GENE RECOMBINATION FOR RESISTANCE TO BACTERIAL WILT AND YIELD COMPONENTS IN BRINJAL

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Gene recombination for resistance to bacterial wilt and yield components in brinjal" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis "Gene recombination for resistance to bacterial wilt and yield components in brinjal" is a record of research work done independently by Smt. Jayalekshmy, V.G. 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

INTRODUCTION

Brinjal (Solanum melongena L.) is an important vegetable crop in the tropics and is widely grown in the Indian plains throughout the year. The unripe fruit of this common and popular vegetable can be cooked in a variety of ways. From the point of view of nutrition, it is comparable with other common vegetables with 1.4 percent protein, 0.3 percent fat and 0.3 percent minerals. The major factor contributing to the popularity of this crop is the relative easiness with which it can be cultivated.

One of the major constraints in the cultivation of brinjal is the incidence of bacterial wilt caused by Pseudomonas solanacearum. In states like Kerala and Karnataka the extent of damage due to this disease is sometimes as high as 90 percent. All the commercial varieties such as Pusa Kranti, Pusal Purple Long, Pusa Purple Round, Arka Kusumkar and Banaras Giant are highly susceptable to this disease. The yield loss consequent to wilt infection is usually very high and at times total (Figure 1). Cultivation of brinjal has consequently become uneconomical or even impossible at many place in Kerala state. The varieties with inherent resistance to bacterial wilt are mostly moderate or poor yielders and the farmers have been forced to be contented with these varieties rather than suffering from total crop losses.

The main draw back of the existing wilt resistant brinjal types is their low production potential and the smaller size of fruits. A study of the relationship between fruit yield and resistance to bacterial wilt in brinjal will be useful in a programme to evolve resistant types with high yield potential.

The present study has been undertaken to investigate the influence of selection for bacterial wilt resistance on the yield and yield contributing traits in brinjal. The major objectives of the study were.

(1) The study of the pattern of variability in the F_2 to gather information on the mode of inheritance of yield contributing traits.

(2) To estimate the influence of bacterial wilt incidence on variability for yield and yield contributing characters.

(3) Correlation studies between yield contributing traits and the influence of selection for resistance on the association between these characters.

Figure 1. Brinjal field infected with bacterial wilt

Figure 1.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Important publications on which the study is based has been reviewed here mainly under three headings viz. resistance to bacterial wilt, genetic analysis of yield and its components and relationship of yield and resistance Solanaceous vegetables.

1) Resistance to bacterial wilt.

a) Nature of the disease.

After a detailed survey of incidence of bacterial wilt caused by Psuedomonas solanacearum, Kelman (1953) has admitted that it is one of the important diseases, affecting Solanaceous vegetables in temperate, subtropical and tropical regions of the world. In India, the bacterial wilt disease is serious in parts of Karnataka, Kerala, Orissa, Maharashtra, Madhya Pradesh, Bihar and West Bengal (Anon., 1974). Shekhawat et al. (1978) observed that the causal organism of bacterial wilt is endemic in India, throughout the west coast, central and deccan plateau of Karnataka, western Maharashtra and MadhyaPradesh, the eastern plains of Assam, West Bengal, Orissa and Chotta Nagpur plateau on potato, tomato, brinjal, chillies and wild datura, the incidence being 10 to 50%. Rao and Sohi

(1977) after conducting a survey on bacterial wilt in brinjal have reported that the incidence ranges from 15 to 60%, during the different seasons. Field losses upto 62.5% occur when brinjal is cultivated in wilt affected areas (Das and Chattopadhyay, 1955). Total destruction of the crop is also not very uncommon.

Jones et al. (1926) have observed that bacterial wilt disease is favoured by high temperatures and is limited to areas and seasons during which such high temperatures are prevalent. Shekhawat et al. (1978) have reported that the disease was more wide spread in heavy and acidic soil (pH 3.5 to 6.9) than in light and neutral to alkaline soils.

Hussain and Kelman (1958) have found that the degree of resistance of different strains was almost proportional to the amount of polysacharides produced by each strain. French and Sequeria (1970) have collected 42 strains of P. Solanacearum from solonaceous and musaceous hosts in North and South America and compared them on the basis of size, shape, colonisation and slime deposition in isolated colonies grown on a tetrasolium medium and melonin formation in a tyrosine medium. The results indicated similarity as well as differences between isolates from different regions in pathogenicity, colony characteristics and host range. Nesmith and Jenkins (1979) have developed a new selective medium for the isolation and quantification of *P. solanacearum* from soil. The basal medium was derived by modification of the standard TTC medium and the final selective medium was prepared by adding antimicrobial compounds at the time of use.

Wallis and Truter (1978) have studied the histopathology of tomato plants infected with *P. solanacearum* with emphasis in ultra structure, through electron microscopy which revealed that, initially only small diameter, cells adjacent to large vessels were invaded, the vessels remaining bacterium free. Some of these cells were stimulated to form tyloses which bulged into the vessels. Bacteria migrated into the tyloses, many of which were ruptured 48 to 72 hours after inoculation liberating the organism and non cellular materials into the vessels. At this time plants began to show the first signs of wilting. Within vessels, bacterial multiplication and spread was rapid and was accompanied by accumulation of large amounts of fine granular materials identified as bacterial extra cellular polysacharides and this is considered as the major cause for the sudden wilting of the plant.

b) Screening techniques.

Many authors have suggested different techniques of innoculation. Winstead and Kelman (1952) have stated that inoculation with pure culture is done mainly by one or a combination of the following methods.

i) Forcing a sharp needle into the stem through a drop of bacterial suspension placed in the axil of the second or third expanded leaf below the stem apex.

ii) Cutting the lateral roots with a scalpel along one side of the plant to a depth of approximately 4 cm and pouring 10 ml of bacterial suspension over the severed roots.

iii) Dipping the roots in a bacterial suspension. Following inoculation, soil moisture was maintained at high levels and temperature held above 30^{o}c. Disease reading was usually made at weekly intervals by classifying each plant to one of the following numerical grades.

Symptom	Grade
No symptom	0
One leaf partially wilted	1
Three leaves wilted	2
All except top 2 or 3 leaves wilted	3
All leaves wilted	4
Dead	5

The number of plants in each symptom category was multiplied by the corresponding numerical grade and the products added. The summation was converted to a disease index value by dividing with the maximum numerical grades for the given number of plants and multiplied by 100.

Gopimony (1968) screened brinjal plants for resistance to bacterial wilt by the sick soil method which consisted of growing the plants in pots containing wilt sick soil collected from the field from where the brinjal plants were recently grown and affected by wilt. Sreenivasan et al. (1969) described a method in which a streak was made at the basal part of the stem of each plant with a sterilised needle and a drop of bacterial suspension prepared from wilted plants placed on it. Cotton wool dipped in sterile water was wound round the stem at the site of the streak. The plants were irrigated with water mixed with chopped up pieces of wilted brinjal plants.

Kuriyama (1975) has reported methods for the establishment of an infected field and for seedling testing. To establish an infected field, brinjal was planted in a good moisture retensive field. When the soil temperature rose above 25°c, 100 ml of the inoculum was injected several times into the soil near each plant at intervals of one month. In the next year and afterwards, soil injection of the pathogen once a year resulted in the occurance of the disease in nearly all plants of the susceptable variety.

For testing seedlings, Kuriyama (1975) used the improvised sand culture method. The seed bed consisted of sand. Culture solution kept at a temperature of 25 to 30°c was sprinkled and circulated in the soil. Five leafed seedlings, with roots washed in water and submerged in inoculum, were planted in the seed bed which was kept at 30°c. Disease resistance could be detected after three to six weeks. Rao et al. (1976) suggested that screening of brinjal types can be done by growing them in a naturally wilt infested soil with a susceptable variety alternated with every two rows of the test variety.

Nilesan (1956) has reported a green house method of inoculation of P. solanacearum as an indicator of field resistance. A highly significant correlation was found between the indices of disease in 16 inoculated selections grown in the green house and the percentage of diseased plants of the same selections grown in the field under infected conditions. Mak and Vijiarungam (1980) have stated that the survival percent in the field is usually higher than that in the green house.

c) Sources of Resistance.

Evaluation of brinjal varieties for resistance to bacterial wilt has been made in several countries, and some resistant varieties are available in Puerto Rico (Nolla, 1931; Rogue, 1941), Phillipines (Anonymous, 1962; Empig et al., 1962), Ceylon (Park and Fernande, 1940), South Africa (Wager, 1946), Japan (Kuncida, 1953; Suzuki et al., 1967) and Martinique (Daly, 1972; 1973). Suzuki et al.,(1967) reported that among the varieties tested in Japan, Taiwan Nuga was the most promising resistant variety.

In India, Sreenivasan et al., (1969) have reported a wild variety Solanum melongena var. insanum as resistant to bacterial wilt. Khan, (1974) after screening several brinjal varieties concluded that the varieties, Long Purple

Udipi, Improved Muktakeshi, Purple Long and Pusa Purple Cluster are resistant to *Psuedomonas solanacearum*. Gowda *et al*., (1974) assessed the reaction of 12 brinjal varieties to wilt infection and found that a variety, Gulla was resistant. Rao and Sohi (1977) reported that Pusa Purple Cluster, a commercial variety was resistant to the wilt disease. Out of 76 lines of brinjal screened for resistance to bacterial wilt, the variety SM-6 from Annamalai was high yielding and resistant under field conditions (Anon., 1980).

Two other wild species, S. *torvum* and *S. xanthocarpum* were resistant to bacterial wilt as reported by Khan (1974). Gopimony and George (1979) in a study, screened 36 forms of *S. melongena* including two wild forms for resistance to *P. solanacearum* and found that only a small fruited wild form *S. melongena* var. *insanum* was completely resistant.

Ninteen brinjal cultivars, including five wilt resistant types obtained from USA and Phillipines, were screened by Rao *et al*.,(1976), through field evaluation followed by artificial inoculation. Under glass house conditions, only Dingaras Multiple Purple and Sinampiro (both from Phillipines) and Pusa Purple Cluster (India) were completely resistant. The other exotic resistant types were either moderately resistant or susceptable under field conditions. Sitaramaiah et al., (1981) reported that Pusa Purple Round, Vijay hybrid, Banaras Giant Green and Pusa Purple Cluster were highly resistant.

d) Breeding for resistance to bacterial wilt.

Daly (1970, 1972, 1973) reported that in crosses between a tolerant Ceylonese variety and susceptable cultivars, the F_1, F_2 and back cross progenies contained a high proportion of tolerant plants. He further reported that homogenous lines were obtained from the above crosses through pedigree selection. These lines showed less than 15% of bacterial wilt incidence, 75 days after planting.

Gopimony and Sreenivasan (1970) have reported that the hybrids of a cross between cultivated brinjal varieties and the wild variety S. melongena var. insanum were completely resistant to bacterial wilt. Jenkins (1974) studied the interaction of Meloidogyne incognita on bacterial wilt incidence in egg plant and reported that the nematodes had no apparent effect on wilt development.

Rao and Anilkumar (1980) reported that the hybrids of a cross between S. melongena and S. indicum were found to exhibit resistance under field conditions to wilt, fruit rot, leaf mosaic virus and brinjal fruit borer.

Gopimony (1983) worked on breeding for bacterial wilt resistance in egg plant. Seeds from a cross between wild *Solanum melongena* var. *insanum* and *solanum melongena* were irradiated with gamma rays. Three M_2 populations derived from selected M_1 plants of low, moderate and high pollen sterility were examined. Nine large fruited mutants were recovered from the moderately sterile population and one from the highly sterile one. Further selection up to the M_7 under conditions of infection with *P. Solanacearum* gave 11 resistant types.

Sheela *et al*., (1984) evaluated 34 *Solanum melongena* breeding lines and one from each of *S. indicum*, *S.macroporum*, *S. integrifolium* and *S. sisymbrifolium*, in the field for resistance to *P. solanacearum*. Seven *S. melongena* lines and *S. integrifolium* were immune to the attack. Significant differences between genotypes were observed for plant height, fruits per plant and fruit weight per plant. A prickly line SM-6-1 with long purple fruit was immune.

e) Genetics of resistance to bacterial wilt.

Many Japanese workers have suggested a polygenic mode of inheritance for wilt resistance. Suzuki et al., (1967) suggested that both in tomato and brinjal, resistance to *P. solanacearum* was determined quantitatively. Kuriyama (1975) stated that breeding a completely resistant strain of brinjal against bacterial wilt might be difficult because of the involvement of polygenes. Yamakava (1976) was of the opinion that it is very difficult to breed a variety which combine high resistance and good agronomic characters.

Indian workers are however of the opinion that bacterial wilt resistance is inherited monogenically. Based on the genetic analysis of the segregation pattern for wilt resistance in the back cross generation involving cultivated brinjal varieties and the wild type *S. melongena* var. *insanum*, Swaminathan and Sreenivasan (1971) have reported that wilt resistance in the wild variety was dominant and monogenic in nature. Vijayagopal and Sethumadhavan (1973) also have reported that resistance to *P. solanacearum* was under monogenic control. Rao and Anilkumar (1980) observed that hybrids obtained by crossing the cultivar, Pusa Purple Long and *S. indicum* exhibit resistance under field conditions. Gopimony (1983) studied the inheritance of bacterial wilt resistance in brinjal and concluded that it is monogenically controlled. This character was confirmed to be purely of a qualitative nature from screening results of F_3M_3 families.

Russel (1978) observed that resistance to P. solanaceanum has been reported to be dominant by some workers and recesiva by some others. However, the expression of resistance can be greatly influenced by environmental factors.

2) Genetic analysis of yield and it's components in brinjal.

Gotoh (1964) conducted a series of genetic studies and reported that the minimum number of genes, governing shape and weight of fruit and period from sowing to flowering are calculated as five, nine and four respectively.

Lal et al.,(1971) have studied the variation in agronomic traits through a seven variety diallel cross and estimated the number of effective factors, governing important characters such as fruit length, number of fruits per plant, plant height and days to flowering. They have also reported that weight of fruits per plant was governed by dominant gene action.

Dhesi et al., (1964) studied heritability of some characters in brinjal and found that the number of branches per plant, number of fruits per plant, fruit weight and fruit length had high heritability. Eldin (1967) studied the inheritance of certain quantitative characters and found that heritability estimates in the broad sense for plant height, number of days to first flowering, fruit shape and yield per plant are high. They also found the partial dominance of tall plants over short and that short plant and early flowering are positively correlated with high yielding ability. They also reported that large fruit was associated with round fruit and with decrease in the number per plant. Eldin et al., (1968) also found partial dominance of tall plants over short, early flowering over late and round fruits over long fruits and that the varieties responded differently to the seasonal changes.

Poter and Singh (1973) conducted a diallel analysis of economic traits in brinjal and found that the plant height and number of fruits per plant were governed by additive gane action, number of primary branches by overdominance and weight of fruits per plant by dominant gene action.

Vijayagopal and Sethumadhavan (1973) in the studies of intervarietal hybrids of S. melongena found that plant height, spread, number of branches, fruit length and protein content were under polygenic control while the degree of spineness was under monogenic dominant gene action.

Gill and Arora (1976) studied the inheritance of quantitative characters in brinjal. The additive gene effects were significant in five crosses for the days taken to flowering, plant height, fruit size and number of fruits per plant and in three crosses for number of branches and in two crosses for yield. The dominance effects were significant in three crosses for days to flowering, number of branches, fruit size index and the number of fruits per plant. There were significant dominance effects in two crosses for yield and in one for plant height. Among the three types of interactions, Additive x Additive interaction was significant and positive in one cross for the days taken to flowering, plant height and fruits size index and in two crosses for the number of fruits and yield. Five crosses had significant additive x dominance components for fruit size index, days taken to flowering and number of fruits per plant and in one cross for yield per plant. The dominance x dominance interaction was significant and positive in three crosses for the number of branches and in two crosses for fruit size index and yield per plant. Transgressive segragants in the F_2s showed that the plants with higher and lower values were present.

Sidhu et al., (1980) worked on genetics of yield components in brinjal. Pusa Purple Long, BR.112, Anshey, R.34 and Sc.126 were crossed in all possible combinations excluding reciprocals. For yield, length of fruit, number of flowers and days to flowering, both additive and dominant gene effects were seen. Dominant alleles were more frequent than recessive alleles for all characters except yield, number of fruits and days to flowering. Heritability estimates varied from 20.9% for yield to 98.8% for fruit length.

Gowda (1977) conducted a diallel analysis of seven varieties of brinjal. Maximum heterosis was seen for the number of fruits per plant. Additive and non additive effects controlled all characters except seeds per fruit for which overdominance was noticed. All characters showed good general and specific combining ability. Narrow sense heritability estimates were 63.48% and 67.48% for number of fruits per plant and number of seeds per fruit respectively.

Singh et al. (1979) did fractional diallel analysis of some quantitative characters in brinjal. Observations on 200 progenies of a diallal cross in *Solanum melongena* indicated that additive gene action is important for number of branches per plant and number of fruits per plant in F_1 and for height and fruit length in F_2. Nonadditive gene action was predominant in the F_1 for height, days to flowering, fruit number per branch and also fruit weight, length and yield per plant. In the F_2 it was nonadditive for branch number per plant and fruit number per plant. Nonadditive gene action predominated both in the F_1 and F_2 for days to flowering, fruit number per branch, fruit weight and fruit yield.

Salimath (1981) did a diallel analysis of nine characters from the varieties Malapur, Pusa Purple Round and four lines. Certain crosses exhibited significant heterosis. All the characters had high estimates of additive and non-additive variance components and high to moderately high, narrow sense heritability estimates.

Cheah et al.(1981) found that canopy spread and total yield per plant showed significant heterosis in the F_1 and F_2. Segregation ratio indicated incomplete dominance of dark purple pigmentation over non purple. Complete dominance of spined calyx over spincless and complete dominance of grooved fruit over smooth, this character involving two loci were reported. Late flowering was partially dominant over early, with number of days to first flowering controlled by nonadditive gene action. Fruit weight in the F_1 was intermediate between that of the parents and the number of loci controlling this character was estimated to be 8. The number of loci controlling fruit shape, length and girth was estimated to be three, three and six respectively.

Toarder et al. (1981) studied the inheritance of some quantitative characters in egg plant. In analysis of the P_1, P_2, F_1, F_2, BC_1 and BC_2 of five single crosses grown at two localities, nonallelic gene effects were detected for yield and nine yield components. High estimates of heritability and genetic gain were seen for fruit number and yield. Dominance effects were more important than additive effects for most of the characters. F_2 means showed high inbreeding depression.

Borikar et al. (1981) conducted diallel analysis in brinjal and found that additive genetic effects predominated for yield per plant, plant height and number of branches per plant.

Genetic analysis of yield and it's components in the egg plant was done by Sale-huzzaman and Alam (1983). Data from the P_1, P_2, F_1, F_2, BC_1 and BC_2 generations showed that additive gene effects predominated for fruit weight while dominance and duplicate epistasis were most important for fruit number and yield. Estimated narrow sense heritability was high for fruit number, moderate for fruit weight and low for fruit yield.

Dixit et al. (1984) studied the gene action for yield characters in egg plant. Analysis of data on yield per plant and 5 yield related characters in the F_1 of an 8 x 8 diallel set showed both additive and non additive type of gene action for yield per plant, fruits per plant and plant height. Additive gene action was important for length, circumference and weight of fruit. There was partial dominance for all characters except yield per plant and plant height, which were controlled by over dominance and complete dominance. Yield per plant, circumference and weight of fruit were mainly determined by dominant alleles.

Singh et al. (1982) made a note on the degree of dominance and parental mean performance in brinjal. Yield per plant and five yield components were investigated. Dominance was assessed for all characters on the basis of mean values for hybrids compared with mean parental value. Two crosses showed overdominance for all characters except yield per plant. All the five crosses showed overdominance for all characters except fruit length, for which dominance was partial. Another two croses showed partial dominance for all characters, except yield per plant.

For improvement of yield and it's components, an understanding of correlation has been very useful. Srivastava and Sachan (1973) conducted a study of correlation and path-analysis in brinjal. Study of yield and six related characters in 25 varieties of Solanum melongena indicated that yield per plant had significant negative correlation with weight of fruits, but had low relation with other characters. The high negative correlation of weight of fruits may be due to it's negative correlation with number of fruits per plant. Number of branches showed very high negative correlation with yield but path coefficient show that the direct effect on yield is negligible.

Singh et al., (1974) conducted correlation and path analysis study in brinjal. He found that yield is positively correlated with fruit length, number of fruits per plant and fruit weight, but negatively with days to flower, plant height and fruit width. Fruit width showed highest direct effect on yield per plant followed by length of fruit and fruit weight which influenced yield through days to flower. The number of fruits per plant also contributed to yield through fruit length. The correlation study along with path analysis will be useful in selecting characters for good plant type.

Hiremath and Rao (1974) did genetic variability and correlation studies in S. melongena. Studies on seven yield characters in fourteen strains showed high heritability and genetic advance for number of fruits per plant, seed weight per fruit and rind thickness. Yield per plant was highly and positively correlated with number of fruits and negatively with rind thickness.

Sinha (1983) conducted path coefficient analysis for yield and seven yield related characters in nineteen varieties of brinjal. The results revealed high GCV and heritability for number of fruits per plant. Yield was positively correlated with fruits per plant, plant height and branches per plant at the phenotypic and genotypic levels and with fruit length/circumference ratio at the genotypic level.

Genetic variability and correlation studies in egg plant were done by Chadha and Paul (1984). Yield and five yield related characters were investigated in forty varieties.

The highest genetic coefficient of variation were for number of fruits per plant and plant height.

3) Relationship of yield and resistance in Solanaceous vegetables.

Not much work has been done in this connection. In brinjal, Vijiagopal and Sethumadhavan (1973) from the studies of the F_2 generation of an intervarietal cross between cultivated brinjal types and the wild type *S. melongena* var. *insanum* reported that the wilt resistant character of the wild parent is closely associated with small fruit size and hence large fruited resistant segregants were absent, in the resistant selections of the F_2 population.

Mak and Vijiarungam (1980) studied the variability in bacterial wilt resistance and interrelationships of some characters of brinjal. Twenty seven varieties were studied in the field for resistance to *Psuedomonas solanacearum* under natural conditions and for thirteen characters including fruit size and yield, and in the green house for resistance using artificial inoculation. Ten varieties had survival rates of 70% in the green house, better four of these were high yielding. Yield per plant was positively correlated with the number of fruits per plant, mean fruit weight, mean fruit length, number of primary branches and number of seeds per fruit. The number of fruits per plant was positively correlated with mean fruit weight.

Volin and Ramosh (1981) worked on the association of brown root rot resistance with yield components and root weight in tomato selections grown in infested and noninfested soils. In 1978-79, eleven selections, one introduction and one cultivar were evaluated on fumigated and unfumigated naturally infected land. On unfumigated land, D 76057 D1 had a greater fruit yield and D 76005 D1 had a greater fruit size. Many of the selections had a greater fruit size and greater root weight. All but one of the selections were more resistant than Flora Dade. On funmigated soil no selection was superior in yield to Flora Dade.

Rathaiah (1983) studied yield and reaction to fruit rot, bacterial wilt and Cercospora leaf spot of chilli cultivars. In two year field trials, Capsicum cultivars Suryamukhi, Cluster, Jwala, G_4 and G_5 were assessed for yields and tolerance to Colletotrichum species, P. solanacearum and Cercospora Capsici. The data were tabulated and found that, Suryamukhi was tolerant to all diseases and gave the highest mean yield.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani, Trivandrum during May 1986 to May 1987.

A. Materials.

Seeds obtained by crossing each of the three bacterial wilt resistant brinjal varieties SM-6, SMI-10 and PPC with the susceptable variety Pusa Purple Long as the pollen parent constituted the basic material, for the study. Salient features of the parental varieties are given in Table 1. The varieties are presented in Figure 2.

B. Methods.

a. Collection of selfed seeds from F_1 plants.

Seeds from the three crosses, SM-6 x PPL, SMI-10 x PPL and PPC x PPL and four varieties SM-6, SMI-10, PPC and PPL were sown. Ten healthy seedlings from each type were planted in pots filled with standard potting mixture. Flowers from each of the seven types were selfed. Well developed long styled flower buds which were expected to open on the next day were located in the evening and covered with butter paper covers.

Table 1. Salient features of varieties used as parents.

Sl. No.	Name	Source	Plant type	Pigmentation	Branching	Fruit characters		
						size	shape	colour
1.	SM-6	Vellanikkara	Erect	Pigmented	Moderate	Medium	Oblong	Light purple
2.	SMI-10	Vellayani	Erect	Pigmented	Moderate	Large	Round	Dark purple
3.	PPC	IARI	Erect	Highly pigmented	Moderate	Small	Oblong	Dark purple
4.	PPL	IARI	Semi spreading	Non pigmented	Profuse	Large	Long	Purple

Figure 2 . Varieties used as parents

Figure 2.

The cover was allowed to remain in position for three to four days, until all the floral parts except the ovary had fallen off. In the case of inflorescences, all the upper flower buds were clipped off and only the lower most flower bud was selfed.

The selfed fruits were harvested when completely mature, the maturity being judged by the change in colour of the outer rind. These were kept for about a week inside the chute of a kitchen chimney. The fruits lost water and became soft. The seeds were then extracted by mashing the fruits in water. All the healthy seeds sank to the bottom and these were separated, cleaned and dried initially in the shade and then in the bright sun for three hours. The dried seeds were stored in paper packets for about 15 to 20 days before sowing.

b. Evaluation of the infected F_2 population

The three F_2 populations and four parents were grown in the field with infested soil. The experiment was laid out in RBD with four replications. Each replication consisted of 13 rows of 20 plants each. Each parent was planted in a single row and each F_2 in three rows. Thus there were 20 plants in each parent and 60 plants in each F_2

Selfed seeds of the three F_1s and four varieties were sown in pots filled with standard potting mixture. Healthy seedlings were selected 40 days after sowing and transplanted in the main field in singles at a spacing of 60 x 75 cm. All the agronomic practices as per the package of practice recommendation of KAU were followed (KAU, 1986).

The first symptoms of wilting were noted at the time of flowering. The wilted plants progressively decline and completely dried off in about a week to ten days (Figure 3). Plants with initial symptoms were uprooted and tested for bacterial wilt. The counts of wilted plants were taken at periodic intervals. The extend of infection in the four varieties and three F_2population can be seen in Figre 4 and Figure 5.

The uprooted wilted plants in the early stage of wilting were cut at the collar region and the cut and was dipped in a beaker of pure water. Within minutes the ooze from the cut end turned the water turbid suggesting bacterial infection.

All the surviving plants in the parental

Figure 3. Stages of wilting

a. Early
b. Middle
c. Late

(a)

(b)

(c)

Figure 3.

Figure 4. Extend of wilt incidence in varieties

a. SM-6 b. SMI-10

(a)

Figure 4.

(b)

Figure 4. (contd.) Extend of wilt incidence in varieties

c. PPC d. PPL

(c)

(d)

Figure 4 (contd.).

Figure 5. Extend of wilt incidence in F_2 populations

a. SM-6 x PPL

b. SMI-10 x PPL

c. PPC x PPL

(a)

(b)

(c)

Figure 5.

and F_2 lines were selected as observational plants. The following observations were made on each of the observational plants in the varieties and the F_2 populations

1. Days to first harvest.

The data of first harvest in each observational plant was recorded and number of days from transplanting to first harvest was counted.

2. Days to final harvest.

Number of days taken from transplanting to harvest of the last fruit in each observational plant.

3. Plant height.

Measurements were taken from the ground level to the topmost bud on the main axis of all observational plants on the day of last harvest.

4. Number of fruits per plant.

Fruits were harvested at weekly intervals. The number of fruits obtained in each harvest was recorded separately for each observational plant. The total fruits in each plant till the last harvest gave the number of fruits per plant.

5. Weight of fruits per plant.

The weight of fruits harvested at weekly intervals in each observational plant was added up till the last harvest.

6. Volume of fruit.

The first three fruits from each observational plant were taken and the volume of each fruit determined by water displacement method.

7. Weight of fruit.

The weight of three fruits whose volume has been determined were taken separately and recorded.

8. Weight/volume ratio.

The weight of three fruits from each observational plant whose volume has been determined were taken separately and weight/volume ratio was computed.

c. Evaluation of the healthy F_2 population

This study was conducted under disease free conditions.

In this experiment also the treatments included the four varieties, SM-6, SMI-10, PPC and PPL and the three F_2s of the crosses, SM-6 x PPL, SMI-10 x PPL and PPC x PPL.

Standard potting mixture for 200 pots was prepared and the mixture was sterilized by passing steam for 4 hours in an autoclave. This was done to ensure that the soil mixture is free from micro organisms.

Seeds were sown and healthy seedlings were transplanted in pots filled with sterilized soil. The pots were arranged in rows of 12 each. The treatments were allotted in four replications. Each replication had a single row of four varieties with three plants in each variety and three rows of 12 plants for each F_2. All the plants were taken as observational plants and data recorded for eight characters. A view of the healthy population in pots is presented in Figure 6.

d. Statistical analysis.

The data obtained from the two experiments were analysed as follows.

1. Comparison of means and variances.

Mean and variance for each character were computed in the three F_2 populations, both under healthy and infected conditions.

The variance in the F_2 population under healthy conditions

Figure 6. Healthy population raised in pots

Figure 6.

for the eight characters were tested for significance with the respective values in the F_2 populations under infected conditions using the F test.

$$F = \frac{n_1 s_1^2 / n_1 - 1}{n_2 s_2^2 / n_2 - 1}$$

Mean of those characters whose variances do not differ significantly under healthy and infected conditions were compared using the 't' test.

$$t = \frac{\left| \bar{x}_1 - \bar{x}_2 \right|}{\sqrt{\frac{n_1 s_1^2 + n_2 s_2^2}{n_1 + n_2 - 2} \left[\frac{1}{n_1} + \frac{1}{n_2} \right]}}$$

Mean of those characters whose variances differed significantly under healthy and infected conditions were tested using Cochran's test (Saxena and Surendran, 1973).

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Critical difference was obtained by.

$$CD = \frac{t_1 \left[\frac{s_1^2}{n_1}\right] + t_2 \left[\frac{s_2^2}{n_2}\right]}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

t_1 = t 0.05 value df. $n_1 - 1$

t_2 = t 0.05 value df. $n_2 - 1$

For the comparison of variances irrespective of the scale of measurement, coefficient of variation was calculated.

$$C.V. = \frac{\text{Standard deviation}}{\text{mean}} \times 100$$

2. Variance analysis.

The adjusted means and variance were estimated from the analysis of covariance of the data generated from the RBD in the case of healthy and infected populations with number of plants per plot as ancillary variate (Das and Giri, 1978). Adjusted mean yield of the i-th variety is given by

$\bar{Y} = \bar{y}i - b\ (\bar{x}i - \bar{x})$.

$\bar{x}i$ and $\bar{y}i$ are the observed mean values of plant number and plot yield respectively of the i-th variety.

b - regression coefficient of 'y' on 'x' as estimated from the error line. $\bar{x}$ - general mean of plant number over all the plots in the experiment.

3. Correlation coefficients.

Correlation coefficients were worked out for pair of characters under study in the infected as well as healthy populations and their significance were tested (Fisher and Yates, 1965).

The significance of the difference between correlation coefficients for all characters in the three F_2 populations under healthy and infected conditions was tested by the following criterion.

$$\text{Test criterion} \quad \frac{|zi - zj|}{SE\ (zi - zj)}$$

Where 'zi' and 'zj' are the transformed values of correlation coefficients (Panse and Sukatme 1957).

RESULTS

R E S U L T S

1. Evaluation of Varieties and F_2 populations.

The results of evaluation of the four varieties SM-6, SMI-10, PPC and PPL and the three F_2 populations SM-6 x PPL, SMI-10 x PPL and PPC x PPL with respect to eight different characters, under infected and healthy conditions are given below.

a) Infected population.

The analysis of covariance and the adjusted mean values are presented in Tables 2 and 3.

1. Days to first harvest

The F ratio was not significant which indicated that there was no significant difference between the varieties and F_2 populations for this character. The means of varieties ranged from 65.0 to 88.2 days whereas the means of the F_2 populations ranged from 69.5 to 80 days.

2. Days to final harvest.

Analysis gave a non-significant F ratio for this character also, which revealed that the varieties and the F_2 populations did not differ significantly. Adjusted means for this character ranged from 71.7 to 111.0 days. The varieties had a

Table 2. Analysis of covariance of infected populations (Varieties and F_2s)

Source	Days to first harvest	Days to final harvest	Plant height	Number of fruits per plant	Weight of fruits per plant	Volume of fruit	Weight of fruit	Weight/ volume ratio
	Mean squares							
Treatments (adj.)	483.7	735.0	506.0	9.3	13422.0	1495.0	1061.0	3.3
Error (adj.)	205.2	356.0	409.0	3.3	3966.0	250.0	160.0	1.5
F value	2.36	2.06	1.23	2.82*	3.38*	5.78**	6.63**	2.20

* significant at 5% level ** significant at 1% level

Table 3. Adjusted means in infected populations (varieties and F_2s)

Sl. No.	Treatments	Percentage of survival	Days to first harvest	Days to final harvest	Plant height (cm)	Number of fruits/plant	Weight of fruits/plant (g)	Volume of fruit (ml)	Weight of fruit (g)	Weight/volume ratio
1.	SM-6	40	79.7	111.0	86.0	4.8	211.4	78.7	61.8	0.78
2.	SMI-10	30	88.2	101.5	83.5	5.2	340.2	108.1	83.6	0.77
3.	PPC	30	86.3	97.3	96.0	7.8	259.6	61.4	43.2	0.70
4.	PPL	25	65.0	84.0	66.2	3.7	207.2	90.3	65.2	0.72
5.	SM-6 x PPL	25	69.5	71.7	70.5	2.2	203.0	100.4	77.2	0.76
6.	SMI-10 x PPL	25	75.0	73.3	70.2	3.9	255.3	75.7	53.4	0.70
7.	PPC x PPL	15	80.0	73.8	89.0	3.9	154.8	56.0	40.2	0.71
8.	C.D. (5%)		N.S.	N.S.	N.S.	2.95	102.00	25.60	20.50	N.S.

N.S. Non significant.

higher and wider range from 84.0 to 111.0 days than the F_2 populations with a range of 71.7 to 73.8 days.

3. Plant height.

In this case also the F ratio was not significant indicating that the varieties and the F_2 populations did not differ significantly. The varieties were found to be taller than the F_2 populations though this difference in height was not significant. The means for varieties ranged from 66.2 to 96.0 cm. The range in the F_2s was 70.5 to 89.0 cm. This was very well within the range for varieties.

4. Number of fruits per plant.

The F ratio was found to be significant for this character which revealed that there were significant differences among the varieties and F_2 populations. The variety PPC had the highest number of fruits (7.8) which was on par with the variety SMI-10, which was in turn on par with SM-6, SMI-10 x PPL, PPC x PPL and PPL. F_2 of the cross SM-6 x PPL had the lowest number of fruits per plant.

Within the varieties, PPL had the lowest and PPC had the highest number of fruits per plant. Within the F_2 populations, there was no significant difference. The varieties thus had larger number of fruits per plant ranging from 3.7 to 7.8, than the F_2 populations, which ranged from 2.2 to 3.9. In the cross SM-6 x PPL, the mean number of fruits in the F_2 was lower than the lower parent (PPL). In the cross SMI x PPL, the F_2 mean was in between the parental means closer to that of the lower parent. In the cross PPC x PPL, the F_2 mean was within the parental means very close to the lower parent.

5. Weight of fruits per plant.

The F ratio for this character was found to be significant which indicated that the varieties and the F_2 populations differed significantly with respect to this character. The variety SMI-10 had the highest weight of fruits per plant (340.2 g) which was on par with PPC and SMI-10 x PPL but was superior to the remaining varieties and F_2 populations. The F_2 of PPC x PPL had the lowest weight of fruits per plant (154.8 g).

Within the varieties, SMI-10 was the highest yielder (340.2 g) and PPL (susceptable parent) the lowest yielder (207.2 g). Within the F_2 populations SMI-10 x PPL had the highest yield (255.3 g) and PPC x PPL (154.8 g), the lowest. In general, the F_2 populations were poor yielders than the parental varieties. In the cross SM-6 x PPL, the F_2 population had lower mean weight of fruits per plant than the lower parental variety. In the cross SMI-10 x PPL, the F_2 population mean was within the parental range and close to the mid parental mean. In the cross PPC x PPL also the F_2 mean was much lower than that of the lower parent.

6. Volume of fruit.

The significant F ratio for this character indicated that the varieties and the F_2 populations differed significantly with respect to this character. The variety SMI-10 had the largest fruit volume (108.1 ml) which was on par with SM-6 x PPL and the variety PPL. The F_2 of PPC x PPL had the lowest fruit volume (56.0 ml).

Within the varieties, SMI-10 had the biggest and PPC had the smallest fruits. Within the F_2 populations, SM-6 x PPL had the biggest fruits (100.4 ml.). The F_2 population of SMI-10 x PPL was the second largest and that of PPC x PPL had the smallest fruit. The mean fruit volume in the F_2 populations ranged from 56.0 to 100.4 ml. which was well within the range of means for the varieties (61.4 to 108.1 ml.). In the cross SM-6 x PPL, the F_2 population had a mean fruit volume higher than both the parents. In SMI-10 x PPL and PPC x PPL the mean fruit volume was lower than that of the respective lower parents.

7. Weight of fruit.

The significant F value revealed that the varieties and the

F_2 populations differed significantly with respect to this character. The variety SMI-10 had the highest weight of fruit (83.6 g) which was on par with the F_2 of SM-6 x PPL and the F_2 of PPC x PPL had the lowest fruit weight.

As in the case of fruit volume, the variety SMI-10 had the highest mean fruit weight and PPC had the lowest. Within the F_2 populations, SM-6 x PPL had the highest mean fruit weight but there was no significant difference between the mean fruit weight of the other two F_2 populations. The range of varietal means (43.2 to 83.6 g) overlaps with the range of the F_2 populations (40.2 to 77.2 g). When the three crosses are taken individually, in the cross SM-6 x PPL the F_2 had a slightly higher mean than the perents but the difference was not significant. But in the other two crosses the F_2 means were lower than the respective lower parents.

8. Weight/volume ratio.

The F value was not significant for this character which indicated that the varieties and the F_2 populations did not differ significantly. The mean of the varieties ranged from 0.72 to 0.74 and overlaped with the range for F_2 populations (0.54 to 0.75).

b) <u>Healthy population</u>

The analysis of covariance and the adjusted mean values are presented in Tables 4 and 5.

1. Days to first harvest.

The significant F value revealed that the varieties and the F_2 populations differed significantly with respect to this character. The F_2 of SM-6 x PPL takes the maximum number of days to first harvest (66.5 days) and was on par with the F_2 populations of PPC x PPL and SMI-10 x PPL and also the variety SMI-10. The variety PPL is the earliest bearing (42.3 days).

Within the varieties, PPL takes the minimum SMI-10 takes the maximum number of days to first harvest. Within the F_2 populations, there was no significant difference for this character. In all the crosses, the F_2 populations were late bearing than the respective parents.

2. Days to final harvest.

Significant F value revealed that the varieties and F_2 populations differed significantly for this character. The F_2 of SMI-10 x PPL took the maximum number of days to final harvest (125 days) followed by the F_2 of SM-6 x PPL which was on par with the F_2 of PPC x PPL. The variety PPL, took the minimum number of days to final harvest (64 days).

When compared to the varieties, the F_2 populations had

Table 4. Analysis of covariance of healthy populations (varieties and F_2s)

	Mean squares							
Source	Days to first harvest	Days to final harvest	Plant height	Number of fruits/ plant	Weight of fruits/ plant	Volume of fruit	Weight of fruit	Weight/ volume ratio
Treatments (adj.)	130.0	589.0	680.0	104.7	55454.0	3679.0	731.0	7.5
Error (adj.)	27.4	39.3	43.5	8.1	20300.0	4703.0	164.0	1.9
F value	4.81**	6.59**	15.6**	12.9**	2.73*	0.78	4.45**	3.94*

* significant at 5% level ** significant at 1% level

Table 5. Adjusted means in healthy populations (Varieties and F_2s)

Sl. No.	Treatments	Percentage of survival	Days to first harvest	Days to final harvest	Plant height (cm)	Number of fruits/ plant	Weight of fruits/ plant (g)	Volume of fruit (ml)	Weight of fruit (g)	Weight/ volume ratio
1.	SM-6	100	55.2	73.0	74.0	7.2	401.0	110.0	58.0	0.52
2.	SMI-10	100	61.5	74.0	95.0	6.3	494.0	130.0	85.0	0.55
3.	PPC	100	54.5	81.0	95.0	20.1	662.0	97.0	46.0	0.47
4.	PPL	64	42.3	64.0	57.0	10.1	738.0	137.0	80.8	0.58
5.	SM-6 x PPL	78	66.5	109.0	76.0	5.5	350.0	75.0	70.0	0.93
6.	SMI-10 x PPL	78	64.3	125.0	75.0	14.0	434.0	59.0	68.3	1.21
7.	PPC x PPL	79	66.1	108.0	78.0	10.0	453.0	147.0	61.6	0.41
8.	C.D. (5%)		11.85	15.0	15.0	6.45	324.7	N.S.	29.00	0.090

N.S. Non significant.

a longer harvesting period. Within the varieties, PPC had the longest harvesting period (81 days) and PPL the shortest period (64 days). Within the F_2 populations, the F_2 of SMI-10 x PPL had significantly more number of days to final harvest than the other two F_2s. In all the crosses, the F_2 means were higher than the respective parental means for this character.

3. Plant height.

The analysis showed significant F value indicating that the varieties and F_2 populations differed significantly for this character. The variety SMI-10 was the tallest (95 cm.) which was on par with the variety PPC. The variety PPL was the shortest (57 cm.). There was no significant difference in height between the three F_2 populations. The plant type variation in the three different F_2 populations is given in Figure 7. The means of varieties ranged from 57 to 95 cm. and the means of F_2 populations were within this range (75 to 78 cm.). In the cross SM-6 x PPL, the mean height of F_2 was higher than the taller parent. But in the other two F_2 populations, SMI-10 x PPL and PPC x PPL, the mean were almost the same as the mid parental mean suggesting polygenic inhritance.

4. Number of fruits per plant.

The significant F value indicated that the varieties and

Figure 7. Plant type variation in the healthy F_2 population.

a. SM-6 x PPL

b. SMI-10 x PPL

c. PPC x PPL

(a) (b) (c)

Figure 7.

the F_2 populations differed significantly with respect to this character. The variety PPC had the maximum number of fruits per plant (20.1) which was on par with the F_2 of SMI-10 x PPL. The F_2 of SM-6 x PPL had the lowest number of fruits per plant (5.5) and was on par with the varieties SM-6, PPL, SMI-10 and the F_2 of PPC x PPL. The means of varieties ranged from 6.3 to 20.1 and the means of F_2 populations from 5.5 to 14.0. In the cross SM-6 x PPL, the F_2 mean was lower than the lower parent SM-6. In the cross SMI-10 x PPL the F_2 mean was higher than the mean of the higher parent PPL. In the cross PPC x PPL, the F_2 mean was almost the same as the mean of the lower parent (PPL).

5. Weight of fruits per plant.

The significant F value revealed that the varieties and the F_2 populations differed significantly with respect to this character. The variety PPL was the best yielder (738 g) but was on par with the varieties PPC, SMI-10 and the F_2s of SMI-10 x PPL and PPC x PPL. The F_2 of SM-6 x PPL was the lowest yielder. The mean weight of fruits per plant in the varieties ranged from 401 to 738 g. and means of F_2 populations ranged from 350 to 453 g. Within the F_2 populations, PPC x PPL was the best yielder.

In the cross SM-6 x PPL, the F_2 mean was lower than the lower parent, SM-6. Same was the case in the other two crosses, SMI-10 x PPL and PPC x PPL.

6. Volume of fruit.

Analysis showed non significant F value which revealed that the varieties and the F_2 populations did not differ significantly for this character. The range of means in the varieties was 97 to 137 ml. and in the F_2 populations it was 59 to 147 ml.

7. Weight of fruit.

The significant F value revealed that the varieties and F_2 populations differed significantly with respect to this character. The variety SMI-10 has the maximum weight of single fruit (85 g) which was on par with the variety PPL and the three F_2 populations. The variety PPC had the lowest weight of single fruit. The means of varieties ranged from 46.0 to 80.8 g. and the means of F_2 populations ranged from 61.6 to 70.0 g. Within the varieties, SMI-10 and among the F_2 populations, SM-6 x PPL had the heaviest fruit. In the cross SM-6 x PPL, the F_2 mean was within the parental limits. In the cross SMI-10 x PPL the F_2 mean was lower than both the parents. In the cross PPC x PPL the F_2 mean was closer to the mid parental mean.

8. Weight/volume ratio.

F value was significant which revealed that the varieties and the F_2 populations differed significantly, for this character. The variety SMI-10 had the highest weight/volume ratio (0.78) which on par with the variety PPL. The F_2 of PPC x PPL had the lowest weight/volume ratio. The means of varieties ranged from 0.65 to 0.78 and means of F_2 populations ranged from 0.64 to 0.67. In all the crosses the mean weight volume ratio of F_2 was lower than that of the lower parent.

II. <u>Comparison of means, variances and coefficients of variation in the F_2 populations under healthy and infected conditions</u>.

a) <u>SM-6 x PPL</u>

The mean, variance, and coefficients of variation of each character in the F_2 population of SM-6 x PPL under healthy and infected conditions and their differences are given in Table 6.

1. <u>Days to first harvest</u>.

Mean number of days to first harvest under healthy and infected conditions were 60.7 and 68.0 respectively. The difference was found to be significant. There was moderately high variance under infrected as well as healthy conditions but the difference was not significant. Coefficients of variation were also similar viz. 23.6% under infected and 25.0% under healthy condition.

Table 6. Means, Variances and Coefficients of variation in the F_2 population of SM-6 x PPL under healthy and infected conditions

Sl. No.	Character	Means			Variances			Coefficient of variation (%)		
		Healthy	Infected	Differ-ance	Healthy	Infected	Differance	Heal-thy	Infe-cted	Diffe-rence
1.	Number of days to first harvest	60.7	68.0	7.3*	234.2	258.0	23.8	25.0	23.6	1.4
2.	Number of days to final harvest	89.2	103.0	13.8	64.0	11728.0	11664.0**	9.0	106.1	97.0
3.	Plant height (cm)	78.8	75.0	3.8	262.0	305.0	43.0*	20.5	23.0	2.5
4.	Number of fruits per plant	8.7	4.4	4.3**	19.2	9.1	10.1**	50.4	68.0	17.6
5.	Weight of fruits per plant (g)	598.0	321.0	277.0**	133047.0	55971.0	77076.0**	61.0	74.0	13.0
6.	Volume of fruit (ml)	111.5	116.0	4.5	1540.0	1233.0	307.0	35.0	30.0	5.0
7.	Weight of fruit (g)	79.0	84.0	5.0	770.0	542.0	228.0	34.0	27.5	6.5
8.	Weight/Volume ratio	0.71	0.72	0.0	0.003	0.015	0.012*	8.2	17.0	8.8

* significant at 5% level   ** significant at 1% level

2. Days to final harvest.

The mean number of days to final harvest under healthy and infected conditions did not differ significantly. But the difference in variance under the two conditions was very high and highly significant. The variance under infected condition was about 200 times the variance under healthy condition. This difference was reflected in the coefficients of variation which showed a difference of 97% ie. 9% under healthy and 106% under infected conditions.

3. Plant height.

The mean plant height under healthy and infected condition showed only a difference of 3.8 cm. and it was not significant. But the variance for this character was significantly different under healthy and infected conditions. However, the difference in the coefficient of variation was only 2.5%.

4. Number of fruits per plant.

The mean number of fruits per plant was 8.7 under healthy condition which was significantly higher than the mean under infected condition (4.4). The variance for this character was also significantly higher ie. almost twice under healthy condition as that under infected condition. But the coefficient of variation was only 17.6% more under infected condition.

F_2 distribution for this character is given in Figure 8. From the figure it is clear that the plants with higher number of fruits were less frequent in the infected population.

5. Weight of fruits per plant.

The mean weight of fruits per plant under healthy condition was significantly higher than that under infected condition. The difference was high (277 g) and highly significant. The fruit yield obtained in this F_2 was higher under healthy condition. There was very high variance both under healthy and infected condition. The variance under healthy condition was more than twice the variance under infected condition and the difference was highly significant. On the other hand, the coefficient of variation was only 13% higher under infected conditon.

Frequency distribution of weight of fruits per plant under healthy and infected condition in the F_2 population is given in Figure 9. It can be seen that the number of higher yielding plants was more under healthy than under infected condition. The infected population on the other hand contained more of low yielding plants than the healthy population.

6. Volume of fruit.

The mean volume of fruit did not differ significantly under healthy and infected conditions. There was very high

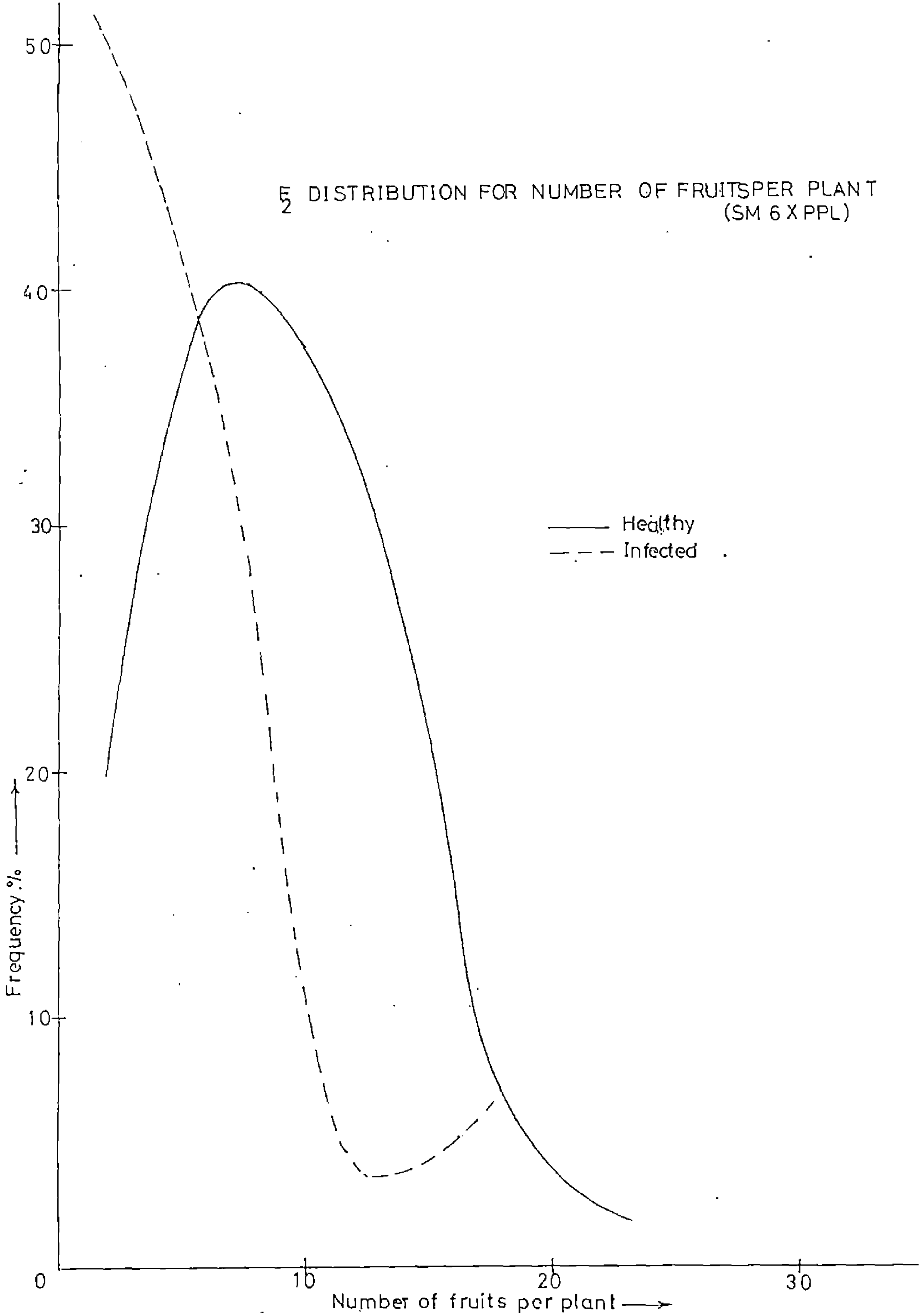

F_2 DISTRIBUTION FOR NUMBER OF FRUITSPER PLANT
(SM 6 X PPL)
Healthy
Infected
Frequency % →
Number of fruits per plant →
0
10
20
30
40
50

Figure 8

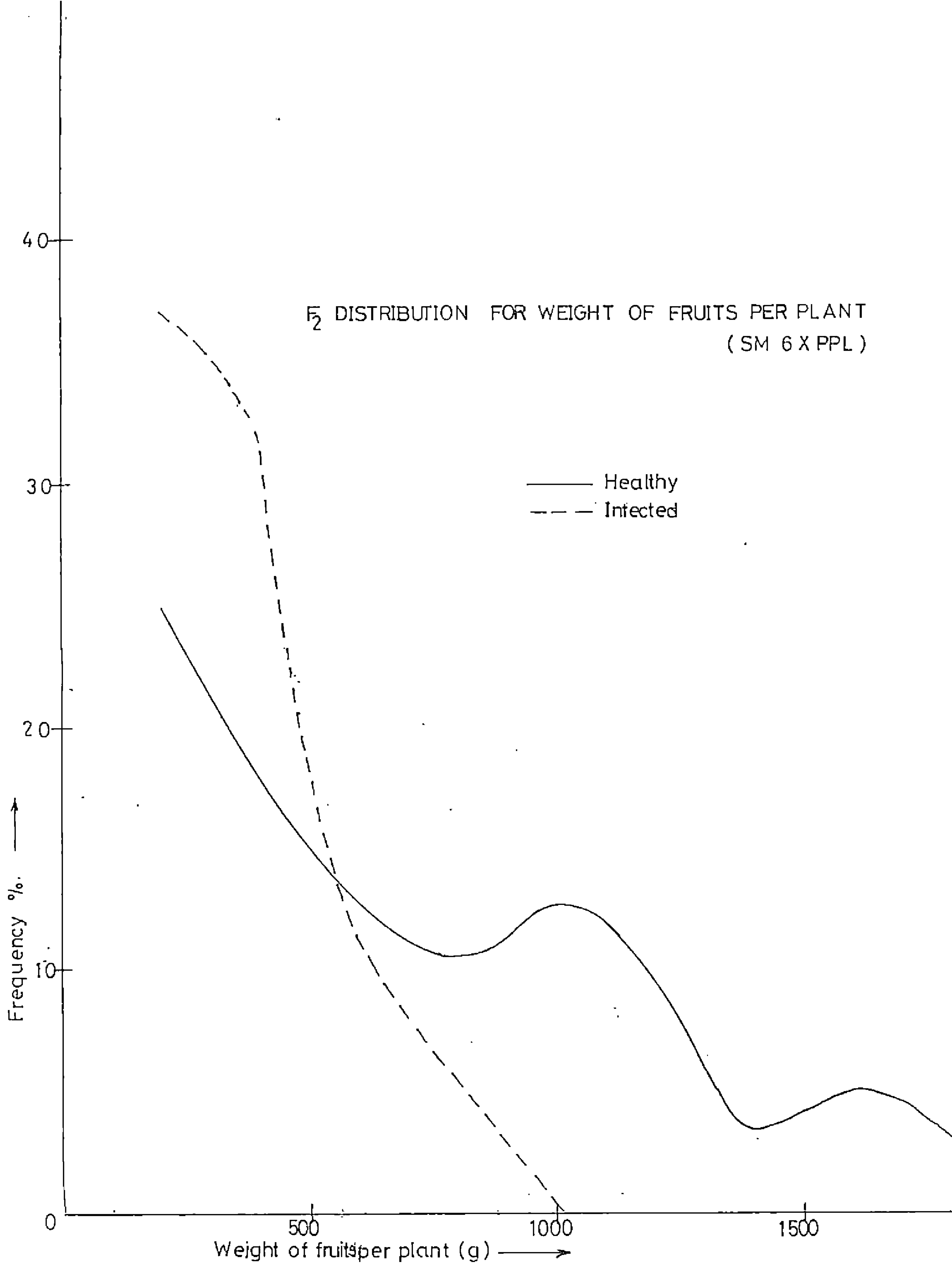

F_2 DISTRIBUTION FOR WEIGHT OF FRUITS PER PLANT
(SM 6 X PPL)
Healthy
Infected
Frequency %.
40
30
20
10
0
500
1000
1500
Weight of fruits per plant (g)

Figure 9

variance for this character under healthy as well as infected conditions. But the difference was not significant. This reflected in the coefficient of variation also, which was 35% under healthy and 30% under infected conditions. The fruit size variation in the healthy F_2 population is presented in Figure 10. F_2 distributions for this character given in Figure 11 also did not show much difference under healthy and infected conditions.

7. Weight of fruit.

Mean weight of fruit under healthy condition differed from that under infected condition, but the difference was not significant. The variance for this character was moderately high under healthy and infected conditions, but they also did not differ significantly. The coefficient of variation under healthy condition was 6.5% more than that under infected condition. Frequency distribution of this character is given in Figure 12 and it can be seen that the infection did not bring about appreciable change in the distribution for this character.

8. Weight/volume ratio.

The mean weight/volume ratio was the same under healthy and infected condition. The variance for this character was very low under healthy as well as infected conditions. But

Figure 10. Fruit size variation in the healthy F_2 population (SM-6 x PPL).

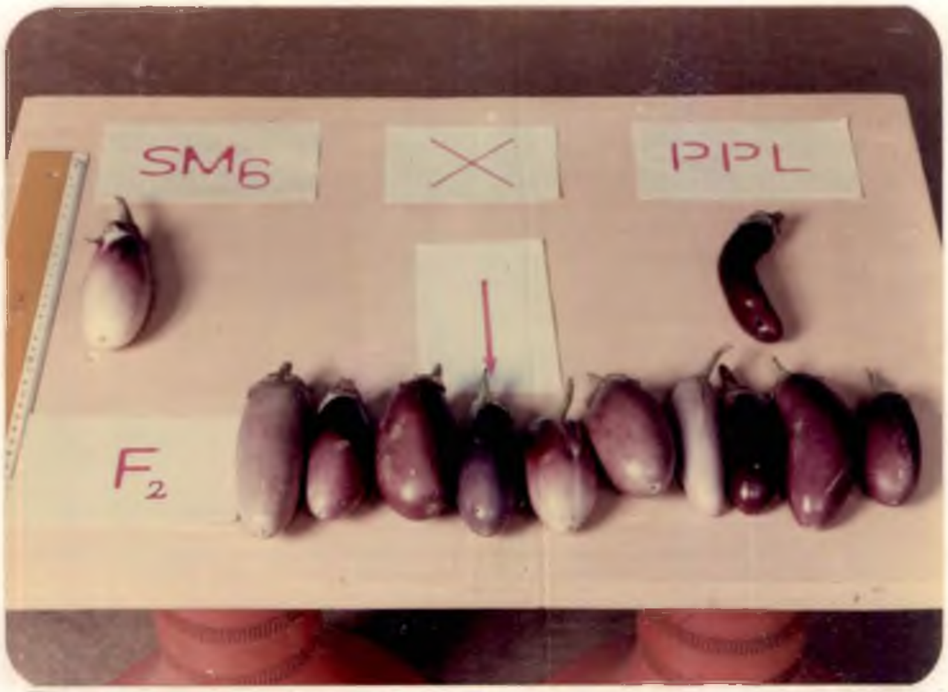
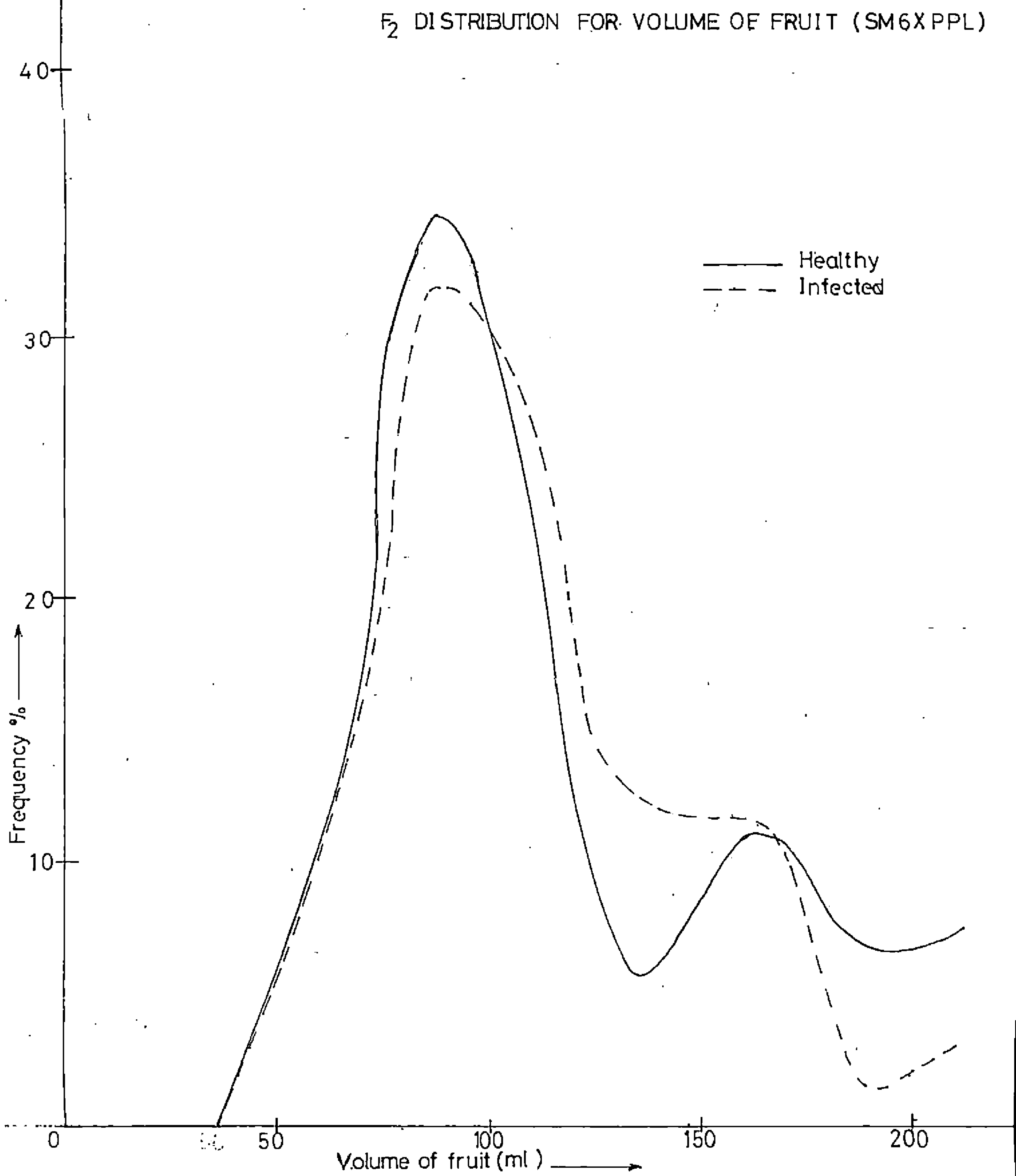


Figure 10.



F_2 DISTRIBUTION FOR VOLUME OF FRUIT (SM6XPPL)
Healthy
Infected
40
30
20
10
Frequency %
0
50
100
150
200
Volume of fruit (ml)

Figure 11

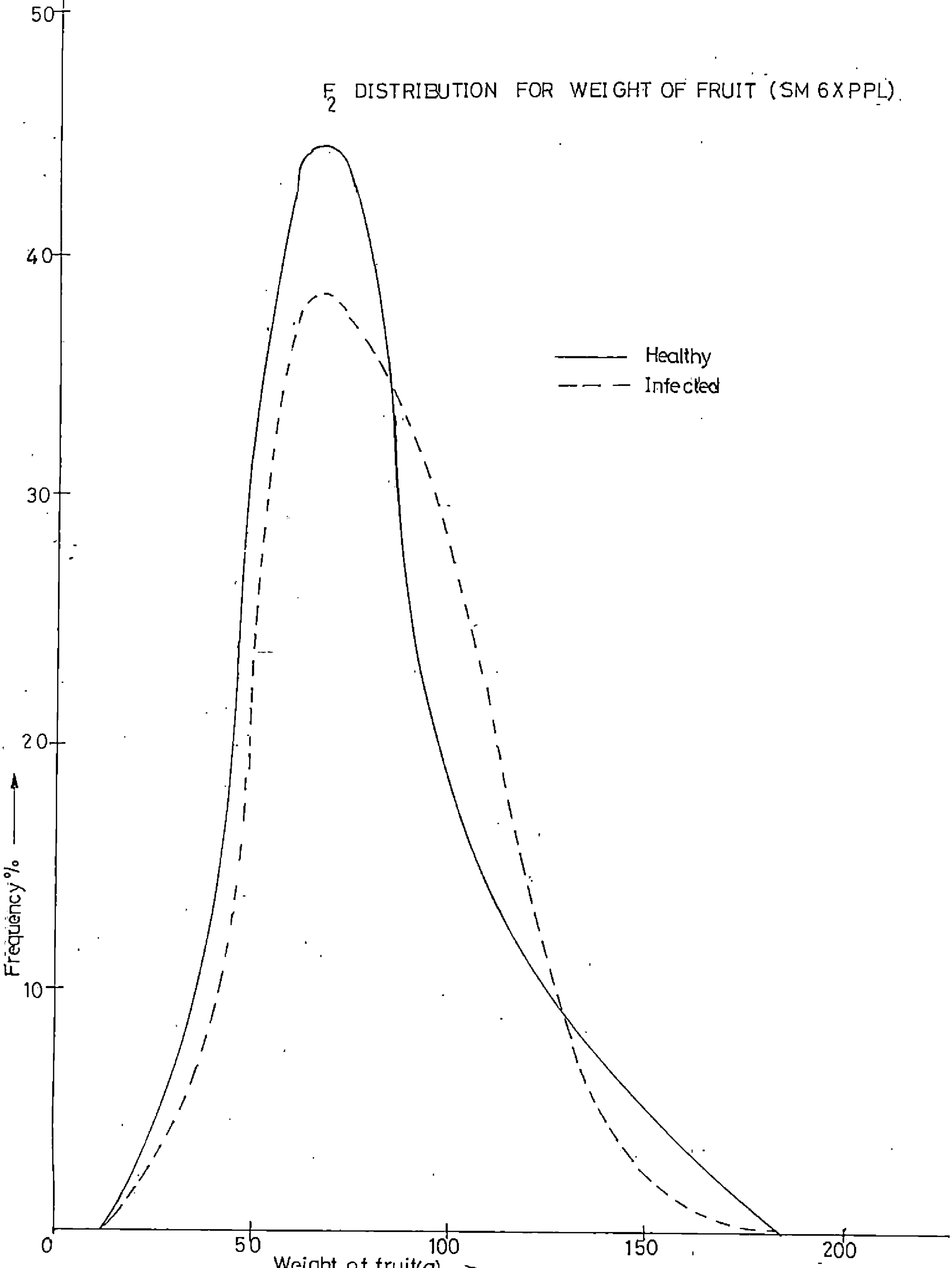

F2 DISTRIBUTION FOR WEIGHT OF FRUIT (SM 6XPPL)
Healthy
Infected
Frequency % →
Weight of fruit(g) →
0
10
20
30
40
50
0
50
100
150
200

Figure 12

the variance under infected condition was significantly higher than that under healthy condition. The coefficient of variation under infected condition was consequently more than twice that under healthy condition.

b) SMI-10 x PPL

The mean, variance and coefficient of variation under healthy and infected conditions in the F_2 population of SMI-10 x PPL are given in Table 7.

1. Days to first harvest.

Mean number of days to first harvest under healthy and infected conditions differed significantly. The mean under infected condition was significantly higher than that under healthy condition. Under infected condition, the plants took about 2 weeks more than under healthy condition to give the first harvest. The variances for this character under healthy and infected conditions were moderately high, but there was no significant difference between them. The coefficient of variation showed only a minor difference (2.6%).

2. Days to final harvest.

The mean number of days to final harvest under healthy and infected conditions differed only by 1.8 days and the difference was not significant. But the variance for this

Table 7. Means, Variances and Coefficients of variation in the F_2 population of SMI-10 x PPL under healthy and infected conditions.

Sl. No.	Characters	Means			Variances			Coefficient of variation (%)		
		Healthy	Infected	Difference	Healthy	Infected	Difference	Healthy	Infected	Difference
1.	Number of days to first harvest	59.0	74.0	15.0**	154.3	306.8	152.5	21.0	23.6	2.6
2.	Number of days to final harvest	95.0	93.2	1.8	35.7	499.6	463.9**	6.2	24.0	17.8
3.	Plant height (cm)	81.0	79.0	2.0	156.0	365.0	209.0*	15.4	24.0	8.6
4.	Number of fruits per plant	13.6	7.2	6.4**	59.7	39.3	20.4	57.0	87.0	30.0
5.	Weight of fruits per plant (g)	701.6	438.3	263.3**	193843.0	167779.0	26064.0	62.8	93.4	30.6
6.	Volume of fruit (ml)	97.5	97.0	0.5	502.0	1611.0	1109.0**	23.0	41.1	18.4
7.	Weight of fruit (g)	70.3	70.0	0.3	340.0	573.0	233.0**	26.2	34.3	8.1
8.	Weight/Volume ratio	0.72	0.72	0.02	0.005	0.007	0.002*	10.0	12.0	2.0

* significant at 5% level ** significant at 1% level

character differed significantly under healthy and infected conditions. Variance under infected condition was about 14 times more than that under healthy condition. This was reflected in the coefficient of variation also which showed an increase of 17.8% under infected than under healthy condition.

3. Plant height.

The difference in mean plant height under healthy and infected conditions was only 2 cm which was non significant. But the variance for this character under healthy and infected conditions differed significantly. The variance under infected condition was more than twice the variance under healthy condition. The difference in coefficient of variation also was high (8.6%) under infected condition.

4. Number of fruits per plant.

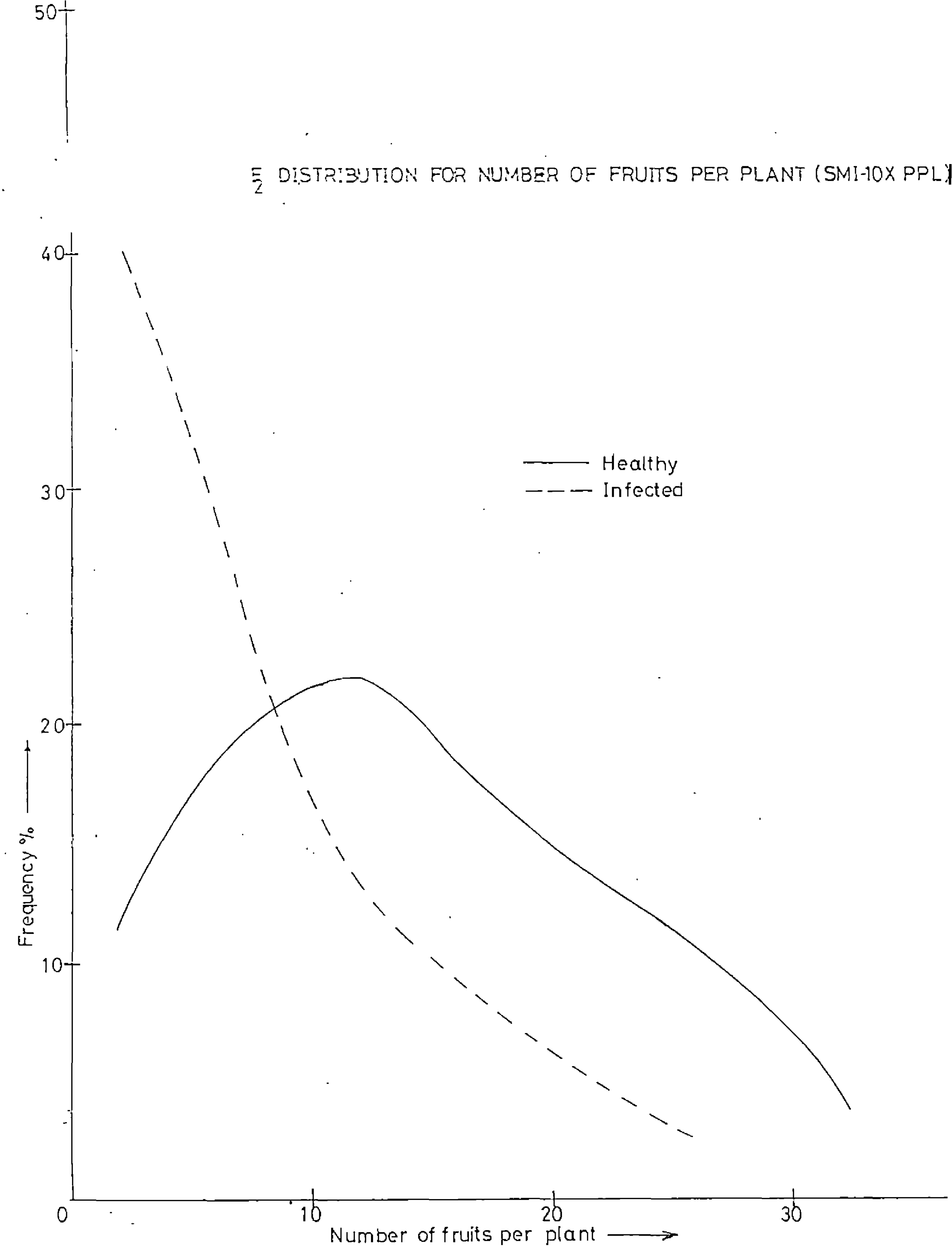
Mean number of fruits per plant under healthy condition was significantly higher than the mean under infected condition. The difference was high ie. 13.6 under healthy and 7.2 under infected condition. But the variance for this character did not differ significantly under healthy and infected conditions. However the coefficient of variation under infected condition was higher than that under healthy condition with a difference of 30%. F_2 distribution for this character given in Figure 13 showed a marked difference under healthy and infected conditions. Number of plants with lesser number of fruits was more under infected condition. The maximum number of fruits per plant under healthy and infected conditions were 33 and 26 respectively.

5. Weight of fruits per plant.

The difference in mean weight of fruits per plant under healthy and infected conditions was high and significant. The variances for this character under healthy and infected conditions were very high, but the difference was not significant. The difference in the coefficient of variation was also high (30.6%). Frequency distribution of weight of fruits per plant under healthy and infected conditions is given in Figure 14. It is seen that the number of higher yielding plants was higher under healthy condition and the number of lower yielding plants was higher under infected condition.

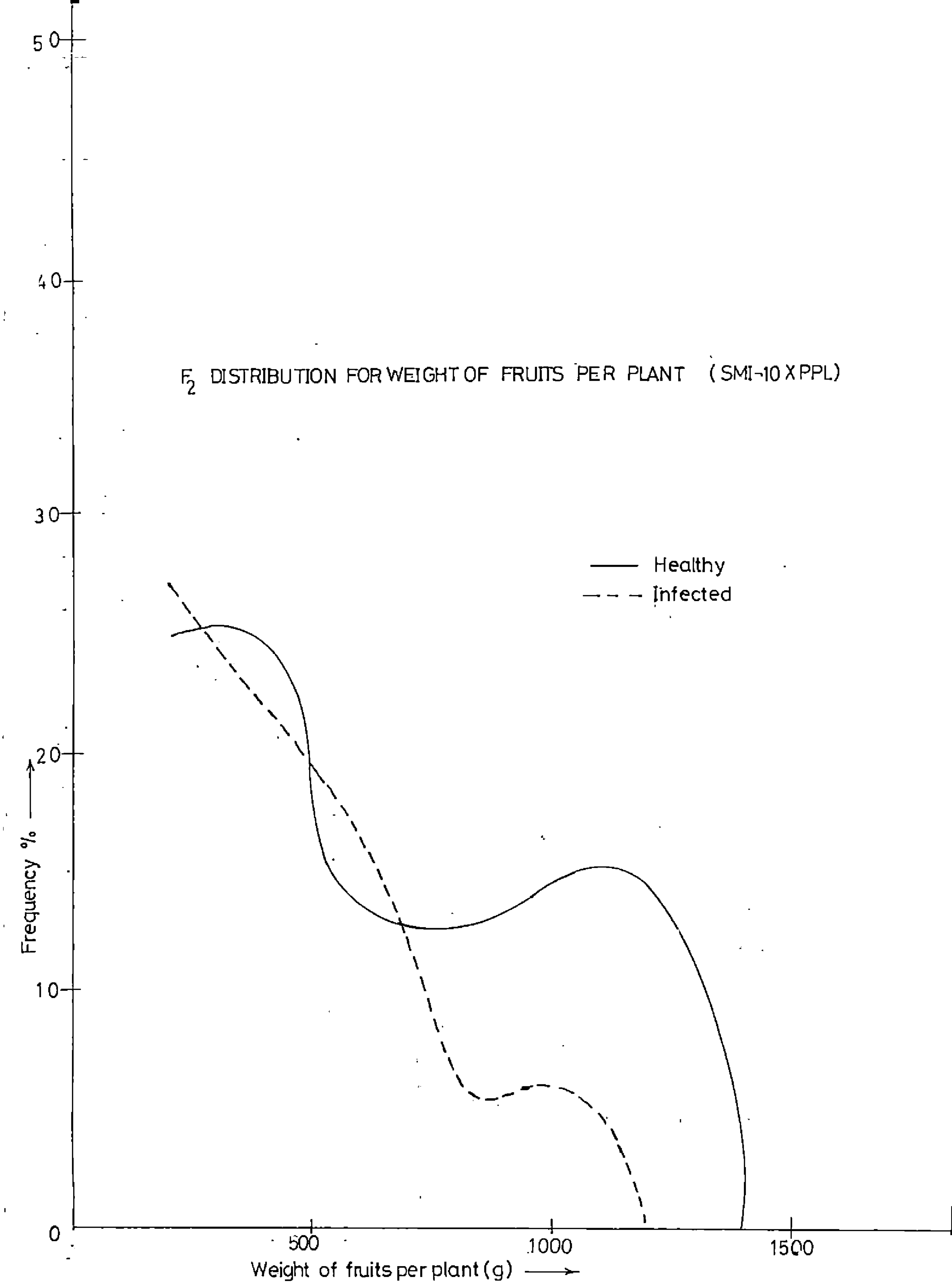
6. Volume of fruit.

The difference in mean volume of fruit under healthy and infected conditions was not significant. But the variance under infected condition was significantly higher than that under healthy condition. Variance under infected condition was more than thrice the variance under healthy condition.



50
DISTRIBUTION FOR NUMBER OF FRUITS PER PLANT (SMI-10X PPL)
40
30
20
10
0
10
20
30
Frequency %
Number of fruits per plant
Healthy
Infected

Figure 13



F2 DISTRIBUTION FOR WEIGHT OF FRUITS PER PLANT (SMI-10 X PPL)
Healthy
Infected
Frequency %
Weight of fruits per plant (g)
0
10
20
30
40
50
500
1000
1500

Figure 14

The coefficient of variation under infected condition was 18.4% more than that under healthy condition. The fruit size variation in the healthy population is given in Figure 15. The F_2 distribution for this character given in Figure 16 showed a slight shift to small size under infected condition. The number of plants with bigger fruits were more under healthy condition.

7. Weight of fruit.

There was no significant difference in the mean weight of fruit under healthy and infected condition. The variance for this character under infected condition was significantly higher than that under healthy condition. This was reflected in the coefficient of variation which showed a difference of 8.1%. F_2 distribution for this character given in Figure 17 also did not show marked change under healthy and infected conditions.

8. Weight/volume ratio.

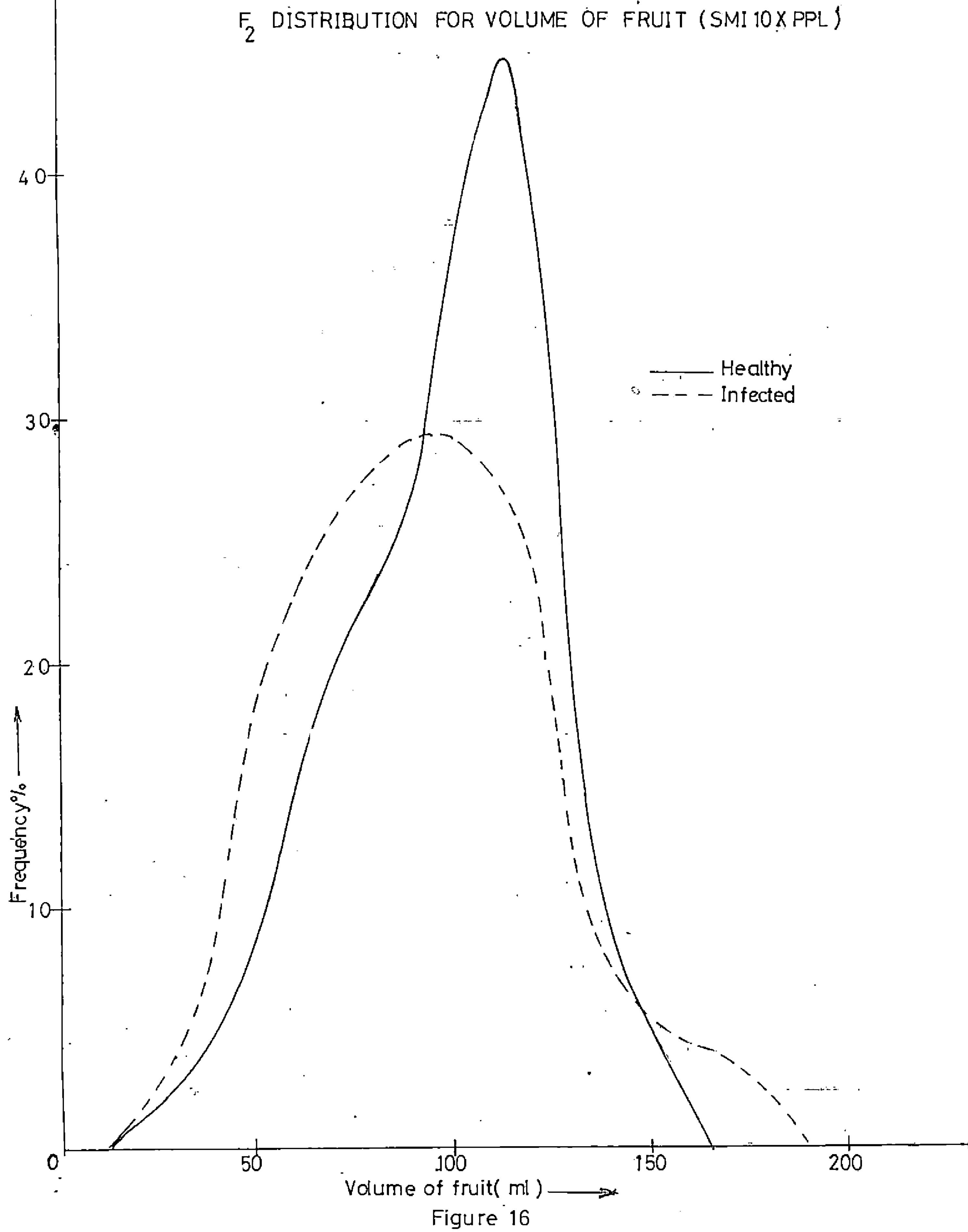
The mean weight/volume ratio did not differ significantly under healthy and infected conditions. But the variance for this character differed significantly eventhough the difference was very small. The coefficient of variation showed a difference of only 2%.

c) PPC x PPL

The mean, variance and coefficient of variation under

Figure 15. Fruit size variation in the healthy F_2 population (SMI-10 x PPL).

Figure 15.



F_2 DISTRIBUTION FOR VOLUME OF FRUIT (SMI 10 X PPL)
Healthy
Infected
Frequency% ⟶
40
30
20
10
0
50
100
150
200
Volume of fruit(ml) ⟶

Figure 16

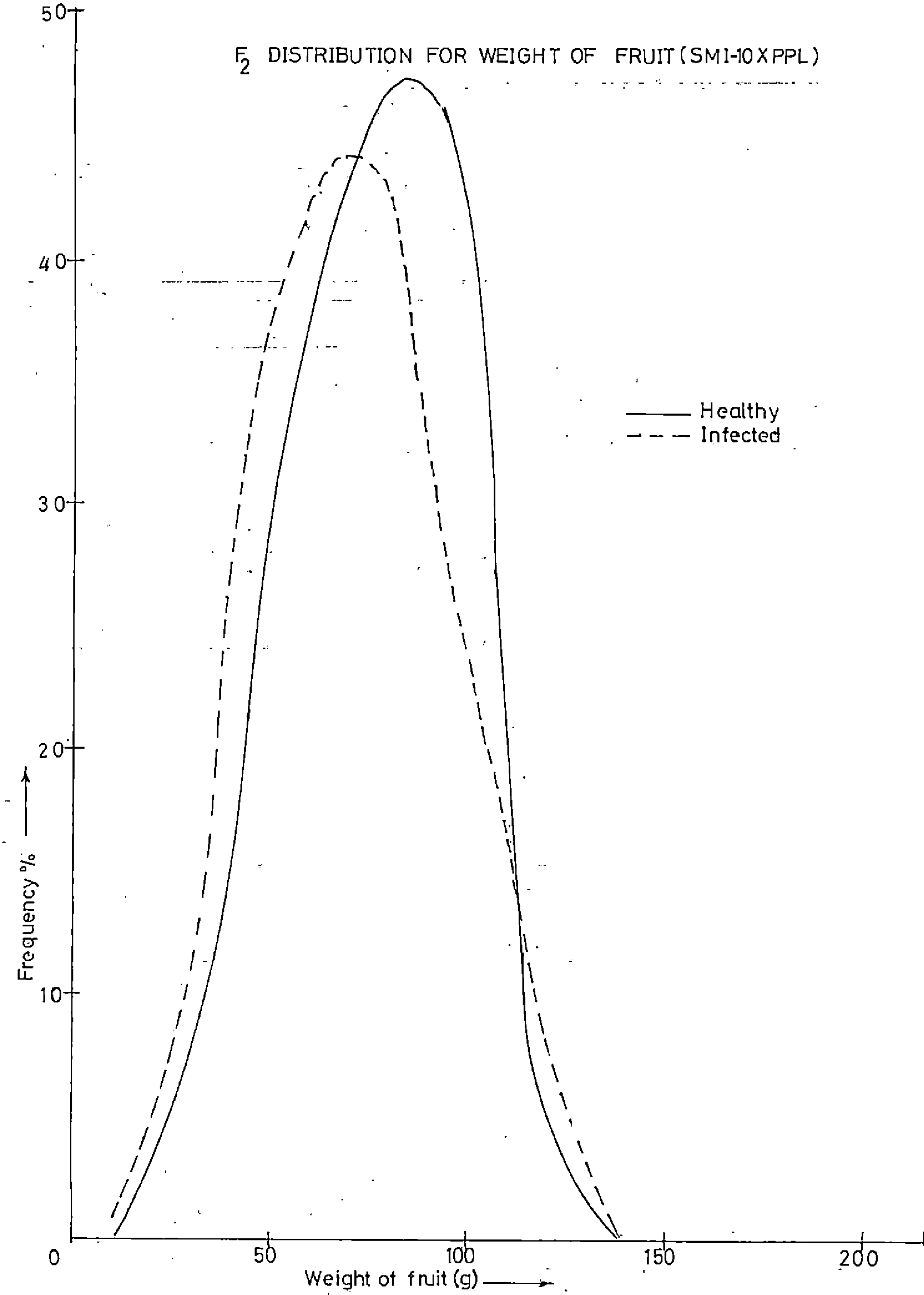

F2 DISTRIBUTION FOR WEIGHT OF FRUIT (SMI-10 X PPL)
Healthy
Infected
Frequency %
Weight of fruit (g)
0
10
20
30
40
50
100
150
200

Figure 17

healthy and infected conditions and their differences are given in the Table 8.

1. Days to first harvest.

The difference in the mean number of days to first harvest under healthy and infected conditions was high and significant. The first harvest under infected condition was delayed by 18.1 days than that under healthy condition. But the variance for this character did not differ significantly under healthy and infected conditions. The coefficient of variation under healthy condition was 8.4% more than that under infected condition.

2. Days to final harvest.

Mean number of days to final harvest under healthy condition was more by only 9 days and this difference was not significant. But the difference in variance for this character under healthy and infected conditions was high and significant. The coefficients of variation showed a difference of 6% with higher value for the infected population.

3. Plant height.

Eventhough the mean height of plant under healthy and infected conditions differed by 7 cm. the difference was not significant. The variance for this character under

Table 8. Means, Variances and Coefficients of variation in the F_2 population of PPC x PPL under healthy and infected conditions.

Sl. No.	Characters	Means			Variances			Coefficient of variation (%)		
		Healthy	Infected	Difference	Healthy	Infected	Difference	Healthy	Infected	Difference
1.	Number of days to first harvest	60.5	78.6	18.1*	150.0	151.0	1.0	24.0	15.6	8.4
2.	Number of days to final harvest	91.0	100.0	9.0	121.0	2211.0	100.0**	9.0	15.0	6.0
3.	Plant height (cm)	84.0	91.0	7.0	216.6	332.5	115.9	17.0	20.1	3.0
4.	Number of fruits per plant	14.0	5.4	8.6**	96.0	11.0	85.1**	71.0	61.4	9.4
5.	Weight of fruits per plant (g)	717.0	249.0	468.0**	186224.0	33628.0	152596.0**	60.2	73.7	13.5
6.	Volume of fruit (ml)	104.0	83.0	21.0*	730.5	2015.2	1284.7**	26.0	54.3	28.3
7.	Weight of fruit (g)	71.5	60.0	11.5	494.0	1097.0	603.0*	31.0	55.0	24.0
8.	Weight/Volume ratio	0.69	0.72	0.04**	7.7	7.1	0.6	12.8	11.5	1.3

* significant at 5% level ** significant at 1% level

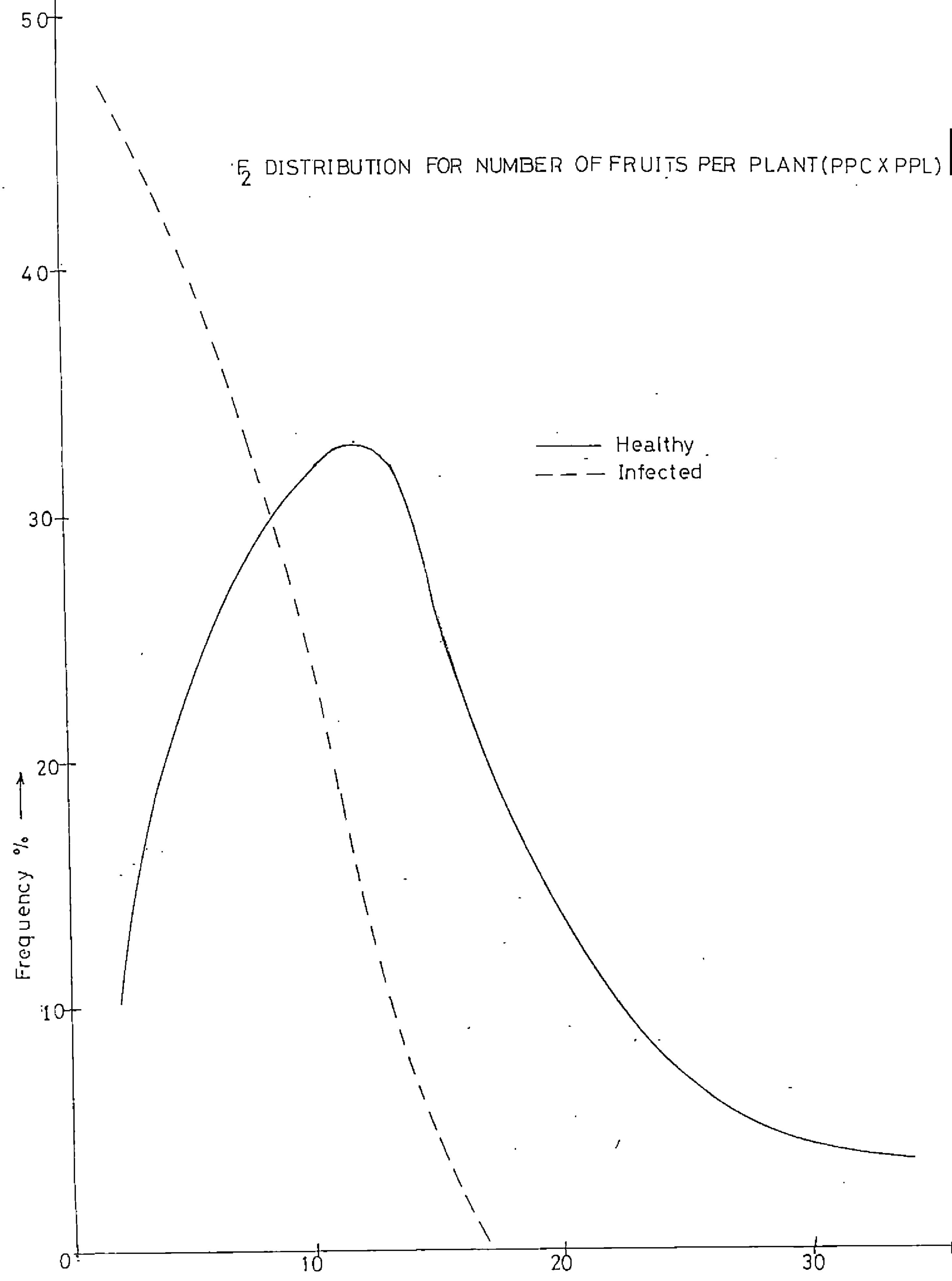
healthy and infected condition also did not differ significantly. The coefficients of variation under infected condition was 3.0% more that that under healthy condition.

4. Number of fruits per plant.

The meen number of fruits per plant under healthy condition was significantly higher and about twice than that under infected condition. There was very high and significant difference in the variance for this character under healthy and infected conditions. The variance under healthy condition was nearly nine times the variance under infected condition. But the coefficient of variation showed a difference of only 9.4%. The F_2 distribution for this character given in Figure 18 showed the marked change brought by infection. The number of plants with higher number of fruits was low under infected condition. The highest number of fruits per plant under healthy condition was 32 where as under infected condition it was only 17.

5. Weight of fruits per plant.

Mean weight of fruits per plant under healthy condition was more than twice the mean under infected condition. There was very high variance for this character under healthy as well as infected conditions. The variance under healthy condition was nearly six times the variance under infected condition, and the difference was highly significant. On the other hand the coefficient of variation under infected



F_2 DISTRIBUTION FOR NUMBER OF FRUITS PER PLANT(PPC X PPL)
Healthy
Infected
Frequency %
Number of fruits per plant
50
40
30
20
10
0
10
20
30

Figure 18

condition was 13.5% more than that under healthy condition. Frequency distributions under healthy and infected conditions are given in Figure 19. As in the other two crosses here also the number of higher yielding plants was more under healthy than under infected condition. The highest yielder gave 1900 g under healthy condition but only 1300 g under infected condition.

6. Volume of fruit.

Mean volume of fruit was significantly higher under healthy condition, by 21 ml. than that under infected condition. Variance for this character under infected condition was significantly higher than that under healthy condition. This was reflected in the coefficient of variation also. The coefficient of variation under infected condition was more than double that under healthy condition. There was a difference of 28.3%. The fruit size variation in the healthy F_2 population is presented in Figure 20. F_2 distribution for this character given in Figure 21 showed that under infected condition, the distribution is shifted to small size suggesting the elimination of plants with higher fruit volume by infection.

7. Weight of fruit.

The mean weight of fruit under healthy condition was

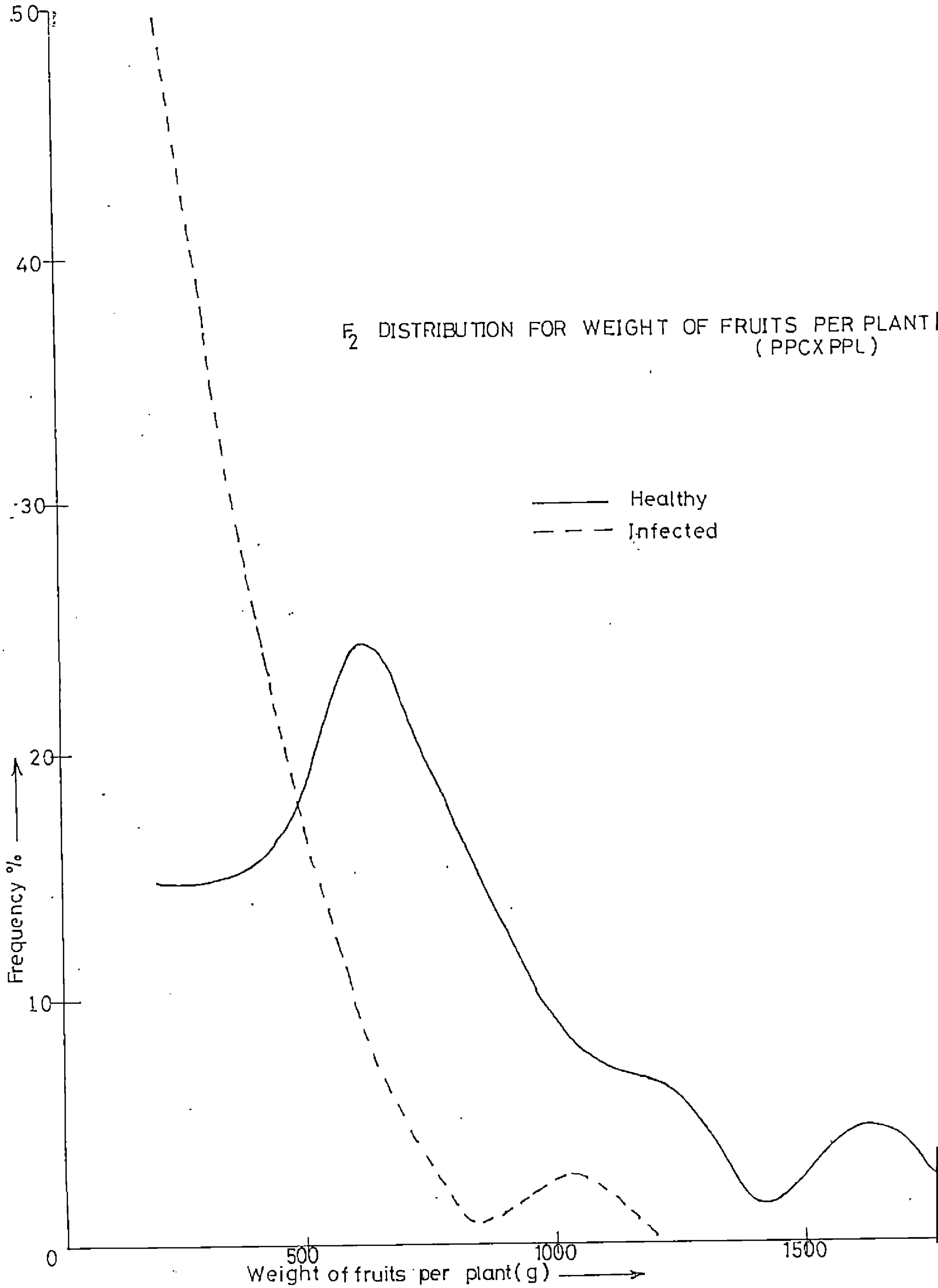

F2 DISTRIBUTION FOR WEIGHT OF FRUITS PER PLANT
(PPC X PPL)
Healthy
Infected
Frequency %
Weight of fruits per plant(g)
0
10
20
30
40
50
500
1000
1500

Figure 19

Figure 20. Fruit size variation in the healthy F_2 population (PPC x PPL).

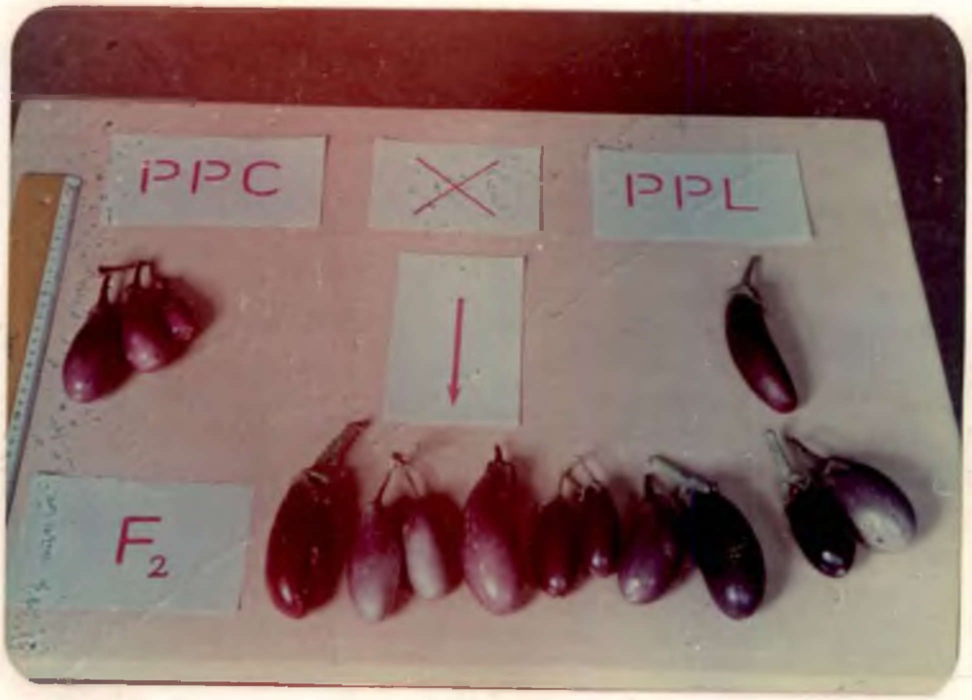
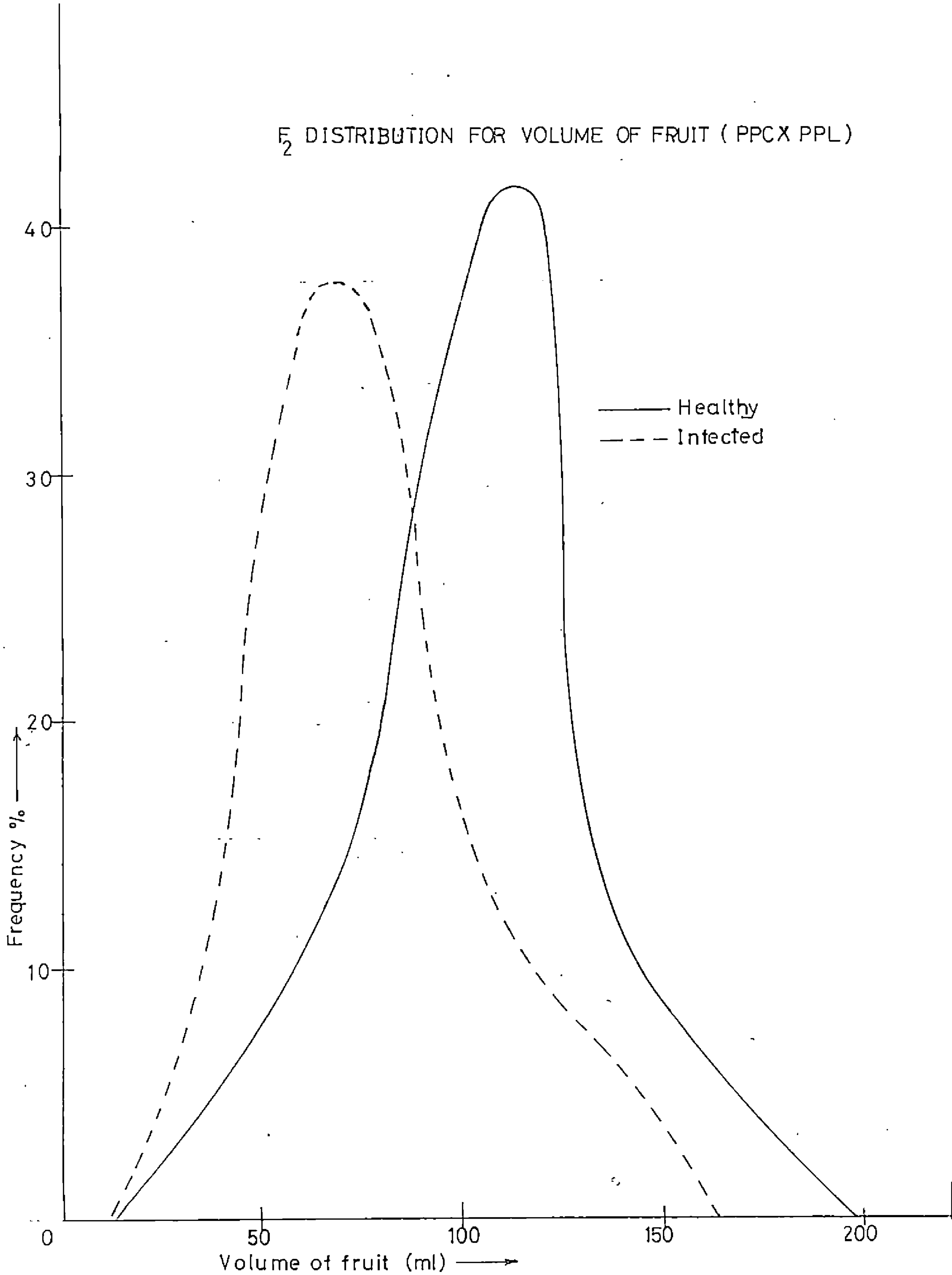


Figure 20.



F_2 DISTRIBUTION FOR VOLUME OF FRUIT (PPC X PPL)
Healthy
Infected
Frequency % →
Volume of fruit (ml) →
0
10
20
30
40
50
100
150
200

Figure 21

higher than that under infected condition but the difference was not significant. The variance under infected condition was very high and significantly higher than that under healthy condition. This was reflected in the coefficient of variation also which under infected condition was 24% more than that under healthy condition. F_2 distribution for this character given in Figure 22 did not show any substantial change under infection.

8. Weight/volume ratio.

Mean weight/volume ratio under infected condition was significantly higher than that under healthy condition. But there was no significant difference in the variance for this character under healthy and infected conditions. The coefficient of variation also did not differ much, it was 12.8% and 11.5% respectively under healthy and infected conditions.

III. Correlations among the various characters in the different F_2 populations under healthy and infected conditions.

The corresponding corelation coefficients in the healthy and infected F_2 populations were compared using the 'Z' test with transformed (Z) values corresponding to the 'r' values.

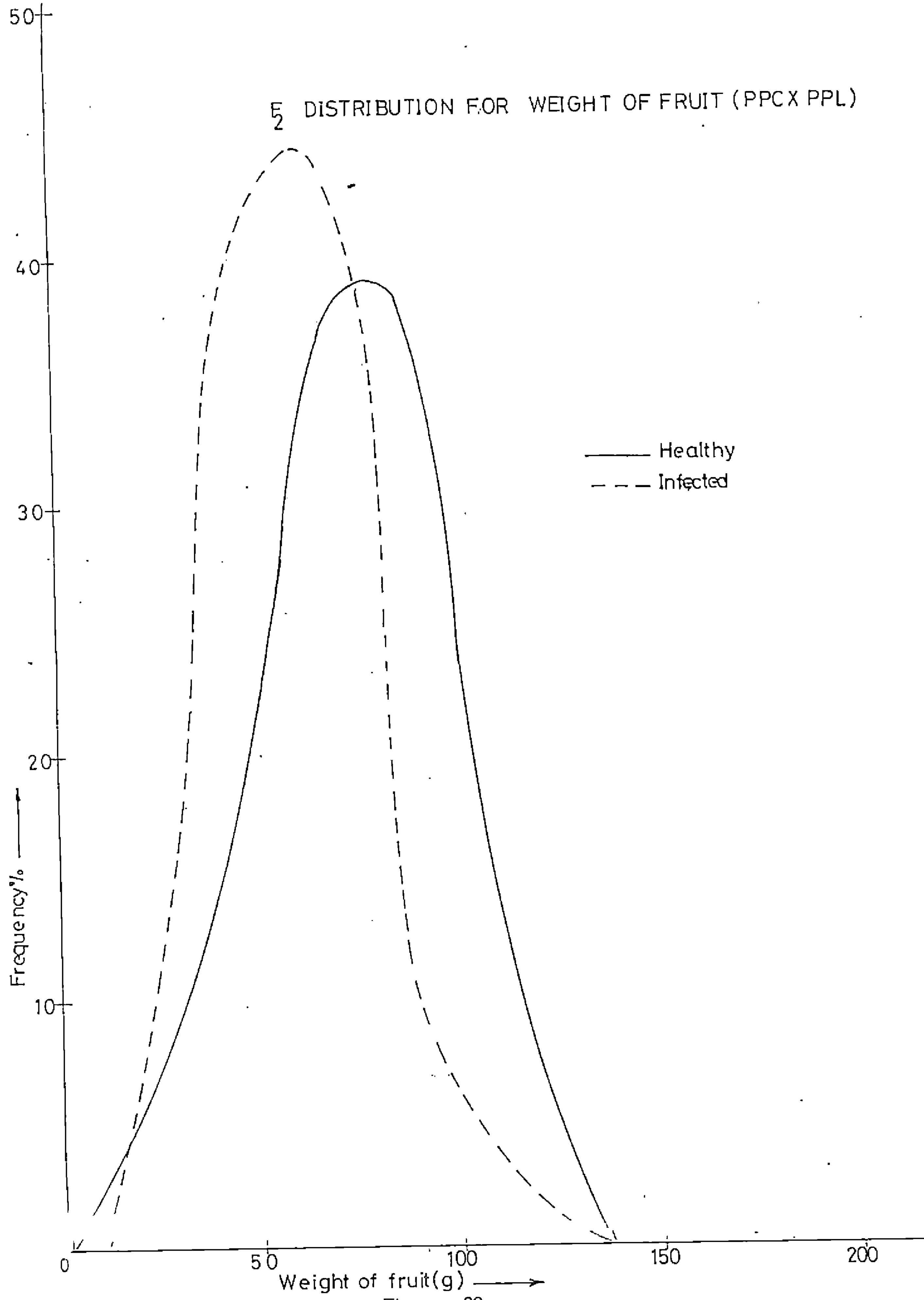

F2 DISTRIBUTION FOR WEIGHT OF FRUIT (PPC X PPL)
Healthy
Infected
Frequency% ⟶
Weight of fruit(g) ⟶
0
10
20
30
40
50
100
150
200

Figure 22

a) <u>SM-6 x PPL</u>

Correlations among the different characters in the F_2 populations of SM-6 x PPL under healthy and infected conditions are given in Table 9.

1. Days to first harvest.

Number of days to first harvest under healthy condition did not have significant positive correlation with any of the other characters. But it had significant negative correlation with, plant height, number of fruits per plant, weight of fruits per plant, volume of fruit, and weight of fruit.

Under infected condition also it did not have significant correlation with any of the other characters.

A comparison of the correlations under healthy and infected conditions revealed that the correlation coefficients of days to first harvest with plant height, number of fruits per plant, weight of fruits per plant, volume of fruit and weight of fruit were significantly different under the two conditions. Number of days to first harvest had high negative correlation with plant height and number of fruits per plant under healthy condition. But under infected condition these correlations were positive but non significant. Correlations of days to first harvest with weight of fruits per plant, volume of fruit

Table 9. Correlation matrix of healthy and infected F_2 populations of the cross SM-6 x PPL (Upper triangle for healthy and lower for infected populations)

Characters	Days to first harvest	Days to final harvest	Plant height	Number of fruits/ plant	Weight of fruits/ plant	Volume of fruit	Weight of fruit	Weight/ volume ratio
Days to first harvest		0.20	-0.42**	-0.47**	-0.65**	-0.33*	-0.33*	0.11
Days to final harvest	-0.08		0.30	0.10	0.08	0.07	0.06	0.03
Plant height	0.09	-0.62**		0.41**	0.64**	0.34*	0.20	0.09
Number of fruits/plant	0.14	-0.04	0.22		0.58**	0.44**	0.34*	-0.02
Weight of fruits/plant	-0.01	-0.03	0.15	0.89**		0.31	0.32*	-0.23
Volume of fruit	-0.08	-0.08	0.05	0.004	0.12		0.58**	0.07
Weight of fruit	-0.09	-0.02	0.12	0.001	0.14	0.89**		0.20
Weight/volume ratio	0.14	0.12	0.16	0.07	-0.16	-0.09	-0.15	

* significant at 5%   ** significant at 1%

and weight of fruit were negative both under healthy and infected conditions. The coefficients were high and significant under healthy condition.

2. Days to final harvest.

This character did not have significant correlation with any of the other characters under healthy condition but the values were mostly positive. Under infected condition the coefficients were mostly negative but significant with plant height only.

3. Plant height.

Plant height under healthy condition had high and significant positive correlation with number of fruits per plant, weight of fruits per plant and volume of fruit. High and significant negative correlation of this character with number of days to first harvest was mentioned earlier.

Under infected condition, it did not have significant correlation with any of the other characters except days to final harvest which was already mentioned. Of the significant correlations, the coefficients with weight of fruits per plant alone differed significantly under healthy and infected conditions.

4. Number of fruits per plant.

It had conspicuous and significant positive correlation with plant height, weight of fruits per plant, volume of fruit and weight of fruit, under healthy condition. But under infected condition, if did not have significant positive correlation with any of the characters except weight of fruits per plant. Significant negative correlation of this character with number of days to first harvest in the healthy population was already mentioned. Of the significant correlations, the coefficients with weight of fruits per plant, volume of fruit and number of days to first harvest were significantly different under healthy and infected conditions.

5. Weight of fruits per plant.

Weight of fruits per plant under healthy condition had high and significant positive correlation with plant height, number of fruits per plant and weight of fruit. It's significant negative correlation with number of days to first harvest was mentioned earlier. Under infected condition it had significant positive correlation only with number of fruits per plant. The correlations with plant height, days to first harvest and number of fruits per plant were significantly different under healthy and infected conditions.

6. Volume of fruit.

Volume of fruit under healthy condition had significant positive correlation with plant height, number of fruits per plant and weight of fruit. Significant negative correlation with days to first harvest was mentioned earlier.

Under infected condition it had significant correlation only with weight of fruit. Of the significant correlations, the coefficients with days to first harvest, number of fruits per plant and weight of fruit were significantly different under healthy and infected conditions.

7. Weight of fruit.

Under healthy condition weight of fruit had significant positive correlation with number of fruits per plant, weight of fruits per plant, and volume of fruit. It had significant negative correlation with number of days to first harvest.

Under infected condition, it had significant positive correlation only with volume of fruit. The correlation under healthy and infected conditions were significantly different with volume of fruit.

8. Weight/volume ratio.

Weight/volume ratio did not have significant correlation with any of the other characters both under healthy and infected conditions.

b) SMI-10 x PPL

The correlation coefficients among different characters in the F_2 populations of SMI-10 x PPL under healthy and infected condition are given in Table 10.

1. Days to first harvest.

In this F_2 population under healthy condition, number of days to first harvest had significant negative correlation with number of fruits per plant, weight of fruits per plant, plant height, weight of fruit and volume of fruit. Under infected condition it had significant positive correlation with days to final harvest and nonsignificant negative correlation with several characters.

The correlations did not differ significantly under healthy and infected condition.

2. Days to final harvest.

Number of days to final harvest under healthy condition had significant positive correlation with plant height, number of fruits per plant, weight of fruits per plant and volume of fruit. Under infected condition it had significant positive correlation only with plant height. Among the significant

Table 10. Correlation matrix of healthy and infected F_2 populations of the cross SMI-10 x PPL (Upper triangle for healthy and lower for infected populations)

Characters	Days to first harvest	Days to final harvest	Plant height	Number of fruits/ plant	Weight of fruits/ plant	Volume of fruit	Weight of fruit	Weight/ volume ratio
Days to first harvest		-0.12	-0.32*	-0.38*	-0.38*	-0.33*	-0.30*	-0.26
Days to final harvest	0.29*		0.42**	0.45**	0.30*	0.34*	0.28	0.09
Plant height	0.01	0.27*		0.34*	0.29	0.34*	0.28	-0.0002
Number of fruits/plant	-0.22	0.21	0.32**		0.76**	0.24	0.28	0.32*
Weight of fruits/plant	-0.18	0.03	0.26*	0.12		0.35*	0.35*	0.28
Value of fruit	-0.17	-0.03	0.04	0.13	0.04		0.96**	0.49**
Weight of fruit	-0.20	-0.09	0.02	0.03	0.10	0.50*		0.65**
Weight/volume ratio	0.04	0.23	0.03	0.02	-0.08	-0.34*	-0.12	

* significant at 5%   ** significant at 1%

values, the correlation with volume of fruit alone differed significantly under healthy and infected conditions.

3. Plant height.

Under healthy condition, plant height had significant positive correlation with number of fruits per plant days to final harvest, and volume of fruit. Under infected condition, plant height had significant positive correlation with days to final harvest, number of fruits per plant and weight of fruits per plant. None of the correlations differed significantly under healthy and infected conditions.

4. Number of fruits per plant.

Number of fruits per plant had significant positive correlation with days to final harvest, plant height, weight of fruits per plant and weight/volume ratio under healthy condition. It also had significant negative correlation with days to first harvest. Under infected condition, it had significant positive correlation only with plant height. Among the significant values, the correlations between number of fruits per plant and weight of fruits per plant differed significantly, under healthy and infected conditions.

5. Weight of fruits per plant.

Under healthy condition, weight of fruits per plant had significant positive correlation with days to final harvest, number of fruits per plant, volume of fruit and weight of fruit. It had significant negative correlation with days to first harvest. Under infected condition it had significant positive correlation only with plant height. Among the significant values, the correlation between number of fruits per plant and weight of fruits per plant only differed significantly under healthy and infected conditions.

6. Volume of fruit.

Volume of fruit under healthy condition had significant positive correlation with days to final harvest, plant height, weight of fruits per plant, weight of fruit and weight/volume ratio. It had significant negative correlation with days to first harvest. Under infected condition, volume of fruit had significant positive correlation only with weight of fruit. Among the significant values, the correlation with days to final harvest, weight of fruit and weight/volume ratio differed significantly under healthy and infected conditions.

7. Weight of fruit.

Under healthy condition, weight of fruit had significant positive correlation with weight of fruits per plant, volume fruit and weight/volume ratio. It had significant negative correlation with number of days to first harvest. Under infected condition it had significant positive correlation only with volume of fruit. Among the significant values, the correlations with volume of fruit and weight/volume ratio alone differed significantly.

8. Weight/volume ratio.

Under healthy condition weight/volume ratio had significant positive correlation with number of fruits per plant, volume of fruit and weight of fruit. Under infected condition it had significant negative correlation with volume of fruit. The correlations of weight/volume ratio with volume of fruit and weight of fruit were markedly different under healthy and infected conditions.

c) PPC x PPL

The correlation coefficients among various characters in the F_2 population of PPC x PPL under healthy and infected conditions are given in Table 11.

1. Days to first harvest.

Under healthy condition, days to first harvest had significant negative correlation with weight of fruits per plant only. Under infected condition it did not have significant correlation with any of the other characters. There was no significant difference in the correlations under healthy and infected conditions.

Table 11. Correlation matrix of healthy and infected F_2 populations of the cross PPC x PPL (upper triangle for healthy and lower for infected populations)

Characters	Days to first harvest	Days to final harvest	Plant height	Number of fruits/ plant	Weight of fruits/ plant	Volume of fruit	Weight of fruit	Weight/ volume ratio
Days to first harvest		0.13	0.09	-0.15	-0.37*	-0.26	-0.14	0.12
Days to final harvest	0.18		0.46**	0.47**	0.39**	0.17	0.19	-0.02
Plant height	0.07	0.003		0.30*	0.22	0.20	0.24	0.07
Number of fruits/plant	-0.18	0.42**	0.09		0.75**	0.02	0.005	-0.03
Weight of fruits/plant	-0.28	0.23	0.33*	0.73**		0.22	0.19	0.02
Volume of fruit	-0.05	0.022	0.40**	-0.10	0.32		0.92*	0.21
Weight of fruit	-0.05	0.066	0.45**	-0.05	0.34*	0.90**		0.50**
Weight/volume ratio	-0.07	0.19	0.37*	-0.24	0.16	0.03	0.17	

* significant at 5%   ** significant at 1%

2. Days to final harvest.

Number of days to final harvest under healthy condition had significant positive correlation with plant height, number of fruits per plant and weight of fruits per plant. Under infected condition, it had significant positive correlation only with number of fruits per plant. The correlations of days to final harvest with plant height differed significantly under healthy and infected conditions.

3. Plant height.

Under healthy condition, plant height had significant positive correlation with days to final harvest and number of fruits per plant. Under infected condition it had significant positive correlation with weight of fruits per plant, volume of fruit, weight of fruit and weight/volume ratio. But none of the correlations differed significantly under healthy and infected conditions.

4. Number of fruits per plant.

Number of fruits per plant had significant positive correlation with days to final harvest, plant height and weight of fruits per plant in the healthy population. Under infected condition, it had significant positive correlation with days to final harvest and weight of fruits per plant. But none of the correlations differed significantly under healthy and infected conditions.

5. Weight of fruits per plant.

Weight of fruits per plant under healthy condition had highly significant positive correlation with number of fruits per plant and days to final harvest. It had significant negative correlation with days to first harvest. Under infected condition it had significant positive correlation with plant height, number of fruits per plant and weight of fruit. None of the correlations differed significantly under healthy and infected conditions.

6. Volume of fruit.

Under healthy condition, volume of fruit had significant positive correlation only with weight of fruit. Under infected condition it had significant positive correlation with plant height and weight of fruit. The correlation of volume of fruit with weight of fruit differed significantly under healthy and infected conditions. Under infected condition, the correlation was significantly higher.

7. Weight of fruit.

Weight of fruit had significant positive correlation with volume of fruit and weight/volume ratio under healthy condition. Under infected condition, it had significant positive correlation with plant height, weight of fruits per plant and volume of fruit. As mentioned earlier the correlation between weight of fruit and volume of fruit was significantly higher under infected condition.

8. Weight/volume ratio.

Under healthy condition, weight/volume ratio had significant positive correlation only with weight of fruit whereas under infected condition it had significant positive correlation only with plant height. However, none of the correlations differed significantly under healthy and infected conditions.

DISCUSSION

DISCUSSION

The main objective of resistance breeding is the incorporation of resistance genes for protection against pests, diseases and environmental stresses into the existing cultivars (Russel, 1978). The effective execution of this objective through conventional breeding methods is always difficult, since the breeder has to see that he improves or at least maintains the important economic characters of the crop during the breeding programme.

Bacterial wilt caused by Pseudomonas solanacearum is one of the devastating diseases afecting solanaceous vegetables in the temperate, subtropical and tropical regions of the world (Kelman, 1953). In India, this disease is serious on brinjal in parts of Karnataka, Kerala, Orissa, Maharashtra, Madhya Pradesh, Bihar and West Bengal (Anon., 1974). Many of the commercial high yielding varieties are not suitalble for cultivation in the wilt endemic areas, because the yield loss is usually very high and at times total. Developing high yielding resistant varieties is the only method for effective and economic control of the disease. One of the major problems in breeding brinjal varieties resistant to bacterial wilt is the close association of resistance with poor yield (Vijayagopal and Sethumadhavan, 1973). An essential prerequisite of a wilt resistance breeding programme therefore involves an indepth study of the relationship between resistance and fruit yield. The loss of high yielding genotypes in the segregating populations, through elimination of susceptable plants, by disease incidence is likely to defeat the recombination breeding programme. The present study explores the possibility of developing brinjal varieties possessing resistance to bacterial wilt and high fruit yield through evaluation of the F_2 populations of intervarietal crosses under healthy and infected conditions. The results obtained are discussed in the following sections.

1. <u>Pattern of variability in the F_2 populations</u>

The parental varieties and the respective F_2 healthy populations were compared to get an insight into the genetic basis of the eight characters studied.

In all the three crosses, there were significant differences between the parents with respect of days to first harvest, suggesting the scope for variability in the F_2. The F_2 means were more than the higher parental means in all the three crosses. There was high variability with more than 20 percent coefficient of variation and two or three peaks in F_2 distribution in all the three crosses. This indicates that the character is governed by major genes with longer duration dominant over shorter duration. Similar results were reported by Gotoh (1964) in Brinjal which indicated four major genes contributing for duration up to flowering. This is also in agreement with the finding of Cheah et al.(1981) that days to first flowering was controlled by nonadditive gene action with late flowering partially dominant over early flowering. However, Eldin et al. (1968) has reported partial dominance of early flowering over late flowering.

The parents in all the three crosses differed significantly with respect to number of days to final harvest. The F_2 means were beyond the upper limit of parental means in all crosses suggesting major gene contributions for this character. However, the variance for this character was low in the F_2 populations with coefficient of variation less than 10 percent suggesting limitted segragation for this character.

In all the three crosses, the parents differed significantly with respect to plant height suggesting scope for variability in the F_2s. In the cross SM-6 x PPL, the F_2 mean was higher than the mean height of the tall parent. But in the other two crosses the F_2 means were close to the mid parental means suggesting polygenic inheritance. This is in agreement with Vijayagopal and Sethumadhavan (1973) but contrary to the results obtained by Narayanan (1984). The latter author found that the F_1 mean exceeded the parental limits.

Mean number of fruits per plant in parents of the crosses, SM-6 x PPL and SMI-10 x PPL did not differ significantly. So normally there is no scope for genetic variation in the F_2 populations of these two crosses. But there is high variability in both the F_2 populations with 50.4 and 57.0 percent coefficients of variation respectively. The apparently normal F_2 distributions for these two crosses (Figures 8 and 13) suggest polygenic inheritance. In the cross PPC x PPL on the other hand, the parents differed significantly with respect to number of fruits per plant. Here the F_2 mean was almost the same as the mean of the lower parent. But the F_2 distribution was mostly normal with slight skewness to the right. Thus in this cross also the character could be controlled by polygenes. The report of Narayanan (1984) that the F_1 mean in this cross was close to the mid parental value lends support to the polygenic concept.

In the cross SM-6 x PPL alone the parents differed significantly with respect to weight of fruits per plant. In all the three F_2 populations, the means were lower than the respective lower yielding parents. This suggests that the character is controlled by major genes. None of the F_2 means were close to the means of the high yielding common male parent. This is contradictory to the statement of Lal <u>et al</u>. (1971) that in case of weight of fruits per plant, higher yield was the dominant character.

In all the three crosses the parents did not differ significantly with respect to volume of fruit indicating that there was no scope for genetic variability in the F_2 populations for this character.

Parents in the cross SMI-10 x PPL did not differ significantly with respect to weight of fruit. In the other two crosses, the parents differed significantly for this character. In these two crosses (SM-6 x PPL and PPC x PPL), the F_2 means were close to the mid parental means suggesting polygenic inheritance for this character. Similar trend was reported by Gotoh et al. (1964) and Cheah et al. (1981) where they found that the fruit weight is controlled by eight and nine genes respectively. But Narayanan (1984) found the F_1 means exceeding the parental limits.

Mean weight/volume ratio of the parents did not differ significantly in any of the three crosses, suggesting very little scope for genetic variability in the F_2 populations. This was reflected in the coefficient of variation which was very low in the three F_2 populations.

2. Influence of wilt incidence on F_2 variability.

A programme of breeding aimed at the improvement of yield with disease resistance derives support from the information on the variability available for these traits in segregating populations. The scope for selection for different characters depends on the variability retained after selection for resistance. So a knowledge of the influence of disease incidence and consequent natural selection for resistance, on the F_2 variability for yield and yield contributing traits is very essential for further breeding works.

Mean number of days to first harvest was significantly higher in all the three infected F_2 populations indicating that early bearing segregants were eliminated by disease incidence. The variance for this character however was not significantly altered by natural selection for resistance in any of the F_2 populations. Therefore, selection for resistance has resulted in directional selection in favour of late bearers.

Natural selection for resistance consequent to disease incidence did not conspicuously influence the mean number of days to final harvest in the F_2 populations. But the variance for this character was markedly increased by disease incidence, which suggests that there is further scope for selection in any direction in the resistant F_2 populations.

Mean plant height in the F_2 populations did not significantly change consequent to disease incidence indicating that this character is not associated with resistance to bacterial wilt. But the variance for plant height was markedly increased by disease incidence in two of the three F_2 populations (SM-6 x PPL and SMI-10 x PPL). The F_2 population of the cross PPC x PPL on the other hand exhibited no significant change in variance consequent to disease incidence, indicating random selection for plant height.

Mean number of fruits per plant in all the three F_2 populations was drastically reduced by disease incidence indicating that plants with larger number of fruits were eliminated. The variance for this character was also markedly reduced by natural selection for resistance in all the F_2 populations. F_2 distribution curve for the number of fruits per plant (Figures 8, 13 & 18) showed that the number of plants with larger number of fruits were less under infected condition than under healthy condition. The above facts indicate that selection for resistance to bacterial wilt has lead to a directional selection in favour of plants with lesser number of fruits per plant.

Mean weight of fruits per plant was also drastically reduced by disease incidence in all the three F_2 populations. This yield reduction is due to the fact that the higher yielding plants were eliminated by selection for resistance. The variance for yield in all the three F_2 populations was reduced by selection of resistant plants. However, in the cross SMI-10 x PPL this reduction was not significant. The reduction in variance consequent to selection for resistance indicates that disease incidence has lead to directional selection in favour of poor yielders. This is very clear from the F_2 distribution graph (Figures 9, 14 and 19), which showed more number of higher yielding plants under healthy condition than under infected condition. The above facts indicate that yield is negatively associated with resistance to bacterial wilt.

In the crosses SM-6 x PPL and SMI-10 x PPL the mean volume of fruit of the F_2 populations was not significantly affected by disease incidence. But in the cross PPC x PPL the mean volume of fruit of the F_2 population was drastically reduced by natural selection for resistance to bacterial wilt. This is in agreement with the finding of Vijayagopal and Sethumadhavan (1973), that large fruited segregants were absent in the resistant F_2 population. This can be clearly observed in the F_2 distribution curve of PPC x PPL (Figure 21). Variance was significantly increased by infection only in the F_2 population of SMI-10 x PPL. The reduction in the F_2 mean of PPC x PPL indicates that natural selection for resistance to bacterial wilt has lead to nonrandum selection for volume of fruit.

Mean weight of fruit in all the three F_2 populations, was unaffected by disease incidence indicating that the character is not associated with resistance to bacterial wilt. F_2 distribution for this character also did not show marked change consequent to disease incidence (Figures 12, 17 and 22). However, variance for this character was substantially higher in two of the three F_2 populations namely, SMI-10 x PPL and PPC x PPL. This may be due to random selection for weight of fruit consequent to elimination of susceptable plants by disease incidence.

In the F_2 population of PPC x PPL alone the mean weight/volume ratio was significantly reduced by disease incidence whereas in the other two F_2 populations the means were mostly unchanged indicating that weight/volume ratio does not have much relation with resistance to bacterial wilt. Variance for this character was significantly increased by infection in the F_2 populations of SM-6 x PPL and SMI-10 x PPL, suggesting that disease incidence has lead to random selection for this character.

3. <u>Correlation studies and the influence of selection for resistance on character associations.</u>

Association of yield contributing traits and the influence of selection for resistance on this association were studied by estimating simple correlation coefficients among the eight characters under healthy and infected conditions, in all the three F_2 populations.

Number of days to first harvest had significant negative correlation with yield under healthy condition in all the three F_2 populations. Similar reports were made by Singh (1974) and Eldin et al. (1967). It also had significant negative correlation with plant height, number of fruits per plant, weight of fruit and volume of fruit in two of the three F_2 populations.

In the F_2 populations of SMI-10 x PPL and PPC x PPL, number of days to final harvest had significant positive correlation with plant height, number of fruits per plant and weight of fruits per plant. It had significant positive correlation with volume of fruit in the cross SMI-10 x PPL and with weight of fruit in the cross PPC x PPL.

Plant height had significant positive correlation with number of fruits per plant in all the three F_2 populations. It had significant positive correlation with weight of fruits per plant in the F_2 population of SM-6 x PPL. This is in agreement with the finding of Sinha (1983), but not with that of Eldin et al. (1967) that the short plant is positively correlated with high yielding ability. Plant height had significant positive correlation with volume of fruit in two of the three F_2 populations.

Number of fruits per plant had highly significant postive correlation with weight of fruits per plant in all the three F_2 populations. Similar reports were made by Singh (1974), Hiremath and Rao (1975), Sinha (1983) and Mak and Vijiarungam (1980). This suggests that number of fruits per plant contributes sizably to fruit yield in brinjal. It also had significant positive correlations with weight and volume of fruit in one F_2 population. The positive correlation of number of fruits per plant with weight of fruit was reported by Mak and Vijiarungam (1980) also.

Weight of fruits per plant had significant positive correlation with fruit weight in two of the three F_2 populations. Similar reports were made by Sinh (1974) and Mak and Vijiarungam (1980). It also had significant positive correlation with volume of fruit in the F_2 of the cross, SMI-10 x PPL.

Between weight and volume of fruit there was significant positive correlation in all the three F_2 populations.

Estimation of the correlation coefficients in the infected F_2 populations, revealed certain changes in the association of yield contributing traits consequent to selection for resistance. In the F_2 population of SM-6 x PPL, the correlation coefficients of number of days to first harvest with plant height and number of fruits per plant were conspicuously altered by disease incidence. Under healthy condition, the correlation coefficients were negative but under infected condition the coefficients were positive. In the F_2 infected populations, the negative correlation of number of days to first harvest with weight of fruits per plant and volume of fruit were also conspecuously reduced. These changes create difficulties in the selection of early plants with high yield from among the resistant F_2 recombinants.

The positive correlation of number of days to final harvest with plant height in the F_2 healthy population of SM-6 x PPL was altered as significant negative correlation under infected condition. In the F_2 population of SMI-10 x PPL, the positive correlation of number of days to final harvest with volume of fruit was markedly reduced and become negative under infected condition. The mean number of days to final harvest was not conspicuously affected by infection. However, due to the change in the association of this character with other yield contributing characters, it appeares to be indirectly associated with resistance to bacterial wilt.

The significant positive correlation of plant height with weight of fruits per plant in the F_2 population of SM-6 x PPL was reduced significantly and became nonsignificant consequent to wilt incidence. This selection for yield based on plant height becomes impossible, though the mean plant height remained unaltered inspite of disease incidence. Significant positive correlation of weight of fruits per plant with number of fruits per plant increased by disease incidence in the F_2 population of SM-6 x PPL, but decreased conspicuously in the F_2 population of SMI-10 x PPL. This difference might be due to differences in the genetic make up of the resistant F_2 segregants in the two populations. However, the close association of these characters with resistance to bacterial wilt has been better emphasised.

Thus in general, the present study has indicated a change in the mean variability and association of the major yield contributing characters, due to natural selection for resistance consequent to disease incidence. Resistance to bacterial wilt has been associated with all the yield contributing characters in one way or the other, either directly or indirectly. It was seen that infection has eliminated the early bearing plants, with large number of fruits per plant and high yield. This has altered the association between the different yield contributing characters, thus creating problems in the identification and selection of resistant plants with high yield potential and other cherished agronomic characters. So indiscriminate selection for resistance to bacterial wilt alone in the F_2 recombinants will not lead to the development of high yielding resistant varieties. The scope for enhancing variability in the resistant fraction needs to be further explored. Backcross breeding or induction of recombinations through mutagenic treatments could probably provide a solution.

SUMMARY

SUMMARY

Bacterial wilt caused by Pseudomonas solonacearum is a great menace to brinjal cultivation in the tropics. most of the commercial varieties being susceptible are not suitable for cultivation because, the yield losses consequent to wilt incidence are usually very high and at times total. Resistance is the only effective means of controlling this disease. But previous reports have shown association of poor yield and wilt resistance. The present investigation was undertaken to explore the possibility of developing brinjal varieties possessing resistance to bacterial wilt and high yield through evaluation and selection in the F_2 of inter varietal crosses, between resistant and high yielding varieties.

Seeds obtained by crossing each of the three bacterial wilt resistant brinjal varieties SM-6, SMI-10 and pusa purple cluster with the susceptible variety Pusa Purle Long as the pollen parent, were sown. The selfed seeds of these F_1s were collected and sown along with seeds from the four parental varieties in a RBD with four replications. The natural incidence of bacterial wilt eliminated the susceptable segragants from the F_2 populations. Observations were made on the surviving resistant plants of the F_2s and the varieties. The same experiment was repeated under

healthy condition by raising plants in pots filled with sterilised soil.

The characters studied were, number of days to first harvest, number of days to final harvest, plant height, number of fruits per plant, weight of fruits per plant, volume of fruit, weight of fruit and weight/volume ratio. The data collected were analysed using the procedure of analysis of covariance. Means and variances for each character were calculated and the correlation coefficients estimated.

The study of F_2 variability for each character under healthy condition gave an idea about the mode of inheritance of the character. Plant height number of fruits per plant and weight of fruit were found to be under polygenic control. Number of days to first harvest and number of days to final harvest were controlled by major genes, with late bearing dominant over early. Weight of fruits per plant was also controlled by major genes with low yielding character as dominant.

Comparison of means and variances under healthy and infected conditions gave an insight into the influence of selection on the expression of these characters. Natural selection for resistance eliminated the early bearers and lead to directional selection in favour of late bearers.

Number of days to final harvest, plant height and weight of fruit were not conspicously influenced. Number of fruits per plant and weight of fruits per plant were drastically influenced by disease incidence leading to directional selection in favour of poor yielders. In one of the three crosses, the mean volume of fruit was conspicously reduced by selection for resistance. Mean weight/volume ratio also was reduced markedly in only one of the three crosses.

Correlation studies indicated the association of characters and the change in association brought about by selection for resistance. Yield was found to be negatively correlated with days to first harvest and positively with plant height number of fruits per plant, weight of fruit and days to final harvest under healthy condition. Other more conspicious positive correlations were between plant height and number of fruits per plant, and between weight and volume of fruit. Numberof fruits per plant also had conspicous positive correlation with weight and volume of fruit. Number of days to first harvest had significant negative correlation with plant height, number of fruits per plant, weight of fruit and volume of fruit in two of the three F_2 populations.

The negative correlation of number of days to first harvest with plant height and number of fruits per plant were altered as positive correlations consequent to disease incidence, this creating difficulties in the selection of early plants with more number of fruits from the resistant F_2 recombinants. Even though the mean number of days to final harvest was not conspicuously affected by disease incidence, the association of this character with other yield contributing characters was conspicuously changed, indicating its indirect association with resistance to bacterial wilt. Similarly, the positive correlation of yield with plant height was significantly reduced consequent to disease incidence even though plant height as such was not affected. Thus selection for yield based on plant height is impossible in the resistant segregants. The positive correlation between yield and number of fruits per plant was also changed markedly by selection for resistance.

The yield and yield contributing characters are thus indirectly or directly associated with bacterial wilt resistance. So the posibility of developing a high yielding resistant variety by selection in the early segragants is very little. Many genotypes with favourable agronomic characters will have to be sacrifised in the process of selection for resistance. The scope for enhancing variability in the resistant factor needs to be further explored. Back cross breeding or induction of recombinations through mutagenic treatments could probably provide a solution.

REFERENCES

REFERENCES

*Anonymous (1962). Bacterial wilt resistant egg plant varieties. Mon. Bull U.P. Coll. Agri. Laguna., 27 (6): 1 - 4.

*Anonymous (1974). Scientific report of Central potato Research Institute for the triennium 1971-73: 120-125.

Anonymous (1980). Research Report of the Kerala Agricultural University for the year 1979-80, Vellanikkara pp. 401.

Borikar, S.T., Makne, V.G. and Kulkarni, U.G. (1981). Note on diallel analysis in brinjal. Indian J. agric. Sci., 51 (1): 51 - 52.

Chadha, M.L. and Paul, B. (1984). Genetic variability and correlation studies in egg plant (S. melongena). Indian J. Hort., 41 (½): 101 - 107.

Cheah, C.H., Kwan, K.H. and Nurmala, M.D. Noor. (1981). Genetics of brinjal (Solanum melongena L.). Abstract. In Fourth International SABRAO Congress. Plant Breeding Abstracts 53(4): 323.

Daly, P. (1970). Search for an egg plant variety tolerant of Pseudomonas solamacearum. Proceedings of the 7th annual meeting of CFCS, 113 - 132.

Daly, P. (1972). Research carried out at IRAT, Martinique with a view to breeding an aubergine variety tolerant to Pseudomonas solamacearum., Agron. Trop. 27 (4): 462 - 472.

Daly, P. (1973). Obtaining a new egg plant variety which is tolerant to Psuedomonas solanacearum Agron. Trop., 28 (1): 23 - 27.

Das, C.R. and Chattopadhyay, S.B. (1955). Bacterial wilt in egg plant. Indian Phytopath., 8: 130 - 135.

Das, M.N. and Giri, N.C. (1979). Design and analysis of experiments. Wiley Eastern Limited, New Delhi, pp. 263 - 265.

Dhesi, N.S., Nandpuri, K.S. and Dhaliwal, C.S. (1964). Heritability of some characters in brinjal. Indian. J. Genet. Pl. Br., 24: 286 - 287.

Dixit, J., Dudi, B.S., Pratap, P.S. and Bhutani, R.D. (1984). Gene action for yield characters in egg plant. Indian J. agric. Sci., 54 (7): 557 - 559

*Eldin, S.A.B. (1967). The inheritance of certain quantitative characters in egg plant. Diss. Abstr., 28: 67-9781. 491.

Eldin, S.A.B., Blackhurst, H.T. and Perry, B.A. (1968). The inheritance of certain quantitative characters in egg plant (Solanum melongena L.). Proc. Amer. Soc. Hort. Sci., 92: 490 - 497.

Empig, L.T., Calub, H.P., Katigbak, M.M. and Deanon, J.R. (1962). Screeming tomato, egg plant and pepper varieties and strains for bacterial wilt (Pseudomonas solanacearum) resistance. Phillipp. agric., 46: 303 - 314.

Fisher, R.A. and Yates, F. (1965). Statistical tables for biological, Agricultural and Medical Research, Edinburough Oliver and Boyal ltd.

French, E.R. and Sequeria, L. (1970). Strains *Pseudomonas solanacearum* from Central and South America, a comparative study. *Phytopath.*, 60: 506 - 512.

Gill, H.S., Arora, R.S. and Pachauri, D.C. (1976). Inheritance of quantitative characters in egg plant. Indian J. agric. Sci., 46 (10): 484-490.

Gopimony, R. (1968). *Study on the F_1 hybrids between and wild brinjal varieties*. M.Sc.(Ag.) Thesis, University of Kerala, unpub.

Gopimony, R. (1983). *Genetic studies in brinjal with relation to bacterial wilt resistance*. Ph.D. thesis, Kerala Agricultural University, unpub.

Gopimony, R. and George, M.K. (1979). Screening brinjal varieties for wilt resistance. *Agric. Res. J. Kerala*, **17** (1): 7 - 10.

Gopimony, R. and Sreenivasan, K. (1970). Studies on brinjal hybridisation. I. Feature F_1 hybrids between cultivated and wild brinjal. *Agric. Res. J. Kerala*, **8**: 101 - 105.

*Gotoh, K. (1964). Genetic studies on egg plant, investigations regarding the degree of heritability and number of effective factors. *Jap. J. Genet.*, **28**: 89 - 97.

Gowda, M.V.D. (1977). Genic analysis of yield and yield components in brinjal (Solanum melongena L.) Mysore J. agric. Sci., 11 (3): 426.

Gowda, T.K.S., Shetty, K.S., Balasubramanya, R.H., Shetty, K.P.V. and Pattil, R.B. (1974). Studies on the bacterial wilt of Solanaceous crops caused by Pseudomonas solanacearum E.F. Smith in the wilt sick soil. Mysore J. agric. Sci., 8 (4): 560-566.

Hiremath, K.G. and Rao, M.R.G. (1974). Genetic variability and correlation studies in Solanum melongena. Mysore J. agric. Sci., 8 (2): 197 - 202.

Hussain, A. and Kelman, A. (1958). Relation of slime production to mechanism of wilting and pathogenicity of Pseudomonas solanacearum Phytopath., 48: 155 - 65.

*Jenkins, S.F. Jr. (1974). Interaction of Pseudomonas Solanacearum and Meloidogyne incognita on bacterial wilt resistant and susceptible cultivars of egg plant. Proc. Amer. Phytopath. Soc., 1974: 169 - 70.

*Jones, L.R., Johnson, J. and Dickson, J.G., (1926). Wisconsin studies upon the relation of soil temperature to plant diseases. Wisc. Agri. Expt. stat. Res. Bull., 71: 129 - 40.

KAU (1986). Package of Practices Recomendations 1986. Extension Division, Mannuthy, Trichur, Kerala, India.

*Kelman, A. (1953). The bacterial wilt caused by Psuedomonas solanacearum. North Carolina Agric. Expt. Stat. Tech. Bull., 99: 194 - 197.

Khan, N.A.A. (1974). Studies on Pseudomonas solanacearum E.F. Smith causing wilt of brinjal, potato and tomato in Mysore state. Mysore J. agric. Sci., 8 (3): 477 - 478.

*Kuncide, K. (1953). Studies on bacterial wilt of egg plants I. Varietal differences of hosts in reaction to the causal bacteria. Ann. Phytopath. Soc. Japan, 17: 133 - 136.

Kuriyama, T. (1975). Testing methods for breeding disease resistant vegetables in Japan. JARQ, 9 (2): 96 - 100.

* Lal, S., Pathak, M. and Singh, H.N. (1971). Study of variation in agronomic traits through a 7 variety diallel of brinjal. Paper presented to the All India Co-ordinated vegetable workshop held at IARI, New Delhi.

Mak, C. and Vijiarungam, A.F. (1980). Variability in bacterial wilt resistance and interrelationships of some chracteristics of brinjal (Solanum melongena L.). SARBRAO J., 12 (1): 65 - 73.

Narayanan, K.K. (1984). Evaluation of intervarietal hybrids of brinjal for yield and resistance to bacterial wilt. M.Sc. (Ag.) Thesis, Kerala, Agricultural University un pub.

Nesmith, W.C. and Jenkins, S.F. Jr. (1979). A selective medium for the isolation and quantification of Pseudomonas solanaceurum from soil. Phytopath., 69 (2): 182 - 185.

Nilesan, L.W. (1956). Evaluation of Irish Potatoes for resistance of Pseudomonas solanacearum. Phytopath., 46 (1): 6 - 33.

*Nolla, J.A.B. (1931). Studies on the bacterial wilt of the solanaceae in Puerto Rico. Puerto Rico Dep. Agric. J., 15: 287 - 308.

* Park, M. and Fernande, M. (1940). A variety of brinjal (Solanum melongena L.) resistant to bacterial wilt. Trop. Agric., 94: 19 - 21.

Panse, V.G and Sukatme, P.V. (1957). Statistical Methods for Agricultural Workers, ICAR, New Delhi, 109 - 113.

Peter, K.V. and Singh, R.D. (1973). Diallel analysis of economic traits in brinjal. Indian J. agric. Sci., 43 (5): 452 - 455.

Rao, G.R. and Anilkumar, (1980). Some observations on interspecific hybrids of Solanum melongena L. Proc. Indian Acad. Sci. (Plant Sci.), 89 (2): 117 - 121.

Rao, M.V.B. and Sohi, H.S. (1977). Control of bacterial wilt in brinjal. Indian Horticulture, 22 (1): 309 - 311.

Rao, M.V.B., Sohi, H.S. and Vijay, B.P. (1976). Reaction of some varieties of brinjal to Pseudomonas Solanacearum. Veg. Sci., 3 (1): 61 - 64.

*Rathaiah, Y. (1983). Yield and reaction to fruit rot, bacterial wilt and Cercospora leaf spot of chilli cultivars. J. Research Assam Agric. University.

*Rogue, A. (1941). Egg plants resistant to bacterial wilt. Puerto Rico Univ. Agric. Expt. Sta. Ann. Rept. for 1939 - 40, 47 - 48.

Russel, G.E. (1978). Plant Breeding for pest and Disease Resistance. Butter worths, London, pp: 485.

Salehuzzaman, M and Alam, M.S. (1983). Genetic analysis of yield and it's components in the egg plant. SABRAO J., 15 (1): 11 - 15.

*Salimath, S.B. (1981). Diallel analysis of yield and yield components in brinjal (Solanum melongena L.). Abstract. Thesis Abstracts 7 (1): 2 - 3.

Saxena, H.C. and Surendran, P.U. (1973), Statistical inference S. Chand & Co. (P) Ltd. New Delhi, pp: 69 - 76.

Sheela, K.B., Gopalakrishnan, P.K. and Peter, K.V. (1984) Resistance to bacterial wilt in a set of egg plant breeding lines. Indian. J. agric. Sci., 54 (6): 457 - 460.

Shekhawat, G.S., Singh, R. and Kishore, V. (1978). Distribution of bacterial wilt and races and biotypes of pathogen in India. J. Indian Potato Assoc., 5 (3): 155 - 165.

Sidhu, A.S., Bhutani, R.D. and Singh, K. (1980). Genetics of yield components in brinjal. (Solanum melongena L. Haryana J. Hort. Sci., 9 (3/4): 160 - 164.

Singh, H.N., Singh, S.N. and Mital, R.K. (1974). Heterosis in brinjal. Indian J. Genet. Pl. Breed., 34 A: 145-147.

Singh, S.N., Singh, H.N. and Azarika, M.H. (1979) Fractional diallel analysis of some quantitative characters in brinjal. Acta Horticulturae 93 : 307 - 316.

Singh, S.N., Singh, N.D. and Azarika, G.N. (1982). A note on degree of dominence and parental mean performance in brinjal S. melongena. Haryana J. Hortic. Sci., 11 (½): 146 - 148.

Sinha, S.K. (1983). Path coefficient analysis for some quantitative characters in brinjal (S. melongena). Madras. agric. J. 70 (6): 351 - 354.

Sitaramaiah, K., Singh, R.S., Viswakarma, S.N. and Dubey, G.S. (1981). Brinjal cultivars resistant to Pseudomonas wilt. Indian Phytopath., 34 (1): 113.

Sreenivasan, K., Gopimony, R., Swaminathan, M. and Pillai, P.K. (1969). On the resistance of a wild brinjal variety to bacterial wilt. Agric. Res. J. Kerala. 7 (1): 39 - 40.

Srivastava, L.S. and Sachan, S.C.P. (1973). Correlation coefficient and path analysis in brinjal. Indian J. agric. Sci., 43 (7): 673 - 675.

Suzuki, I., Sugahara, Y., Kotani, A., Todaka, S. and Shimada, H. (1967). Studies on breeding egg plant and tomato for resistance to Pseudomonas solanacearum. I. Investigation on methods for evaluating resistance and on sources of resistance for breeding. Plant Breeding Abstracts, 37 (3): 5225.

Swaminathan, M. and Sreenivasan, K. (1971). Studies brinjal hybridisation-II. Transference of bacterial wilt resistance from a wild brinjal variety to cultivated brinjal varieties Agric. Res. J. Kerala, 9 (1): 11 - 13.

*Toarder, O.I., Islam, O.N., Salehuzzaman, M. and Alam, M.S. (1981). Inheritance of some quantitative characters in egg plant (Solanum melongena L.) Genetica Polonica 22 (1): 91 - 102.

Vijayagopal, P.D. and Sethumadhavan, P. (1973). Studies on intervarietal hybrids of Solanum melongena L. Agric. Res. J. Kerala. 11 (1): 43 - 46.

*Volln, R.B. and Ramosh, (1981). The Association of brown root rot resistance with yield components and root weight among tomato selections grown in infested and non infected soil in Dade country Florida. Proceedings of the Florida state horticultural society 1980, 93: 224 - 226.

Wager, V.A. (1946). Egg plants resistant to bacterial wilt. Farming in South Africa, 21: 410 - 412.

Wallis, F.M. and Truter, S.J. (1978). Histopathology of Tomato plants infected with Pseudomonas solanacearum with emphasis on ultrastructures. Physiol. plant pathol., 13 (3): 307 - 317.

Winstead, N.N. and Kelman, A. (1952). Inoculation techniques for evaluating resistance to Pseudomonas solanacearum. Phytopath., 42 (11): 628 - 634.

Yamakawa, K. (1976). Breeding for disease resistance of vegetable crops in Japan-Solanaceae. JARQ, 10 (4): 187 - 192.

* Originals not seen

GENE RECOMBINATION FOR RESISTANCE TO BACTERIAL WILT AND YIELD COMPONENTS IN BRINJAL

BY

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ABSTRACT OF A THESIS

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ABSTRACT

Brinjal (Solanum melongena) is an important vegetable crop of India. It's cultivation is threatened by the bacterial wilt disease caused by Psuedomonas solanacearum in many places. The cultivation of resistant high yielding varieties is the only effective method of controlling the disease. But the assocation of bacterial wilt resistance with poor yield has obstructed onventional breeding approaches aimed at deriving useful recombinations. The present study explores the possibility of developing a resistant high yielding variety by selection in the segragating generation of inter varietal crosses.

The F_1 plants of the crosses between three resistant varieties, SM-6, SMI-10 and Pusa purple cluster with the susceptable variety Pusa purple long as the male parent, were selfed. The seeds were sown and seedlings raised under two environments. (1) In the field where there is chance for natural incidence of bacterial wilt. (2) In pots with sterilised soil under healthy condition. In both the experiments, mean, variance and correlation coefficients of yield and yield contributing characters were estimated.

Study of F_2 variability has revealed that, the characters plant height number of fruits per plant and weight of fruit

are governed by polygenes. The characters, number of days to first harvest, number of days to final harvest and weight of fruits per plant were governed by major genes with late bearing and low yield dominant over early bearing and high yield respectively. Comparison of means and variances under healthy and infected condition gave an insight into the influence of selection on the expression of these characters. Natural selection for resistance eliminated the early bearers and high yielders leading to directional selection in favour of late bearers and poor yieldrs.

Correlation studies indicated the association of characters and the change in association brought by selection for resistance. Yield was found to be negatively correlated with days to first harvest and positively with plant height, number of fruits per plant, mean weight of fruit and days to final harvest, under healthy condition.

The results is general showed that natural selection for resistance has eliminated the early bearing plants with larger number of fruits per plant and high yield. This has altered the association between the different yield contributing characters thus making difficult the recovery of plants with high yield and other favourable characters in the resistant F_2 fraction. All the yield contributing characters are associated with bacterial wilt resistance either directly or indirectly. Selection for resistant types in the F_2 will therefore lead to the loss of many high yielding genotypes. The scope for enhancing variability in the resistant fraction needs to be explored. Back cross breeding or induction of recombinations through mutagenic treatments could probably provide a solution