STUDIES ON CORRELATION IN BHINDI

(*Abelmoschus esculentus* L. MOENCH)

By

MARTHA MARY, K. J.

THESIS

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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Smt. K.J. Martha Mary, under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

(P. KUMARA PILLAI)
Principal.

(K. GOPAKUMAR)
Lecturer in
Agricultural Botany.

Agricultural College &
Research Institute,
Vellayani, Trivandrum,
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PROFESSOR OF AGRL. BOTANY.

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C O N T E N T S

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INTRODUCTION

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In recent years, statistical methods have found considerable application in plant breeding procedures.

In any crop improvement programme the maximum consideration is attributed towards selection of types for high yield. Yield is a complex character which is often polygenic in inheritance and subject to fluctuations in the environment to a great deal, and this introduces complications and difficulties in arriving at a more or less accurate estimation of the yield potential. On the other hand, there are several other characteristics, which, unlike the yield and other similar polygenic characters, are under the control of a relatively small number of genes which have more or less pronounced effects of their own and are less susceptible to environmental variations. It has also been found that it is possible to make measurement of these characters with enough reliability and accuracy. On the contrary, such accurate measurements could not be carried out in the case of polygenic characters. However, it has been noticed that relationships, which are often constant and definite, exist between such

complex quantitative characters as yield, and the less complex qualitative characters. Statistical procedures have often been found to help one acquire reasonably accurate knowledge of these relationships. A knowledge of such relationships, if available, can no doubt be of great use in selection procedures, especially when the less important and readily readable characteristics can be used as dependable indicators of the more important and complex ones. Realising the great importance of this particular aspect, attempts have been and are being made in various crop plants to know the relationship between economically important and unimportant characters. In many instances, the knowledge, thus acquired, have proved themselves to be of great practical utility.

Bhindi or okra (Abelmoschus esculentus, Linn.) is considered as one of the most important vegetable crops in India as well as elsewhere. The very availability of its edible fruits during most of the seasons of the year, the relatively low cost of production, and its amazing adaptability to a wide range of climatic and soil conditions are some of the reasons why it is considered as one of the most

favoured vegetable crops of the world. In addition, it is a crop which produces fruits substantially rich in almost every nutritional factor for human consumption.

Studies have been conducted in this crop on various aspects like, culture, hybridisation etc. However, it is realised that enough studies on the correlations as those mentioned above have not been carried out so far.

Yield in bhindi, like that in many other crops is a polygenic character which does not render itself suitable for any direct study. At the same time, it is hoped, that several other characteristics could be recognised, which contribute considerably and more or less directly towards yield, and these characteristics, unlike the yield, render themselves suitable for comparatively easy and accurate study. Therefore, it is felt, that a knowledge of the correlation between the yield and the component characters, if could be understood, could be of considerable help towards furthering improvements in this crop, especially in selecting the parents for a hybridisation programme.

In this, an attempt has been made to study the inter-relationship between and among yield, height of plant, number of leaves, number of branches, fruit length, fruit girth and number of fruits in ten different varieties of bhindi.

Variation is an important characteristic which is to be given enough attention in correlation studies. Lesser the variability, it is understood, less dependable will be the estimation of the correlations and vice versa. Realising this fact an attempt has also been made towards the study of the variability with respect to the characters studied for correlation.

It is hoped, that the results of this investigation, and the conclusions arrived at, can, in every respect, provide attempts on further improvement of this crop with a sound and reliable scientific basis.

This work has been carried out in the Division of Agricultural Botany, Agricultural College, Vellayani with the above views in mind.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In the recent past several attempts have been made in different crops to find out the correlation between yield and several of its important component characteristics. Following is a review of the work so far carried out in this aspect.

Correlations

Different characters of a plant are often correlated with each other.

a) Correlation between qualitative characters:

Ball (1910) stated that in sorghum, brown or black coloured grains are associated with bitter taste due to presence of tannins.

Chinoy (1947) found correlation of yield in wheat with 1000 grain weight.

Krishna Rao (1948) reported that resistance to insect pest on millets was associated with pigmentation.

Ahmed et al (1950) Afzal and Ghani (1950) reported that in cotton, resistance to jassids was highly correlated with pilosity of the plant, the more resistant types showing greater degree of hairiness on the under surface of the leaf. They considered toughness of vein to be associated with jassid resistance.

Aiyar (1958) observed that under dry cultivation yield of ragi was positively correlated with the total rainfall received.

Porter (1958) while studying the inheritance of shedding in wheat varieties observed that correlation coefficients between seed length and shedding of F_1 plants in a cross were, in all cases, small and not significant. In the F_2, however, he obtained significant correlation between seed width and shedding.

b) Correlation of quantitative characters:

Rice (Oryza sativa)

In rice (Oryza sativa) Vibar (1920) recorded that height, length of panicle and duration were positively correlated with yield, although increased straw weight was not always associated with yield.

Eide and Bhalerao (1927) reported high positive correlation between yield and number of leaf bearing tillers and a low value of correlation for length of the main panicle.

Mahalanobilis (1934) studying the various characters of 147 varieties of rice noted that mean yield was correlated with number of tillers per plant and length of leaf, but was independent of characters like size of grain, height of plant and duration.

Narasinga Rao (1937) observed that yield was highly correlated with number of tillers, length of panicle and number of grain per ear.

Chakraverthy (1940) observed no significant relationship between minor characters like length, breadth and thickness of grain, flag leaf dimension, exertion etc.

Ganguli and Sen (1941) have recorded that yield was positively correlated with height of tillers, length of panicle and number of grains per panicle.

Ramiah (1953) reported that positive correlation existed between mean yield and number of tillers per

plant. He also presented the association of yield with height, ear-length and mean number of grains per ear as positive, but feeble.

Ekkichi (1954) recorded high positive correlation of yield with tillering, weight of ear, length of ear, number of grains per ear etc.

Ghose et al (1956) in their study of inter varietal correlations found that length and number of panicle were positively correlated with yield, while height had only a negligible contribution.

Sayed and Krishna murthy (1956) in a biometrical study in rice, under different spacings, reported that the contribution of length of earhead and number of tillers was positive and the number of ear-bearing tillers was positive and the number of ear-bearing tiller, the most potent yield component.

Chandramohan (1964) studied seven characters in a short duration variety of rice, TKM.6, and reported that the number of ear-bearing tillers, number of grains per plant and yield of straw have very high association with yield, plant height and number of grains per primary ear showing moderate correlation with yield.

Varkey (1964) noted that in twenty varieties of rice yield of grain is correlated with number of ear-bearing tillers, yield of straw, height of primary ear and plant height.

Yesh (1965) reported that the correlation between grain yield and effective tillers was highly significant and grain yield and days from transplanting to heading were negatively correlated.

Muhammed Khursheed Ahemed and Suryanarayana Rao (1965) reported in a hybrid rice that ear-bearing tillers were found to be the most highly correlated component with grain yield, followed by the number of grains per panicle, and the length of panicle respectively. Therefore, while choosing a rice plant for hybridization, the axillery attributes of ear-bearing tillers, number of grains per panicle and length of panicle may be considered in the order of priority as characters for selection.

Sivasubramonian et al (1966) found that in rice the distribution of length of panicle was normal while it was positively skewed in the case of number of grains and chaff per panicle. The association between these

characters was positive and highly significant. No single factor affect the other characters to a large extent was evident from the partial correlation analysis.

Jowar (Sorghum sp.)

Kottur and Chavan (1928) studied correlation between yield and number of internodes, thickness, length and weight of ear head. They observed that weight of ear head was highly correlated with yield.

Kohle (1951) observed that height of plant, number of internodes, girth of stem and length, thickness and weight of ear head, together contributed for the yield of grain and fodder.

VishnuSwarup and Chaugale (1962) studying on selection indices for the grain and fodder yields in Sorghum vulgare varieties, indicated that grain yield was positively correlated with plant height, but negatively correlated with stalk diameter and fodder yield. Characters like days for panicle emergence, number of leaves and seed weight did not have any correlation with yield.

Rhewal et al (1964) observed a positive correlation between yield and diameter and height and internode number. Those between yield and height and yield and diameter were significant at 5% level, while yield and internode number and yield and diameter, were not significantly correlated.

Ragi (Eleusine sp.)

Mahadevappa and Ponnaiya (1962) made investigations on fifteen varieties of Eleusine coracana. The results indicated that out of the six characters studied, three characters viz., the number of ear-bearing tillers, number of fingers per plant and weight of straw per plant were positively and significantly associated with the yield of grains.

Wheat (Triticum sp.)

Love (1912) noticed a positive correlation between height of plant and yield and between yield and average weight of kernels.

Army (1918) studied correlation of characters with special reference to the weight of seed and observed that increase in yield of kernels was very closely

accompanied by an increase in number of kernels, number of clums, and total length of spikes and some what less closely with an increase in average weight of kernels and average height of clum.

Hayes et al (1927) studied the association between yield and reaction to certain diseases on other characters of spring and winter wheat recorded that there was significant positive correlation between height of plant and yield.

Pal and Butany (1947) recorded independence of yield to number of kernels per spike and average weight grains per plant.

Welbel (1956) while studying the association of yield and its component characters noticed phenotypic correlations with many heads, high grain yield, high kernel weight and high bushel weight.

Sikka and Jain (1958) reported that grain yield showed high positive correlation coefficients with number of grains per ear and 1000 grain weight.

El-ghaws and El-Ballel (1961) while studying twelve varieties of wheat observed that yield was

positively and significantly correlated with characters exhibiting great variation within individual varieties (plant and straw weight and number of spikes per plant).

Gandi et al (1963) while studying the genotypic variability and correlation coefficients relating to grain yield and a few other quantitative characters in Indian wheat, found that number of ear per plant and 1000 grain weight gave high estimates of heritability and genetic advance. These were highly and positively correlated with grain yield.

Bhide (1963) conducted inheritance and correlation studies in vulgare wheat population. He found positive correlation between the characters like tillers per plant and grains per ear, and ear length germination and stand at thriving and negative correlation in germination and number of days taken to flower.

Corn (Zea mays)

Jenkins (1929) found that within the inbred lines, yield was correlated significantly and positively with plant height, number of ears per plant, ear length, ear diameter while it was correlated significantly and negatively with date of silking and ear shape index.

Robinson et al (1949) recorded strong association of yield with ear weight.

Barley (Hordium vulagare)

Bonnet and Woodworth (1931) studying the number of ears and 1000 grain weight contributed appreciably to yield.

Grafhius et al (1952) also obtained the similar results.

Pearl millet (Pennisetum typhoides)

Mahadevappa and Ponnaiya (1967) observed that in Pearl millet, yield of grain had strong and positive association with length and diameter of peduncle, density of grain, yield of primary ear, tillering capacity and yield of straw, while it showed negative correlation with plant height and no correlation with surface area of primary ear and 1000 grain weight.

Ayyangar et al (1936) observed correlation of characters like length and weight of penduncle, number of grains and number and thickness of tillers, with yield in the order of importance.

Senker et al (1963) observed that among phenotypic and genotypic correlations were estimated among plant height, yield and four of the yield components namely spike length, spike girth, spike density and seed size. All the five characters showed a positive and significant correlation with yield.

Jute (Corchorus sp.)

Roy (1966) reported that plant height was correlated negatively with flowering time in the three varieties of Corchorus olitorius.

Shukula and Singh (1967) while studying the phenotypic, genotypic and environmental correlation coefficients for jute reported that environmental correlation coefficients for all pairs of characters were positive and significant except those with the flowering days which were negative. The coefficient of heritability was maximum for flowering days, while genetic advance was maximum for fibre weight. Selection based on discriminant function did not give any advantage over straight selection based on fibre yield only. Discriminant function based on basal diameter and on plant height which had relative

efficiencies of 92.22 and 94.5 percent respectively may prove to be of value in selection too high fibre yield when information on fibre yield is not available.

Cotton (Gossypium sp.)

Pense and Khargonakar (1949) found a positive correlation between lint yield, number of bolls, weight of lint per boll and weight of lint per seed in cotton.

Kamalanathan (1962) correlated three characters number of bolls per plant, number of seeds per boll and lint index.

Kamalanathan (1966) reported that among the seven characters studied for lint yield, number of bolls per plant, number of seeds per boll and lint index showed a very close association. These three characters together are capable of influencing lint yield to the extent of 64.83 percent.

Manning (1956) observed that characters like number of bolls per plant, seeds per boll and lint per seed as the primary components of yield in cotton.

Groundnut (Arachis hypogeae)

Ling in (1954) reported in the analysis of yield and its related characters in groundnut (Arachis hypogeae) showed that number of pods per plant, weight of pods per plant and number of seeds per pod were found to have a marked influence on yield.

Mishra (1956) stated that there is correlation between seed size and leaf characters of groundnut.

Mishra (1958) noticed strong association between characters, yield size of seed of kernels per pod.

The results obtained in respect of number of mature pods in confirmity with respect to Dorairaj (1961).

Chandra Mohan et al (1964-65) observed that number of mamure pods in groundnut and weight of plant (haulm) have high positive correlation with yield. These two characters showed a very high positive correlation with yield are themselves have high association between each other.

Lin and Chen (1967) reported in groundnut that correlations among pairs of plant characters like

length of main stem, number and length of branches, number of leaflets, position of terminal pod, number of pods per plant, average weight per pod and yield of pods.

Coconut (Cocos nucifera)

Krishnamurthy and Patel (1932) recorded positive correlation between yield and total number of leaves, height of trunk and number of female flowers.

Linseed (Linum usitatissimum)

Kedaranath et al (1960) found significant positive correlation between yield and capsule number.

Gingelly (Sesamum indicum)

Varisai et al (1964) recorded correlation between yield and 1000 seed weight, capsule number and capsule size in 100 varieties when all the varieties were taken together the three components showed significant positive correlation with yield.

Castor (Ricinus communis)

Sindagi (1965) in the study of genotypic variability and correlation coefficients relating to yield and a few other quantitative characters in castor.

Mustard (Brassica juncia)

Chaudhari (1967) while studying correlation between yield and contributing characters of Brassica juncia and the phenotypic, genotypic and environmental level, yield was highly associated with number of pods per plant, number of secondary branches and number of primary branches. The genotypic correlations were generally lower. Most of the phenotypic and environmental correlations between the yield attributing characters themselves are significant.

Sugarcane (Saccharum sp.)

Varma (1963) showed consistant positive and significant correlations with number of millable canes and cane weight, but under certain treatments and in certain years was also influenced by germination percentage, number of tillers per plant and plant weight.

Sing and Jain (1968) observed that thickness of the cane, number of internodes per clump, yield of cane per clump and juice percent per clump are inversely associated with number of canes per clump. Significant positive correlation between height of the main shoot was found with thickness of the cane, number of internodes per clump, yield of canes per clump and juice percent per clump. Thickness of the cane also had positive association with number of internodes per clump, yield of cane per clump and juice percent. High positive correlation was noticed between yield of cane per clump and juice percent. Number of internodes per clump was also correlated with yield of cane per clump and juice percent.

Potato (Solanum sp.)

Neeas (1957) recorded that a higher correlation was detected between size of tuber and size of starch grains then between starch grains.

Steineck (1959) in potato studied characters like the number of shoot per plant, the number of tubers per plant and yield components differed in their importance for each variety. The higher the shoot

number, the lower was the number of tubers per plant increased with the number of shoots but the relationship was complex.

Singh and Jain (1965) in potato var. Majestic noted that the yield per plant was significantly positively associated with number of leaves per plant, number of branches per plant, fresh shoot per plant and height of the main shoot. The positive non-significant association was observed between height of the main shoot and number of branches per plant.

Chillies (Capsicum sp.)

Sankara Narayan Pillai (1967) found in chillies, yield is strongly associated with plant height, number of branches, number of flowers and number of fruits.

Mungbean (Phaseolus aureus)

Balram Singh and Bhatnagar (1965) reported while studying correlation and regression analysis in an F_2 population showed that the number of days from seeding to harvesting in Phaseolus aureus can be predicted fairly accurately from the number of days from seeding

to initiation of flowering. The characters were positively and significantly correlated.

Pea (Pisum sativum, L.)

Yatendra et al (1965) observed that in Pea, the number of branches and leaves were correlated with the yield per plant. Length of the pod and weight of the green pods were correlated with the number of seeds and weight of green seeds and the last two characters are also correlated. There is no correlation between height and yield.

Zyl (1966) determined the correlation coefficients for the yield components of six cultivars and progenies of sample cross between Pisum sativum. Number of shoots per plant was correlated with the number of pods per plant. Similarly, the number of pods per plant was correlated with yield. It is concluded that selection programmes should concentrate on the number of shoots per plant.

Field bean (Phaseolus vulgaris)

Wallace (1959) observed that in seven varieties of field bean, the variety with greatest leaf area

usually gave the highest yield. The varieties differed in the ratio, leaf area, total dry weight. The onverse relationship between net assimilation rate and leaf area useful as a selection index in breeding for higher yields.

De Aruda (1959) studied nine varieties of beans showed a highly significant correlation between the weight of stem plus leaves and the weight of seeds produced. The regressive coefficient (b) = 0.34.

Hibiscus sp.

Sanyal and Datta (1954) observed that plant height and base diameter have been found to be the most suitable critiria for selection since these characters are highly correlated with fibre yield.

Gracia and Asico (1957) indicated that the length, height and basal diameter of kernel in Hibiscus cannabinus stems were positively correlated with fibre yield. Also noted that fresh weight of stem and percent of fibre recovery were negatively correlated.

Bhindi (Abelmoschus esculentus)

Shanmuga Sundaram (1950) reported that periodic picking of tender fruits in bhindi induced the plants to produce more fruits.

Rao (1953) also found that periodical picking of fruits vegetable stimulated the plants to produce large number of fruits than the treatment.

Perkins et al (1953) also found that the plants which were frequently harvested bore continuously while those on which the pods were allowed to mature exhibited alternate bearing in fruiting.

Khole and Chavan (1964) observed that the yield of okra is directly correlated with the length and thickness of the fruit and number of fruits produced per plant. They also noted that though these factors are governed by the genetical constitution of the plant, the stage at which the fruit is plucked equally responsible for yield. The stage of picking is also important from the point of view of quality.

Roman (1965) stated that hybrids showed early flowering, early maturity and high individual fruit weight.

Kamalanathan and Thamburaj (1968) observed that when okra crop was harvested continuously for vegetable it yielded more than when left for seed. There was also rapid crop growth.

Heritability

Heritability is defined as the proportion of observed variability which is due to heridity, the reminder being due to environmental causes.

Panse (1940) had emphasised the importance of heritable variability and genetic analysis of the character for selection efficiency and rate and these depend upon the number and magnitude of relationship of factors.

Determination of heritability depends upon the fraction of the genetic variation to the total variation of the characters. The effectiveness of selection in plant breeding depends upon the variable present in the material and the extent to which it is heritable.

Heritability has been determined in several crops.

Masuo and Kkuche (1955) reported that phenotypic correlation between stem weight, plant height, but the genotypic correlations differed between crosses in Flax. Both phenotypic and genotypic correlations between seed weight, number of capsules per plant and number of seeds per plant were high.

Stith (1956) reported that in cross between the commercial upland cotton, Acala and the wild variety, Hop, on the basis of phenotypic and genotypic correlations in the F_2 and F_3 it is concluded that lint percent is unfavourably associated with other fibre properties and selection for large boll size would result as longer, stronger and fine fibres but low lint percent, where fibre fineness is the chief breeding aim.

Dhesi et al (1964) has shown in the crosses of egg plant that number of branches per plant, number of fruits per plant, fruit weight and fruit length had a high heritability in the cross R34 x Nurki than other two as these having lower heritabilities.

Kennedchuk (1965) found that heritability estimates were to be larger and more reliable for F_3 than for F_2 seed weight and number of seeds per pod

were found to be heritable than yield or pod number per plant in four soyabean lines.

Pokhariyal et al (1966) Pearl millet (Pennisetum typhoides) found that the width of leaf girth of ear showed evidence of high heritability and moderate genetic advance, while stem diameter plant height and length of leaf possessed relatively lower heritability and low genetic advance. The height of main clum, length of main ear, seed weight yield of main stem ear and fodder yield indicated high genetic coefficient of variability compared to other characters. These characters showed high heritability as well as high genetic advance over the respective mean, which appeared to suggest that heritability was probably owing to the additive gene effects in these characters. Also reported that plant height, length and width of leaf, stem diameter and girth of main ear were positively and significantly correlated with yield.

In several populations of Allium cepa and S_1 progenies Mc Collum (1966) estimated heritability for the weight, height, diameter and shape index of the bulbs (height - diameter). High positive genetic

correlations and low environmental correlations were found between bulb height and shape index. He also reported that genetic and environmental correlations were between diameter and shape. Genetic correlations between weight and shape were much lower than environmental ones.

Narasimha Rao and Pardhasarathi (1968) noted in ragi (Eleusim sp.) a wide range of phenotypic variation for most of the ten characters studied. Very high genetic coefficient of variation was observed for grain yield and plant height which stalk diameter had the lowest. Plant height, peduncle length and panicle length exhibited high heritability values, while panicle length alone showed the highest genetic gain. So in plant breeding a character having high variability coupled with high genetic advance is very helpful in selection work.

MATERIALS AND METHODS

MATERIAL AND METHODS

A. MATERIAL

The material used in this investigation consisted of ten varieties of bhindi (*Abelmoschus esculentus* L. Moench) obtained from a collection of varieties maintained in the Division of Botany, Agricultural College and Research Institute, Vellayani. These ten varieties exhibited wide variation in their habit of growth, stature, nature of branching and also in the morphology of different plant parts especially, the leaves, fruits etc.

The list of varieties and some of their salient features are presented in Table 1.

B. METHODS

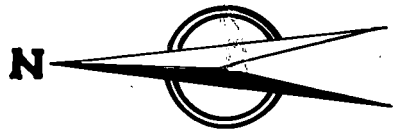
Plants were grown under uniform conditions in randomised blocks with the ten varieties replicated three times. Each plot contained twelve plants out of which nine plants were selected at random and labelled. Thus there were altogether 270 plants (10 varieties x 3 replications x 9 plants) from which were labelled and from which alone the data was collected and recorded.

Table I

Description of varieties of bhindi used in the study

Varieties	Stature	Stem	Leaf	Leaf	Leaf	Petiole	Petiole	Fruit	Fruit	Fruit	% of fruit set
V_1	Tall	Not pigmented	Deeply lobed	Generally 5 lobed	Pubescent	Long	Not pigmented	Long	Smooth	5-9 locules	82.94
V_2	Short	Pigmented	Deeply lobed	Generally 5 lobed	Glabarous	Inter-mediate	Pigmented	Inter-mediate	Smooth	5-9 locules	73.82
V_3	Short	Pigmented	Less deeply lobed	Generally 5 lobed	Pubescent	Long	Pigmented	Inter-mediate	Spiny	5-8 locules	67.23
V_4	Short	Not pigmented	Deeply lobed	Generally 5 lobed	Glabarous	Inter-mediate	Pigmented	Inter-mediate	Smooth	7-9 locules	71.29
V_5	Median	Not pigmented	Less deeply lobed	Generally 5 lobed	Pubescent	Inter-mediate	Pigmented	Inter-mediate	Smooth	5-10 locules	81.26
V_6	Tall	Not pigmented	Deeply lobed	Generally 5 lobed	Glabarous	Long	Not pigmented	Long	Smooth	5-8 locules	81.71
V_7	Short	Not pigmented	Less deeply lobed	Generally 7 lobed	Pubescent	Short	Not pigmented	Short	Spiny	6-10 locules	86.57
V_8	Median	Not pigmented	Less deeply lobed	Generally 5 lobed	Pubescent	Long	Not pigmented	Inter-mediate	Less spiny	5-10 locules	77.65
V_9	Short	Pigmented	Less deeply lobed	Generally 7 lobed	Pubescent	Short	Pigmented	Short	Spiny	5-9 locules	69.74
V_{10}	Tall	Pigmented	Less deeply lobed	Generally 5 lobed	Glabarous	Long	Pigmented	Long	Smooth	7-9 locules	83.33

Fig. 1. Layout plan of the field experiment



LAY-OUT OF THE FIELD EXPERIMENT

V_1	V_6	V_8	V_5	V_{10}	V_9	V_2	V_3	V_7	V_4
V_2	V_7	V_4	V_{10}	V_9	V_3	V_1	V_6	V_5	V_8
V_9	V_{10}	V_1	V_6	V_8	V_5	V_2	V_7	V_4	V_3

DESIGN. 10 X3 . RANDOMISED BLOCK DESIGN

V_1 , V_2 , V_3 .....V_{10} VARIETIES

SINGLE PLOT. 3METERS X3 METERS

FIG 1

Characters studied

Plants were studied for the following characters.

1. Height of plant,
2. Number of leaves,
3. Number of branches,
4. Stem thickness,
5. Total number of flowers,
6. Total number of fruits,
7. Weight of fruits (yield of fruits),
8. Length of fruit,
9. Girth of fruit,
10. Percentage of fruit set,
11. Mean weight of fruits.

1. Height of plant

Height was measured to the nearest centimeter from the ground level to the tip of the plant. The maximum height were recorded at full maturity of the plants.

2. Number of leaves

Total number of leaves produced per plant was estimated by counting the number of nodes on the main stem and branches at full maturity.

3. Number of branches

All the branches were counted at the time of full maturity and recorded.

4. Stem thickness

Stem thickness was recorded at full maturity using a pair of calipers.

5. Total number of flowers

The number of flowers in each plant was recorded daily. The total number of flowers produced by each plant was consequently estimated by adding together the figures obtained for each day.

6. Total number of fruits

Number of fruits for individual plants was recorded at each harvest. From these observation the total number of fruits produced per plant can be calculated.

7. Weight of fruits (Yield of fruits)

The weight of fruits per plant at each harvest recorded gave the total weight of fruits produced per plant.

8. Length of fruit

The length of fruits for each fruit recorded at each harvest.

9. Girth of fruit

The girth of fruits for each fruit recorded at each harvest.

10. Percentage of fruit set

From the total number of flowers produced per plant and total fruits produced per plant the percentage of fruit set for each variety calculated.

11. Mean weight of fruit

Total weight of fruits produced per plant was recorded. Total number of fruits produced per plant was also recorded. The mean weight of fruit was estimated from this.

Statistical procedure

The whole data were tabulated variety-wise (for twenty seven plants) and for all varieties taken

together (Two hundred and seventy plants) in order to suit the following analytical method.

(i) Study of varietal difference

Analysis of variance was worked out for the eleven characters mentioned above to find out whether the varieties differed significantly or not for these characters.

Source of variation	Degree of freedom	Sum of squares	Mean squares	Variance ratio (F)
Replication	(r-1)	SS.R	S^2R	S^2R/S^2E
Varieties	(V-1)	SS.V	S^2V	S^2V/S^2E
Error	(r-1)(V-1)	SS.V.R.	SS.E	
Total	(rV-1)			

Where, 'r' is the number of replication and 'V' is the number of varieties.

Variance ratios ie., F. ratio for varieties were calculated and compared with the critical value of 'F' for (V-1) and (r-1)(V-1) degrees of freedom at five percent and one percent levels of significance.

(ii) Study of correlation

Coefficients of correlation were worked out for yield and each one of the following seven characters for each variety separately as well as for all the varieties combined together.

1. Height of plant
2. Number of leaves
3. Number of branches
4. Stem thickness
5. Length of fruit
6. Girth of fruit
7. Number of fruits

In addition, among these characters which were tested for their relationship with yield, namely height of plant, number of leaves, number of branches, stem thickness, fruit length, fruit girth and number fof fruits, the correlations were also worked out separately and mutually. For estimating the coefficient of this mutual correlation the varieties were taken together. Coefficients of simple correlation were worked out by the formula given by Hays et al (1955).

$$r = \frac{SP\ XY}{\sqrt{SSX.SSY}}$$, where

SP XY denotes sum of products of the two variables X and Y, SSX the sum of squares of the variable X and SSY the sum of squares of the variable Y.

The partial correlation of yield against the height of plant, length of fruit, girth of fruit and number of fruits was worked out taking all the varieties together.

For calculating the partial correlations, the formulae suggested by Yule and Kendall (1950) were used.

$$r_{12.3} = \frac{r_{12} - (r_{13})\ (r_{23})}{\sqrt{(1-r_{13}^2)\ (1-r_{23}^2)}}$$, where

r_{12}, r_{13} and r_{23} are simple correlation coefficients between the dependent variables X_1 and X_2, X_1 and X_3 and X_2 and X_3 respectively.

$$r_{12.34} = \frac{r_{12.3} - (r_{14.3})\ (r_{24.3})}{\sqrt{(1-r_{14.3}^2)\ (1-r_{24.3}^2)}}$$

$$r_{12.345} = \frac{r_{12.34} - (r_{15.34})\,(r_{25.34})}{\sqrt{(1-r_{15.34}^2)\,(1-r_{25.34}^2)}}$$

$r_{12.3}$, $r_{12.34}$, $r_{12.345}$ etc. are partial correlation coefficients for the different associations between the respective variables.

Multiple correlation coefficient (R) was calculated for the yield against, height of plant, number of leaves, number of branches, stem thickness, length of fruit, girth of fruit and number of fruits after the following formulae.

$$R_{1.(23)} = \sqrt{1-(1-r_{12}^2)\,(1-r_{13.2}^2)}$$

$$R_{1.(234)} = \sqrt{1-(1-r_{12}^2)\,(1-r_{13.2}^2)\,(1-r_{14.23}^2)}$$

$$R_{1.(2345)} = \sqrt{1-(1-r_{12}^2)\,(1-r_{13.2}^2)\,(1-r_{14.23}^2)(1-r_{15.234}^2)}$$

$$R_{1.(23456)} = \sqrt{1-(1-r_{12}^2)(1-r_{13.2}^2)(1-r_{14.23}^2)(1-r_{15.234}^2)\,(1-r_{16.2345}^2)}$$

$$R_{1.(234567)} = \sqrt{1-(1-r_{12}^2)(1-r_{13.2}^2)(1-r_{14.23}^2)\,(1-r_{15.234}^2)(1-r_{16.2345}^2)(1-r_{17.23456}^2)}$$

$$R_{1.(2345678)} = \sqrt{1-(1-r_{12}^2)(1-r_{13.2}^2)(1-r_{14.23}^2)(1-r_{15.234}^2)\,(1-r_{16.2345}^2)(1-r_{17.23456}^2)(1-r_{18.234567}^2)}$$

where r_{12} is total correlation coefficient between characters 1 and 2 and $r_{13.2}$, $r_{14.23}$, $r_{15.234}$, $r_{16.2345}$ etc. are partial correlation coefficients.

The significance of the simple, partial and multiple correlation coefficients was tested by reference to the table of critical values of correlation coefficients at the five percent and one percent levels of significance given by Snedicor (1931).

The phenotypic and genotypic variances for the different characters were computed from the respective tables of analysis of variance.

Heritability

Determination of heritability depends upon the fraction of the genetic variation to the total variation of the character which was computed from the table of analysis of variance.

$$\text{Genotypic variance} = \sigma^2_g$$

$$\text{Phenotypic variance} = \sigma^2_p$$

$$\text{Heritability} = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

EXPERIMENTAL RESULTS

RESULTS

Since variability of the different characters is an important feature in correlation studies, an attempt has been made to study this aspect in this investigation.

Studies on the variability

The variability with respect to eleven characters were studied over all the varieties taken together. The results are presented in the Tables 2 to 12.

Height of plant

As seen from Table 2 the analysis of variance shows that there exists no significant variability in bhindi with respect to this character at the intra-varietal level.

Number of leaves

The Table 3 shows that the varieties do not differ significantly in number of leaves as shown by the low value of F ratio.

Table 2

Analysis of variance - Plant height

Sources	S.S.	Df	Variance	F ratio
Total	958689.87	29		
Replications	87300.27	2	43650.135	2.004
Varieties	479355.20	9	53261.68	2.445
Error	392034.40	18	21779.688	

Table 3

Analysis of variance - Number of leaves

Source	S.S.	Df	Variance	F ratio
Total	540831.37	29		
Replications	130870.87	2	65435.44	5.075*
Varieties	177864.03	9	19762.67	1.533
Error	232096.47	18	12894.25	

* Significant at 5% level

Number of branches

As seen from the Table 4 there is significant difference in the number of branches as shown by the value of F ratio.

Table 4

Analysis of variance - Number of branches

Sources	S.S.	Df	Variance	F ratio
Total	6688.3	29		
Replications	77.6	2	38.8	0.03
Varieties	4588.3	9	509.8	4.54**
Error	2022.4	18	112.36	

** Significant at 1% level

Stem thickness

As seen from the Table 5 the analysis shows that there exists no significant variability in bhindi with respect to this character at the intravarietal level.

Table 5

Analysis of variance - Stem thickness

Sources	S.S.	Df	Variance	F ratio
Total	107.53	29		
Replications	9.96	2	4.98	1.35
Varieties	31.10	9	3.46	0.94
Error	66.47	18	3.69	

Number of flowers

The varieties do not differ significantly in number of flowers as shown by the low value of F ratio from the Table 6.

Number of fruits

The varieties do not differ significantly in respect of this character namely, number of fruits as shown by the low value of the F ratio (Table 7).

Table 6

Analysis of variance - Number of flowers

Sources	S.S.	Df	Variance	F ratio
Total	46255.40	29		
Replications	10648.90	2	5324.45	3.59*
Varieties	8978.73	9	997.64	0.07
Error	26627.77	18	1479.32	

* Significant at 5% level

Table 7

Analysis of variance - Number of fruits

Sources	S.S.	Df	Variance	F ratio
Total	39509.49	29		
Replications	8208.07	2	4104.04	3.65*
Varieties	11065.47	9	1229.49	1.09
Error	20235.95	18	1124.22	

* Significant at 5% level

Yield of fruits

As seen from the Table 8 the analysis shows that there exists no significant variability in bhindi with respect to this character and the intravarietal level.

Table 8

Analysis of variance - Yield of fruits

Sources	S.S.	Df	Variance	F ratio
Total	13767236.67	29		
Replications	3132223.27	2	1566111.635	3.71*
Varieties	3038464.67	9	337607.785	0.79
Error	7594548.73	18	421919.37	

* Significant at 5% level

Length of fruit

The varieties do not differ significantly in the character, namely fruit length as indicated by the low value of F ratio from the Table 9.

Table 9

Analysis of variance - Length of fruit

Sources	S.S.	Df	Variance	F ratio
Total	7630786.00	29		
Replications	1434827.85	2	717413.93	4.22*
Varieties	3138316.16	9	348701.79	2.05
Error	3057641.99	18	169868.99	

* Significant at 5% level

Girth of fruit

As seen from the Table 10 the analysis shows that there exists no significant variability with respect to this character at the intravarietal level.

Percentage of fruit set

The varieties do not differ significantly in the character, namely percentage of fruit set as indicated by the low value of F ratio from Table 11.

Table 10

Analysis of variance - Girth of fruit

Sources	S.S.	Df	Variance	F ratio
Total	1337743.30	29		
Replications	167025.95	2	83512.98	1.70
Varieties	287380.63	9	31931.18	0.65
Error	883336.72	18	49074.62	

Table 11

Analysis of variance - Percentage of fruit set

Sources	S.S.	Df	Variance	F ratio
Total	2780.55	29		
Replications	109.36	2	54.68	0.74
Varieties	1342.98	9	149.68	0.20
Error	1328.21	18	73.79	

Mean weight of fruits

The analysis of variance Table 12 shows that there exists significant variability in bhindi with respect to this character at the intravarietal level.

Table 12

Analysis of variance - Mean weight of fruits

Sources	S.S.	Df	Variance	F ratio
Total	128.61	29		
Replications	1.75	2	0.87	0.33
Varieties	79.34	9	8.82	3.16*
Error	47.52	18	2.64	

* Significant at 5% level

Of these eleven characters studied for the variability, the critical difference had been worked out in respect of number of branches and mean weight of fruits, the two characteristics which exhibited significant variability, with a view to group the ten varieties of bhindi studied in distinct groups.

Fig. 2. Graphical representation of the varietal variation in:

A. Height of plant

B. Number of branches

C. Number of leaves

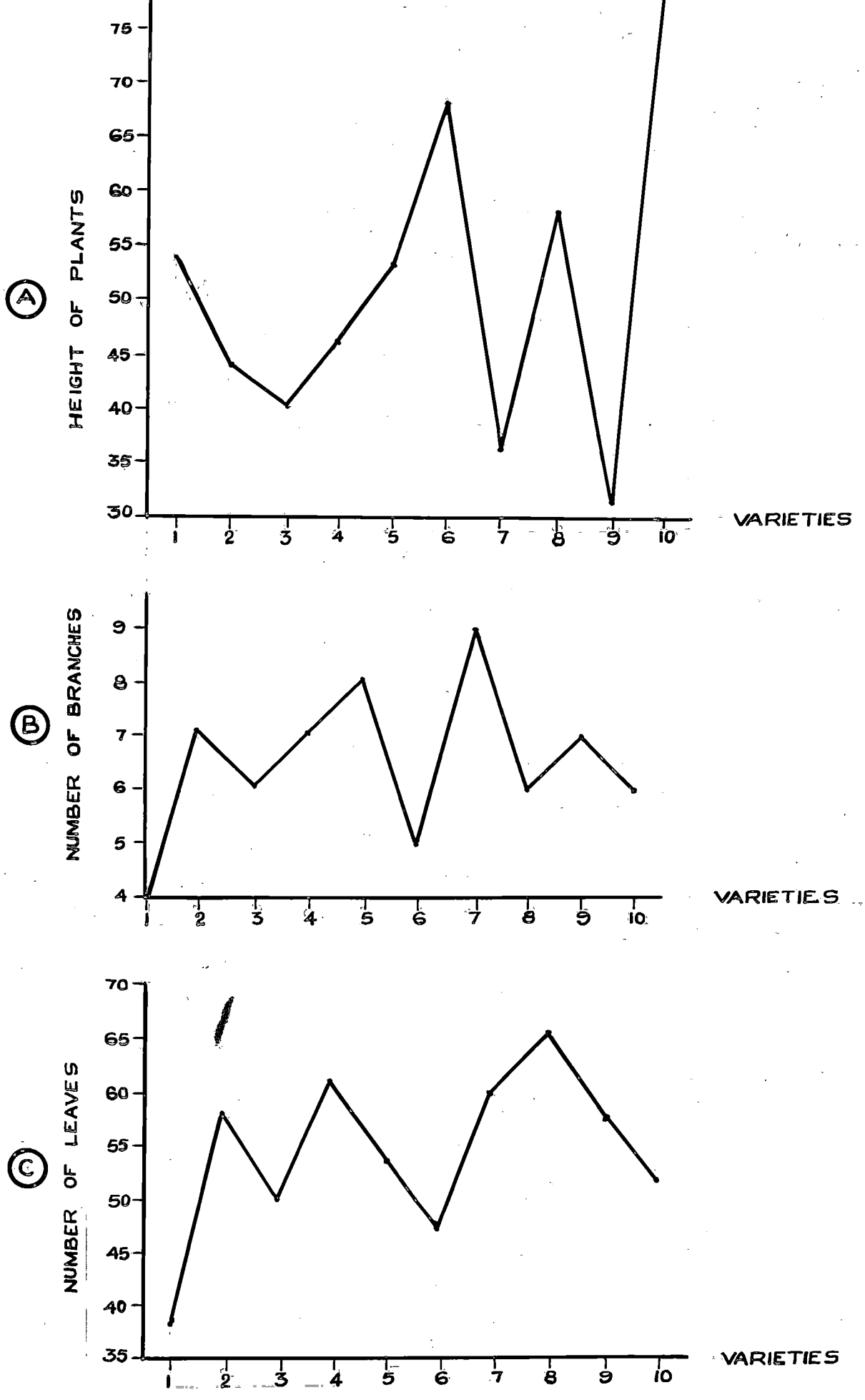

A
HEIGHT OF PLANTS
75
70
65
60
55
50
45
40
35
30
1 2 3 4 5 6 7 8 9 10
VARIETIES
B
NUMBER OF BRANCHES
9
8
7
6
5
4
1 2 3 4 5 6 7 8 9 10
VARIETIES
C
NUMBER OF LEAVES
70
65
60
55
50
45
40
35
1 2 3 4 5 6 7 8 9 10
VARIETIES

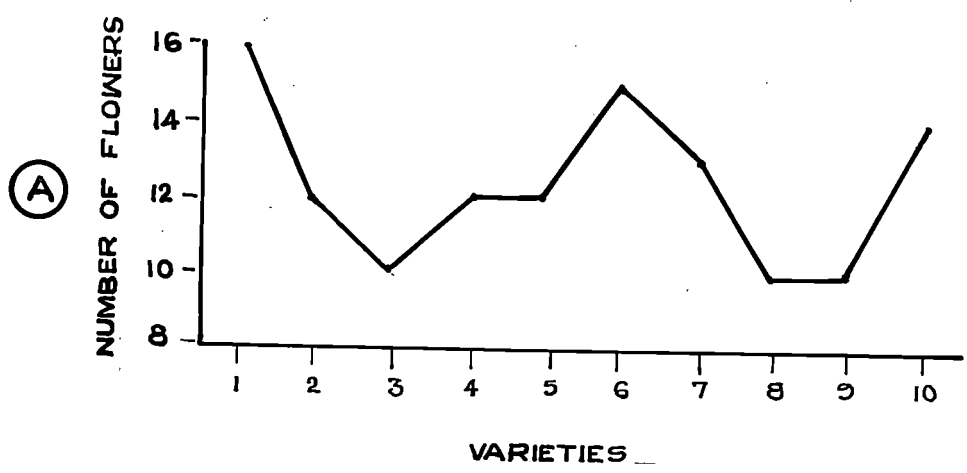
FIG 2

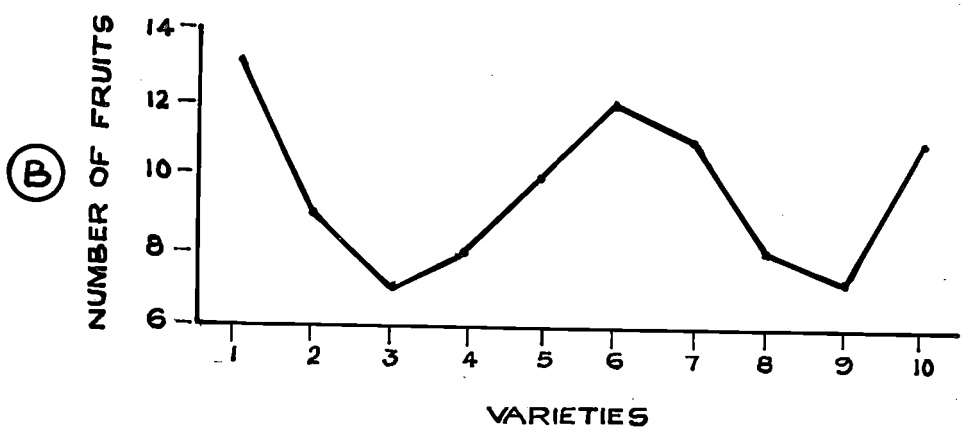
Fig. 3. Graphical representation of varietal variation in:

A. Number of flowers

B. Number of fruits

C. Percent of fruit set


A
NUMBER OF FLOWERS
16
14
12
10
8
1 2 3 4 5 6 7 8 9 10
VARIETIES


B
NUMBER OF FRUITS
14
12
10
8
6
1 2 3 4 5 6 7 8 9 10
VARIETIES

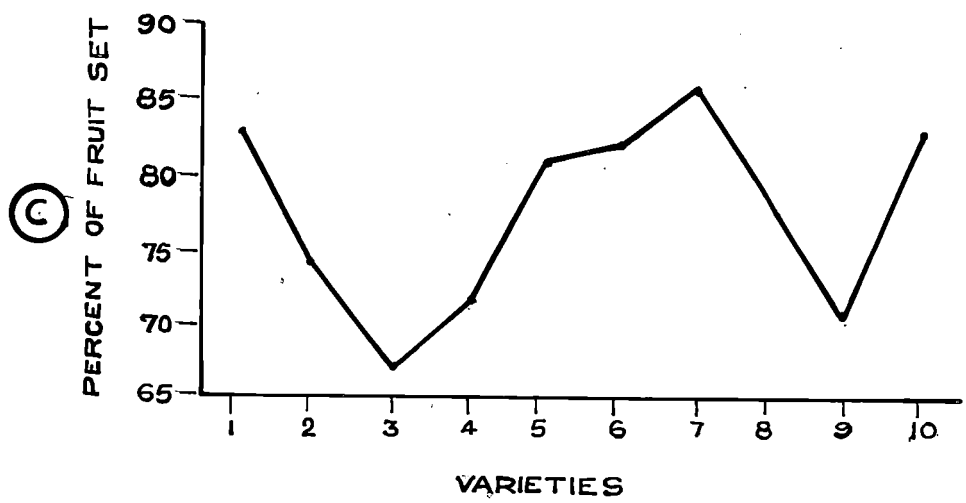

C
PERCENT OF FRUIT SET
90
85
80
75
70
65
1 2 3 4 5 6 7 8 9 10
VARIETIES

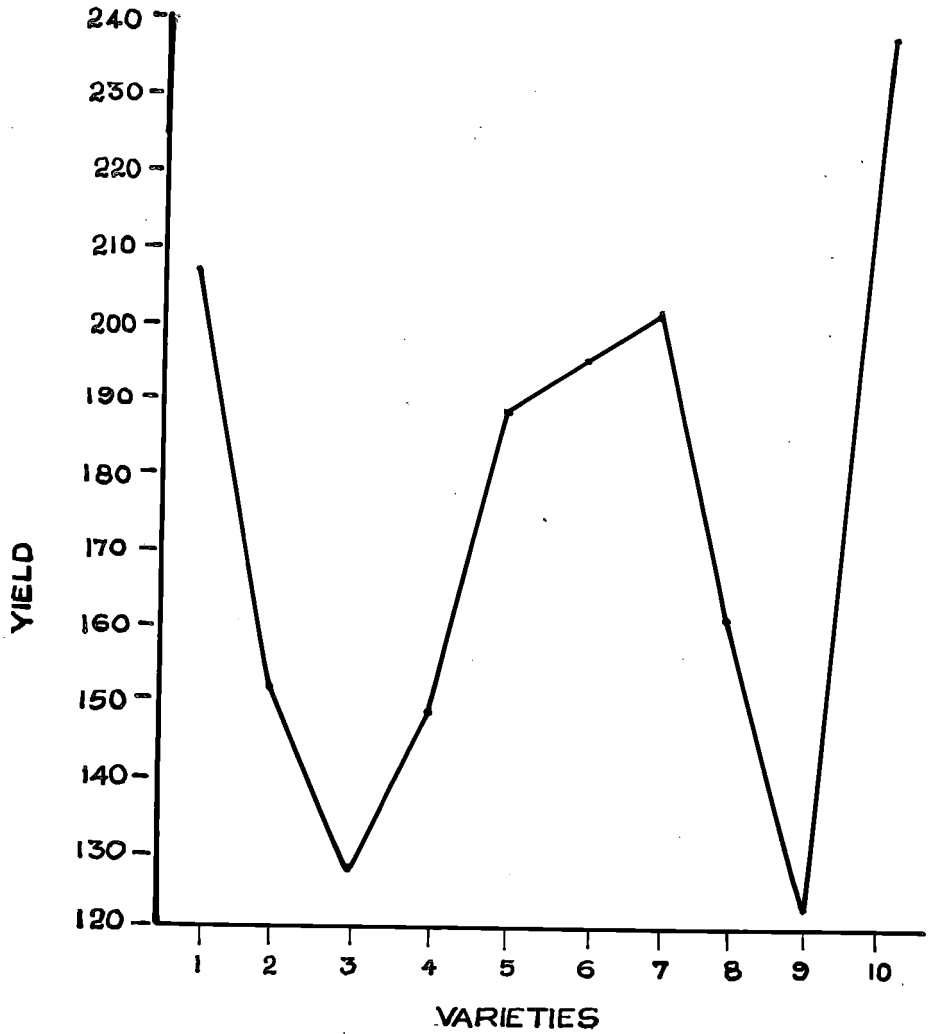
FIG 3

Fig. 4. Graphical representation of varietal variation in:

A. Yield

B. Mean weight of fruits

(A)


240
230
220
210
200
190
180
170
160
150
140
130
120
YIELD
1
2
3
4
5
6
7
8
9
10
VARIETIES

(B)

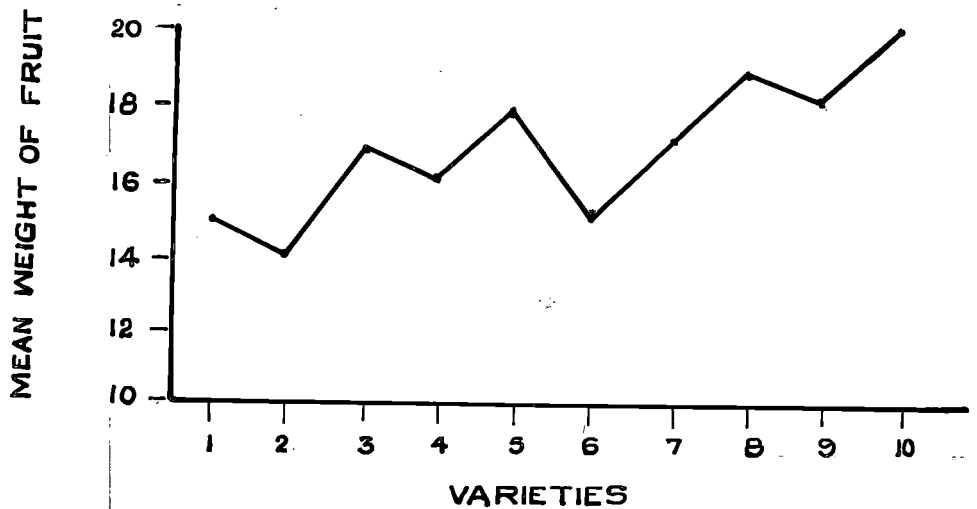
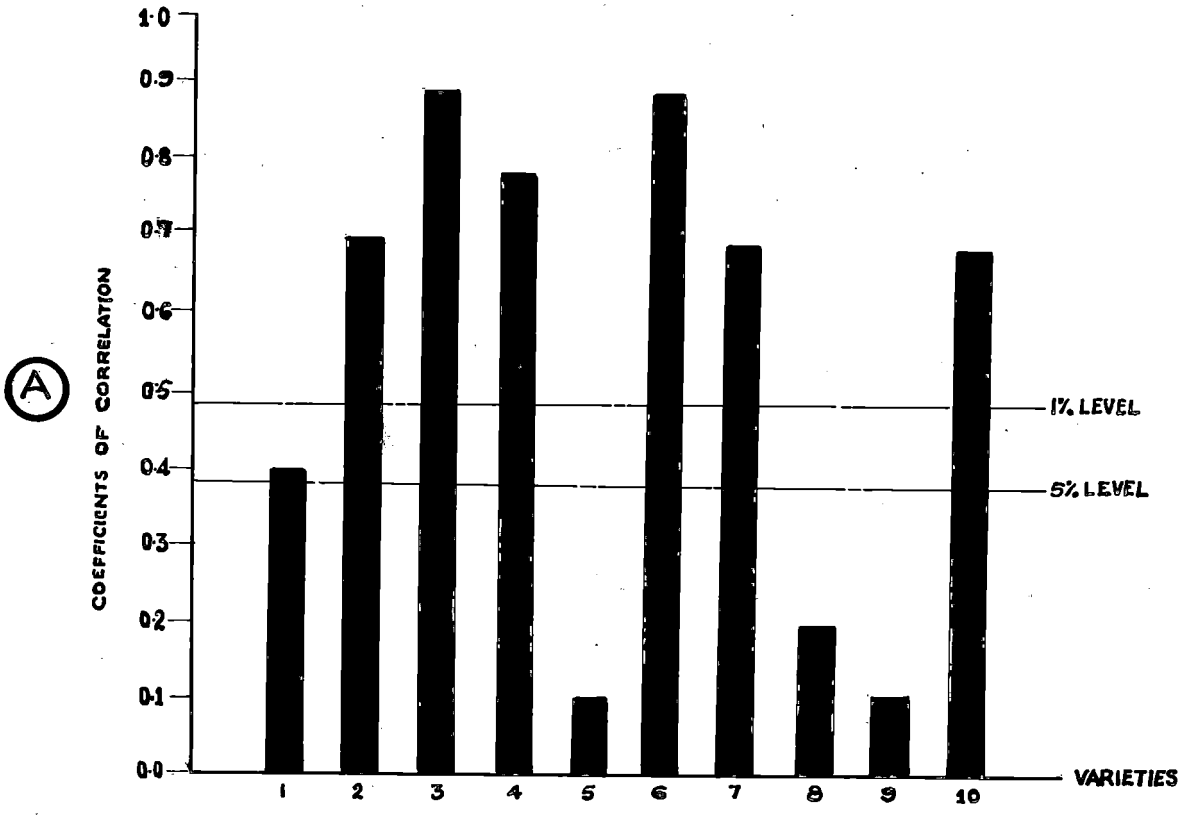

20
18
16
14
12
10
MEAN WEIGHT OF FRUIT
1
2
3
4
5
6
7
8
9
10
VARIETIES

FIG 4

Fig. 5. Bar diagrams showing coefficient of correlation for varieties between yield and height of plants and branches


A
COEFFICIENTS OF CORRELATION
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·0
1% LEVEL
5% LEVEL
VARIETIES
1
2
3
4
5
6
7
8
9
10

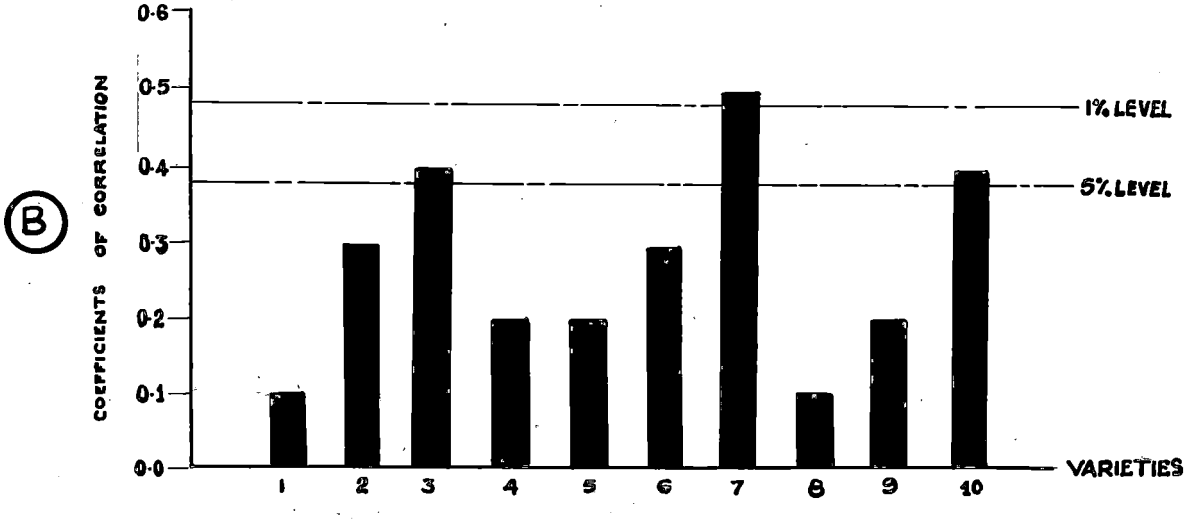
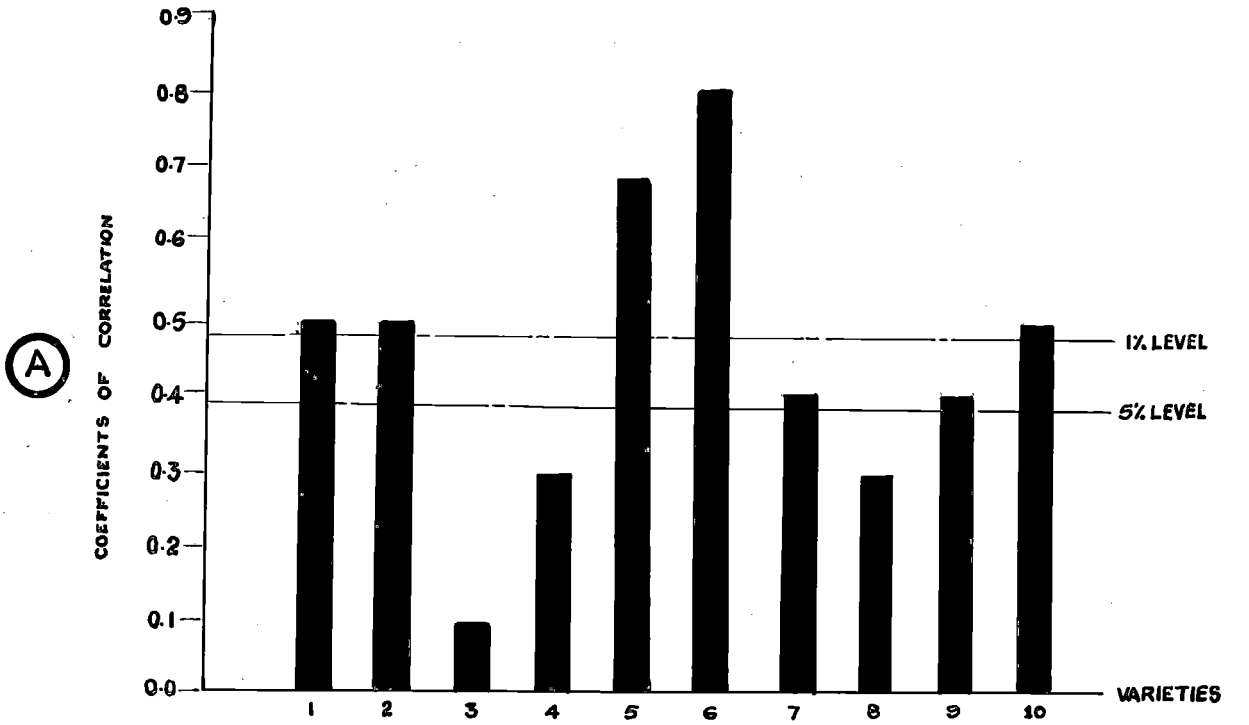

B
COEFFICIENTS OF CORRELATION
0·6
0·5
0·4
0·3
0·2
0·1
0·0
1% LEVEL
5% LEVEL
VARIETIES
1
2
3
4
5
6
7
8
9
10

FIG 5

Fig. 6. Bar diagrams showing coefficient of correlation for varieties between yield and number of leaves and stem thickness


A
COEFFICIENTS OF CORRELATION
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·0
1% LEVEL
5% LEVEL
VARIETIES
1
2
3
4
5
6
7
8
9
10

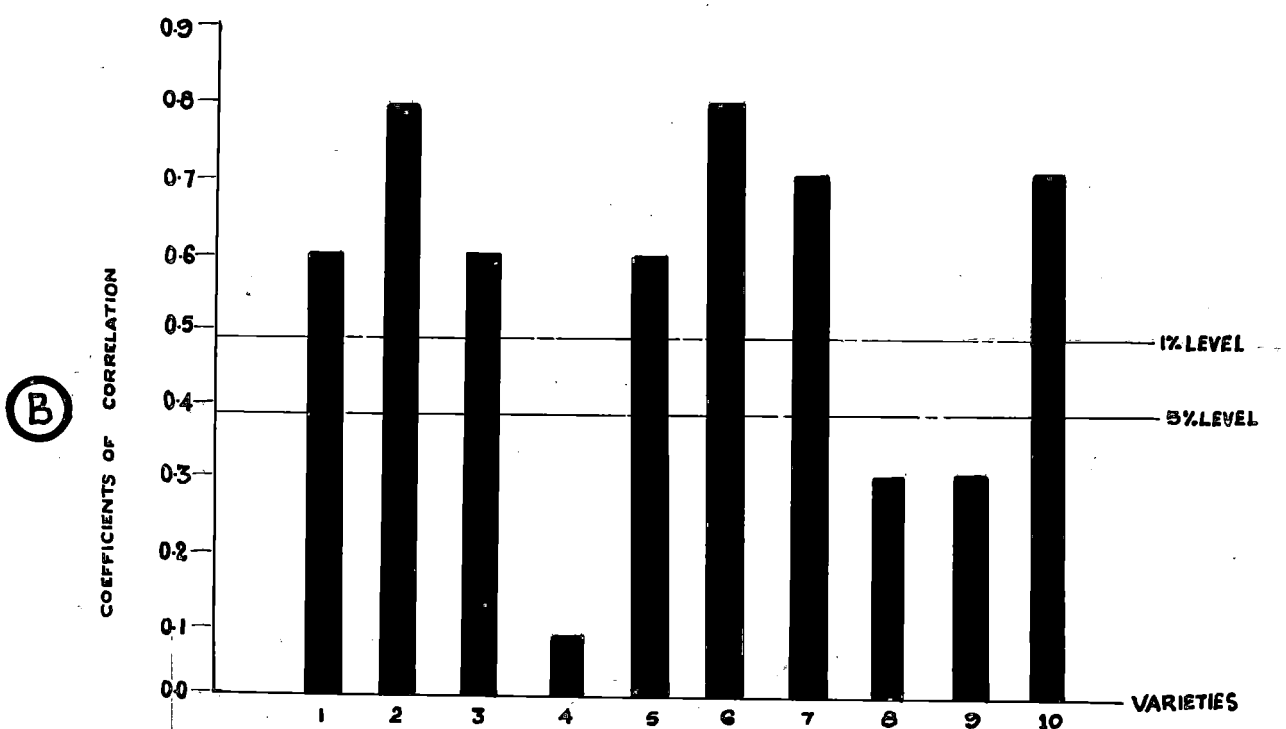
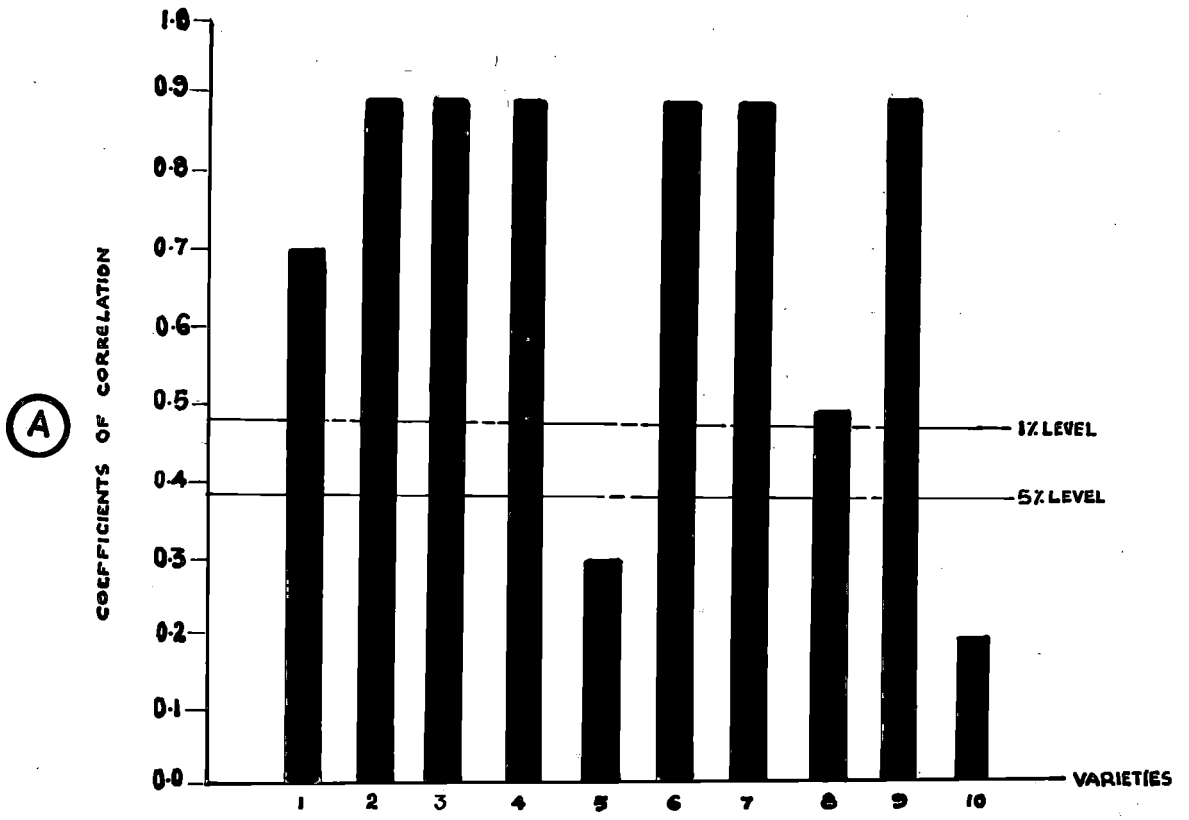

B
COEFFICIENTS OF CORRELATION
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·0
1% LEVEL
5% LEVEL
VARIETIES
1
2
3
4
5
6
7
8
9
10

FIG 6

Fig. 7. Bar diagrams showing coefficient of correlation for varieties between yield and fruit length and girth


A
COEFFICIENTS OF CORRELATION
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·0
1% LEVEL
5% LEVEL
VARIETIES
1
2
3
4
5
6
7
8
9
10

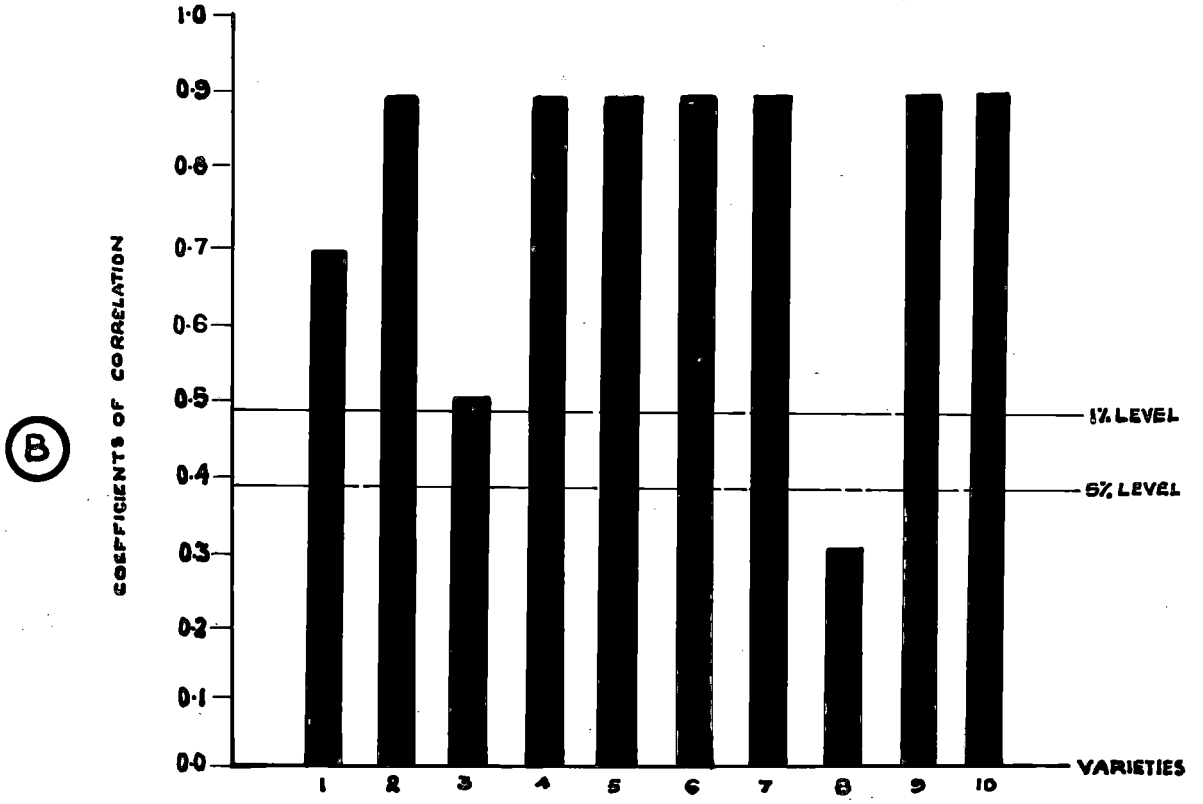

B
COEFFICIENTS OF CORRELATION
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·0
1% LEVEL
5% LEVEL
VARIETIES
1
2
3
4
5
6
7
8
9
10

Fig. 9. Bar diagram showing coefficient of correlation for varieties between yield and number of fruits

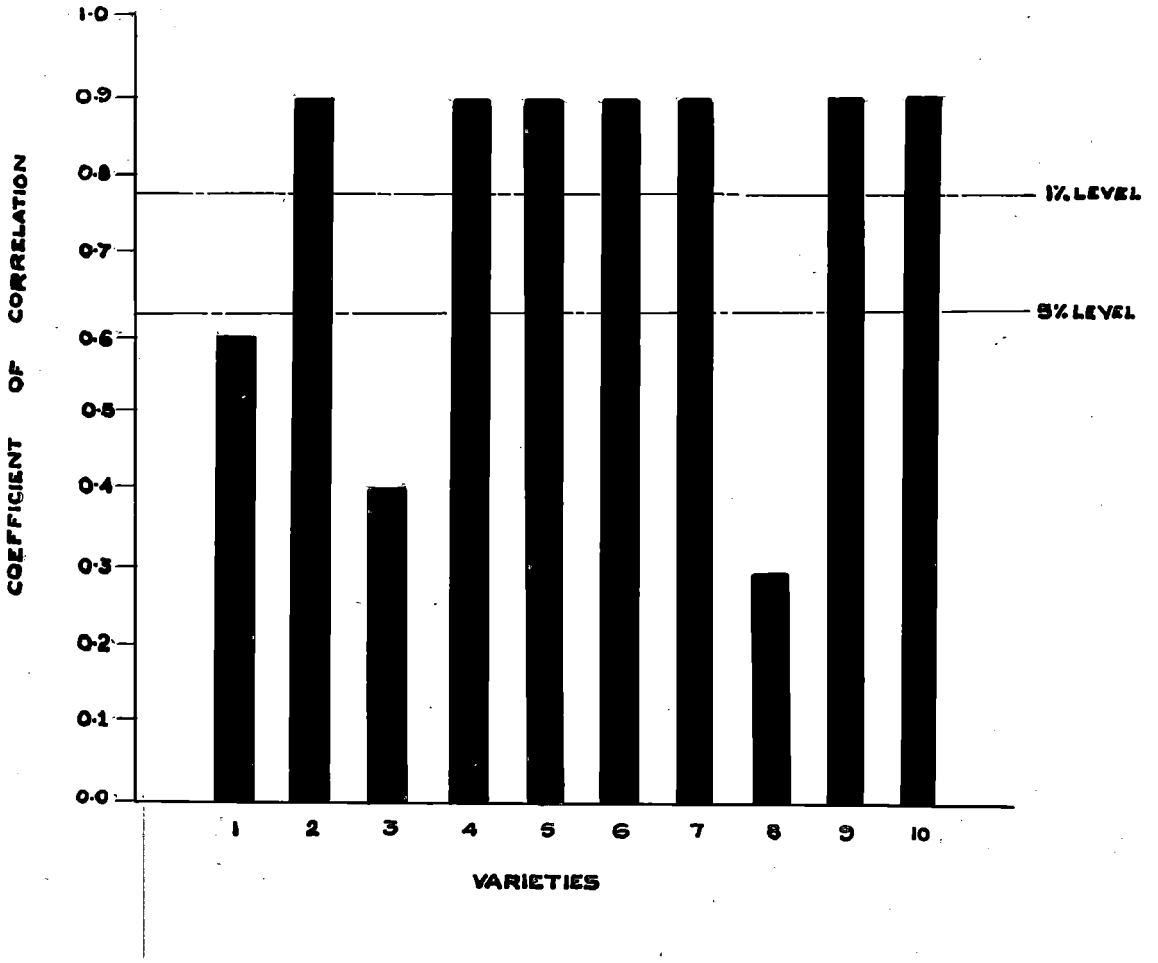

COEFFICIENT OF CORRELATION
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·0
1% LEVEL
5% LEVEL
1
2
3
4
5
6
7
8
9
10
VARIETIES

Fig 9

Fig. 8. Bar diagram showing coefficient of correlation for varieties between yield and seven other characters associated with yield, for the variation as a whole

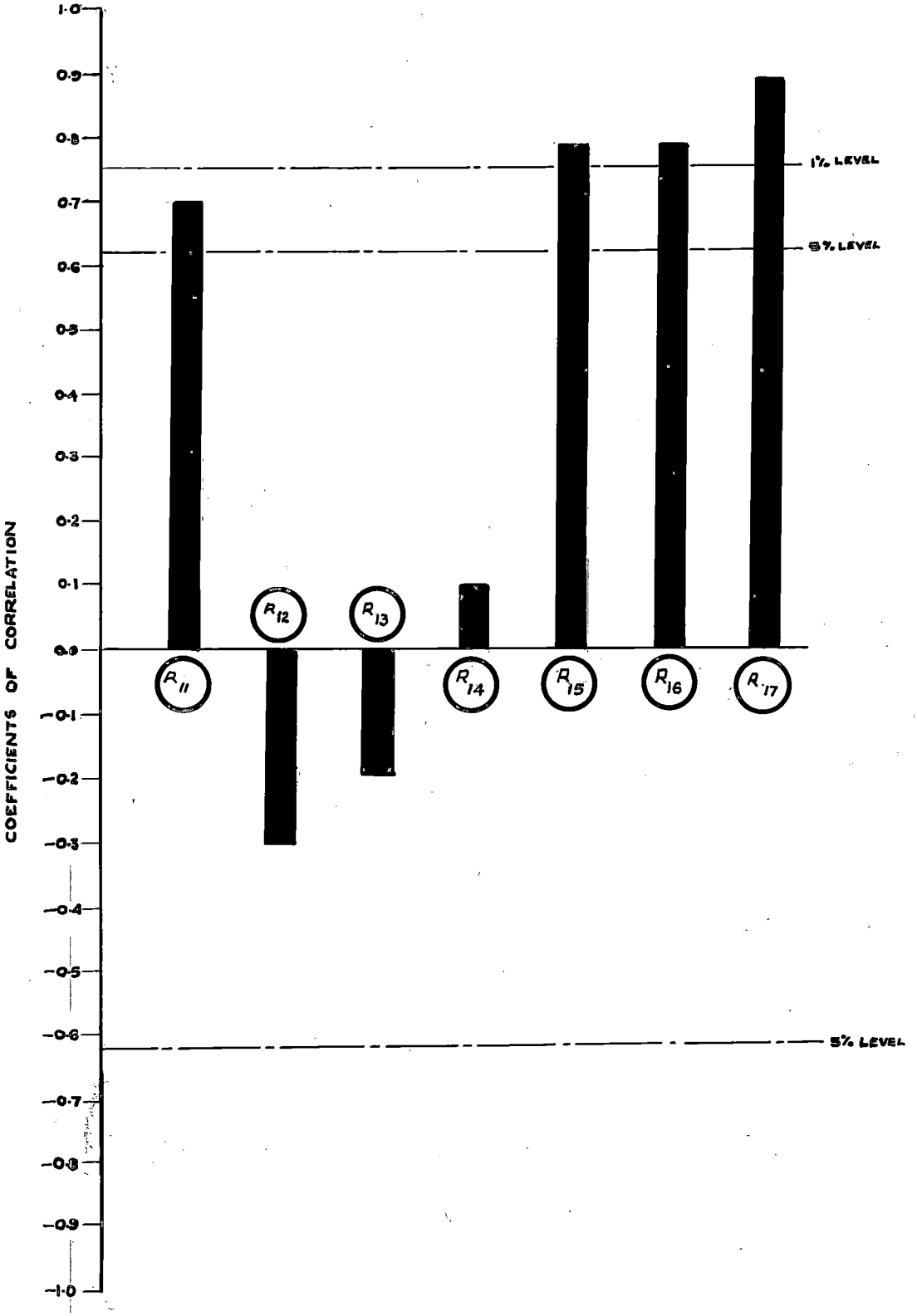

COEFFICIENTS OF CORRELATION
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·0
-0·1
-0·2
-0·3
-0·4
-0·5
-0·6
-0·7
-0·8
-0·9
-1·0
1% LEVEL
5% LEVEL
5% LEVEL
R11
R12
R13
R14
R15
R16
R17

Fig 8

For the number of branches the critical difference is estimated to be 2.01 and based on this the varieties are arranged as follows:-

V_1	V_6	V_3	V_{10}	V_8	V_2	V_4	V_9	V_5	V_7
3.70	5.33	5.93	6.18	6.44	7.07	7.29	7.59	8.11	8.66

This, further, emphasises that eventhough significant differences is noticed distinct grouping in respect of the varieties is not possible on the basis of number of branches. The superiority of the variety V_7 in its ability to produce more branches is undoubted over V_1, V_6, V_3, V_{10} and V_8. Similarly, that of V_5 is also clearly established over that of V_1, V_6 and V_3. However, it has become clear that V_7 and V_5 eventhough differ from one another, do not show any significant differences.

Similarly, for the mean weight of fruits the critical difference has been estimated to be 2.77. The varieties are arranged as follows:-

V_6	V_1	V_2	V_7	V_5	V_3	V_4	V_9	V_8	V_{10}
15.36	15.70	16.31	17.21	17.45	17.56	17.95	18.97	19.63	20.26

Here also it is noticed that distinct grouping of the varieties on the basis of this character is not possible. V_{10}, the variety recording the maximum value for mean weight of fruits exhibit unquestioned superiority over V_6, V_1, V_2, V_7 and V_5. The variety, V_8 shows superiority over V_6, V_1 and V_2. However V_{10} and V_8 fail to differ from one another significantly.

It is seen from the above two instances, that with respect to number of branches and mean weight of fruits eventhough significant differences exist at inter varietal level, no distinct grouping of the varieties is possible.

Studies on the correlation

Correlation between yield and each one of the characters, plant height, number of leaves, number of branches, stem thickness, fruit length, fruit girth and number of fruits was studied for each one of the

ten varieties separately as well as over all the varieties taken together, the results of which are presented in Tables 13 and 14 respectively.

Yield and height of plant

Yield and height of plants is observed to be significantly and positively correlated in almost all the varieties except for V_5, V_8 and V_9.

Yield and number of leaves

Between yield and number of leaves significant positive correlation is noticed only in the case of V_1, V_2, V_5, V_6, V_7, V_9 and V_{10}. For V_3, V_4 and V_8 the values for the correlation, however, have been found to be not significant.

Yield and number of branches

With regard to the yield and the number of branches majority of the varieties show no significant correlation. V_{10}, V_7 and V_3, however, exhibited significant relationships which are positive.

Table 13

Simple correlation coefficients between yield and seven other characters in each of the ten varieties

Characters / Varieties	Plant height	No. of leaves	No. of branches	Stem thickness	Fruit length	Fruit girth	No. of fruits
V_1	0.498**	0.579**	0.177	0.620**	0.718**	0.733**	0.689**
V_2	0.763**	0.532**	0.351	0.802**	0.959**	0.958**	0.921**
V_3	0.981**	0.194	0.461*	0.683**	0.567**	0.961**	0.469
V_4	0.894**	0.342	0.249	0.135	0.962**	0.951**	0.928**
V_5	0.188	0.789**	0.220	0.609**	0.986**	0.957**	0.978**
V_6	0.944**	0.874**	0.361	0.838**	0.958**	0.979**	0.975**
V_7	0.749**	0.448*	0.552**	0.746**	0.971**	0.941**	0.961**
V_8	0.263	0.307	0.184	0.311**	0.326	0.589**	0.325**
V_9	0.137	0.497**	0.251	0.377	0.974**	0.973**	0.953**
V_{10}	0.703**	0.546**	0.482	0.747**	0.991**	0.208	0.975**

* Significant at 5% level

** Significant at 1% level

Yield and stem thickness

The stem thickness shows significant positive correlation except for V_4 and V_9.

Yield and fruit length

With regard to the relationship between yield and fruit length, highly significant positive values are observed for correlation in all the varieties except V_8.

Yield and fruit girth

Between yield and fruit girth there is highly significant and positive correlation in the varieties except for V_{10} where absence of significant relationship is indicated.

Yield and number of fruits

With regard to yield and number of fruits there is very high significant correlation in all the varieties except for V_3, where the relationship has been recorded to be not at all significant.

The result of studies on the correlation of various characteristics when all the ten varieties were considered as a whole, is presented in Table 14.

Table 14

Coefficients of correlation between yield and associated characters for all the varieties

Sl. No.	Associations tested	Coefficients of correlation (r)
1	Yield and height of plant	0.753*
2	Yield and number of leaves	-0.309
3	Yield and number of branches	-0.233
4	Yield and stem thickness	0.132
5	Yield and fruit length	0.879**
6	Yield and fruit girth	0.861**
7	Number of fruits	0.896**

* Significant at 5% level
** Significant at 1% level

Yield and height of plants

The coefficient of correlation obtained is positive and at the same time only moderately significant.

Yield and number of leaves

The coefficient has been noticed to be negative though not significant.

Yield and number of branches

The correlation coefficient is recorded to be not at all significant.

Yield and stem thickness

As in the case of yield and number of branches here also the relationship has been found to be not significant.

Yield and fruit length

The coefficient of correlation between these two characters have been found to be highly significant and positive.

Yield and fruit girth

The relationship between yield and fruit girth is also indicated by a highly significant positive value for the coefficient of correlation.

Yield and number of fruits

The highly significant and positive value for the correlation obtained in this case itself is indicative

of a strong and direct relationship between the two attributes.

In addition to the above correlation worked out, the correlations among height of plant, number of leaves, number of branches, stem thickness, fruit length, fruit girth and number of fruits, the characters believed to be associated with yield have also been estimated, the results of which has been presented in Table 15.

The relationship of the number of fruits with fruit girth has been noticed to be positive and highly significant, that between number of fruits and height of plant is positive and moderately significant and those between number of fruits and number of leaves, number of fruits and number of branches, number of fruits and stem thickness and number of fruits and fruit length though positive not at all significant.

Fruit girth has been observed to be highly associated with fruit length and the relationship indicates the positive bearing between the two. On the other hand, the relationships between fruit girth and height of plant, fruit girth and stem thickness, fruit girth and number of leaves and fruit girth and

Table 15

Correlations between characters associated with yield

Sl. No.	Characters	No. of leaves	No. of branches	Stem thickness	Fruit length	Fruit girth	No. of fruits
		Correlation coefficients (r)					
1	Height of plant	-0.391	-0.583*	0.888**	0.849**	0.362	0.629*
2	Number of leaves		0.865**	0.166	-0.609	-0.296	0.496
3	Number of branches			0.150	0.203	-0.023	0.351
4	Stem thickness				0.026	0.093	0.43
5	Fruit length					0.692**	0.186
6	Fruit girth						0.898**

number of branches have always been found to be not at all significant and when the associations between fruit girth, height of plant and fruit girth and stem thickness gave positive though non-significant values for the coefficient. Those between fruit girth and number of leaves and fruit girth and number of branches gave indications of negative values and also not significant.

The associations between fruit length and height of plant, fruit length and number of leaves, fruit length and number of branches and fruit length and stem thickness, when studied have been observed to give in consistant values for the coefficient of correlation. Highly significant positive relationship has been noticed for the first of the above four associations studied. For the remaining three the association has been found to be not at all significant. However between fruit length and number of leaves the association as is seen from the table indicates an inclination towards the negative sign.

Between stem thickness and height of plant when the value obtained for the coefficient of correlation appears to be positive and highly significant those

between stem thickness and number of leaves and stem thickness and number of branches have been found to be not significant.

Number of branches and height of plants show negative and moderately significant association. On the other hand the association between number of branches and number of leaves is observed to be positive and highly significant.

Between number of leaves and height of plant the value for coefficient of correlation appears to be not at all significant. However, a tendency towards a negative relationship is indicated in the value.

The results of partial correlation found out between yield and plant height, yield and fruit length, yield and fruit girth, yield and number of fruits are presented in Tables 16, 17, 18 and 19 respectively.

It has been noticed from Table 16 that yield and plant height the value for the coefficient of correlation is positive and significant whereas that for the association between these two characters inclusive of the combined influence of fruit length,

fruit girth and number of fruits is also positive but at the same time highly significant (Table 16).

Table 16

Partial correlation between yield of fruits and plant height

Sl. No.	Character association	Degrees of freedom	Correlation coefficient (r)
1	r 12	268	0.753*
2	r 12.3	267	0.027
3	r 12.4	267	0.982**
4	r 12.5	267	0.464*
5	r 12.34	266	-0.752*
6	r 12.35	266	0.707*
7	r 12.45	266	0.453
8	r 12.345	265	0.788**

** Significant at 5% level

* Significant at 1% level

Similar trend is noticed in the associations between yield of fruits and fruit length (Table 17), yield and fruit girth (Table 18) and yield and number of fruits (Table 19).

Table 17

Partial correlation between yield of fruits and fruit length

Sl. No.	Character association	Degrees of freedom	Correlation coefficient (r)
1	13.	268	0.879**
2	13.2	267	0.692*
3	13.4	267	0.804**
4	13.5	267	0.963**
5	13.24	266	-0.433
6	13.25	266	0.384
7	13.45	266	0.421
8	13.245	265	0.850**

* Significant at 5% level

** Significant at 1% level

Table 18

Partial correlation between yield of fruits and fruit girth

Sl. No.	Character association	Degrees of freedom	Correlation coefficient (r)
1	14.	268	0.861**
2	14.2	267	0.959**
3	14.3	267	0.738*
4	14.5	267	0.287
5	14.23	266	0.935**
6	14.25	266	0.927**
7	14.35	266	0.484
8	14.235	265	0.995**

* Significant at 5% level

** Significant at 1% level

Table 19

Partial correlation between yield of fruits and number of fruits

Sl. No.	Character association	Degrees of freedom	Correlation coefficient (r)
1	r 15.	268	0.896**
2	r 15.2	267	0.699*
3	r 15.3	267	0.956**
4	r 15.4	267	0.148
5	r 15.23	266	0.404
6	r 15.24	266	0.293
7	r 15.34	266	0.927**
8	r 15.234	265	0.749*

* Significant at 5% level

** Significant at 1% level

Multiple correlation with yield against plant height, number of leaves, number of branches, stem thickness, fruit length, fruit girth and number of fruits, when worked out and presented as according to Table 20 has always been found to give highly significant relationships for every one of the combined influences.

Table 20

Multiple correlation between yeald of fruits, plant height, number of leaves, number of branches, stem thickness, fruit length, fruit girth and number of fruits

Sl. No.	Particulars	Degrees of freedom	Coefficient of correlation
1	R 1.23	267	0.985**
2	R 1.234	266	0.794**
3	R 1.2345	265	0.798**
4	R 1.23456	264	0.957**
5	R 1.234567	263	0.990**
6	R 1.2345678	262	0.999**

** Significant at 1% level

In addition to the various aspects of correlation worked out as has already been detailed above an attempt has also been made to study the phenotypic variation exhibited by the ten different varieties in respect of plant height, number of leaves, number of branches, stem thickness, number of flowers, number of fruits, yield of fruits, fruit length, fruit girth, percentage of fruit set and mean weight of fruits, with a view to facilitate comparison.

The results are presented in Tables 21 and 22. It has been noticed from these two tables that the varieties not only differed in the values for the mean but also in their extent of variability.

Summarised in Table 23, are particulars of each one of plant height, number of leaves, number of branches, stem thickness, number of flowers, number of fruits, yield of fruits, fruit length, fruit girth and mean weight of fruits, for all the ten varieties taken together.

Since it is realised that the observed phenotypic variability is nothing but the sum total of varying proportions of that due to heredity and environment, an

Table 21

Phenotypic variations in various plant characters according to varieties
(Mean of characters)

	Plant height	No. of leaves	No. of branches	Stem thick-ness	No. of flowers	No. of fruits	Yield of fruits	Fruit length	Fruit girth	% of fruit set	Mean Wt. of fruits
V_1	62.81	38.15	3.70	1.41	15.85	13.14	206.37	6.00	5.35	9.32	15.70
V_2	44.33	58.63	7.07	1.52	12.59	9.29	151.52	11.52	5.95	8.03	16.31
V_3	40.81	50.22	5.93	1.48	10.85	7.29	127.29	11.17	6.24	7.50	17.45
V_4	46.07	60.88	7.29	1.56	12.00	8.55	148.67	11.88	5.95	7.60	17.95
V_5	53.37	67.26	8.11	1.62	12.25	9.96	188.85	11.60	6.35	9.07	18.97
V_6	68.00	47.19	5.33	1.46	15.59	12.74	195.63	12.56	5.38	8.92	15.36
V_7	36.74	60.19	8.66	1.67	13.51	11.70	201.70	9.82	7.64	9.58	17.21
V_8	58.55	65.22	6.44	1.66	10.44	8.11	159.00	12.64	6.11	8.59	19.63
V_9	31.70	58.59	7.59	1.54	10.04	7.00	122.88	7.42	7.51	7.72	17.56
V_{10}	79.52	52.04	6.18	1.81	14.00	11.66	237.74	14.20	5.82	9.23	20.26

Table 22

Coefficient of variations of plant characters according to varieties

	Plant height	No. of leaves	No. of branches	Stem thick-ness	No. of flowers	No. of fruits	Yield of fruits	Fruit length	Fruit girth	% of fruit set	Mean Wt. of fruit
V_1	45.19	31.43	40.35	23.41	1.12	46.19	75.73	51.36	49.96	35.56	7.89
V_2	43.04	27.35	35.65	14.48	3.97	50.59	55.90	47.22	50.32	33.47	7.60
V_3	22.27	22.13	91.15	13.72	5.76	35.52	42.46	40.24	40.09	31.23	7.54
V_4	26.02	28.94	20.32	14.29	3.45	58.12	47.78	54.78	59.68	31.25	6.94
V_5	49.12	39.96	20.35	22.22	3.13	73.23	67.11	54.22	60.45	35.42	6.23
V_6	47.72	48.46	30.76	27.39	1.15	60.13	70.16	61.80	61.88	33.64	7.63
V_7	23.27	35.35	30.94	14.37	2.98	44.96	48.43	45.53	44.49	35.72	7.44
V_8	33.39	46.13	28.26	20.84	5.47	47.23	159.72	48.89	48.16	26.44	6.23
V_9	101.30	21.53	23.18	9.22	5.65	36.72	39.02	37.92	36.29	24.26	7.52
V_{10}	30.63	37.37	29.61	26.52	2.76	60.81	65.97	63.11	62.87	35.68	6.13

Table 23

Phenotypic variations in various plant characters

Sl. No.	Characters	Unit	Range	General mean	S.E. of mean	C.D. (0.05)
1	Height of plant	cm	14 - 147	52.19	8.97	28.13
2	Number of leaves	count	18 - 152	55.69	6.88	21.64
3	Number of branches	count	2 - 14	6.28	0.71	2.01
4	Stem thickness	cm	0.8 - 3.2	1.5	1.28	0.365
5	Number of flowers	count	4 - 35	12.71	2.58	7.33
6	Number of fruits	count	2 - 32	9.94	2.25	6.39
7	Yield of fruits	g	10 - 595	174.52	4.35	123.81
8	Fruit length	cm	5 - 21	11.93	5.34	75.56/plant
9	Fruit girth	cm	4 - 10	6.09	1.19	43.11/plant
10	Mean weight of fruits	g	15.36 - 20.26	17.64	0.09	2.77

attempt has been made towards partioning the variability and the results are presented in the respect to the different characters in Table 24.

It is seen from this table that the relative amounts of heritable (genotypic) and non-heritable (error) components vary considerably among the ten characters studied. For height of plant, number of branches, fruit length and mean weight of fruits it has been found that the genotypic component amounts more than the error component whereas the reverse has been recorded against number of leaves and number of fruits. Further, it is indicated, that the genotypic or heritable component is considerably high in the case of number of branches and mean weight of fruits only.

In order to have more information on this aspect the genetic coefficient of variation and heritability have also been worked out as represented in Table 25.

It is noticed from this table that heritability varies considerably from character to character. of the six characters studied for heritability, namely, height of plants, number of leaves, number of branches, number of fruits, fruit length and mean weight of fruits,

Table 24

Estimates of phenotypic, genotypic and error variances of different characters

Sl. No.	Characters	Phenotypic variance	Genotypic variance	Error
1	Height of plant	53261.68	31481.95	21779.69
2	Number of leaves	19762.67	6868.42	12894.25
3	Number of branches	509.80	397.44	112.36
4	Stem thickness	3.46	-	3.69
5	Number of flowers	997.64	-	1479.32
6	Number of fruits	1229.49	105.27	1124.22
7	Yield of fruits	337607.19	-	421919.37
8	Fruit length	348701.79	178832.80	169868.99
9	Fruit girth	31931.18	-	49074.26
10	Mean weight of fruits	8.82	6.18	2.64

Table 25

Genetic coefficient of variation, heritability and means for various characters

Sl. No.	Characters	Genetic coefficient of variation	Heritability percent	Mean
1	Height of plant	246.38	59.11	52.19
2	Number of leaves	110.90	34.85	55.84
3	Number of branches	77.13	77.95	6.28
4	Number of fruits	7.70	8.56	9.94
5	Fruit length	1224.34	51.28	11.93
6	Mean weight of fruits	35.49	70.06	52.65

spectacularly high values are noted against number of branches (77.95%) and mean weight of fruits (70.06%), the only two characteristics in respect of which alone the ten different varieties of bhindi showed significant variability. The lowest value for heritability has been found to be recorded against number of fruits (8.56). For the remaining characters the values were intermediate.

DISCUSSION

DISCUSSION

The results obtained in this experiment yield considerably important informations especially in those regarding the intervarietal variability of character and the relationship existing between and among several of these characteristics in bhindi.

On the variability of characters

Varieties, in general, are observed to exhibit considerable variability with respect to plant height, number of leaves, number of branches, stem thickness, number of flowers, number of fruits, yield of fruits, length of fruit, girth of fruit, percent of fruit set and mean weight of fruits. Of these eleven characters studied in the analysis of variance varieties, even-though appear to differ from one another, significant difference could be noticed only with respect to two of these features, namely, number of branches and mean weight of fruits.

Yield being one of the most important characters, and the varieties showing no significant differences from one another in this aspect, one is lead to believe

that all the ten varieties did not differ much from one another. Similar conclusions could be drawn on the basis of all the other characteristics mentioned above except for the two, number of branches and mean weight of fruits, in the case of which significant differences have indeed been observed. Again, between these two characteristics, the difference noticed has been found to be very high for number of branches, whereas it has been only moderate for mean weight of fruits. It is concluded, that the ten varieties of bhindi, dealt with in this investigation, differed predominantly in the case of number of branches, moderately in respect of mean weight of fruits, and not at all in respect of the remaining nine characteristics.

On the basis of the characters which have been found to exhibit significant differences, an attempt has also been made to arrange the varieties in an order as has already been mentioned earlier under the results.

It has become evident that varieties, eventhough exhibit significant difference from one another in respect of number of branches and mean weight of fruits, it has not been possible to define each one to a distinct group.

These findings are conclusive of that the ten varieties of bhindi used in this study do not differ much from one another inspite of certain degree of significant differences noticed with respect to a few characters.

Further, with respect to yield, which is the most important characteristic, the varieties, when did not exhibit any significant variability from one another, significant variability could be noticed with respect to these two of the less important characters alone.

Table 21 along with table 22 helps in the comparison of the ten varieties on the basis of the different characters studied.

Height of plant

The maximum value for the mean plant height has been recorded against V_{10} when the minimum has been against V_9 (Table 21). From table 22 it appears that the varieties differed in the extent of variability on this character. When the maximum variability has been recorded against V_9 the minimum is against V_3. These observation indicate that there is considerable

difference between the varieties in respect of this character at the intravarietal level, ie., some varieties exhibit more of this variability whereas others exhibit less, an indication probably of a difference at the varietal level.

Number of leaves

The maximum value for number of leaves has been recorded against V_5 when the minimum has been against V_1 (Table 21). From table 22 it appears that the varieties differed in the extent of variability on this character. When the maximum variability has been recorded against V_6 the minimum is against V_9. These observation indicate there is considerable difference between the varieties in respect of this character at the intervarietal level.

Number of branches

The maximum value for mean number of branches has been recorded against V_7, and minimum against V_1. In this case the maximum variability has been recorded against V_3 the minimum is against V_9. These observations point out that there is no appreciable amount of difference between the varieties with regard to this character at the intervarietal level.

Stem thickness

With regard to this character, the maximum and minimum values for extent of variability are recorded against V_{10} and V_7 respectively, ie., some varieties exhibit more of this variability whereas others show less, an indication probably of a difference at the varietal level.

Number of flowers

The maximum value for mean number of flowers has been recorded against V_1 and minimum is against V_9 (Table 21). The maximum variability has been recorded against V_3 the minimum is against V_1. These observations indicate there is considerable variation between the varieties.

Number of fruits

Similar findings are also obtained with regard to this character.

Yield of fruits

The maximum and minimum values for the mean have been recorded against V_{10} and V_9 respectively. The

coefficient of variation also shows extreme values against the varieties V_1 and V_9 respectively, ie., some varieties exhibit more of this variability whereas others exhibit less, which seems to be due to a difference at the varietal level.

Length of fruit

Here the maximum and minimum values for the mean have been recorded against the varieties V_{10} and V_9 respectively. The coefficient of variation for this character also ranges from V_{10} to V_9.

Girth of fruit

With regard to this character also some varieties exhibit more of variability whereas others less, probably due to a difference at the varietal level.

Percent of fruit set

In this character the values for the variability clearly show that there is no appreciable amount of variability existing at the varietal level.

Mean weight of fruit

The mean values for this character range from 15.70 to 20.26. Therefore the varieties exhibit only a slight variation among them.

Thus, in general, in respect of the extent of intravarietal variability of these eleven characters, all the varieties seem to differ from one another.

On the correlation of characters

Yield of fruits and height of plant have shown significant positive values of correlation coefficients in eight varieties. The correlation in the remaining varieties was positive though of a low magnitude (Table 13). With regard to the combined correlation taking all the varieties together, the correlation coefficient was positive and highly significant for height of plant, length of fruit and girth of fruit and number of fruits (Table 14). This might be due to the closer association of the tested characters in the varieties V_1, V_2, V_3, V_4, V_5, V_6, V_7 and V_{10}.

Elimination of the influence of the three variables namely, length of fruit, girth of fruit and

number of fruits in combination did not decrease the value of absolute correlation between yield and plant height. This is indicated of the low amount of influence that these eliminated variables have on the association of the two characters. Elimination of the variables 4 and 5 (girth of fruit and number of fruits) decreased the strength of association between yield and plant height considerably (Table 17).

Similar findings were recorded in various other crops. Chandramohan and Ponnaiya (1961) showed variation of correlation among varieties with respect to yield and plant height in rice. Working in the same crop Ramiah (1953) and Ghose et al (1956) reported only feeble correlation between these characters, while, Ganguli and Sen (1941) and Chandramohan (1964) recorded positive significant correlation between yield and plant height. Positive correlations between the two characters were recorded by other workers, Love (1912) and Hayes et al (1925) in wheat, Kottur and Chavan (1928) and Khole (1951) in sorghum, Jenkins (1924) in corn, Kumar and Ranga Rao (1949) and Sikka and Gupta (1949) in sesamum.

Yield of fruits and length of fruit showed high positive correlation values in all the varieties

studied except V_8 (Table 13) when all the varieties were taken together the correlation coefficient was also high and positive (Table 14). The uniform high values of correlation at the varietal level and when all the varieties were treated as a whole, presumably indicate the genetic basis of this association. A similar result has already been put forward by Kedharnath et al (1960) in their experiments with linseed.

Elimination of the effect of other three variables namely, plant height, fruit girth and number of fruits did not affect in any direction the strength of the relationship of these two characters (Table 18). This clearly revealed that the eliminated variables did not exert any appreciable amount of influence on the relationship of these two characters. However, the exclusion of the components, plant height, fruit girth and number of fruits in combination has increased the value of the partial correlation coefficient.

Of the seven characters analysed, fruit length and number of fruits appeared to be the most intimately correlated characters with yield of fruits (Table 13). The correlation coefficients in both cases were high and

positive invariably in all the varieties which might be due to the strong genetic basis of the relationship of these two characters towards the yield.

Highly significant values of correlation were obtained when all the varieties were treated as a whole (Table 14) in the case of the relationship between yield and height of plant, fruit length, fruit girth and number of fruits. This is suggestive of the greater intensity of relationship between these characters.

Partial correlation between yield and fruit girth eliminating the effects of three variables namely plant height, fruit length and number of fruits was high significant and positive. This is indication of greater degree of influence these eliminated characters have got in interrelationship of the tested characters. However, this elimination of the variables namely (fruit length and number of fruits) decrease the correlation coefficient considerably (Table 16), which suggests the appreciable amount of influence these characters have got upon the intensity of relationship between yield and fruit girth.

With regard to yield and number of fruits when all the varieties, were taken together so as to get the combined correlation coefficient, the value was positive and highly significant.

Elimination of the effects of plant height, fruit length and fruit girth in combination resulted in a decreased value of correlation coefficient that between the association between the itself. This is indicative of that the eliminated characters have an appreciable amount of influence upon the yield. However, the elimination of the variables 2, 3 and 4 (plant height, fruit length and fruit girth) decreases the value of correlation coefficient considerably (Table 19) which is in indication of the fact that the appreciable amount of influence these characters have got upon the intensity of relationship between yield and number of fruits. Similar association was reported by Weatherspoon and Wents (1934), Shigh (1947), Waddle (1954), Johnson et al (1955) and Brim et al (1959) in soybean, Ling (1954) and Mishra (1958) in groundnut, Kedharnath et al (1960) in linseed, Kumar and Ranga Rao (1941) and Sikka and Gupta (1949) and Varisai et al (1964) in gingelly.

The correlation of yield with number of leaves and number of branches and stem thickness was found to be feeble when compared to those with other components studied. (Table 13). Correlation of number of leaves with yield was significant in all varieties except V_3 and V_7, the value tended to be of a low magnitude. In the case of the combined estimate of correlation the result negative was not significant.

Among the components studied, number of branches possessed appreciable association with yield of fruits in varieties V_3, V_7 and V_{10}. The low values of correlation is suggestive of the feeble relationship of this character with yield. Further the combined estimate of correlation gave the lowest positive value. In general, yield and number of branches did not appear to be strongly correlated.

Between yield of fruits and stem thickness, the different varieties showed high positive significance with yield except in varieties, V_4, V_8 and V_9. Further the combined estimate of correlation gave the lowest positive value among all the characters studied. In general, yield and stem thickness did not appear to be strongly correlated.

Interrelationship between the yield components

Table 15 reveals the features of interrelationship between the seven contributory factors of yield of which showed relatively stronger association with yield viz., plant height, fruit length, fruit girth and number of fruits. Plant height possessed a positive high significant correlation with stem thickness, fruit length and number of fruits. Similarly mutual correlation of number of fruits with fruit girth, number of leaves with number of branches were also have high positive significant correlation. The components of yield, fruit length and fruit girth also showed a high degree of association. This is suggestive of the usefulness of the contributary characters for the formulation of a multiple selection criterion for yield of fruits.

Significant and positive values of multiple correlation between yield and all the seven components of yield might be a further proof to the high magnitude of contribution of these characters towards yield (Table 20).

On the genetic components of variance

For height of plant, number of branches, fruit length and mean weight of fruits it has been found that the genotypic component amounts more than the error component whereas the reverse has been recorded against number of leaves and number of fruits. Further, it is indicated, that the genotypic or heritable component is considerably high in the case of number of branches and mean weight of fruits only (Table 24).

Heritability specifies the proportion of the total variability that is due to genetic causes, or the ratio of the genetic variance to the total variance. With lower heritables, the degree of overlap increases progressively, and more and more difficulty is encountered in distinguishing among genotypes on phenotypic grounds eventhough genetic control is monogenic. The relative amount of heritable and non-heritable components of the variability suggest that the genetic component of variability is fairly large in all the characters (Table 25).

In conclusion, it is to be pointed out, that, eventhough, the ten different varieties of bhindi did not differ from one another significantly with respect

to nine out of the total eleven characters studied, namely, height of plant, number of leaves, stem thickness, total number of flowers, total number of fruits, weight of fruits, length of fruit, girth of fruit and percentage of fruit set, they did exhibit significant differences in respect of two characters, number of branches and mean weight of fruits. Further, between these two characters the difference with respect to number of branches have been noticed to be highly significant. Studies on correlation evidently seems to suggest that yield, the most important characteristic, is directly related to height of plant, fruit length, fruit girth and number of fruits, where the three characters mentioned last have been found to be associated with yield to a considerable extent. This finding has been made when all the varieties were considered together as a whole. However, when the varieties were studied separately it has been noticed that these characters exhibited varying degrees of association. The only attribute in this study that has been found to bear a direct relationship with yield in all the varieties studied without any exception and also when the varieties were taken as a whole has been found

to be the length of fruit. It has also been recorded that the genotypic variation in respect of their character is higher than the value for the variation due to error and the heritability value for this has also been found to be fairly high. This leads to the realisation of the scope and practical utility of this character, namely fruit length, as a valid indicator of the otherwise complex but important character namely the yield of fruits in bhindi, in selection procedures, especially in the selection of parents in a hybridisation programme.

SUMMARY

SUMMARY

An attempt has been made to study the relationship between yield and several of its component characters as height of plant, number of leaves, number of branches, thickness of stem, number of flowers, number of fruits, yield of fruits (in weight), length of fruit, girth of fruit, percentage of fruit set and mean weight of fruits in ten different varieties of bhindi (Abelmoschus esculentus, Linn.).

The analysis of variance has shown that the varieties do not differ significantly from one another for these characters except for number of branches and mean weight of fruits.

Yield, the most important characteristic has been found to be directly correlated with height of plant, fruit length, fruit girth and number of fruits when the varieties were considered as a whole. On the other hand, when they were considered separately the only character that has been found to be highly significant and positively associated with yield in the case of every one of the ten varieties has been observed to be the

length of fruit. It has also been found that the value for the genotypic variation for the characters is higher than that for the variation due to error. This character, showing a higher value for heritability, and with its possessing a direct relationship with yield seems to indicate itself its possible practical utility as a valid indicator of the yield potential in the selection of parents in a hybridisation programme in bhindi.

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* Originals not seen

ILLUSTRATIONS

PLATE I

Photograph of the varietal variation in leaf shape

PLATE II

Photograph of the varietal variation in fruit shape

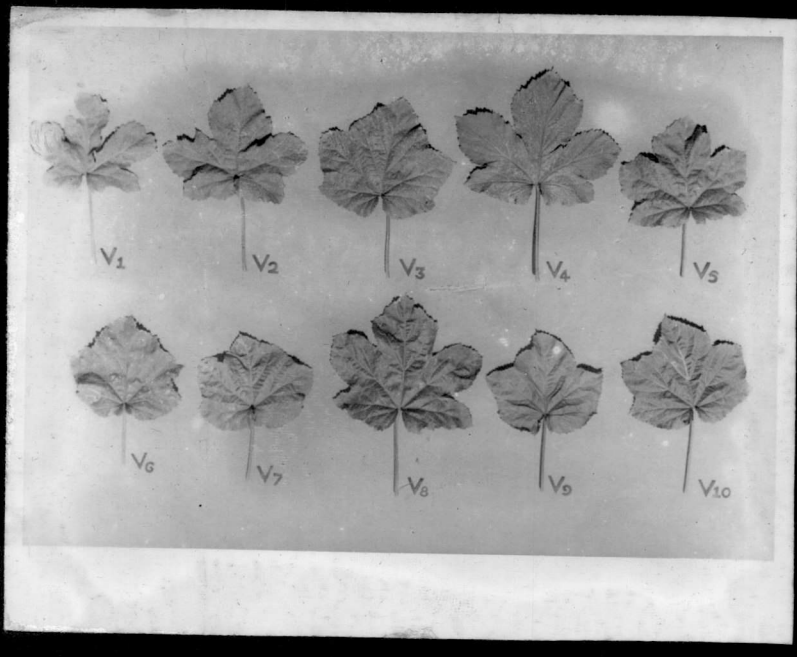


PLATE I

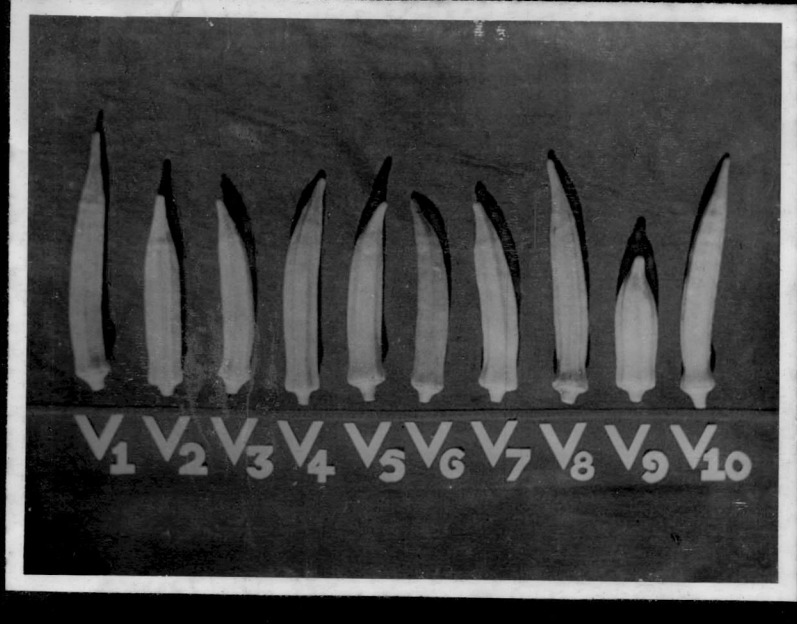
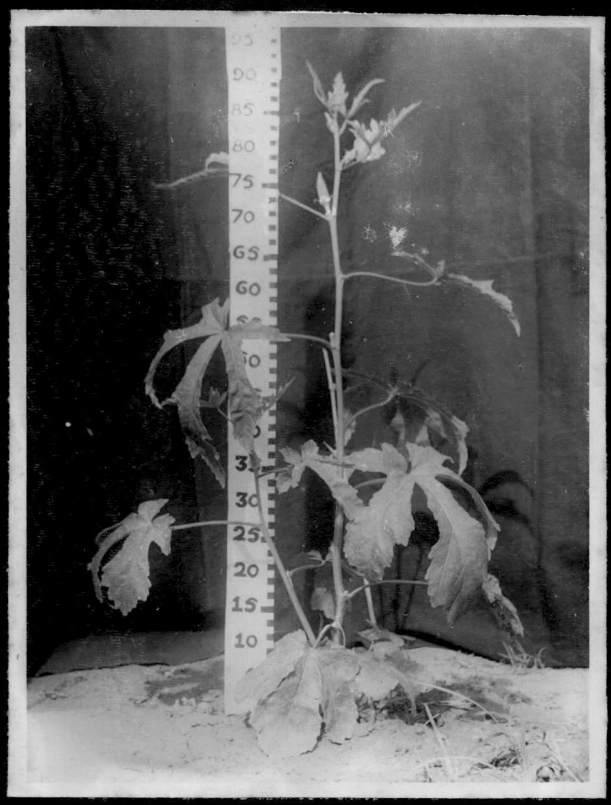


PLATE II

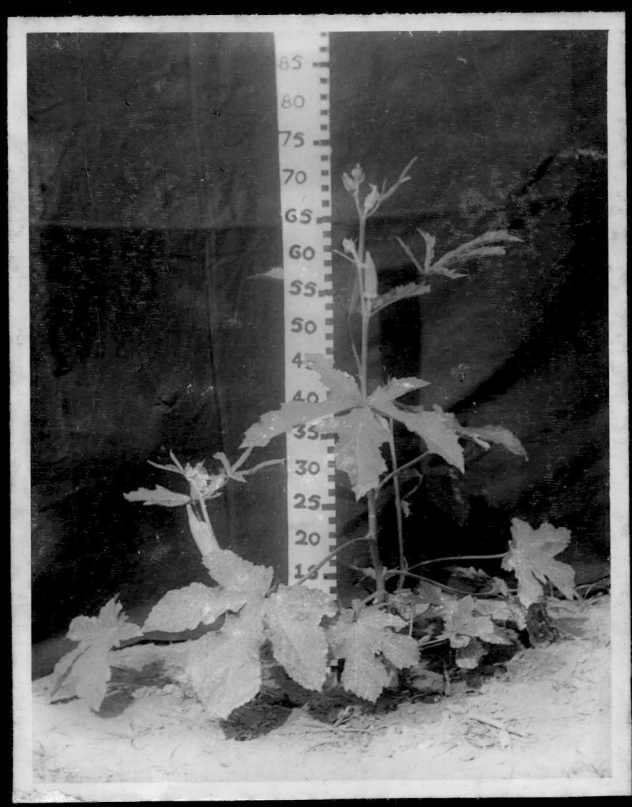
PLATE III

Photograph of the variation in plant height in varieties V_1 and V_2

PLATE III



V_1

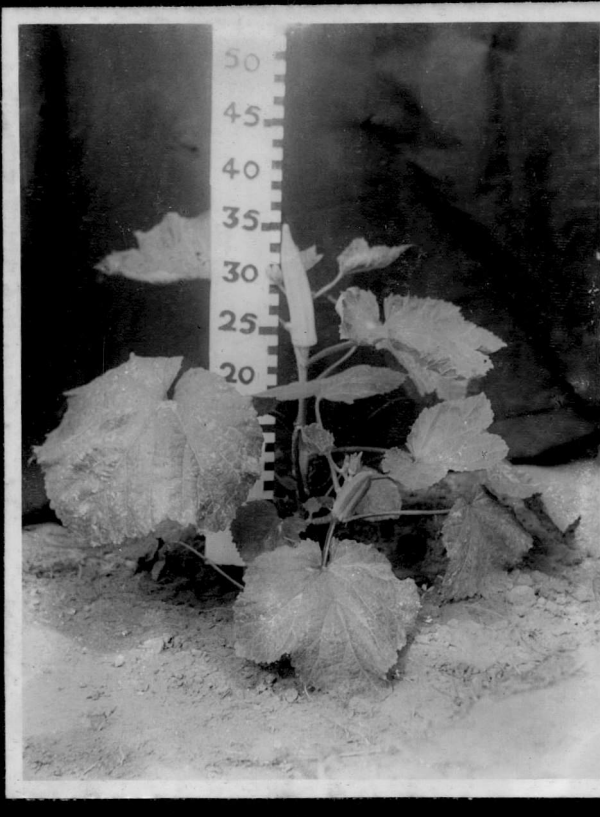


V_2

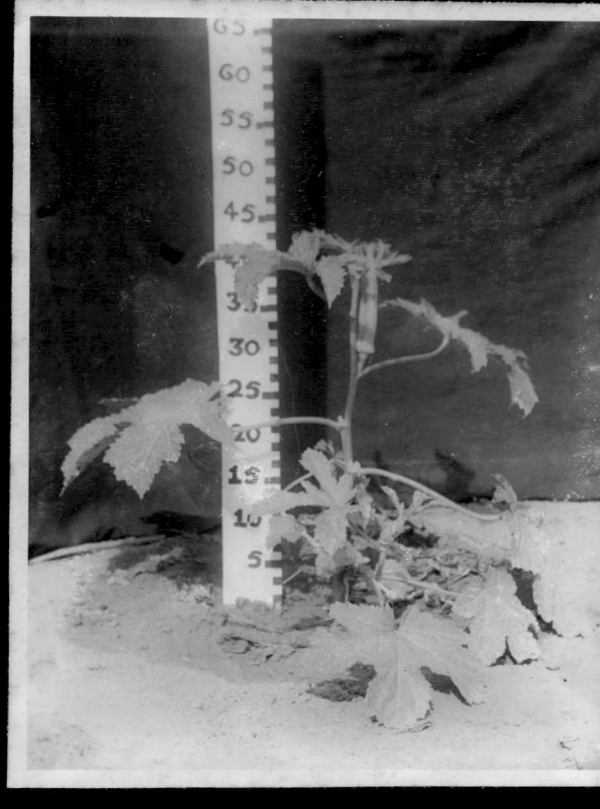
PLATE IV

Photograph of the variation in plant height in varieties V_3 and V_4

PLATE IV



V_3

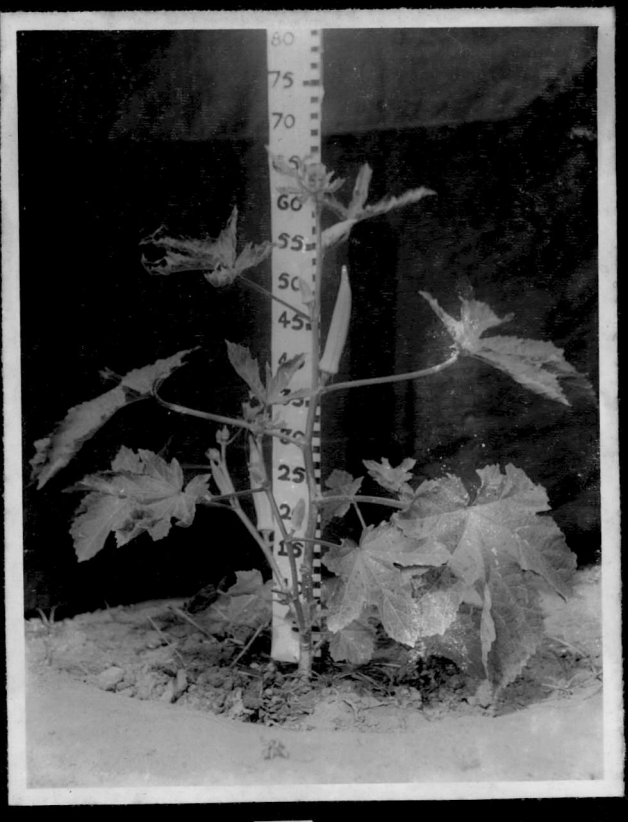


V_4

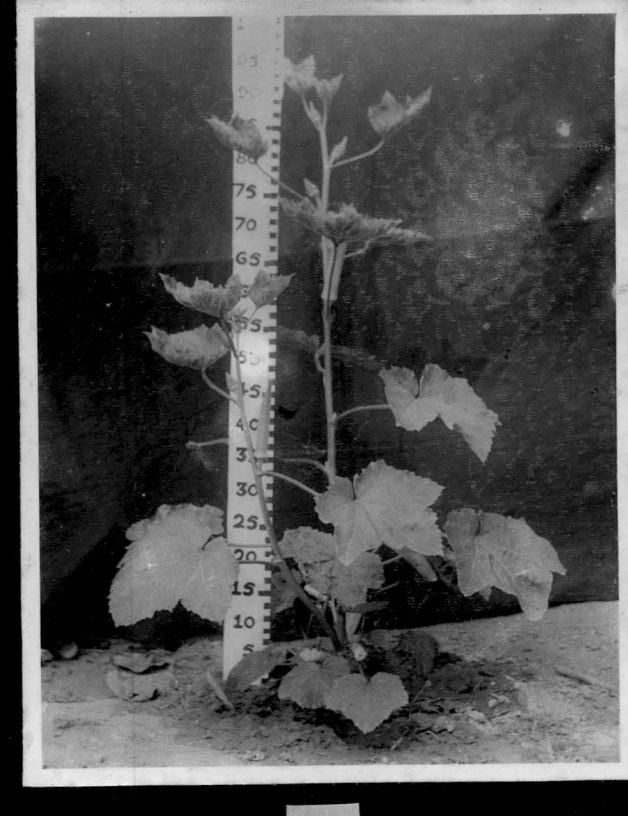
PLATE V

Photograph of the variation in plant height in varieties V_5 and V_6

PLATE V



V_5

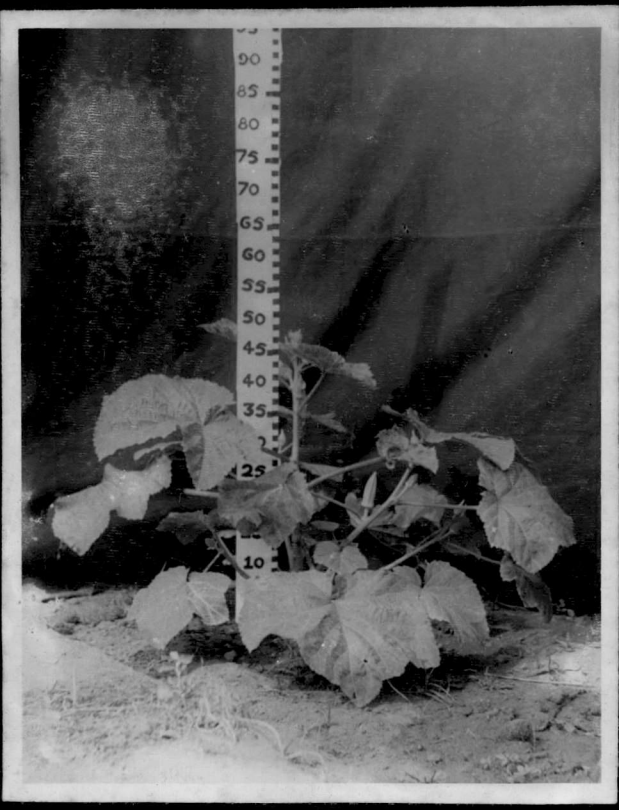


V_6

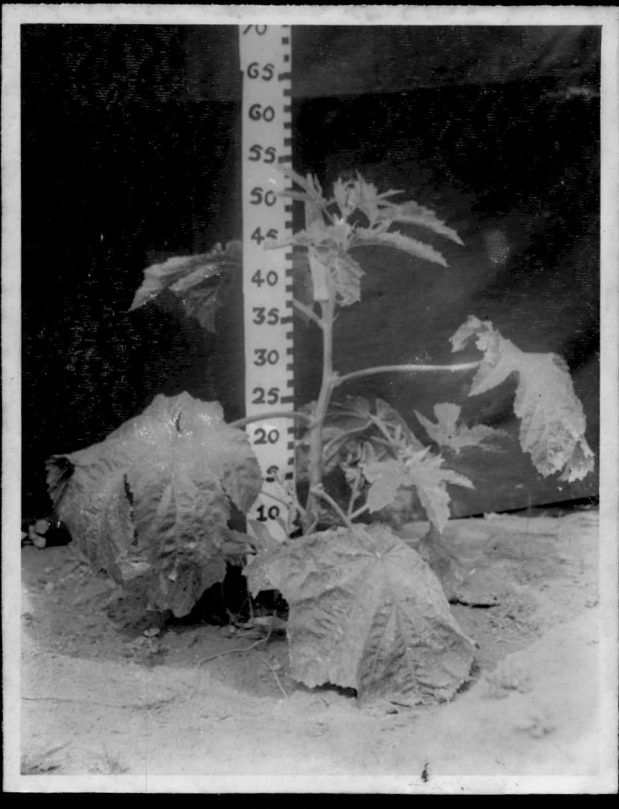
PLATE VI

Photograph of the variation in plant height in varieties V_7 and V_8

PLATE VI



V_7

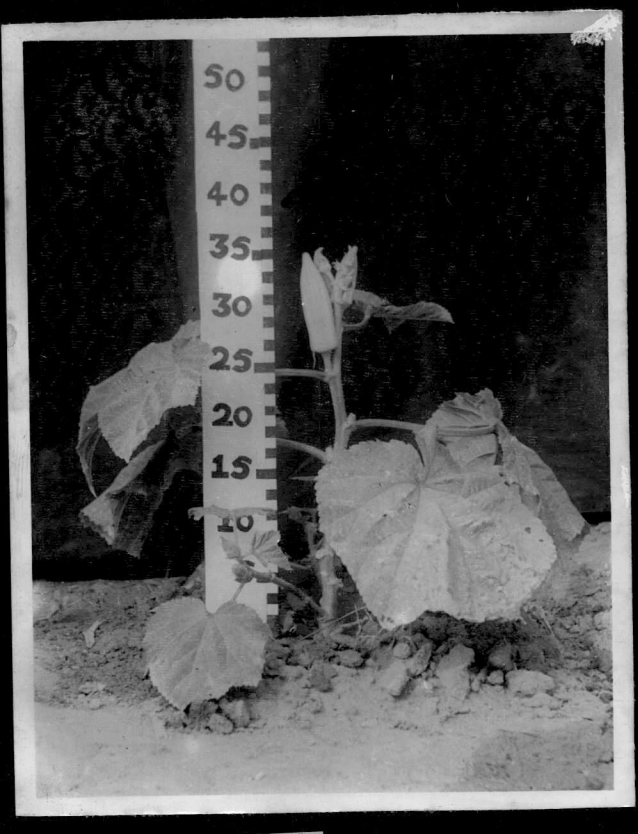


V_8

PLATE VII

Photograph of the variation in plant height in varieties V_9 and V_{10}

PLATE VII



V_9

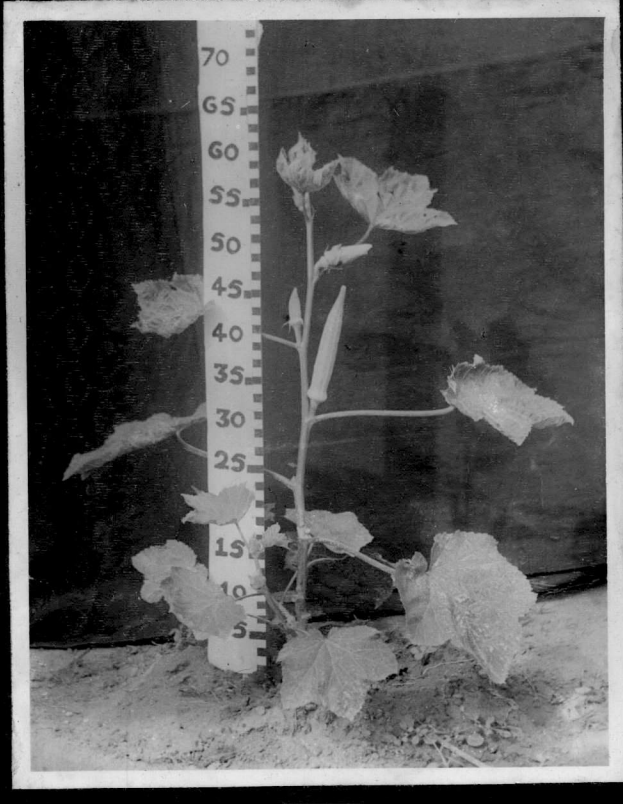


PLATE VIII

Photograph of the variation in fruit size in varieties V_1 and V_2

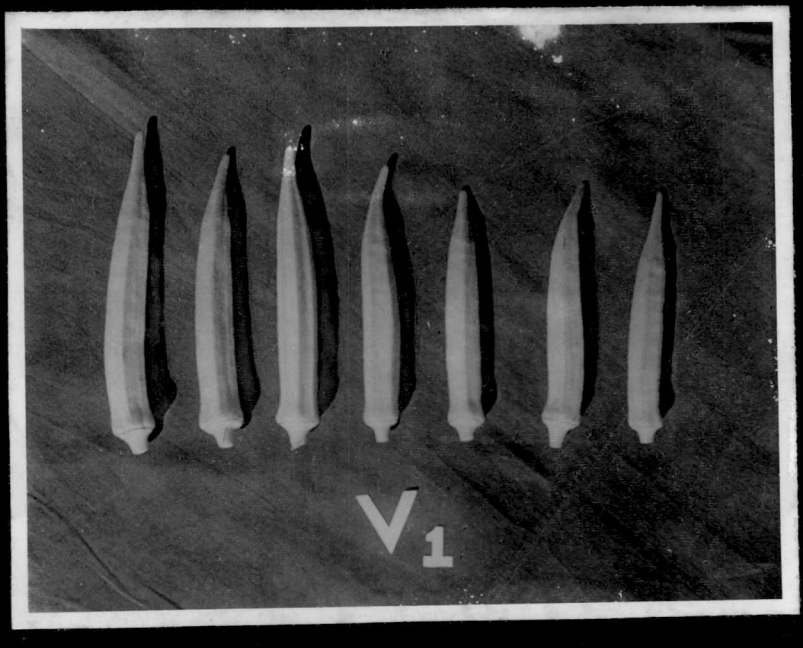


PLATE VIII

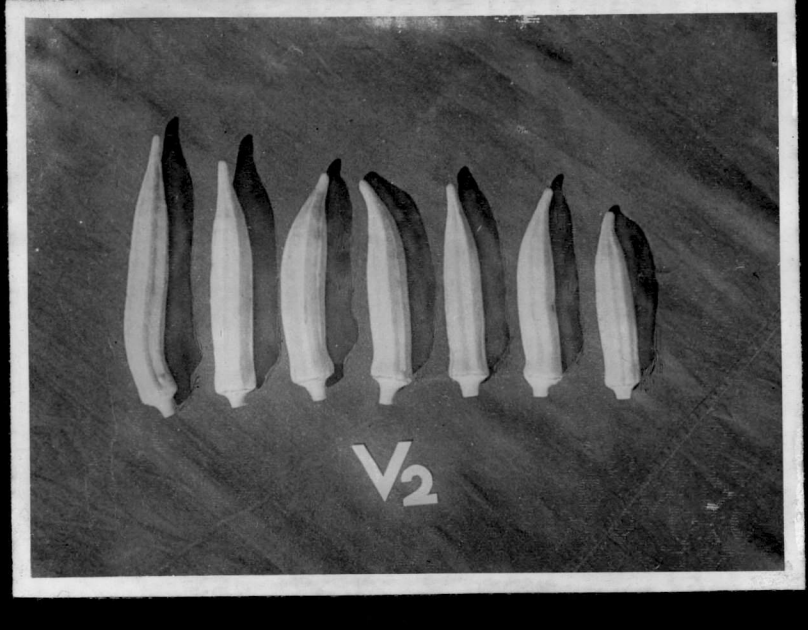


PLATE IX

Photograph of the variation in fruit size in varieties V_3 and V_4

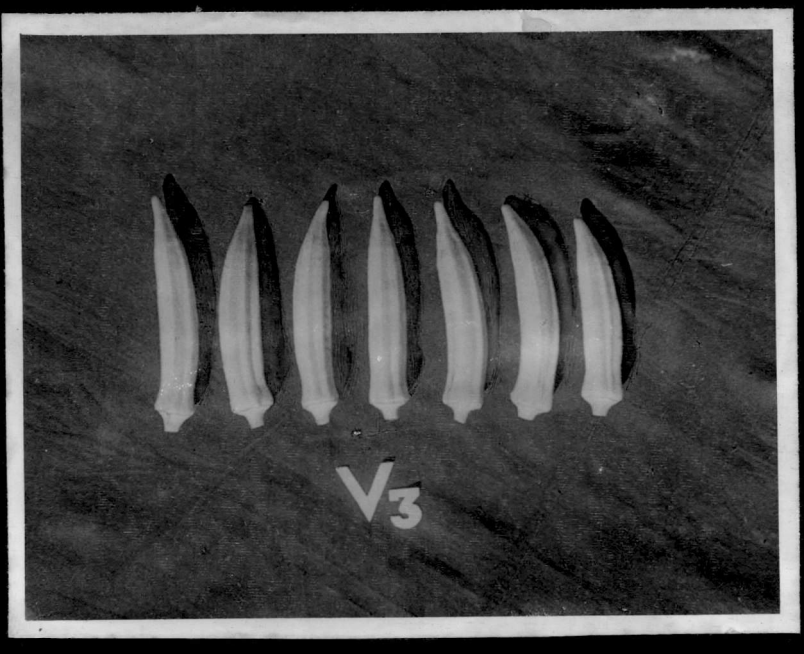


PLATE IX

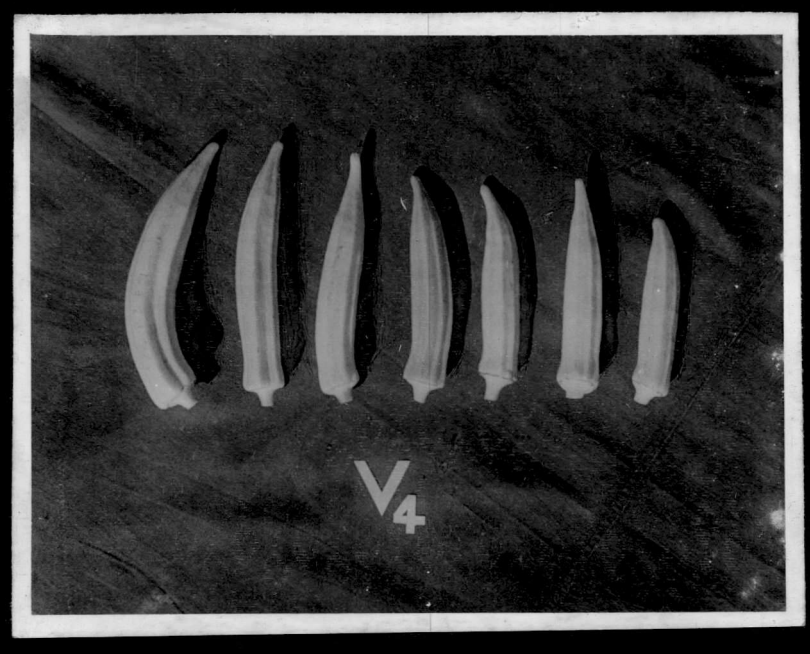


PLATE X

Photograph of the variation in fruit size in varieties V_5 and V_6

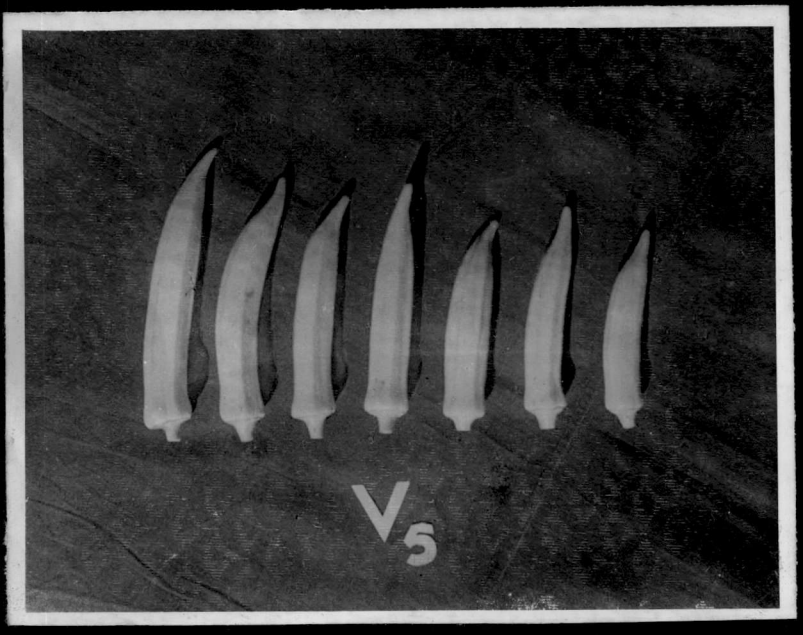


PLATE X

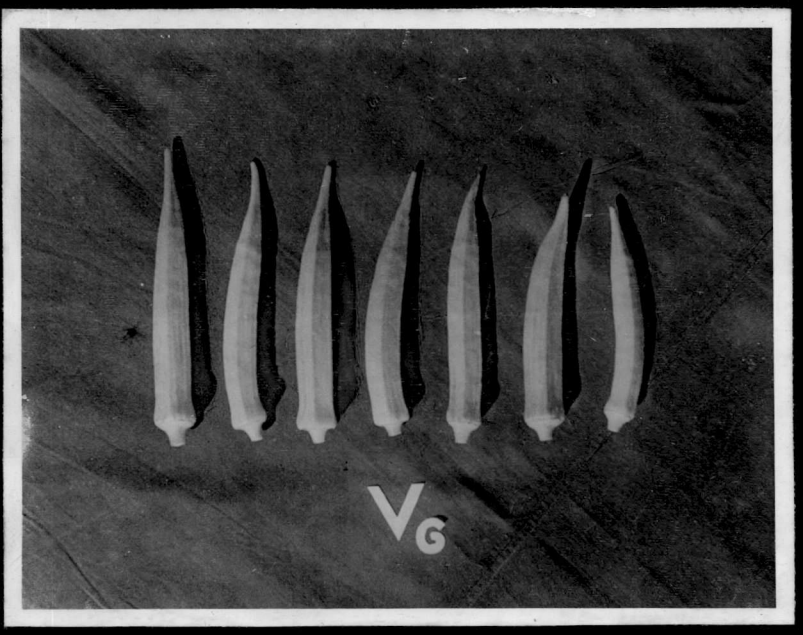


PLATE XI

Photograph of the variation in fruit size in varieties V_7 and V_8

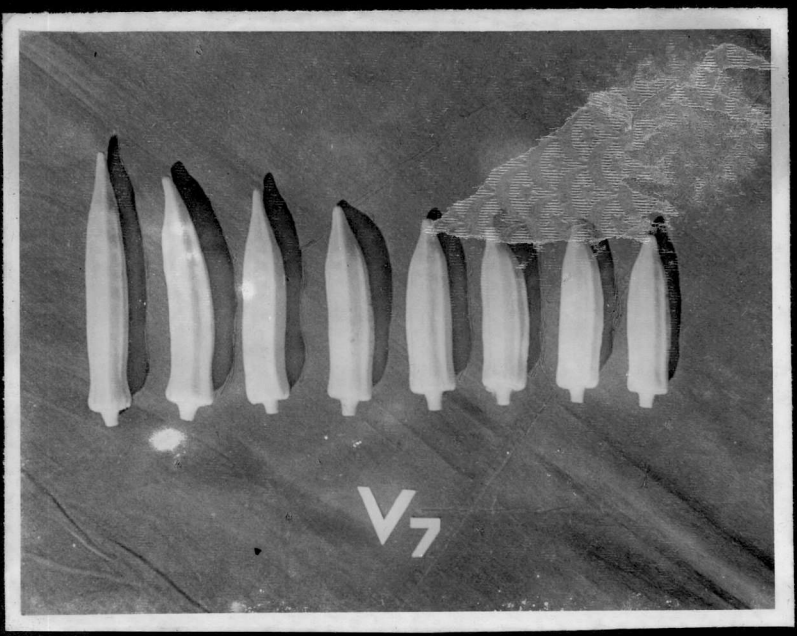


PLATE XI

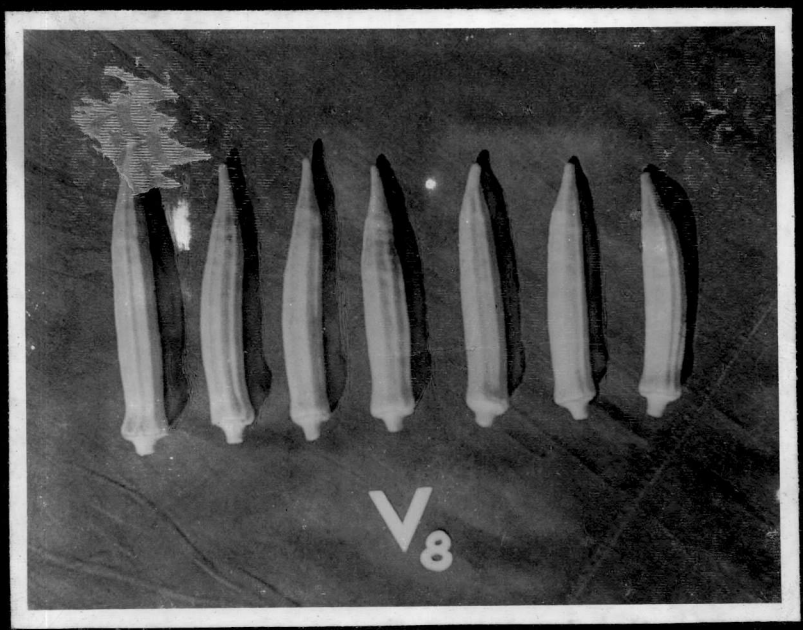
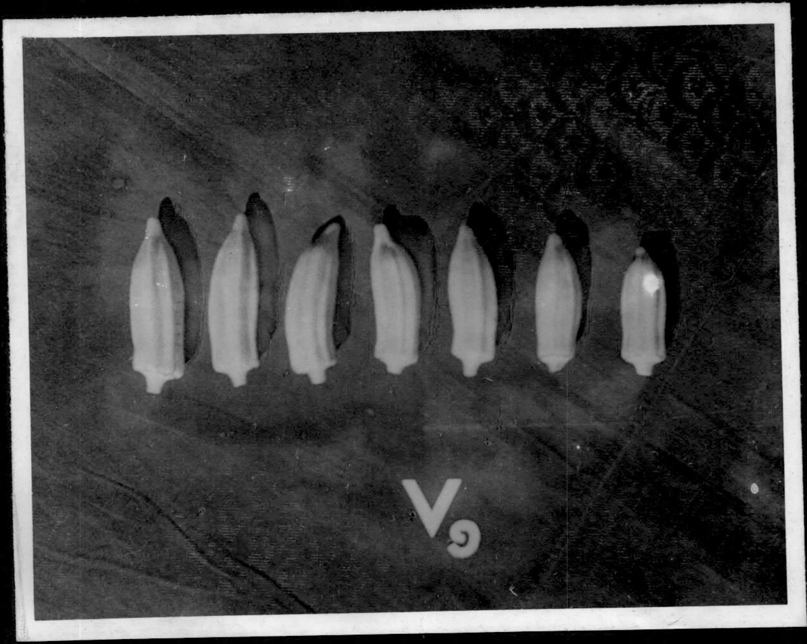


PLATE XII

Photogfaph of the variation in fruit size in varieties V_9 and V_{10}


V9


V10