave significant heterosis in all crosses.

6. Number of leaves per plant

Statistical analysis of the mean number of leaves produced by the parents and hybrids are presented in Table VIII. The mean number of leaves produced by the parents and hybrids are shown in the table.

Among the parents, Local recorded maximum number of leaves 152.7 and the minimum by YRFN-3, 117.3. Among the hybrids the maximum number of leaves was produced by the cross Walter x Local, 156.6 and the minimum by YRFN-3 x Local, 114.1. From the table it was evident that the hybrids VF_{36} x $Mech_9$, Local x $Mech_9$, VF_{36} x Local and Walter x Local show an increase in the number of leaves over their respective parents. The hybrids YRFN-3 x Local and $Mech_9$ x VF_{36} were inferior to their respective parents. The crosses $Mech_9$ x Walter, Walter x $Mech_9$ and $Mech_9$ x Local were inferior to their better parents but superior to their inferior parents. The crosses VF_{36} x $Mech_9$, Local x $Mech_9$, VF_{36} x Local and Walter x Local recorded heterosis over mean of parents, better parents and general mean. The cross $Mech_9$ x Walter recorded heterosis over general mean only. But the hybrids Walter x $Mech_9$ and $Mech_9$ x Local recorded heterosis over mean of parents

Table VIII

Number of leaves per plant

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean (135.4)	Mean of parents	Better parent
1.	C1 (P1xP5)	117.3	129.5	123.4	114.1	-	-	-	-	-
2.	C2 (P2xP3)	136.1	139.0	137.6	123.3	-	-	-	-	-
3.	C3 (P3xP2)	139.0	136.1	137.6	150.2	9.2	8.1	10.9	5.5**	4.3**
4.	C4 (P2xP4)	136.1	152.7	144.4	143.7	-	-	6.1	-	--
5.	C5 (P4xP2)	152.7	136.1	144.4	149.3	3.4	-	10.2	2.8*	-
6.	C6 (P2xP5)	136.1	129.5	132.8	136.1	2.5	-	0.5	1.8	-
7.	C7 (P5xP2)	129.5	136.1	132.8	143.0	7.7	5.1	5.6	6.3**	3.5**
8.	C8 (P3xP5)	139.0	129.5	134.3	141.6	5.4	1.8	4.5	4.1**	1.1
9.	C9 (P4xP5)	152.7	129.5	141.1	156.6	11.0	2.5	15.6	8.8**	1.9

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

**Significant at both 5 and 1 per cent level

*Significant at 5 per cent level

and general mean.

When VF_{36} and Walter are taken as female parents, significant heterosis was seen in all the hybrids obtained. $Mech_9$ as male parent gave significant heterosis in all the hybrids evolved.

7. Number of leaflets per leaf

The results of analysis are tabulated in Table IX. The mean number of leaflets per leaf of the parents and hybrids are recorded.

The parent Local recorded the maximum number of leaflets per leaf, 19.0 and the minimum was recorded by the parent VF_{36}, 11.0. Among the hybrids VF_{36} x Local recorded the maximum number of leaflets per leaf, 20.3 and recorded percentage of heterosis over mean of parents, better parent and general mean. The minimum number of leaflets per leaf was exhibited by the hybrid Walter x $Mech_9$, 12.3. The value shown by the hybrid VF_{36} x Local was superior to the value shown by all other hybrids and parents. The hybrids YRFN-3 x Local, $Mech_9$ x Local and Local x $Mech_9$ were intermediate with respect to the number of leaflets per leaf to their respective parents. The hybrids $Mech_9$ x VF_{36}, VF_{36} x $Mech_9$, $Mech_9$ x Walter, VF_{36} x Local and Walter x Local recorded

Table IX

Number of leaflets per leaf

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean (13.1)	Mean of parents	Better parent
1.	C1 (P1xP5)	11.1	19.0	15.1	13.2	-	-	-	-	-
2.	C2 (P2xP3)	11.3	11.0	11.2	12.6	13.0	11.5	-	1.2	1.0
3.	C3 (P3xP2)	11.0	11.3	11.2	13.2	18.4	16.8	0.7	1.3	1.2
4.	C4 (P2xP4)	11.3	12.3	11.8	12.9	9.3	4.9	-	0.9	0.5
5.	C5 (P4xP2)	12.3	11.3	11.8	12.3	4.2	-	-	0.4	-
6.	C6 (P2xP5)	11.3	19.0	15.2	16.3	7.6	-	24.4	0.9	-
7.	C7 (P5xP2)	19.0	11.3	15.2	17.1	12.9	-	30.5	1.6	-
8.	C8 (P3xP5)	11.0	19.0	15.0	20.9	39.3	10.0	59.5	4.8**	1.5
9.	C9 (P4xP5)	12.3	19.0	15.7	19.7	25.9	3.7	50.3	3.4**	0.6

P1 -- YRFN-3 P3 -- VF_{36}

P2 -- $Mech_9$ P4 -- Walter P5 -- Local

**Significant at both 5 and 1 per cent level

heterosis over their respective mean of parents and better parents. Significant heterosis was observed only in the two hybrids VF_{36} x Local and Walter x Local.

8. Area of leaves

The results of analysis are tabulated in Table X. The mean area of leaves of parents and hybrids are tabulated in table.

Among the parents, Walter manifested the maximum leaf area of 84.4 sq.cm followed by $Mech_9$, Local, VF_{36} and YRFN-3. YRFN-3 exhibited the minimum leaf area of 65.4 sq.cm. As regards hybrids all the nine hybrids surpassed their better parents with respect to leaf area.

The maximum leaf area was observed in the hybrid VF_{36} x $Mech_9$, 94.3 sq.cm. This cross showed maximum percentage of heterosis over mean of parents (34.1), better parent (30.6) and general mean (30.4).

The minimum leaf area of 81.6 sq.cm was observed in the hybrid VF_{36} x Local. All the hybrids exhibited heterosis over their respective mean of parents better parents and general mean.

Significant heterosis was found in all crosses when compared to the mean of parents.

Table X

Area of leaves in sq.cm

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean (72.3)	Mean of parents	Better parent
1.	C1 (P1xP5)	65.4	68.8	67.6	83.4	24.3	21.2	15.3	7.1**	5.7**
2.	C2 (P2xP3)	72.2	68.5	70.3	85.1	21.1	17.9	17.7	6.4**	4.9**
3.	C3 (P3xP2)	68.5	72.2	70.3	94.3	34.1	30.6	30.4	7.7**	6.9**
4.	C4 (P2xP4)	72.2	84.4	78.3	86.1	9.9	20.1	19.1	3.4**	6.5**
5.	C5 (P4xP2)	84.4	72.2	78.3	91.0	16.2	7.8	25.8	5.5**	2.5*
6.	C6 (P2xP5)	72.2	68.8	70.5	82.0	16.3	13.5	13.4	5.0**	3.7**
7.	C7 (P5xP2)	68.8	72.2	70.5	86.8	23.1	20.2	20.1	7.1**	5.6**
8.	C8 (p3xP5)	68.5	68.8	68.6	81.6	18.9	18.6	12.8	5.5**	4.9**
9.	C9 (P4xP5)	84.4	68.8	76.6	90.6	17.5	6.6	24.4	5.8**	2.1

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

**Significant at both 5 and 1 per cent level

*Significant at 5 per cent level

MEAN LEAF AREA OF PARENTS AND HYBRIDS

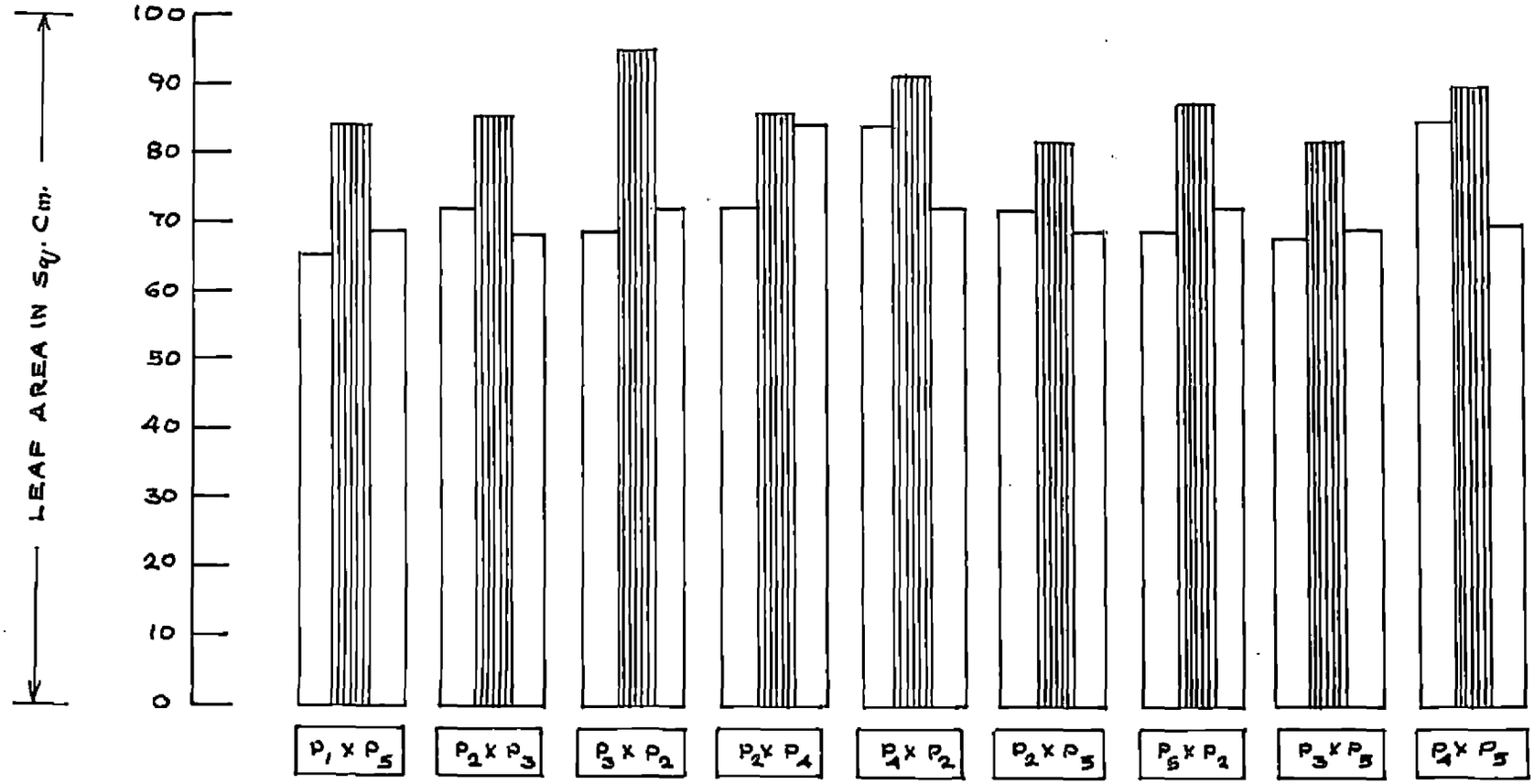

FIG: 2

The mean leaf area of parents and hybrids are presented in Figure 2.

9. Time of flowering

The mean number of days taken from sowing to flowering by F_1 hybrids and parents are shown in Table XI.

Table XI reveals that the parent YRFN-3 took minimum number of days for flowering (47.5) and Walter the maximum (51.3). It can be observed from the table that four of the hybrids were intermediate between their parents with respect to the time of flowering. They were YRFN-3 x Local, $Mech_9$ x VF_{36}, $Mech_9$ x Walter and $Mech_9$ x Local. The hybrids VF_{36} x $Mech_9$, Walter x $Mech_9$, Local x $Mech_9$, VF_{36} x Local and Walter x Local showed earliness in flowering compared to their respective earlier parents.

The hybrid VF_{36} x $Mech_9$ took minimum number of days for flowering (47.0) and the cross Walter x Local the maximum (50.5 days).

Fig.3 represents the mean time of flowering of parents and hybrids.

10. Percentage of pollen sterility in parents and hybrids

The results are tabulated and presented in Table XII.

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Table XI

Time of flowering (Mean number of days taken from sowing to flowering by F_1 hybrids and parents)

Sl. No,	Treatments	Mean	Parental mean	Percent deviation of F_1 mean from	
				Earlier parent	Parental mean
1.	P1	47.5			
2.	P2	49.3			
3.	P3	50.7			
4.	P4	51.3			
5.	P5	50.6			
6.	C1 (P1 x P5)	48.5	49.05	0.21(+)	1.12(-)
7.	C2 (P2 x P3)	50.3	50.00	0.20(+)	0.60(+)
8.	C3 (P3 x P2)	47.0	50.00	4.66(-)	6.00(-)
9.	C4 (P2 x P4)	50.1	50.30	1.62(+)	0.39(+)
10.	C5 (P4 x P2)	49.0	50.30	0.60(-)	2.58(-)
11.	C6 (P2 x P5)	50.2	49.95	1.82(+)	0.50(+)
12.	C7 (P5 x P2)	49.0	49.95	0.60(-)	1.90(-)
13.	C8 (P3 x P5)	50.3	50.65	0.59(-)	0.69(-)
14.	C9 (P4 x P5)	50.5	50.95	0.19(-)	0.49(-)

P1 - YRFN-3 P3 - VF_{36}

P2 - $Meoh_9$ P4 - Walter P5 - Local

MEAN TIME OF FLOWERING OF PARENTS AND HYBRIDS

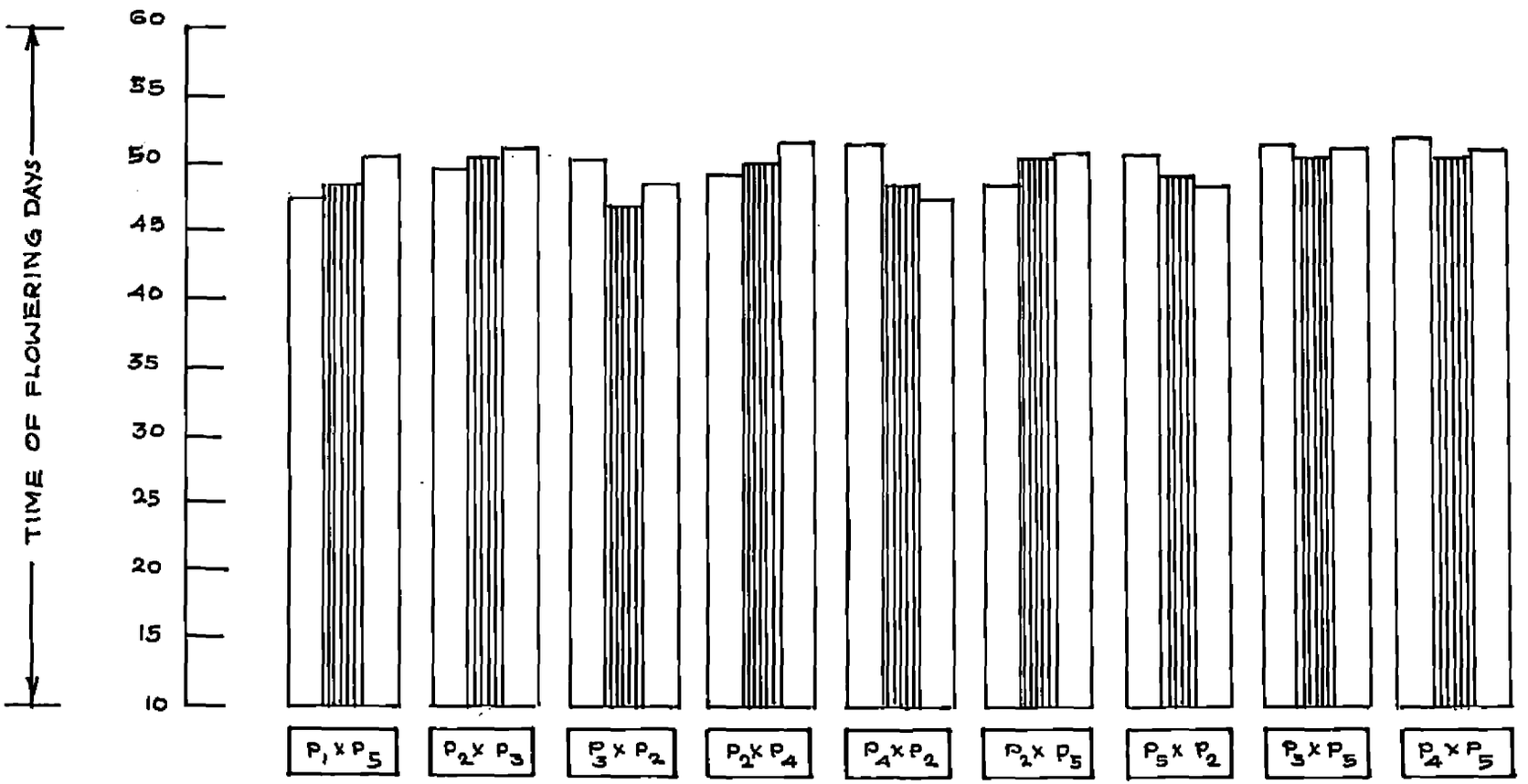

FIG: 3

Table XII

Percentage of pollen sterility in parents and hybrids

Sl. No.	Treatments	Percentage of pollen sterility	Mean of parents	Per cent deviation of F_1 mean from the	
				Better parent (more sterile)	Parental mean
1.	P1	15.3			
2.	P2	12.7			
3.	P3	18.6			
4.	P4	38.2			
5.	P5	17.0			
6.	C1 (P1 x P5)	20.9	16.1	23.5(+)	29.8(+)
7.	C2 (P2 x P3)	41.2	15.6	121.5(+)	164.7(+)
8.	C3 (P3 x P2)	71.8	15.6	284.9(+)	360.2(+)
9.	C4 (P2 x P4)	40.6	30.4	6.2(+)	33.5(+)
10.	C5 (P4 x P2)	70.8	30.4	85.3(+)	132.9(+)
11.	C6 (P2 x P5)	35.4	14.8	108.2(+)	139.1(+)
12.	C7 (P5 x P2)	58.4	14.8	241.1(+)	301.2(+)
13.	C8 (P3 x P5)	50.3	17.8	170.4(+)	182.5(+)
14.	C9 (P4 x P5)	70.0	27.6	83.2(+)	153.7(+)

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

MEAN POLLEN STERILITY IN PARENTS AND HYBRIDS

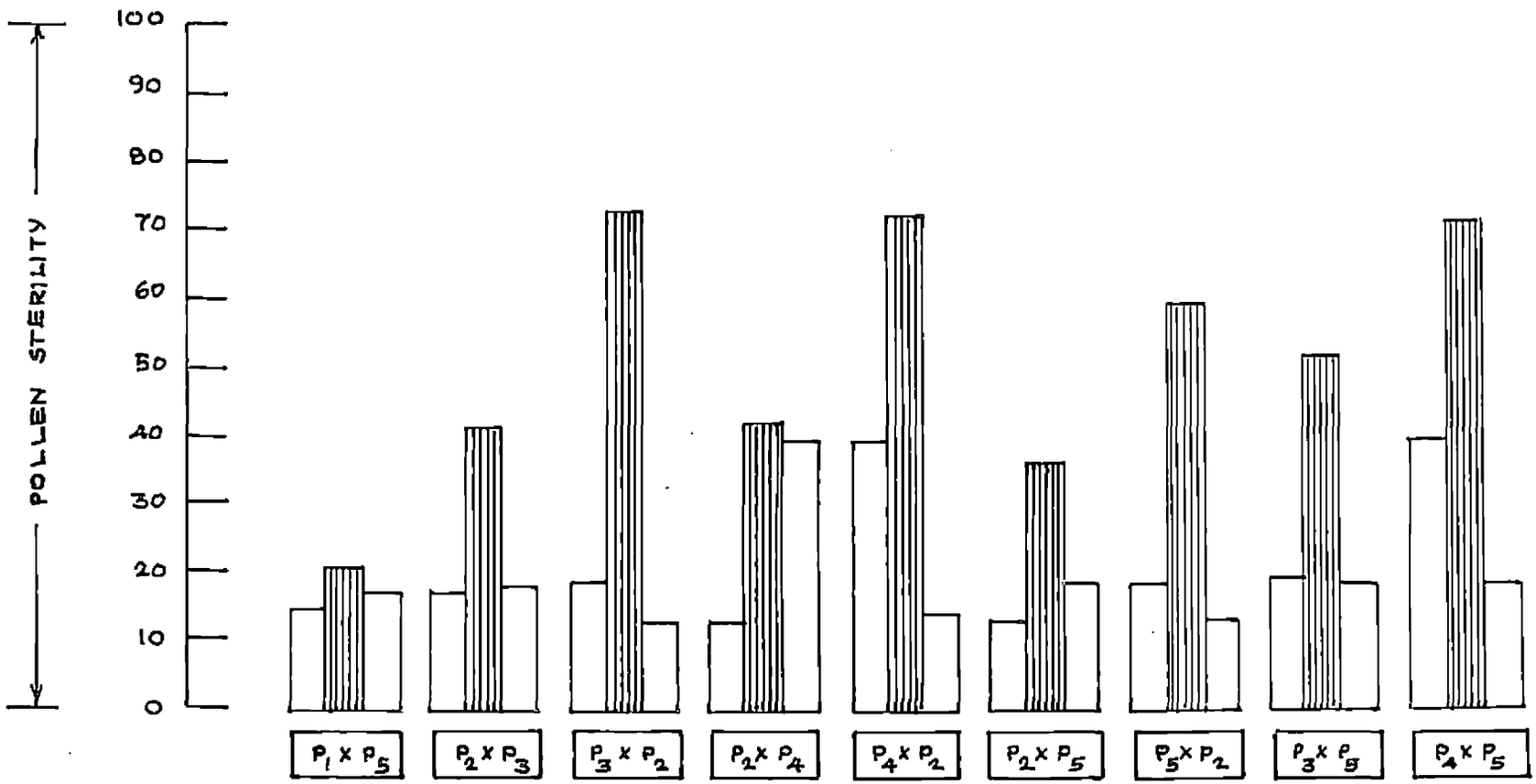

FIG: 4

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The maximum pollen sterility among parents was observed in Walter (38.2 per cent) and the minimum in $Mech_9$ (12.7 per cent).

A high degree of pollen sterility was manifested by all the nine hybrids, and it varied from 20.9 to 71.8 per cent. All the hybrids showed a spectacular increase in pollen sterility from the respective better parent. The maximum amount of increase was registered by VF_{36} x $Mech_9$, the increase over the better parent being 284.9 per cent. This was followed by Local x $Mech_9$, the increase over better parent was 241.1 per cent. The minimum increase was observed in $Mech_9$ x Walter the increase over better parent was 6.2 per cent.

All the nine hybrids showed marked increase in pollen sterility over their respective parental means. The maximum being 360.2 per cent exhibited in VF_{36} x $Mech_9$ which is followed by Local x $Mech_9$ being 301.2 per cent. The pollen sterility of parents and hybrids are shown graphically in Figure 4.

11. Percentage of fruit set

The results are tabulated and presented in Table XIII.

Table XIII

Percentage of fruit set

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) test for comparison with	
						Mean of parents	Better parent	General mean (46.1)	Mean of parents	Better parent
1.	C1 (P1xP5)	45.6	47.2	46.4	80.0	72.4	69.5	73.5	5.5**	4.6**
2.	C2 (P2xP3)	46.9	53.6	50.3	68.0	35.3	26.8	47.5	2.8**	1.9
3.	C3 (P3xP2)	53.6	46.9	50.3	48.3	-	-	4.6	-	-
4.	C4 (P2xP4)	46.9	39.3	43.1	48.5	12.6	3.4	5.2	0.9	0.2
5.	C5 (P4xP2)	39.3	46.9	43.1	38.6	-	-	-	-	-
6.	C6 (P2xP5)	46.9	47.2	47.1	62.1	32.0	31.5	34.7	3.4*	2.1
7.	C7 (P5xP2)	47.2	46.9	47.1	57.9	23.0	22.5	25.5	1.7	1.5
8.	C8 (P3xP5)	53.6	47.2	50.4	55.8	10.6	4.1	20.9	0.8	0.3
9.	C9 (P4xP5)	39.3	47.2	43.3	43.0	-	-	-	-	-

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

**Significant at both 5 and 1 per cent level

*Significant at 5 per cent level

PERCENTAGE OF FRUIT SET OF PARENTS AND HYBRIDS

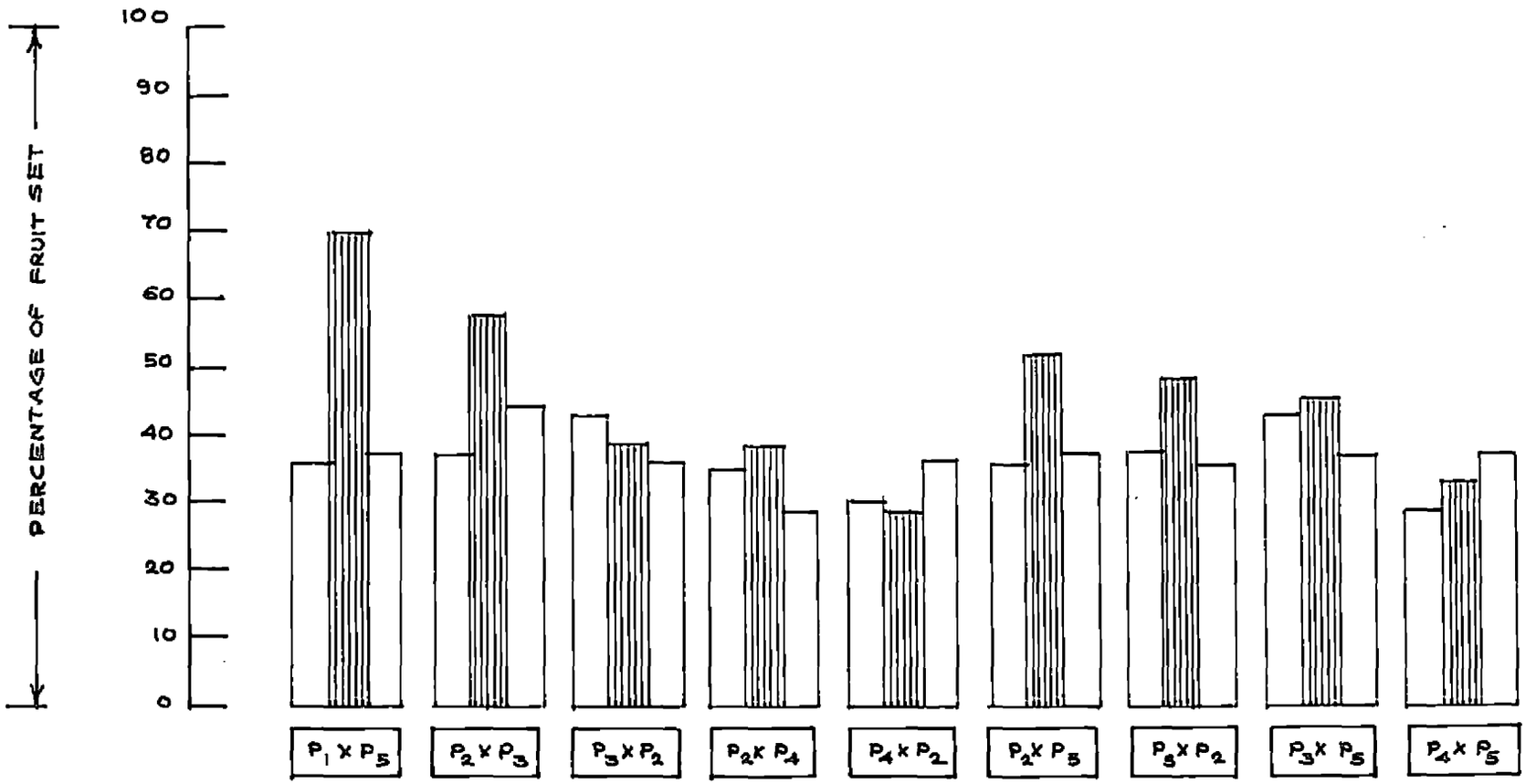

FIG: 5

Among the parents, the maximum fruit set was observed in VF_{36} and the minimum in Walter, being 53.6 per cent and 39.3 per cent respectively. The hybrid YRFN-3 x Local recorded the maximum percentage of fruit set (80.0) and Walter x $Mech_9$ the minimum (38.6).

Out of the nine crosses studied six crosses showed increase in percentage of fruit set over their respective better parents and parental mean. They showed heterosis in percentage of fruit set over better parents, parental means and general mean. Three showed decrease in fruit set when compared to the better parent and parental mean. But they were intermediate to their parents. The cross YRFN-3 x Local recorded maximum heterosis in percentage of fruit set viz., 72.4, 69.5 and 73.5 over mean of parents, better parents and general mean respectively. Significant heterosis was obtained in crosses YRFN-3 x Local, $Mech_9$ x VF_{36} and $Mech_9$ x Local. Mean percentage of fruit set of parents and hybrids are represented in Fig.5.

12. Number of fruits per plant

The results are tabulated and presented in Table XIV. The mean number of fruits produced by parents and hybrids are tabulated and presented in Table XIV.

Table XIV

Number of fruits per plant

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean (15.1)	Mean of parents	Better parent
1.	C1 (P1xP5)	12.0	24.6	18.3	22.3	21.9	-	47.7	2.4*	-
2.	C2 (P2xP3)	13.0	12.5	12.8	13.5	5.9	3.5	-	0.5	0.3
3.	C3 (P3xP2)	12.1	13.0	12.8	11.8	-	-	-	-	-
4.	C4 (p2xP4)	13.0	12.3	12.7	10.3	-	-	-	-	-
5.	C5 (P4xP2)	12.3	13.0	12.7	12.0	-	-	-	-	-
6.	C6 (P2xP5)	13.0	24.6	18.8	13.9	-	-	-	-	-
7.	C7 (P5xP2)	24.6	13.0	18.8	12.6	-	-	-	-	-
8.	C8 (P3xP5)	12.5	24.6	18.6	14.2	-	-	-	-	-
9.	C9 (P4xP5)	12.3	24.6	18.4	11.8	-	-	-	-	-

P1 --- YRFN-3 P3 --- VF_{36} P5 --- Local

P2 --- $Mech_9$ P4 --- Walter

*Significant at 5 per cent level

Among the parents Local recorded the maximum number of fruits per plant being 24.6 and the minimum of 12.0 by YRFN-3. Among the hybrids YRFN-3 x Local recorded the maximum number of fruits (22.3) and $Mech_9$ x Walter the minimum (10.3).

The cross YRFN-3 x Local was statistically superior over the parental mean and recorded a heterosis of 21.9 percent. The hybrid $Mech_9$ x VF_{36} exhibited heterosis when compared to the parental mean and also the better parent. But the values are not statistically significant.

The hybrids VF_{36} x $Mech_9$, $Mech_9$ x Walter, Walter x $Mech_9$, Local x $Mech_9$ and Walter x Local were inferior to their respective parents with respect to the number of fruits. The crosses YRFN-3 x Local, $Mech_9$ x Local and VF_{36} x Local remained intermediate to their respective parents for this character.

13. Weight of fruits per plant

Yield as measured by the weight of fruit per plant was analysed. Mean weight of fruits per plant of parents and hybrids were tabulated in Table XV.

Of the parents $Mech_9$ recorded the maximum weight of fruits per plant (652.4 g) and the minimum by Local

Table XV

Weight of fruits per plant (gm)

Sl. No.	Cross	Female parent	Male Parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parent	Better parent	General mean (₹71.9)	Mean of parents	Better parent
1.	C1 (P1xP5)	423.1	304.3	363.7	496.9	36.6	17.4	5.3	2.5*	1.1
2.	C2 (P2xP3)	652.4	414.0	533.2	547.4	2.6	-	16.0	0.3	-
3.	C3 (P3xP2)	414.0	652.4	533.2	958.0	79.0	46.8	10.3	6.2**	4.9**
4.	C4 (P2xP4)	652.4	538.4	595.4	548.9	-	-	16.3	-	-
5.	C5 (P4xP2)	538.4	652.4	595.4	575.0	-	-	21.8	-	-
6.	C6 (P2xP5)	652.4	304.3	478.4	480.8	0.5	-	1.8	0.5	-
7.	C7 (P5xP2)	304.3	652.4	478.4	557.3	16.5	-	18.0	1.5	-
8.	C8 (P3xP5)	414.0	304.3	359.2	430.6	19.8	4.0	-	1.3	0.3
9.	C9 (P4xP5)	538.4	304.3	421.4	560.3	32.9	4.1	18.7	2.6*	0.4

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

**Significant at both 5 and 1 per cent level

*Significant at 5 per cent level

MEAN WEIGHT OF FRUITS OF PARENTS AND HYBRIDS

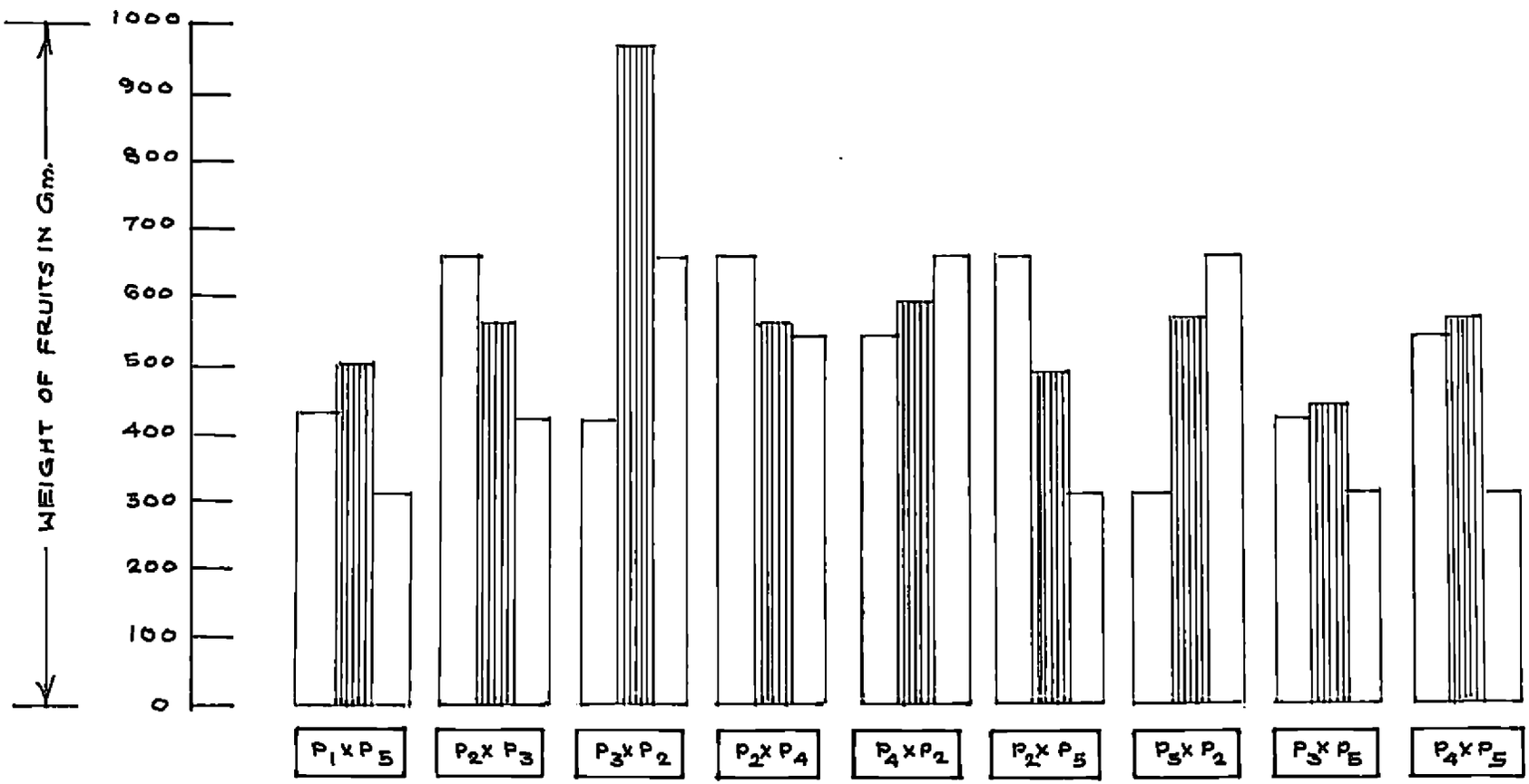

FIG: 6

(304.3 g). The hybrid VF_{36} x $Mech_9$ recorded the maximum weight of fruits (958.0 g) and the minimum by VF_{36} x Local (430.6 g).

The hybrid VF_{36} x $Mech_9$ exhibited superiority over the other hybrids and parents. The hybrids YRFN-3 x Local, VF_{36} x Local and Walter x Local also recorded an increase in fruit weight over their respective parents. The hybrids $Mech_9$ x VF_{36}, $Mech_9$ x Local and Local x $Mech_9$ exhibited superiority over their mean of parents only. The crosses YRFN-3 x Local, VF_{36} x $Mech_9$, VF_{36} x Local and Walter x Local exhibited heterosis over their better parents and mean of parents. The maximum percentage of heterosis was exhibited by the cross VF_{36} x $Mech_9$. The crosses YRFN-3 x Local, $Mech_9$ x VF_{36}, VF_{36} x $Mech_9$, $Mech_9$ x Walter, Walter x $Mech_9$, $Mech_9$ x Local, Local x $Mech_9$ and Walter x Local showed heterosis over general mean. The hybrids $Mech_9$ x VF_{36}, $Mech_9$ x Walter, Walter x $Mech_9$, $Mech_9$ x Local and Local x $Mech_9$ were intermediate to their respective parents with respect to the weight of fruits per plant.

VF_{36} x $Mech_9$ exhibited significant heterosis when compared to the parental mean and also the better parent. YRFN-3 x Local and Walter x Local also gave significant heterosis when compared to parental means. The mean weight

of fruits per plants of the parents and hybrids are represented in Fig.6.

14. Size of fruits (Volume of fruits)

The results of analysis are shown in Table XVI. The mean volume of fruits in cc of hybrids and parents are recorded in the table.

From the table it can be concluded that among the parents, $Mech_9$ exhibited the maximum volume of fruit being 56.2 cc and the minimum by Local being 13.3 cc. Among the hybrids VF_{36} x $Mech_9$ exhibited maximum size of fruit (78.9 cc) and YRFN-3 x Local the minimum (30.3 cc).

Among the nine hybrids studied five crosses namely YRFN-3, x Local, VF_{36} x $Mech_9$, $Mech_9$ x Walter, VF_{36} x Local and Walter x Local were superior to their better parents and they recorded heterosis over their mean of parents and better parents. The other four hybrids $Mech_9$ x VF_{36}, Walter x $Mech_9$, $Mech_9$ x Local and Local x $Mech_9$ were intermediate to their respective parents in the volume of fruit. They showed heterosis over mean of parents. The maximum percentage of heterosis was recorded by VF_{36} x $Mech_9$.

Significant heterosis was observed in five hybrids viz. YRFN-3 x Local, VF_{36} x $Mech_9$, $Mech_9$ x Walter, VF_{36} x Local

Table XVI

Size of fruits (in cc)

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean 33.1	Mean of parents	Better parent
1.	C1 (P1xP5)	25.2	13.3	19.3	30.8	60.2	22.3	-	3.1**	1.3
2.	C2 (P2xP3)	56.2	30.0	43.1	42.5	-	-	28.5	-	-
3.	C3 (P3xP2)	30.0	56.2	43.1	78.9	83.1	40.5	13.8	7.3**	4.1**
4.	C4 (P2xP4)	56.2	33.3	44.7	60.6	35.3	7.8	83.0	4.3**	1.1
5.	C5 (P4xP2)	33.3	56.2	44.7	49.3	10.4	-	49.1	1.3	-
6.	C6 (P2xP5)	56.2	13.3	34.7	42.7	22.6	-	28.6	2.1	-
7.	C7 (P5xP2)	13.3	56.2	34.7	41.7	20.2	-	26.0	1.9	-
8.	C8 (P3xP5)	30.0	13.3	51.7	32.0	47.5	6.4	-	2.6*	0.4
9.	C9 (P4xP5)	33.3	13.3	23.3	39.6	70.1	19.1	19.7	4.4**	1.4

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

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

and Walter x Local. In all hybrids having VF_{36} as female parent there was significant heterosis. Local as male parent gave rise to hybrids with significant heterosis except in $Mech_9$ x Local.

15. Number of locules per fruit

The mean number of locules per fruit of the parents and hybrids are recorded in the Table XVII.

The parents Local, VF_{36} and Walter recorded the maximum number of locules per fruit (8). The minimum number was recorded by the parent YRFN-3 (6).

All the nine hybrids were inferior to their better parents with respect to the number of locules per fruits. The hybrids YRFN-3 x Local, Walter x $Mech_9$, $Mech_9$ x Local and Local x $Mech_9$ showed the same value as that of their inferior parents. The values with respect to the number of locules per fruit shown by the hybrids $Mech_9$ x VF_{36}, $Mech_9$ x Walter, VF_{36} x Local and Walter x Local were less than those of their inferior parents. The maximum number of locules was recorded by the hybrid VF_{36} x $Mech_9$ (7.2) which was superior to the inferior parent. None of the hybrids showed heterosis over better parents, mean of parents or general mean.

16. Number of seeds per fruit from parents and F_1

The data regarding the number of seeds per fruit in

Table XVII

Number of locules per fruit

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean (7.4)	Mean of parents	Better parent
1.	C1 (P1xP5)	6.0	8.0	7.0	6.0	-	-	-	-	-
2.	C2 (P2xP3)	7.0	8.0	7.5	6.0	-	-	-	-	-
3.	C3 (P3xP2)	8.0	7.0	7.5	7.2	-	-	-	-	-
4.	C4 (P2xP4)	7.0	8.0	7.5	6.0	-	-	-	-	-
5.	C5 (P4xP2)	8.0	7.0	7.5	7.0	-	-	-	-	-
6.	C6 (P2xP5)	7.0	8.0	7.5	7.0	-	-	-	-	-
7.	C7 (P5xP2)	8.0	7.0	7.5	7.0	-	-	-	-	-
8.	C8 (P3xP5)	8.0	8.0	8.0	7.0	-	-	-	-	-
9.	C9 (P4xP5)	8.0	8.0	8.0	7.0	-	-	-	-	-

P1 - YRFN-3
P2 - $Mech_9$
P3 - VF 36
P4 - Walter
P5 - Local

$F_2^{F_1}$ and parental seeds are shown in Table XVIII.

Among the parents, Local recorded maximum number of seeds per fruit (502) and $Mech_9$, the minimum (12.7). Among the nine hybrids studied, VF_{36} x Local recorded the maximum number of seeds per fruit (86.9) and $Mech_9$ x VF_{36} the minimum (20). Out of nine crosses studied, $Mech_9$ x Walter and VF_{36} x Local registered conspicuous increase in number of seeds per fruit. The maximum increase in seed number was noticed in $Mech_9$ x Walter the percentage of increase from the better parent and parental mean being 84.8 and 140.6 respectively. The other crosses which showed percentage of heterosis over better parents and mean of parents were VF_{36} x $Mech_9$, $Mech_9$ x VF_{36}, Local x $Mech_9$ and VF_{36} x Local. All the hybrids except two recorded heterosis over general mean. All the nine hybrids showed heterosis over mean of parents. Three hybrids were intermediate to their parents and one was inferior to the inferior parent in number of seeds.

Significant heterosis, when compared to the general means was observed in the crosses YRFN-3 x Local, VF_{36} x $Mech_9$, $Mech_9$ x Walter, Local x $Mech_9$, VF_{36} x Local and Walter x Local. In all crosses where VF_{36} is the female parent

Table XVIII

Number of seeds per fruit from parents and F_2 F_1

Sl. No.	Cross	Female parent	Male parent	Mean of parents	Mean of F_1	Heterosis % over			Test criterion (t) for comparison with	
						Mean of parents	Better parent	General mean (24.7)	Mean of parents	Better parent
1.	C1 (P1xP5)	15.1	50.2	30.7	39.9	22.2	-	61.5	2.5*	-
2.	C2 (P2xP3)	12.7	18.2	15.5	20.0	29.4	9.8	-	1.4	0.2
3.	C3 (P3xP2)	18.2	12.7	15.5	25.4	64.9	39.0	2.8	2.5*	1.6
4.	C4 (P2xP4)	12.7	23.7	18.2	43.8	140.6	84.8	77.3	8.6**	5.9**
5.	C5 (P4xP2)	23.7	12.7	18.2	21.1	15.9	-	-	1.3	-
6.	C6 (P2xP5)	12.7	50.2	31.5	34.9	11.0	-	41.2	1.2	-
7.	C7 (P5xP2)	50.2	12.7	31.5	54.5	73.2	8.4	121.0	7.7**	1.2
8.	C8 (P3xP5)	18.2	50.2	34.2	86.9	154.0	73.1	25.1	17.0**	10.7**
9.	C9 (P4xP5)	23.7	50.2	37.0	43.0	16.4	-	79.0	2.7*	-

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

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

heterosis was significant. Local as male parent gave significant heterosis except in the case $Mech_9$ x Local. In VF_{36} x Local and $Mech_9$ x Walter there was significant heterosis when compared to the better parent also.

17. Weight of seeds (1000 seed weight)

Mean weight of seeds of parents and hybrids are tabulated in Table XIX.

When the weight of 1000 seeds was taken into account YRFN-3 and VF_{36} registered the maximum seed weight among the parents (3200 mg each) and Local the minimum (2700 mg). Of the nine hybrids studied, YRFN-3 x Local recorded the maximum 1000 seed weight (4000 mg) and $Mech_9$ x VF_{36} and Walter x Local, the minimum (3500 mg each). All the nine hybrids exhibited an increase over their better parent as well as parental mean. Maximum increase in seed weight was recorded by the cross $Mech_9$ x Walter the increase being 30 per cent. Minimum increase was recorded by the cross $Mech_9$ x VF_{36} and was 9.4 per cent. All of the nine hybrids exhibited an increase over the respective parental means in seed weight ranging from 14.7 to 35.6 per cent.

Table XIX

Weight of seeds (1000 seed weight)

Sl. No.	Treatments	Weight of 1000 seeds in (mg)	Parental mean	Per cent deviation of F_1 mean from the	
				Better parent	Parental mean
1.	P1	3200			
2.	P2	2900			
3.	P3	3200			
4.	P4	3000			
5.	P5	2700			
6.	C1 (P1 x P5)	4000	2950	25.0(+)	35.6(+)
7.	C2 (P2 x P3)	3500	3050	9.4(+)	14.7(+)
8.	C3 (P3 x P2)	3900	3050	21.9(+)	27.9(+)
9.	C4 (P2 x P4)	3900	2950	30.0(+)	32.2(+)
10.	C5 (P4 x P2)	3600	2950	20.0(+)	20.0(+)
11.	C6 (P2 x P5)	3600	2800	24.1(+)	28.5(+)
12.	C7 (P5 x P2)	3700	2800	27.5(+)	32.1(+)
13.	C8 (P3 x P5)	3900	2950	21.8(+)	32.2(+)
14.	C9 (P4 x P5)	3500	2850	16.6(+)	22.8(+)

P1 - YREN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

18. Germination capacity of F_2 and parental seeds

The germination capacity of F_2 and parental seeds are illustrated in Table XX and XXI.

Among the five parents Walter recorded the maximum germination percentage of 91 which is followed by YRFN-3, $Mech_9$, VF_{36} and Local. The variety Local showed only 66 per cent, the minimum germination. Of the hybrids, the maximum germination was observed in cross VF_{36} x Local (100 per cent) and the minimum germination was noticed in the cross $Mech_9$ x VF_{36} (66 per cent). The percentage of deviation of F_2 seeds from the better parents and the parental means in germination capacity are shown in Table XX. When germination capacity of F_2 seeds were tested eight out of nine hybrids were found to be superior compared to the parental means. The increase ranged from 10.3 per cent in YRFN-3 x Local to 46.3 per cent in VF_{36} x Local. One hybrid showed a decrease in germination percentage, the decrease being 3.3 per cent in $Mech_9$ x VF_{36}.

When the better parent was considered, all the seven hybrids out of nine were superior in germination. The increase ranged from 8.7 per cent in $Mech_9$ x Walter and Walter x Local to 47.0 per cent in VF_{36} x Local. Two hybrids showed a decrease in germination percentage, the decrease being 2.9 and 3.3 per cent each in YRFN-3 x Local and $Mech_9$ x VF_{36}

Table XX

Germination capacity of F_2 and parental seeds

Sl. No.	Treatments	Percentage germination on the											
		4th day	5th day	6th day	7th day	8th day	9th day	10th day	11th day	12th day	13th day	14th day	15th day
1.	P1	76	82	88	89	89	89	89	89	89	89	89	89
2.	P2	9	26	45	48	52	55	55	63	68	68	68	68
3.	P3	-	23	43	48	50	50	53	53	63	68	68	68
4.	P4	45	55	60	70	72	78	80	89	91	91	91	91
5.	P5	10	17	20	22	25	31	42	47	50	55	61	66
6.	C1 (P1 x P5)	35	50	64	73	76	80	81	83	84	85	86	86
7.	C2 (P2 x P3)	38	43	50	56	60	61	63	65	66	66	66	66
8.	C3 (P3 x P2)	-	-	15	32	42	53	62	62	62	81	81	81
9.	C4 (P2 x P4)	41	51	63	68	74	83	84	86	91	93	99	99
10.	C5 (P4 x P2)	51	56	61	66	72	75	80	87	88	90	91	91
11.	C6 (P2 x P5)	52	68	70	80	81	83	85	87	87	87	87	87
12.	C7 (P5 x P2)	40	51	62	67	72	80	85	85	85	85	85	85
13.	C8 (P3 x P5)	51	61	66	76	82	90	92	94	95	98	100	100
14.	C9 (P4 x P5)	62	72	85	89	90	92	94	97	98	99	99	99

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

Table XXI

Germination capacity of F_2 and parental seeds

Sl. No.	Treatments	Germination percentage	Parental mean	Per cent deviation of F_2 from the	
				Better parent	Parental mean
1.	P1	89			
2.	P2	68			
3.	P3	68			
4.	P4	91			
5.	P5	66			
6.	C1 (P1 x P5)	86	77.5	3.3(-)	10.3(+)
7.	C2 (P2 x P3)	66	68.0	2.9(-)	3.3(-)
8.	C3 (P3 x P2)	81	68.0	19.1(+)	19.1(+)
9.	C4 (P2 x P4)	99	79.5	8.7(+)	23.2(+)
10.	C5 (P4 x P2)	91	79.5	-	14.4(+)
11.	C6 (P2 x P5)	87	67.0	27.9(+)	29.8(+)
12.	C7 (P5 x P2)	85	67.0	25.0(+)	26.8(+)
13.	C8 (P3 x P5)	100	67.0	47.0(+)	46.3(+)
14.	C9 (P4 x P5)	99	78.5	8.7(+)	26.1(+)

P1 - YRFN-3 P3 - VF_{36}
P2 - $Mech_9$ P4 - Walter P5 - Local

respectively.

B. Qualitative characters of parents and hybrids

The observations pertaining to the qualitative characters are furnished in Table XXII.

1. Stature of plant

Among the five parents studied Local and $Mech_9$ were of medium, VF_{36} and Walter were of tall and YRFN-3 was of short stature. Of the nine hybrids, six of them i.e., $Mech_9$ x Walter, Walter x $Mech_9$, $Mech_9$ x VF_{36}, VF_{36} x $Mech_9$, VF_{36} x Local and Walter x Local were tall in stature and three hybrids viz. YRFN-3 x Local, $Mech_9$ x Local and Local x $Mech_9$ were medium in stature.

2. Spread of plants

The parent Walter recorded compact spreading nature and YRFN-3, $Mech_9$, VF_{36} and Local recorded semi compact spreading nature.

Among the hybrids YRFN-3 x Local, $Mech_9$ x VF_{36}, $Mech_9$ x Walter, $Mech_9$ x Local, Local x $Mech_9$ and VF_{36} x Local recorded semicompact spreading nature and the hybrids VF_{36} x $Mech_9$, Walter x $Mech_9$ and Walter x Local exhibited compact spreading nature.

Table XXII

Qualitative characters of parents and hybrids

Sl. No.	Characters	P1	P1 x P5	P5	P2	P2 x P3	P3	P3 x P2
1.	Stature	Short	Medium	Medium	Medium	Tall	Tall	Tall
2.	Spread	Semi-compact	Semi-compact	Semi-compact	Semi-compact	Semi-compact	Semi-compact	Compact
3.	Stem pigmentation	Green	Green	Green	Green	Green	Green	Green
4.	Leaf size	Large	Large	Medium	Large	Large	Medium	Large
5.	Flower size	Medium	Medium	Small	Medium	Large	Medium	Medium
6.	Petal colour	Yellow	Yellow	Yellow	Very pale yellow	Very pale yellow	Yellow	Very pale yellow
7.	Anther colour	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
8.	Fruit size	Small	Small	Small	Large	Medium	Small	Medium
9.	Fruit shape	Elongated	Round	Round	Oval	Round	Oval	Oval
10.	Fruit apex	Pointed	Blunt	Blunt	Pointed	Pointed	Pointed	Pointed
11.	Colour of mature fruit	Reddish yellow	Red	Red	Reddish yellow	Red	Red	Red

Table XXII
(Continued..)

Sl. No.	Characters	P4	P2 x P4	P4 x P2	P2 x P5	P5 x P2	P3 x P5	P4 x P5
1.	Stature	Tall	Tall	Tall	Medium	Medium	Tall	Tall
2.	Spread	Compact	Compact	Compact	Compact	Compact	Compact	Compact
3.	Stem pigmentation	Green	Green	Green	Green	Green	Green	Green
4.	Leaf size	Large	Large	Large	Large	Large	Large	Large
5.	Flower size	Large	Large	Large	Medium	Medium	Medium	Large
6.	Petal colour	Very pale yellow	Pale yellow	Pale yellow	Very pale yellow	Yellow	Yellow	Very pale yellow
7.	Anther colour	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
8.	Fruit size	Medium	Large	Large	Medium	Medium	Small	Medium
9.	Fruit shape	Oval	Oval	Oval	Round	Round	Round	Round
10.	Fruit apex	Slightly pointed	Slightly pointed	Slightly pointed	Blunt	Blunt	Blunt	Blunt
11.	Colour of mature fruit	Red	Red	Red	Red	Red	Red	Red

P1 - YRFN-3 P3 - VF_{36}
P2 - $Mech_9$ P4 - Walter P5 - Local

3. Stem pigmentation

All the parents and hybrids showed no change in stem pigmentation. All were green in colour.

4. Leaf size

Among the parents YRFN-3, Walter and $Mech_9$ showed large sized leaves and Local and VF_{36} medium sized leaves.

Among the hybrids, all of them exhibited large sized leaves.

5. Flower size

Among the parents YRFN-3, VF_{36} and $Mech_9$ recorded medium sized flowers, Local, small sized flowers and Walter, large sized flowers.

Among the hybrids YRFN-3 x Local, VF_{36} x $Mech_9$, $Mech_9$ x Local, Local x $Mech_9$ and VF_{36} x Local showed medium sized flowers and $Mech_9$ x VF_{36}, $Mech_9$ x Walter, Walter x $Mech_9$ and Walter x Local recorded large sized flowers.

6. Petal colour

Among the parents, Local, YRFN-3 and VF_{36} exhibited Yellow petals and $Mech_9$ and Walter exhibited very pale yellow petals.

Among the hybrids $Mech_9$ x VF_{36}, VF_{36} x $Mech_9$, $Mech_9$ x Local and Walter x Local exhibited very pale yellow petals and the hybrids $Mech_9$ x Walter and Walter x $Mech_9$ exhibited pale yellow petals and YRFN-3 x Local, Local x $Mech_9$ and VF_{36} x Local recorded yellow coloured petals.

7. Anther colour

All the parents and hybrids recorded yellow coloured anthers.

8. Fruit size

The parents YRFN-3, VF_{36} and Local produced small sized fruits, Walter produced medium sized fruits and $Mech_9$ produced large sized fruits.

Among the hybrids YRFN-3 x Local and VF_{36} x Local produced small sized fruits. The hybrids $Mech_9$ x Local, Local x $Mech_9$, $Mech_9$ x VF_{36}, VF_{36} x $Mech_9$ and Walter x Local produced medium sized fruits and $Mech_9$ x Walter and Walter x $Mech_9$ produced large sized fruits.

9. Fruit shape

Of the five parents Walter, VF_{36} and $Mech_9$ produced oval fruits, Local round fruits and YRFN-3 elongated fruits.

Of the nine hybrids six hybrids viz. YRFN-3 x Local, $Mech_9$ x VF_{36}, $Mech_9$ x Local, Local x $Mech_9$, VF_{36} x Local and

Walter x Local showed round shaped fruits and VF_{36} x $Mech_9$, $Mech_9$ x Walter and Walter x $Mech_9$ produced oval shaped fruits.

10. Fruit apex

Among the parents, YRFN-3, VF_{36} and $Mech_9$ produced fruits with pointed apex and Walter produced fruits with slightly pointed apex. The parent Local produced fruits with blunt apex.

Among the hybrids, five showed fruits with blunt apex. They are $Mech_9$ x Local, Local x $Mech_9$, VF_{36} x Local, Walter x Local and YRFN-3 x Local. The hybrids $Mech_9$ x VF_{36} and VF_{36} x $Mech_9$ produced fruits with pointed apex. The fruit apex of the hybrids $Mech_9$ x Walter and Walter x $Mech_9$ was only slightly pointed.

11. Colour of mature fruit

Two parents $YRFN_3$ and $Mech_9$ produced reddish yellow coloured fruits and three parents VF_{36}, Walter and Local produced red coloured fruits.

Among the hybrids, all the nine produced red coloured fruits.

C. Genetic parameters

The phenotypic variance, genotypic variance,

Table XXIII

Genetic parameters

Sl. No.	Characters	Range	General mean	SE_M	Phenotypic variance	Genotypic variance	Heritability percentage	Genetic advance through the selection of the best 5% (as % mean)
1.	Height of seedlings	9.0-15.5	10.6	0.02	8.62	7.82	90.1	71.30
2.	Height of plants	105.0-152.0	135.9	0.69	1607.10	1585.66	98.6	61.10
3.	Number of branches per plant	10.0-18.0	14.4	0.15	35.62	30.88	97.3	83.70
4.	Number of leaves per plant	113.0-159.0	135.4	0.76	1508.90	1482.20	98.2	59.10
5.	Area of leaves	44.0-94.0	72.3	1.40	516.80	429.50	83.1	54.80
6.	Number of leaflets per leaf	9.0-21.0	13.1	0.23	112.20	109.73	97.8	166.10
7.	Percentage of fruit set	27.2-76.8	46.1	1.54	220.70	113.76	52.6	35.60
8.	Number of fruits per plant	10.0-33.0	15.1	0.47	290.80	269.30	92.7	219.80
9.	Total weight of fruits per plant	210.0-778.0	471.9	16.27	173355.40	161448.50	93.1	172.50
10.	Size of fruit	10.0-67.5	33.0	1.08	2330.20	2281.78	97.9	300.00
11.	Number of locules per fruit	5.0-8.0	7.4	0.08	7.99	7.67	95.9	76.20

heritability and genetic advance for the eleven characters studied are tabulated in Table XXIII. High heritability percentages of over 90 per cent were observed for the characters, height of plants, number of leaves per plant, number of leaflets per leaf, number of branches per plant, number of locules per fruit, total weight of fruits per plant, number of fruits per plant, size of fruit and height of seedlings. Percentage of fruit set was the least heritable character.

Among the yield attributes size of fruit has the maximum heritability and it is found that size of fruit can be increased three fold simply by selection of the best 5 per cent. Number of fruits per plant can also be increased by 219.8 per cent through selection. Genetic advance through selection of the best 5 per cent is 172.5 per cent for total weight of fruits per plant and 166.1 for number of leaflets per leaf. For the other characters genetic advance that can be achieved by selection is smaller.

II. Chemical studies

Percentage of sucrose content in fruits

The results are tabulated and presented in Table XXIV.

Table XXIV

Percentage of sucrose content in fruits

Sl.No.	Treatment	Percentage of sucrose content	Mean of parents	Per cent deviation of F_1 mean from the	
				Better parent	Parental mean
1.	P1	2.09			
2.	P2	1.69			
3.	P3	1.95			
4.	P4	1.81			
5.	P5	2.10			
6.	C1 (P1 x P5)	2.50	2.07	18.1(+)	20.7(+)
7.	C2 (P2 x P3)	2.25	1.82	15.3(+)	23.6(+)
8.	C3 (P3 x P2)	1.80	1.82	7.6(-)	1.0(-)
9.	C4 (P2 x P4)	2.05	1.75	13.2(+)	17.1(+)
10.	C5 (P4 x P2)	1.51	1.75	16.5(-)	13.7(-)
11.	C6 (P2 x P5)	2.45	1.89	16.6(+)	29.5(+)
12.	C7 (P5 x P2)	1.89	1.89	10.0(-)	-
13.	C8 (P3 x P5)	2.45	2.02	16.6(+)	21.2(-)
14.	C9 (P4 x P5)	2.23	1.95	5.1(+)	14.3(+)

P1 - YRFN-3 P3 - VF_{36}

P2 - $Mech_9$ P4 - Walter P5 - Local

SUCROSE CONTENT IN PARENTS AND HYBRIDS

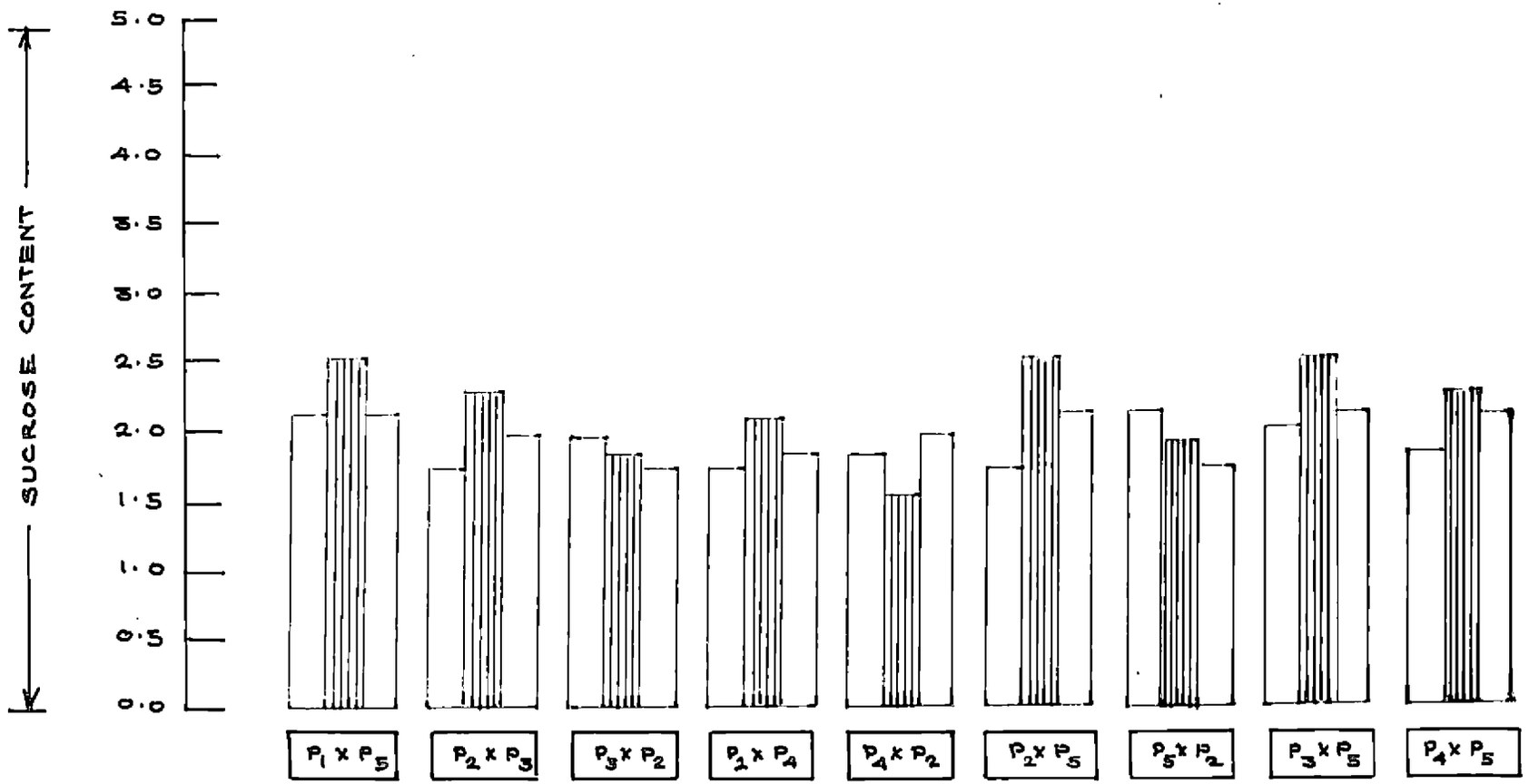

FIG: 7

Among the parents, the variety Local exhibited the maximum percentage of sucrose (2.10) which was closely followed by YRFN-3, 2.09 per cent.

Six hybrids YRFN-3 x Local, $Mech_9$ x VF_{36}, $Mech_9$ x Walter, $Mech_9$ x Local, VF_{36} x Local and Walter x Local surpassed their respective parents in their sucrose content, the increase being 18.1 per cent, 15.3 per cent, 13.2 per cent, 16.6 per cent, 16.6 per cent and 5.1 per cent respectively. The other three hybrids showed a decrease in sucrose content from their respective better parents, the percentage being 7.6, 16.5 and 10.0 respectively. Five of the hybrids showed a marked increase over their parental mean also. The maximum increase over parental mean was manifested by $Mech_9$ x Local, the increase being 29.5 per cent. The minimum amount of increase over parental mean was exhibited by Walter x Local being 14.3 per cent. Sucrose content in parents and hybrids are graphically represented in Figure 7.

DISCUSSION

DISCUSSION

The data on the cytomorphological characters of the hybrids are discussed below:

Though hybridization work was done in all combinations, fruit setting was noticed only in fourteen crosses. In crosses between VF_{36} x Walter and Walter x YRFN-3 no viable seeds were obtained. This may be due to either defective endosperm, embryo or both. The phenomenon of post fertilization failure has been observed by many workers in various crosses. Brink and Cooper (1944) found that the embryo started normal development in the cross Secale cereale x Hordeum jubatum, but then collapsed in early stage. This according to them was due to the inability of the endosperm to compete with the adjoining maternal tissue. Iyyer, Sulbha and Swaminathan (1961) have given evidence of a somatoplasmic sterility mechanism underlying seed failure in some jute crosses. In the cross Walter x VF_{36}, Local x VF_{36} and Local x Walter, eventhough viable seeds were obtained, the seedlings did not survive. Similar results were reported by Krishnappa and Chennaveeriah (1965) in a cross between Solanum acculeatissimum and S. kharianum. Gopimony (1968) in a cross between Thorny giant (S.melongena) and

S. melongena var. insanum and Pillai (1973) in a cross between C. frutescens x C. pendulum. Considerable reduction in the production of seeds by the hybrids may be due to the failure of the process concerned with the normal development of pollen, embryosac, embryo or endosperm. This is in conformity with the findings of Gopimony (1968) in brinjal and Pillai (1973) in chillies.

Quantitative characters

Heterosis was noticed in many of the quantitative characters. Hybrid vigour was first studied by Kolreuter (1763). Since then it has continued to be a problem of interest to geneticists as well as breeders who utilize this phenomenon in a planned breeding programme for crop improvement. It is generally accepted that this increased vigour of F_1 over the mean of parents is due to the combined action of favourable factors either dominant or partially dominant based on mathematical expectations. On the other hand Shull (1912) attributed heterosis to the effect of an altered nucleus interacting with a relatively unaltered cytoplasm.

The results of the present investigation point towards the fact that the extent of degree of expression of heterosis in L. esculentum varies with different parental

combinations. This difference between the crosses may perhaps be due to the different degrees of genetic diversity between the parents. The characters for which heterosis was noticed were height of plants, number of leaves, number of leaflets per leaf, leaf area, number of branches, duration of flowering, number of fruits per plant, percentage of fruit set, weight and size of fruits, number and weight of seeds per fruit and germination capacity of parental and hybrid seeds.

Plant size is mainly constituted by plant height and number of branches. During the present investigation, 7 crosses showed positive heterosis in seedling height. When Local was taken as male parent as well as female parent, there was heterosis in case of seedling height. When $Mech_9$ was taken as female parent, then also heterosis in seedling height was observed. $Mech_9$ x Walter exhibited significant heterosis when compared to the better parent. This observation of enhanced seedling height is in conformity with the results of Chaudhary and Mishra (1966) and Viswanathan (1967) in Solanum who have attributed such vigour due to heterotic effect. The hybrid Walter x $Mech_9$ showed intermediate position between parents which is quite in accordance with the Nilson Ehle's hypothesis of quantitative inheritance.

Similar observations were made by Pal and Singh (1946) and Mishra (1961) in brinjal, Ucini (1973) and Rajki (Mrs) and Pal (1962) in tomato and Pillai (1973) in Capsicum.

Observations regarding the ultimate plant height of hybrids revealed that five out of nine hybrids showed positive heterosis. The crosses VF_{36} x $Mech_9$, Walter x $Mech_9$ and Walter x Local exhibited significant heterosis when compared to their parental means. The cross VF_{36} x $Mech_9$ gave significant heterosis when compared to better parent also. In crosses involving $Mech_9$ as male parent heterosis was noticed. When VF_{36} and Walter were taken as female parents there also heterosis was noticed in the case of height of plants, which is quite in conformity with the results of Viswanathan (1967) in brinjal and Pillai (1973) in Capsicum. The hybrids $Mech_9$ x VF_{36}, $Mech_9$ x Walter, and $Mech_9$ x Local exhibited negative heterosis while their reciprocal hybrids showed positive heterosis with regard to plant height. This difference in reciprocal cross points to the possible role of cytoplasm in the transmission of character or due to difference in environmental factors. This has to be established by further studies. One hybrid YRFN-3 x Local remained intermediate between the parents in

accordance with the inheritance of quantitative characters.

The number of branches is another equally important economic character contributing to plant size. The more the number of branches, the greater will be the number of leaves which ultimately will result in the production of increased number of fruits since fruits are borne in leaf axils. This increases the final yield output of the crop. In the present study, six hybrids were superior to their better parents, mean of parents and general mean in the number of branches. They are VF_{36} x $Mech_9$, Walter x $Mech_9$, $Mech_9$ x Local, Local x $Mech_9$, VF_{36} x Local and Walter x Local. Significant heterosis was shown in all the crosses with Local as the male parent except the cross YRFN-3 x Local. When $Mech_9$ was taken as female parent no significant heterosis was achieved in any of the crosses except in $Mech_9$ x Local. When $Mech_9$ was taken as male parent, there was significant heterosis. VF_{36} and Walter as female parents gave significant heterosis in all the crosses. Similar heterotic effects in production of branches have been recorded by Kaida (1926), Kakishaki(1939,31) and Viswanathan (1967) in brinjal and Nair (1970) and Pillai (1973) in Capsicum. Three hybrids (YRFN-3 x Local, $Mech_9$ x VF_{36} and $Mech_9$ x Walter) were intermediate in number of branches between parents which is in agreement with the

hypothesis of quantitative inheritance propounded by Nilson Ehle. Mishra (1961) in brinjal and Pillai (1973) in Capsicum also have reported similar findings.

Increase in number of leaves, leaflets per leaf and leaf area will remarkably enhance the photosynthetic activity which will have a direct bearing on yield. In the present investigation, four out of nine hybrids (VF_{36} x $Mech_9$, Local x $Mech_9$, VF_{36} x Local and Walter x Local) showed superiority over their parents in number of leaves, thus confirming the positive heterotic effect. When VF_{36} and Walter are taken as female parents, there was significant heterosis in all the hybrids obtained. $Mech_9$ as male parent also gave significant heterosis in all the hybrids evolved. The crosses VF_{36} x $Mech_9$, Walter x $Mech_9$ and Local x $Mech_9$ gave heterosis. But their reciprocals did not give significant heterosis. Similar heterotic effects were recorded by Balya (1918) in brinjal and Pillai (1975) in Capsicum, Peat and Whittington, (1965) in tomato. Three hybrids were intermediate ($Mech_9$ x Walter, Walter x $Mech_9$ and $Mech_9$ x Local) in number of leaves. Similar results have been obtained by Venkitaramani (1940) in brinjal hybrids. The number of leaves produced by YRFN-3 x Local and $Mech_9$ x VF_{36} were found to be lower than that of the parents. With regard to the

number of leaflets per leaf five out of nine hybrids were superior to their respective parents. Significant heterosis was observed only in the two hybrids VF_{36} x Local and Walter x Local with regard to number of leaflets per leaf. This finding is in agreement with the results of Rajki (Mrs) and Pal (1964) and Sahrigy et al. (1970) in tomato.

With respect to area of leaves all the hybrids exceeded their respective parents. Significant heterosis was found in all crosses when compared to the mean of parents in the case of leaf area. Significant heterosis was found in all the crosses except one cross i.e. Walter x Local when compared with better parent. Similar results were recorded by Rajki (Mrs) and Pal (1964), Doroshev and Iovva (1966) in tomato and Nair (1970) in chillies.

Another important economic character is earliness in blooming. Hybrids VF_{36} x $Mech_9$, Walter x $Mech_9$, Local x $Mech_9$, VF_{36} x Local and Walter x Local showed earliness in flowering when compared to the earlier parent which was similar to the observation of Saakjan (1964) Young (1966) and Stambera (1968) in tomato, Lantican et al.(1965), Viswanathan (1967) and Gopimony (1968) in brinjal and Nair (1970) and Pillai (1973) in Capsicum. All the other hybrids

were intermediate between their parents with regard to the time of flowering which followed the pattern of quantitative inheritance.

The percentage of pollen sterility was higher in all the hybrids. Meiotic abnormalities like fragments, unequal separation and laggards were noticed in the hybrids. These types of meiotic abnormalities largely control the pollen fertility. Similar results were recorded by Viswanathan (1967) in brinjal, Nair (1970) and Pillai (1973) in Capsicum. Each pollen mother cell gives rise to four pollen grains and hence there is always a tendency of increase in the percentage of pollen abnormalities. The pollen mother cell abnormality and the resultant pollen sterility have a direct bearing in the fruit set and the number of seeds per fruit. However, there was no absolute correlation between pollen sterility and yield in certain crosses. This can be explained by the fact that yield is governed by the nature and function of both the gametes. This is in agreement with the observations of Malhova (1965) who recorded a complete or partial sterility caused by disturbed meiosis and structural and functional defects of the embryosac.

With regard to the percentage of fruit set, six hybrids viz., YRFN-3 x Local, $Mech_9$ x VF_{36}, $Mech_9$ x Walter, $Mech_9$ x Local, Local x $Mech_9$ and VF_{36} x Local outyielded their respective parents. However significant heterosis was obtained in crosses YRFN-3 x Local, $Mech_9$ x VF_{36} and $Mech_9$ x Local. The increased fruit set may be attributed to the heterotic effect. Kodrashova (1970) in tomato, Rao (1965) and Gopimony (1968) in Solanum, Nair (1970) and Pillai (1973) in Capsicum have reported similar effects. The percentage of fruit set in the hybrids VF_{36} x $Mech_9$ and Walter x Local remained intermediate between the parents. This is in agreement with the findings of Pillai (1973) in Capsicum. One hybrid Walter x $Mech_9$ was inferior to its parents showing a negative heterotic effect. This can be explained as a result of the large number of meiotic abnormalities occurring in these hybrids.

The number of fruits produced by the hybrids YRFN-3 x Local, $Mech_9$ x Local and VF_{36} x Local remained intermediate to that produced by the parents. The hybrid YRFN-3 x Local exhibited significant heterosis over parental mean. Similar results have been obtained by Venkitaramani (1946) in brinjal and Pillai (1973) in Capsicum. The hybrid $Mech_9$ x VF_{36} outyielded its respective parents and mean of

parents showing a positive heterotic effect. Nagai and Kaida (1926), Tetesi (1927), Pal and Singh (1940, 1941), Viswanathan (1967) in brinjal, Abrorimova (1970), Crill and Burgis (1971) in tomato and Nair (1970) and Pillai (1973) in chillies have reported similar results. On the other hand the hybrids VF_{36} x $Mech_9$, $Mech_9$ x Walter, Walter x $Mech_9$, Local x $Mech_9$ and Walter x Local were statistically inferior to their respective parents showing negative heterotic effect. This can be attributed to the possible production of inviable gametesas a result of irregular meiosis in these hybrids.

Hybrids $Mech_9$ x VF_{36}, $Mech_9$ x Walter, Walter x $Mech_9$, $Mech_9$ x Local and Local x $Mech_9$ were found to be intermediate between their parents as regards the weight of fruits, agreeing with the principle of inheritance of quantitative characters. The hybrids YRFN-3 x Local, VF_{36} x $Mech_9$, VF_{36} x Local and Walter x Local outyielded their respective parents showing heterotic effects. The hybrid VF_{36} x $Mech_9$ exhibited significant heterosis when compared to the parental mean and also the better parent. YRFN-3 x Local and Walter x Local gave significant heterosis when compared to the parental means. Similar results were recorded by Stambera (1965), Chaudhary and Sangha (1966), Torres and Fernandez

(1966), Daskalov et al.(1967) and Breshnev (1973) in tomato hybrids.

The fruit size of the hybrids $Mech_9$ x VF_{36}, $Mech_9$ x Local, Walter x $Mech_9$, Local x $Mech_9$ were also found to be intermediate between their parents. However significant heterosis was observed in five hybrids viz., YRFN-3 x Local, VF_{36} x $Mech_9$, $Mech_9$ x Walter, VF_{36} x Local, and Walter x Local. In all hybrids having VF_{36} as female parent there was significant heterosis. Local as male parent gave rise to hybrids with significant heterosis except in $Mech_9$ x Local. Similar results were reported by Androniscesu and Enaschescu (1966), Nair (1970) and Pillai (1973) in Capsicum. The hybrids YRFN-3 x Local, VF_{36} x $Mech_9$, $Mech_9$ x Walter, VF_{36} x Local and Walter x Local outyielded their respective parents showing heterotic effect. Similar results were recorded by Hosir (1965), Douce (1969), Oniscenko (1970) and Abrosimova (1971) in tomato hybrids.

As regards the number of locules per fruit, all the nine hybrids were inferior to their better parents showing negative heterotic effect. The hybrids YRFN-3 x Local Walter x $Mech_9$, $Mech_9$ x Local and Local x $Mech_9$ recorded same value as that of their inferior parents. The hybrids $Mech_9$ x VF_{36}, $Mech_9$ x Walter, VF_{36} x Local and

Walter x Local gave a lower value, for locule number to that of the inferior parents. The hybrid VF_{36} x $Mech_9$ was found to be intermediate between their parents. None of the hybrids showed heterosis over better parents. This is quite in accordance with the observations recorded by Alpatjev (1966) Salib and Mallah et al.(1970), Ahuja (1968) and Chaudhary and Khanna (1972) in tomato.

With regard to the number of seeds per fruit, significant heterosis when compared to the parental means, was observed in the crosses YRFN-3 x Local, VF_{36} x $Mech_9$, $Mech_9$ x Walter, Local x $Mech_9$, VF_{36} x Local and Walter x Local. In all the cases where VF_{36} was the female parent, heterosis was significant. Local as male parent gave significant heterosis except in the case $Mech_9$ x Local. In VF_{36} x Local and $Mech_9$ x Walter there was significant heterosis when compared to the better parent also. Similar results were reported by Szwadiak (1965) in tomato, Kakishaki (1931) and Viswanathan (1967) in brinjal and Pillai (1973) in Capsicum. The other four hybrids displayed the intermediate condition in the number of seeds per fruit. This is quite in accordance with the result of Nair (1970) in chillies.

An increase in seed weight was observed in all the nine hybrids. The increase in seed weight may be due to increase in the size of the embryo due to heterotic effect. Similar results were recorded by Kakishaki (1931) in brinjal, Swadiak (1965), Popova and Mihajlov (1970) in tomato and Singh and Singh (1969) and Pillai (1973) in chillies.

Qualitative characters

The inheritance of many of the qualitative characters like pigmentation of plant parts, colour of fruits, shape of fruits etc. can be studied easily because, the individuals can be separated and grouped into sharply distinct classes by visual observations without resorting to any scale of measurements. Such characters show a discontinuous variation.

Results relating to the inheritance of stem pigmentation, leaf shape, petal colour, anther colour, fruit shape, nature of fruit and colour of mature fruit obtained were recorded. Considering the stature of plant, tall stature was dominant over medium. This is in conformity with the results of Bunescu and Pirlea (1966) in tomato. Larger size of leaves was also dominant over medium.

With regard to the size of fruit, large size was dominant over medium and small. Similar results were obtained by Oniscenko (1969) and Abrusimova (1971), in tomato. Regarding the fruit shape, the blunt nature of fruit apex was found to be dominant over pointed apex.

Regarding the colour of mature fruit, red colour was dominant over reddish yellow. This is in conformity with the findings of Barrios and Mosokar (1972) in Capsicum.

Genetic parameters

The yield attributes viz., number of fruits per plant, weight of fruits per plant and size of fruit were found to have high heritability values. Genetic advance through selection of the best 5 per cent for these three characters were also very high indicating that by selection yield can be increased. Height of plants, number of leaves per plant, number of leaflets per leaf, number of branches per plant, number of seeds per fruit and number of locules per fruit were also found to be highly heritable.

Chemical studies

Tomato provides a source of Sugar (sucrose). Different varieties exhibit varied ranges of this nutrient content. Nature of inheritance of this character formed

another important objective of the present investigation.

The sucrose content in six hybrids viz., YRFN-3 x Local, $Mech_9$ x VF_{36}, $Mech_9$ x Walter, $Mech_9$ x Local, VF_{36} x Local and Walter x Local surpassed their better parents indicating positive heterosis. This is quite in conformity with the results of Esipova (1964) Chulkova and Chulkov (1969) and Breshnov (1973) in tomato and Nair (1970) in chillies. Two hybrids VF_{36} x $Mech_9$ and Local x $Mech_9$ remained intermediate to their parents in sucrose content agreeing with the results of Nair (1970) in chillies.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

The present investigations were carried out in College of Agriculture, Vellayani during the year 1974-75. Five varieties of Lycopersicon esculentum viz., YRFN-3, $Mech_9$, VF_{36}, Walter and Local were utilised for intercrossing. Investigations on the quantitative and qualitative characters, heterosis, hybrid sterility and sucrose content of the parents and hybrids were undertaken.

Though the hybridization work was done in all combinations, there was fruit setting only in fourteen crosses. YRFN-3 as male parent failed to cross with any other varieties except with Walter. In this case though fruit setting was occurred, seeds obtained were not viable. YRFN-3 as female parent also failed to cross with any other varieties except with Local. $Mech_9$ as female parent succeeded to cross with three other varieties viz., VF_{36}, Walter and Local and as male parent with VF_{36}, Walter and Local and in all the six crosses, seeds were viable and seedlings survived. VF_{36} as female parent and male parent succeeded to cross with three other varieties viz., $Mech_9$, Walter and Local, but seedlings obtained only in three crosses. Walter as female parent succeeded to cross with the other four varieties and as male parent with three varieties.

But seedlings obtained in only 3 crosses. Local as female parent succeeded to cross with 3 varieties and as male parent with all the other 4 varieties and seedlings obtained in 5 crosses. $Mech_9$ proved to be the best variety because in all the six crosses it produced viable seeds and seedlings.

All the hybrids registered a reduction in number and percentage of germination of F_1 seeds.

The hybrids exhibited heterotic effect for several economically desirable characters like height of seedlings, height of plants, number of leaves per plant, area of leaves, number of branches per plant, time of flowering, yield of plant, percentage of fruit set, sucrose content of the fruit etc. There was a positive correlation between leaf area and yield of fruit.

Pollen sterility was more in all the F_1 hybrids which had a direct bearing in the fruit set.

All the hybrids registered an increase in number, weight and percentage of germination of F_2 seeds. The hybrids $Mech_9$ x Walter and Walter x $Mech_9$ were poor in performance in all the economically desirable characters except for time of flowering.

Dominance was noticed for tall stature of plant over medium stature, large size of fruit over small size, blunt nature of fruit apex over pointed nature, red colour of mature fruit over reddish yellow colour in all the crosses.

The yield attributes viz., number of fruits per plant, weight of fruits per plant and size of fruit were found to have high heritability values. Genetic advance through selection of the best 5 percentage for these characters were also very high indicating that by selection yield can be increased.

Economically the most desirable hybrids were YRFN-3 x Local, VF_{36} x $Mech_9$ and Walter x Local in which the increase in yield was 79 per cent, 36.6 per cent and 32.9 per cent respectively over their parental mean.

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PLATES

PLATE No.1

Fig.I a. Photograph of the fruits of the hybrid YRFN-3 x Local and the respective parents

Fig.I b. Photograph showing the locules of the fruit of the hybrid YRFN-3 x Local and that of the respective parents

Fig.II a. Photograph of the fruits of the hybrids $Mech_9$ x VF_{36} and VF_{36} x $Mech_9$ and their respective parents

Fig.II b Photograph showing the locules of the fruits of the hybrids $Mech_9$ x VF_{36} and VF_{36} x $Mech_9$ and that of their respective parents.

Fig.I a

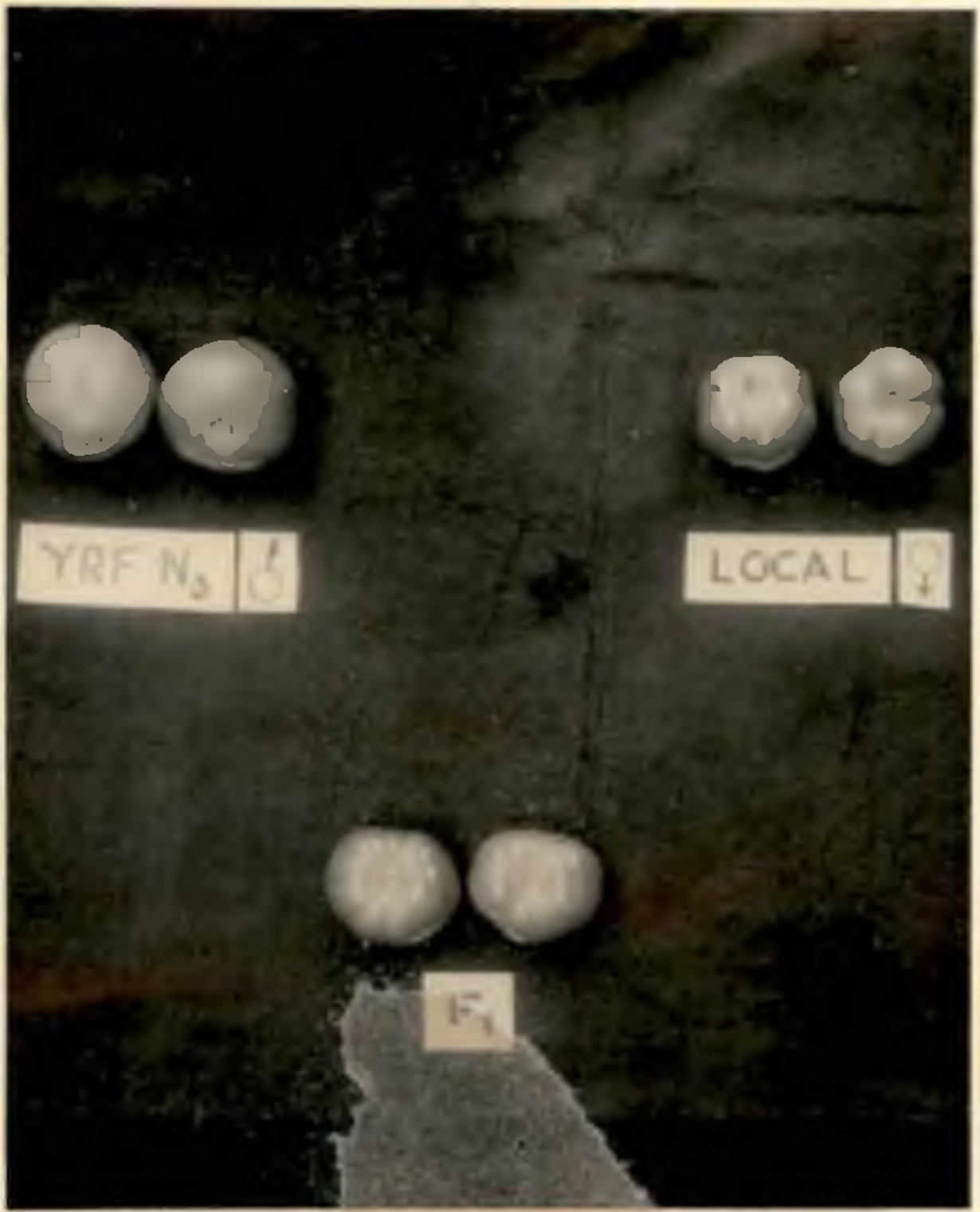

Fig.I a

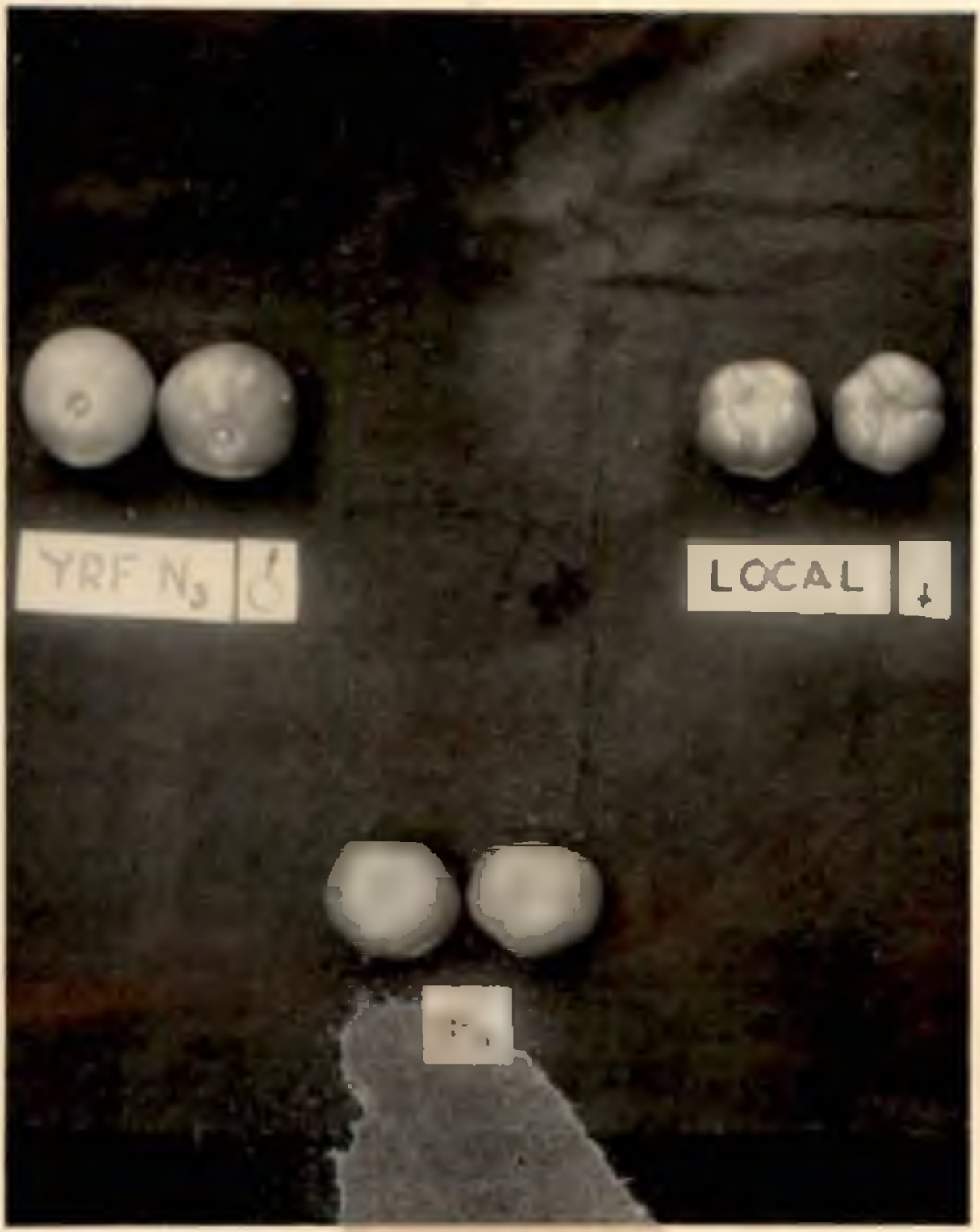

PLATE No.2

Fig. I a. Photograph of the fruits of the hybrids $Mech_9$ x Walter and Walter x $Mech_9$ and their respective parents

Fig. I b. Photograph showing the locules of the fruits of the hybrids $Mech_9$ x Walter and Walter x $Mech_9$ and that of their respective parents

Fig II a. Photograph of the fruits of the hybrids $Mech_9$ x Local and Local x $Mech_9$ and their respective parents

Fig II b. Photograph showing the locules of the fruits of the hybrids $Mech_9$ x Local and Local x $Mech_9$ and that of their respective parents

Fig. I a

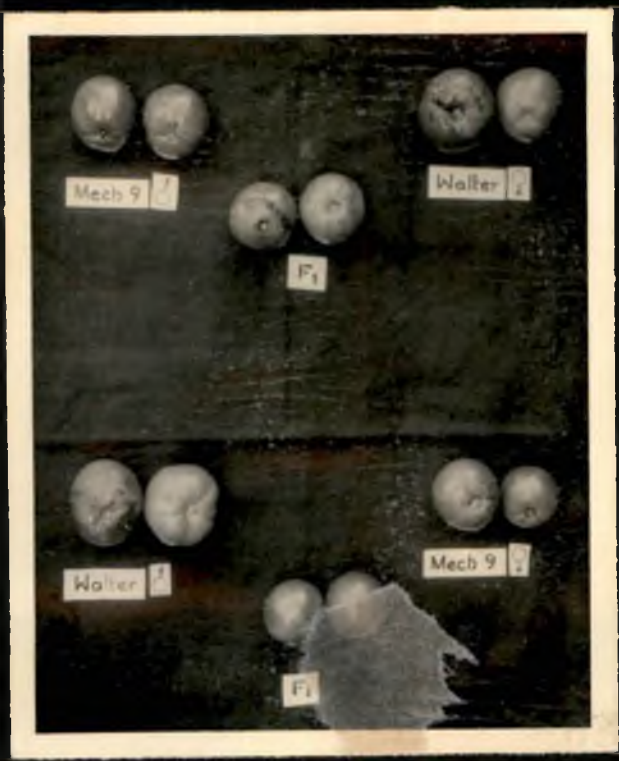

Fig. II a

PLATE No.3

Fig.I a. Photograph of the fruits of the hybrid VF_{36} x Local and the respective parents

Fig.I b. Photograph showing the locules of the fruit of the hybrid VF_{36} x Local and that of the respective parents

Fig.II a. Photograph of the fruits of the hybrid Walter x Local and the respective parents

Fig.II b. Photograph showing the locules of the fruit of the hybrid Walter x Local and that of the respective parents

Fig. I a