STUDIES ON GROWTH AND BEARING HABITS OF CERTAIN VARIETIES OF BHENDI (*Abelmoschus esculentus* (L.) Moench.) WITH SPECIAL REFERENCE TO FRUIT MATURITY AND QUALITY

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CHAPTER I

INTRODUCTION

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Vegetables constitute a substantial part of human diet, supplying some of the vital substances required for normal growth and health such as vitamins and minerals in which other food materials are deficient. Aykroyd (1936) recommends ten ounces of vegetables per day per individual for the normal functions of the human system. The nutritive aspect of diet and the richness of the components in terms of their dietetic value are being demanded of practically all articles of food and particularly vegetables.

The growing awareness of the importance of vegetables in human diet has made people conscious of the nutritive values of the market produce. This quality conciousness has been steadily growing with the rise in standards of living. Research in vegetable crops is directed towards production of not only high yielding types but also those of the best quality. Processing industries have in recent times developed considerably and these are demanding material of highly specific qualities.

Bhendi or Okra (Abelmoschus esculentus Linn.) as a vegetable finds an important place in India. The ease with which it is cultivated with no exacting requirements, its availability during the major part of the year at a relatively inexpensive cost and above all its amazing adaptability to a wide range of climatic conditions makes bhendi a favoured vegetable crop both with the cultivator as well as consumer.

Bhendi is a warm season crop and is cultivated all over India and in most of the tropical countries. In other countries, especially the United States there is a growing demand for this vegetable and in 1949 it occupied an area of about 16,843 acres, mostly in the Southern States according to Thompson and Kelly (1957).

As a vegetable in tender stages, bhendi is very nutritious. At the edible stage, pods contain 90 per cent water 2 per cent protein, 7 per cent carbohydrates and 1 per cent minerals. It is a good source of calcium and iron and vitamins like A and B in the diet. Young pods also contain vitamin C but it is lost rapidly after harvest, nearly half of it disappearing in 24 hours of harvest (Boswell 1951; Purewal 1944).

For the cultivator, the performance and yield of the crop are important and for the consumer, the quality is the foremost factor both for immediate use in households as well as in processing industries. The development of fibre in the fruit of bhendi at an early stage makes it impossible to keep the fruit on the plant beyond a critical stage. The period is so critical that a delay of even a day or two make the fruits quite useless as a vegetable. At the same time harvest of very tender pods brings in poor returns. It is therefore very important that this critical stage is fixed for each variety. There is hardly a vegetable crop in which harvest at proper maturity is so important as in the bhendi, not only in the interests of its eating quality but also from the stand point of its nutritive value.

No maturity standards exists at present for this vegetable in India. Even from the point of descriptive studies of the

Bhendi varieties in India, our knowledge is fragmentary.

Although some studies have been carried out in Bhendi on aspects like culture, pollination and maturity, a detailed study in general and the varietal reaction in particular seems to be lacking. The experience of the growers is still the guiding factor in determining the stage of maturity in this crop. Under these circumstances a detailed study on factors like growth of plants, growth of pods, stage of maturity, yield and the biochemical changes that occur during maturity becomes necessary to decide the suitability of growing Bhendi in different seasons.

The present study was therefore initiated with a view to determining the varietal variations in the morphological and yield characters as well as to study the development of the fruits in relation to its maturity and nutritive value. Particular attention has been devoted to the study of the composition of the fruit at the time of its edible maturity and to determine the extent of deterioration in its edibility with progressive maturity.

CHAPTER II

REVIEW OF LITERATURE

I. Varietal description and observations on growth

Description of the numerous varieties of bhendi and their classification has been attempted in the past. Venkatramani (1946) described six varieties and came to the general conclusions in respect of classification that bhendi can be grouped mainly into tall and dwarf types. Other characters involved are the branching habit, length of the fruit and number of ridges on the fruit. Rao (unpublished) studied a number of varieties at the Agricultural College and Research Institute, Coimbatore and grouped the varieties based upon characters such as stem colour, spininess of stem and branches, leaf shape and fruit colour. He considers that stem colour and spininess may prove as primary characters in the classification work. Thompson and Kelly (1957) suggested the classification of bhendi varieties according to the growth behaviour, size of plant, pod colour and shape.

According to Tisdale and Nelson (1956) who quote Webster, growth is defined as "the progressive development of an organism". The relationship between the measure of growth employed and the time factor is closely linked and they suggest the general pattern of growth is one of initial small increase in size followed by rapid increase in growth and last by a period during which the size of plant increases only slowly or not at all. Both genetic and environmental factors govern the growth and of the

environmental factors temperature, radiant energy, moisture supply, soil reaction, soil aeration, composition of atmosphere, biotic factors and supply of mineral nutrient elements are considered.

Beattie (1908) observed that bhendi pods began to be produced very soon after the plants start into rapid growth and continue to form for several weeks, especially if all the pods are removed while young and no seeds are allowed to ripen on plants. He further stated that as the pod is the only part of the plant ordinarily used for food, it was desirable to secure a rapid growth in order to produce greatest quantity of marketable pods. Singh (1920) working on the physiological aspects of growth of bhendi suggested that a simultaneous decline of many physiological activities as the growth proceeds is due to the qualitative changes in protoplasm with the advance of age. It has been reported by Shanmugasundaram (1950) that periodic picking of tender fruits induces the plants to produce more fruits and more than 10 pickings for vegetable purposes, lowered the number of seed producing pods, thus proving the relationship between vegetative growth and reproductive phase.

Perkins, Miller and Dallyn (1952) reported that plants harvested every three to four days bore three times as many pod as did plants on which the pods were allowed to mature. In the former bearing was almost continuous while in latter plant growth was severely checked and bearing occurred in a series of waves.

Pal, Sikka and Singh (1955) explained the behaviour of bhendi variety Pusa Makhmali in relation to season. The authors reported that it takes about 50 days from sowing to flowering in summer and in rainy season this period is extended by another ten days. They also found out that summer fruiting phase lasts for about two months while in rainy season it continues right upto the winter.

In cotton the growth of plant as well as the boll has been studied by several workers with reference to climatic conditions, mainly the temperature, humidity and rainfall. Since bhendi is similar to cotton in several respects it is believed that the growth behaviour of the latter may have similar effects.

Growth is affected by several factors and as such the analysis of growth curves is a difficult matter. Bailey and Traught (1967) quote Hildebrandt "no successful method has yet been brought forward by which the value of climatic complex to produce growth, in any plant may be deduced from instrumental data".

In the development of a plant the word growth is used to denote the continual laying down of new differentiated cells from undifferentiated meristematic tissue which constantly occur in a rapidly developing plant resulting in an increase in height and finally increase in mass or dry weight. The rate of differentiation, rate of elongation and rate of increase in mass, affect the general rate of development of the plant and bring about life cycle of plant which results in yield. Therefore the different aspects of growth of the plant and the environmental factors influencing the growth and the final yield are of vital

importance.

According to Balls (1916) there is a direct relationship between the number of flowers produced on particular day and the growth of the main stem of the plant on a corresponding day twenty nine days previous. The growth of stem is influenced by temperature and the best continuous growth of cotton plant has been reported to be at 90°F. It has been shown that temperatures above 90°F accelerate growth for a short time but later the growth is retarded. Balls also reported that growth rate at night to be more than during day.

Mason (1928) reported that the growth of main axis of cotton was retarded on overcast humid days and this has been attributed to the check in assimilative activities of the plant.

Ludwig (1931) reported the seasonal variation in the square period and boll period. He noted that this character was not changed by cultural operations and manuring.

Brown (1938) reported that stripped plants grew taller and produced more late blossoms and bolls, matured a greater percentage of late set bolls and remained green longer.

Mastur (1950) found that flowering rate was also affected by climatic conditions mainly temperature. The results of his investigations on cotton proved that the varieties which were able to produce their fruiting branches at higher temperature and where the day was long, matured their fruits early. The author concluded that there was probably an effect of night temperature.

In Japan work on the growth of broad bean plant was recorded under influence of varying temperatures by Ueki and Igawa (1959). They noted that under high temperature treatment stem and leaf growth was increased. High temperature hastened the period from sowing to germination but prolonged the period of flowering. Fruit set was however smaller at high temperatures even though flowering was profuse. Flower bud differentiation and growth were accelerated and varietal differences could be observed. Maturity and seed ripening were also accelerated with increased growth rate of pods (Ueki 1956 and 1957).

Lambert and Linck (1956) reported that heat treatment during a period of five days before full bloom, to fifteen days after full bloom, reduced fresh weight and number of peas. Monselise and Went (1958) recorded highest growth of pea plants at high day temperatures. Ottoson (1959) observed that light conditions, soil type and nutrient supply did not appreciably increase the growth of plants in peas.

Went (1944, 1945) studied the effect of temperature in relation to growth of tomatoes. He concluded that 30°C was the optimal temperature for growth and below 16°C there was inhibiting effect. In his studies he found that temperature was the most deciding factor than humidity of air, light illumination, light intensity and nutrition in the growth of tomato plants and slight differences in night temperatures caused considerable differences in the rate of stem elongation and fruit set. Fruit set was maximum at night temperature of 16°C to 26°C irrespective of day temperature. Ward (1956) reported that the least temperature for fruit set in tomatoes is between 70°to 80°F.

II. Influence of pruning on plant growth and yield

In bhendi the practice of pruning has not been reported so far. However contradictory results have been reported both from India and abroad in other crops such as cotton, peas and tomatoes.

Venkatraman and Jaganatha Rao (1933) reported that on a comparison of productivity of 'bored' plants (cotton plants where terminal bud gets destroyed by shoot borer and which develop lateral branches in top nodes profusely) found that these naturally topped plants gave signifiantly higher yield. Joshi, Goda and Shaw (1941) also noted this phenomenon and reported the increase in the development of lateral branches.

It has been reported that the practice of topping in cotton is done regularly in U.S.S.R with increased returns. Ripening of bolls has been reported to be hastened by topping and that the energy of the plant is directed from vegetative growth to fruiting side with the result that the boll number is increased, their size improved and the quality of the lint bettered (Sikka and Avtar Singh (1961).

Several authors have also reported decrease in the yield trend following topping in cotton (Redding and Kimbrough 1906; Ayres 1931; Templeton 1931; Guruswami Raja and Neelakantan 1950). Christidis and Harrison (1955) while cautioning about the pruning practice in cotton suggest that time of pruning is very decisive if at all pruning to be successful.

Sugiyama, Nishi and Kato (1949) tried pruning of leaves and apex in broad beans. Plucking of leaves reduced the number

of branches, flowers and fruits. Removal of apex caused the branching to be little more abundant but no increase in pod set was observed. Plucking the flowers increased the food supply and made the bunches grow longer and branch better and the number of flowers produced subsequently was higher.

Wolf and Hartmann (1942) reported an experiment in muskmelon in which six different fruit and plant pruning treatments were tried. Fruit set increased in the treatment in which plants were kept pruned to one main branch and two axillary branches from which the growing points were removed. Pruning treatments seemed to have no particular influence on the length of time required to produce a mature fruit.

Reports of pruning trials in tomato are many. Under different conditions of growth and the several treatments of pruning adopted by different workers, there are evidences both in support of pruning as well as against in relation to plant growth and yield.

Hemphill and Harnack (1942) as against the single stem pruning tried retaining of two side shoots and more than four side shoots with their growing points removed by pinching when each shoot had produced two leaves. In the former treatment they obtained 12.1 per cent increased yield while in the later the increase was 13.5 per cent. Similarly Sayre (1942) and Swarda (1942) also recorded significantly higher yields with pruning. Sayre suggests topping of the seedlings if transplanting is unduly delayed while Swarda (1949) warns that removal of too many shoots in early ripening varieties will reduce yield.

Kerr (1949) reported the removal of all the side shoots of tomatoes and contradicts the statement of Hemphill and Burneck (1948) stating that there was no effect on yield when the laterals with only two leaves were kept. Smerda (1949) conducted pinching trials with tomato and found that the removal of a number of shoots from tomato plants gave an earlier better ripening and more valuable crop. Halsey and Jamison (1950) also reported the significant increase in yield in five tomato varieties when pruned under conditions of Florida.

Experiments by Persson and Kramer (1953) showed that pruning of laterals and staking tomato plants specially in bushy vigorous types was beneficial, while Cooper (1956) was of opinion that retention of all axillary shoots below the first inflorescence on the main stem of tomatoes and removal of all others led to almost threefold increase in total yield, compared with the plants on which all the axillary shoots had been removed. However, the former treatment decreased yields of the first few pickings. Dabska and Koslowska (1959) reported that of the different pruning methods adopted, single stem with all the laterals retained and pinched out above the first cluster produced highest yield of marketable fruits in tomato.

Work at Ghana by McEwen (1961) revealed that removal of laterals were better than topping in case of indeterminate tomato varieties to increase yield while the trials by Chipman (1963) in determinate variety of tomato showed that mean maximum yields of early ripe fruits were obtained from plants topped 77 or 87 days after sowing and there was no significant differences between date of topping and yield.

While the above is the review in favour of the practi

pruning a few works have shown either no significant difference between pruned and unpruned or complete failure of pruned plants in relation to yield in tomatoes. Moore (1950) reported that pruning had little effect on yield or fruit size in plants pruned to two branches and three branches per plant as compared to control. Reports from the Glasshouse crops Research Institute and Cawthorn Institute for 1954-55 revealed negative results as a result of pruning treatments in tomatoes. Strydom (1955) under South African conditions recorded that pruning should not be conducted in tomatoes.

III. Influence of pod maturity at harvest on growth of plants and total yield

The growth of the plant such as height of main axis, branching and bearing are influenced by the pods maturing on the plant. Bentlie (1905) observed that the growth of plant continued for several weeks especially if all the pods were removed while still young and no seeds were allowed to ripen on plant. Harvey (1951) came to a general conclusion that bhendi plant possesses an extremely delicate balance between vegetative and reproductive activity. According to Perkins et al (1952) in plants which were harvested regularly at three to four days interval the bearing was almost continuous while in plants which were allowed to mature seeds, the plant growth was severely checked and bearing occurred in a series of waves. Rao (1953) has also recorded the stimulant action on growth by periodic picking. Bailey (1950) reported that in plants in which pods were retained the growth was suspended until the seeds have matured when a second growth may take place.

Parthakur and Haroonh (1961) noted the prolonged fruiting period when the bhendi pods were harvested at third or fourth day after flowering.

The work of Joshi et al (1941) revealed that the life cycle of cotton plant was chiefly governed by the presence or absence of growing flower buds. When all the buds were removed artificially the life of the plant was correspondingly prolonged suggestive of the influence of growing flower buds on the growth of plants. Similar results have been obtained by defruiting and defloration experiments. It was also observed that the number of bolls formed after the early defruiting was much more than in controls.

In tomatoes, Lachman (1946) reported that removal of fruits at an early stage increased the vigour and total life of plants indicating that the development of fruits on the plant reduced the total duration of the crop.

Mack and Laning (1939) have demonstrated in beans that the yields were significantly reduced if pods were allowed to remain on the basal portion of plants throughout the season.

IV. Fruit maturity and quality

In bhendi, only tender pods are preferred for use as vegetable because pods develop fibre at an early stage of development.

Beattie (1906) reported that the pods became ready for picking in the later parts of the day after the flower opened although the time required to produce a marketable pod varied according to the age of plant and conditions under which it was grown, but he suggested that pods should always be gathered irrespective of size while they were still soft and before seeds were half grown.

As per the observations made by Leslie and Godfrey (1938) in

Canada the optimum stage of picking the pods is said to be when they attain two to three inches length. Caldwell et al (1945) were of opinion that in bhendi used for dehydration process, the variety and stage of maturity were the factors that determine the quality of the processed product. Purewal and Randhawa (1947) suggested that the pods should be picked at six to seven days after flower opening when the tenderness, quality and colour are at its best.

Culpepper and Moon (1941) working on the maturity aspects of Perkins improved variety of bhendi, reported that the table quality in this variety was the highest in 4 to 6 days old pods, when they are 2.5 to 3.0 inches long. Flavour and texture were also found to be best at this stage.

It has been reported by Boswell (1951) and Boswell and Reed (1962) that except in unusually hot weather bhendi pod reaches a very good stage for eating in four to six days after the flower opens and at this stage the pods are usually three to three and a half inches long which are tender and free of fibre. A delay of one or two days will yield tough and poor quality pods. Rao (1953) found that the best stage of harvest of bhendi pods as seventh day after petal fall when the size of pods at this time was three to four inches. Woodroof and Williams as quoted by Sistrunk et al (1960) reported that specific gravity and number of pods per pound decreased with maturity and the fibreness occurred at the pod tip on seventh day from flowering and developed gradually towards the base of the pod.

Sistrunk, Jones and Millar (1960) observed that the lowest dry matter content was at eight to ten days from flowering, varying

with variety but there was not much influence of dry matter content among varieties at any particular stage. The fibre content increased steadily after 13th day thus decreasing the pod quality. They also observed that pod weight of all varieties showed marked increases after fourth day. By these studies they concluded that there was only negligible difference at any given sampling date in dry matter content of pods of different varieties and that edible maturity of pods was closely related to early decline in dry matter content. Fibre development in pods increased, destroying their edibility and the dry matter content decreased beyond the eighth or ninth day after flowering.

It has also been reported by Parthakur and Baroosh (1961) that fibre formation in pods started from sixth day of fruit formation and there was a sudden increase of the fibre content from ninth day after flowering. They recommend the harvest of Bhendi on the third or fourth day after flowering.

Karwowska (1960) studied the stringiness of runner beans in relation to age of pod and variety. The fibre content at half of its full size was found to range between 0.01 per cent and 1.50 per cent and this is said to be the optimum stage for harvest. Guyer, Kramer and Ide (1950) reported that with later harvesting, the seed fibre and ascorbic acid content of the pods increased and water content and the concentration of green and yellow pigments decreased. They concluded that harvesting at an early stage of maturity produced good yields as well as quality. Ross, Drakke and Moore (1956) found that crude fibre content and tough string count of beans as an index of maturity.

Showfelt and Mohr (1957) subjected yellow snap beans for

harvesting frequencies of three, five, eight and 12 days. There was not much difference in yield in different harvesting frequencies but texture ratings decreased from very good for third day interval, to fair to good for twelve day interval. Harvesting at five to eight day interval has been recommended.

Attempts to arrive at an easy method to find out the suitable maturity stage in canning peas has made certain progress. Sayre, Williamson and Kertes (1951) explained two types of mechanical tests for measurement of tenderness namely (i) puncture test in which pressure on a needle causes the strap spring which hold the needle to move downward. The movement is transmitted to a micrometer and when the needle drops through the seed coat of the pea there is a sudden deflection of the dial pointer and this point on the dial is the puncture reading for that pea and (ii) crushing test to measure the firmness of the pea as a whole. In this method tension put on the peas will be measured at the point of crushing of the seed coats.

Martin (1937) developed another device called tenderometer for finding out the quality of raw peas. This is also based on the principle of crushing. Lynch and Mitchel (1950) were able to correlate the percentage of alcohol insolubls solids and the results of a hand operated maturometer. The results also agreed with organoleptic determinations. Lynch and Mitchel (1950 b) explained about another device operating on the principle of puncturing to find out the quality of peas.

Strachan and Torfason (1952) compared methods of measuring the maturity of peas including testing in brine, chemical analysis and use of crushing device and various tenderometers and these methods were found to be satisfactory in judging the quality.

Kramer and Amalid (1953) reported methods for measuring the tenderness and maturity of raw peas by means of shear press. It was found to be equal in precision and accuracy to the tenderometer and superior to texturometer.

Torfason, Hennecke and Strachan (1956) conducted extensive studies with maturity of canning peas. Results indicated that all objective measurements of maturity were comparable to texture measured organoleptically. The highest correlations of physical measurements of maturity were for the tenderometer, texturometer and pressure tester. Similar observations have been made by Schneider (1953), Sulunkhe et al (1957) and Ottoson (1950).

V. Fruit maturity and composition

It has been reported that bhendi contains 90 percent water two per cent protein, seven per cent carbohydrates and one per cent minerals on fresh basis at the time of edible maturity (Roswell,1961; Purewal 1944; Basu and Gosh (1943) but the variations at different stages have not been recorded so far.

In beans, Guyer et al (1960) reported that with later harvesting of fruit, the seed fibre and ascorbic acid contents of the pods increased and water content and concentration of colour pigments decreased.

Culpepper and Moon (1943) studied the differences in the composition of the fruits of cucurbita varieties at different ages in relation to culinary use. They found that the mean total solid contents decreased during the first ten days of growth and then increased to the 40th day stage after which there was a slow decline. The sugars increased during the developmental period and the first

60 days of storage. The acid hydrolyzable polysaccharids increased rapidly to 30 or 40 days stage and then almost quickly decreased to 90 days stage after which the decline was slow. Acidity, astringency and total nitrogen decreased to the 10 or 30 day stage and then increased slowly to the end of the storage period, while the nitrate nitrogen increased to the 60th day stage and then declined to the end of the storage period, the direction of the changes being reverse of those in the total nitrogen. The authors attribute flavour, consistency and appearance to the composition of the fruit at different stages.

Hoover and Dennison (1953) recorded an increased seed shell out per cent, specific gravity, refractive index and specific conductance of the southern pea (Vigna sinensis) while the moisture per cent decreased gradually as the pod matures. In peas Danielson (1956) found that at the end of the ripening process sugar content decreased rapidly. Enachescu, Jordachescu and Marinescu (1961) reported that dry matter, starch, crude protein, cellulose, total sugars, ascorbic acid, vitamin B, chlorophyll and carotenoid contents were on an increase with the approach of eating maturity in green peas. But sugar, ascorbic acid crude protein and vitamin B, contents of dry matter decreased.

The carbohydrate metabolism and nitrogen metabolism have been studied by Andreotti and Ceci (1955) and Andreotti (1956) in tomato in relation with fruit maturity and ripening. The total and reducing sugars in tomato fruits were found to increase from about 15 to 40 per cent on dry basis during ripening while starch content gradually decreased and finally completely disappeared. The percentage of nitrogen on fresh weight basis decreased during ripening.

Values were maximum during the earlier stages of ripening and minimum when the fruits became yellow red. However on dry basis the percentage of total nitrogen observed slight increase. Similarly the protein nitrogen content showed a decreasing tendency on both dry and fresh weight basis. Mineral content calculated as percentage in both dry weight and fresh weight basis decreased slightly at first but increased towards the end of ripening process.

Yamaguchi et al (1960) noted that in tomatoes T.S.S. and reducing sugars increased while total acids decreased with ripeness and total amino acids remained relatively constant throughout the stages of maturity. Similar recordings were also done by Freeman and Woodbridge (1960).

The mineral uptake and the ash content of the different tissues of the plant has been reported to be of variable nature influenced by soil moisture, mineral concentration, soil type soil reaction etc (Robertson 1951; Fried and Shapiro 1961; Gardner et al 1952).

VI. Morphology and developmental anatomy of the fruit

In bhendi, Purewal and Randhawa (1947) reported that pods attain their full length in 18 days after opening of flowers. They found that the pod increased in length at a slow rate but progressive, for the first five days and then at a very quick phase for the next two days and again at a degressive slow rate for the next eight days. The fruit increased in length from 0.95 cm. to 18.4 cm. in fifteen days. The rate of growth of pod was found to be more during night time than in day the reason being attributed to low water transpiration. Culpepper and Moon (1941) stated that the rate of growth was somewhat doubled

for each 10°F rise of temperature at all stages of development of the pod.

Venkatramani (1953) reported that the pod reaches the maximum size in ten days after pollination.

Carr and Skene (1961) studied the pod growth in French beans. Pod growth commenced immediately after anthesis and was completed in 16 to 17 days.

Sinnot (1945) studied the growth of cucurbit fruits and came to the following conclusions (i) in all lines growth consisted of tw o phases namely the first with a constant exponential rate followed by a phase of continually decreasing rate until growth ceased and in larger fruits each phase was comparatively longer (ii) there was differences in growth rate of various lines under study (iii) environmental factors had marked influence on rate of growth and there was an inverse relationship between growth rate and growth duration in various seasons.

Growth rate in various other crops has been studied. Zaitzew (1937) found a high negative correlation between maturation periods of bolls and temperature in cotton. Crowther (1944) reported that maturation period in cotton was shorter in Egypt than in Sudan and this has been attributed to the higher temperature in Egypt during the active boll maturation period. Sethi et al (1960) have clearly illustrated the effect of soil and atmospheric temperature on the ripening of the bolls. According to them bolls developing during the falling temperature mature slowly. They conclude that the earlier half period of maturation of boll is spent in growth and second half in internal development without

changes in the boll size. Tukey and Young (1938) cite Conners (1919) who showed that the growth in fruit of peach occurred in 3 stages viz., (i) rapid development of the fruit apparently due to mainly to increase in size of seed (ii) rest period during which seed is formed and stone becomes hard and (iii) period of rapid growth of flesh to maturity.

They also recognised three stages in the development of sour cherry namely (i) rapid development (ii) retarded development and (iii) rapid development. They have also described the histological aspects of the fruit development.

Soundararajan (1960) found that the rate of development of the sapota fruit was rapid in the initial stages, followed by an interphase of relatively less rapid to almost static condition for a short period and then gradual increase. Once the fruit reached maturity there was practically no increase either in the length or the diameter of the fruit. Singh (1951 b) also reported similar trend. In avocado and seeded bananas the growth curves have been reported as of sigmoid nature while in parthenocarpic banana the curve was found to be variable (Schroeder 1958; Simmonds 1953 b).

Study of the histological development of Golden delicious apple was taken up by Bell (1954) at different stages of maturity. The extensive intercellular space system in this variety is said to be the cause of marked shrivelling.

Sundararaj (1956) brought about the differentiation of the pericarp into peel and the pulp and the structures comprising them namely the mesocarp and endocarp in bananas. The possibility of comparative histological studies to throw light on the keeping quality in bananas has been discussed.

Boynton and Wilde (1959) reported that in many fruits such as red raspberry, peach, plum, apricot and cherry the early and late periods of rapid growth were interrupted by a period in which the growth rate in size and volume of the fruit was greatly decreased.

CHAPTER III

MATERIALS AND METHODS

The investigations dealt with in this dissertation were carried out at Agricultural College and Research Institute, Coimbatore for three seasons namely winter, summer and monsoon between November 1962 and October 1963.

Six varieties of bhendi viz., Pusa Sawani, Red Bhendi, English green, Sabour Selection, Indian Bhendi and College Orchard were selected for the study and the seeds were obtained from selfed flowers from the vegetable Research Scheme of the Horticultural Section. The crops were raised in the field in randomised blocks with three replications. Only one seedling was retained per hole and for the various observations, plants were selected at random. Uniform culture, manuring, irrigation and plant protection measures were given for all the treatments.

I. Varietal description and observations on growth

All the six varieties were described according to a descriptive blank prepared for the purpose. Measurements of plant height, stem diameter at the first node, number of branches, spread of the plant and the internode length of individual plants were recorded. The measurements were taken at fortnightly intervals starting with the first reading thirty days after sowing.

For the purpose of observation of growth behaviour, the plants were selected at random representing all the replications and the height and diameter of the main stem were taken from the marked points of the base of the main axis namely the first node.

Data were collected till the end of flowering. The pods were harvested at tender stage of development namely 6-7 days after flowering in all the plants. The total number of pods and their weight were recorded. Other morphological characters were recorded at the peak flowering stage of the plant. Statistical analysis of the measurements was done for each of the attributes to study the varietal variations if any. The observations were recorded over three seasons namely November to February; February to May and July to October.

IX. Influence of pruning on plant growth and yield

The following were the treatments:

a) nipping of terminal bud 45 days after sowing,

b) nipping the lateral branches and allowing only the terminal bud to grow and

c) Control

In all the treatments the fruits were harvested in the edible stage of maturity viz., six to seven days after opening of flower. The shoot length (sum of the length measurements of the main shoot and branches) and number of branches were recorded. The influence of pruning on yield of fruits was also noted by recording the number as well as weight of pods at each picking.

In this case also ten plants were taken under each treatment for the study and the observations were recorded in three varieties viz., Red Chendi, Pusa Sawani and Indian Chendi for summer and monsoon seasons of 1962-63. In order to study the relationship between the total length of shoots and the yield of fruits, correlations were worked out in 180 pairs of observations, regardless of varieties.

III. Influence of pod maturity at harvest on growth of plants and total yield

In order to study the influence of harvesting fruits of different stages of maturity on growth and yield behaviour of plants the following trial was initiated. As in the case of experiment II ten plants of uniform size were taken for study for each of the following treatments in three varieties viz., Red Bhendi, Pusa Sawani and Indian Bhendi.

a) harvesting every 5th day after flower opening,
b) harvesting every 7th day after flower opening,
c) harvesting every 9th day after flower opening,
d) harvesting every 11th day after flower opening,
e) harvesting every 13th day after flower opening,
f) harvesting every 15th day after flower opening.
g) allowing the fruits to mature and dehisce on the plants.

In all the treatments individual flowers were tagged and fruits arising therefrom were harvested at the specified intervals.

Observations were recorded on plant height, stem diameter, number and weight of fruits. In order to study the relationship between length of fruits and the total yield (weight) simultaneous observations of the length of the fruits at the above stages of maturity were recorded and correlated with corresponding yield figures. The trial was carried out during July to October.

IV. Fruit maturity and quality

a) Crude fibre development: This was determined chemically as per A.O.A.C. method. Fruits in each variety were harvested at different stages of maturity from the tender stage and upto the stage at which

they develop fibre and become inedible as judged by the texture of the fruit. Samples of pods were taken for analysis at 5th, 7th, 9th, 11th, 13th, 15th and 17th days after flower opening.

Fruits from the tagged flowers, fifteen at each stage of maturity and each variety were gathered at random, cut into pieces immediately and dried in the steam oven. The dry samples were then powdered to pass through two m.m sieve, sampled again and analysed for crude fibre.

b) Organoleptic tests: Organoleptic tests were conducted in order to correlate the crude fibre development and the edibility of the pods at different stages of maturity as in IV (a). Sampling was done as in (a) and the fruits cut into small pieces. The material (50 grams) was then boiled for fifteen minutes at 10 pound pressure in a pressure cooker. All the six samples were cooked at a time to ensure uniformity. 1.5 grammes of spice powder and 0.5 gramme of powdered salt were added. The quality was adjudged by a panel of five judges for the following attributes.

Flavour and aroma	15 marks
Mucilage	15 marks
Fibre content	30 marks
Seediness	15 marks
Taste	25 marks

c) Cutting strength of pods at different stages of maturity

An instrument was designed to record the cutting strengths of pods at different stages of maturity. The pods were tagged and harvested on 5th, 7th, 9th, 11th, 13th and 15th day after flowering which were tried with the instrument and the readings recorded.

The pressure required for the initial cut was only noted. Twentyfive pods in each of the varieties at these stages were tried.

e) Specific gravity of pods at different stages of maturity

The specific gravity was recorded by finding the weight and the volume by displacement at different stages of maturity, the stages being the same as in (c) for all the varieties under study, with an object to correlate the specific gravity and fibre development.

V. Fruit maturity and composition

Protein (in terms of nitrogen), carbohydrates and ash content of pods at various stages of maturity viz., 5th, 7th, 9th, 11th, 13th and 15th day after flowering were estimated. Sampling was done as in case of crude fibre analysis.

Estimation of nitrogen to find out the crude protein was done as per the A.O.A.C method. Carbohydrates were determined in terms of total starch according to the procedure, standardised by Pirt and Whelan (1951). The method in brief consisted as follows:

The starch dissolved in 0.25 N NaOH by heating for not more than five minutes, is hydrolysed in 1.5 N H_2SO_4 for 2 hours at 100°C and the liberated glucose estimated by means of Somogyi 1945 reagent. The weight of glucose multiplied by 0.900 gives the weight of starch originally present.

Ash content was estimated by igniting the moisture free substance in a muffle furnace.

The relationship of the above constituents and crude fibre

development was determined for the summer season crop.

VI. Morphology and developmental anatomy of the fruit

Ten pods under each of the varieties were kept under observation. Flowers were tagged on the day of opening and further developments in terms of length from epicalyx to the tip of the pod and diameter at the broadest point were recorded daily till the pods showed signs of dehiscence. The rate of growth at different stages of maturity of the pod were studied. This aspect was recorded in all the three seasons to assess the seasonal fluctuation if any.

In order to study the relationship between seed content and length of pods, thirty pods in each of the varieties, seven days after flower opening were selected and the number of seeds as well as length of pods were recorded. The relationship between the length and weight of pods at this stage was also studied.

For the study of the developmental anatomy of the fruit, transverse sections at the central region of the fruit were taken at sixteen stages of maturity starting from the day prior to anthesis and extending upto pod dehiscence. The description of the anatomical structure of the fruit has been attempted and tissues that contribute for the developsent of fibre in bhendi pods was studied with variety Pusa Sawani. The specimens were first fixed in formalin acetic acid and then sections were taken with aid of a razor as well as a hand microtome. The transverse sections were mounted in pure glycerine with safranin as staining agent.

CHAPTER IV

RESULTS

I. Varietal description and observations on growth

The record of the description of the six varieties made according to a descriptive blank prepared for the purpose is given in Table 1. The descriptive blank is appended (Appendix VII).

Apart from the plant growth, yield and earliness which have been statistically analysed and presented in the pages that follow, the varietal description reveals the following salient morphological differences among the varieties studied.

The height and diameter of the stem, length and breadth of leaf are highly variable as seen from the data. The colour of the leaf seems to be fairly distinct of the variety, the range being from olm green to dark green and purple blotches. Pedicel length among the varieties ranged from 1.8 cm. in Sabour Selection to 1.8 cm. in Red Bhendi, the colour being not distinct, except in Red Bhendi where it was purplish. Calyx colour also seems to be uniform in all the varieties. In Red Bhendi alone the calyx colour was different, which was rocellin purple. Corolla colour presented varying shades of yellow, except in Red Bhendi where it was sulphur yellow with reddish streaks. The eye spot at the base of the corolla revealed distinct varietal variations. While varieties Pusa Sawani, Red Bhendi, English Green and Indian Bhendi showed varying shades of purple on either side, in Sabour Selection and College Orchard the eye spots were only on the inner side while on the outerside the corolla colour merged upto the base.

Table 1. Varietal description

Characters	PUSA SAWANI (Plate I)	INDIAN [illegible] (Plate II)
Habit:	Medium 45.5 cm. in height, bushy 2598 sq. cm. Number of branches 11, branches spreading.	Semi dwarf, 43.1 cm. stem diameter 1.45 cm. spreading 2580 sq. cm. Number of branches 8.1, branches crawling.
Stem:	Round, unarmed, green with stray patches of purple, internode length 4.83 cm.	Round, pubescent, purple patches in green becoming more pigmented in older plants - internode length 4.95 cm.
Leaf:	Lamina 10.7 (4.0 to 18.0) cm. long, 12.8 (5.0 to 20.0) cm. broad, deeply lobed, pubescent, colour forest green (25 GG-Y/i, plate XVII) Petiole 16.4 (3.4 to 19.6) cm. long green with stray pinkish streaks, pubescent.	Leaf: Lamina 11.9 (6.8 to 20.0) cm. long 17.0 cm. (8.5 to 25.0) broad, deeply lobed, hairy, colour light elm green (27' G.Y/k Plate XVII) Petiole 18.01 cm. (6.1 to 22.0) pinkish, prickly.
Inflorescence:	First flowering 42.8 days after flowering, early. Flowers singly in leaf axils, 5.4 cm. long 5.19 cm. broad. Pedicel 1.54 cm. long, kildsregreen (29" GG-Y/b Plate XXXI) pubescent, calyx kildsregreen, 2.19 cm. long, Corolla sulphur yellow (25 YG-[illegible]-y/f Plate V) on either side. Corolla base bordeaux (71 V - RR/k Plate XII) inside and pansy purple (69 RV - R/k Plate XII) inside. Corolla length 3.34 cm. Calyx corolla ratio 3:1.52. Style 1.30 cm. long whitish, 5 lobed stigma, club shaped, dahlia purple (67 V.R/k Plate XII). Anthers picric yellow (25 yellow/d Plate IV)	Flowering in 43.8 days after sowing. Flowers singly in leaf axils, 4.06 cm. long 3.78 cm. broad, pedecil 1.29 cm long, pale cendre green (25 green/f Plate VI), hairy. Calyx napthalene yellow (25' yellow/f Plate XVI), 2.22 cm. corolla martius yellow (23 yellow/f Plate IV) on either sides. Corolla base villet carmine (69 RV - R/m Plate XII) inside and pansy purple outside (69 RV-R/K Plate XII), Corolla length 3.91 cm., calyx corolla ratio 1:1.76, style 1.57 cm. long, whitish, 5 lobed stigma, club shaped, dahlia purple (67.VR/k Plate XII) Anthers martius yellow (25 yellow/f Plate IV).
Fruit characters:	Fruit medium 10.06 cm. long, 1.425 cm. broad at edible stage. Colour bissay green (27 G-Y/i Plate XVII) pubescent, five angled, apical end slightly curved, smooth, weight 17.6 g. at edible stage . Number of locules 5, slipiness high, Dehisces in 51.1 days. Mean number of fruits per plant 16.8.	Fruits short 10.33 cm. long, 1.45 cm broad at edible stage colour dull green yellow (27 G-Y/ Plate XVII) pubescent, 5 angled, apical end curved, smooth. Weight 17.5 g. at edible stage. Number of locules 5, slipiness high. Dehisces in 52.0 days. Mean number of fruits per plant 15.2
Seed characters:	Colour yellowish olive (25" yellow Plate XXX) Shape globose 0.520 (0.45 to 0.59) cm. long, 0.535 (0.48 to 0.60) cm. broad. Hundred seeds weighing 6.4 g. Number of seeds per fruit 77.0 (46 to 107). Germinability good 98%.	Colour yellowish olive (25" yellow Plate XXX) Shape globose 0.492 (0.38 to 0.55) cm. long and 0.492 (0.44 to 0.56) cm. broad, 100 seeds weighing 5.52 g. Number of seeds per fruit 73.2 (61 to 90). Germinability good 95%.
General	medium duration, resistant to vein clearing, high yielder	Medium duration. Fairly resistant to vein clearing disease, susceptible to borer attack, moderate yielder.

Table 1. (contd)

Characters	SABOUR SELECTION (Plate III)	ENGLISH CREEP (Plate IV)
Habit	Dwarf 41.1 cm. stem diameter 1.21 cm., semi erect 1800 sq. cm. Number of branches 2.8, branches semi erect.	Small, 51.7 cm. stem diameter 1.8 cm. erect. 3105 sq. cm. Number of branches 3.4, branches crawling.
Stem	Round, pubescent, green with purple shades, internode length 4.90 cm.	Round, prickly, green and purple mixed, internode length 7.45 cm.
Leaf:	Lamina 10.6 (4.5 to 15.7) cm. long, 12.0 (4.6 to 22.0) cm. broad deeply lobed, pubescent, colour forest green (25' GG-Y/a Plate XVII). Petiole 15.5 (2.9 to 25.0) cm. long greenish with purple tinge, pubescent.	Lamina 12.1 cm. (5.4 to 21.0 cm.) long, 14.9 (8.0 to 29.0 cm.) broad; lower leaves slightly lobed, upper leaves moderately lobed, pubescent. Colour helleboregreen (25'YG-Y/a Plate XVII) Petiole 18.05 cm. long (4.8 to 32.8 cm.) pigmented with pinkish shade and hairy.
Inflorescence:	First flowering 42.6 days after sowing. Flowers singly in leaf axils, 3.60 cm. long, 3.11 cm. broad. Pedicil 1.20 cm. long, pale yellow green (31 Y.G/f Plate VI) pubescent. Calyx 1.74 cm. long, pale green yellow (27 GY/f Plate V). Corolla sulphur yellow (25 YG y/f Plate V) on either side, corolla base dahlia purple (67 V.R./k Plate XII) inside, corolla-base and sulphur yellow outside. Corolla length 2.79 cm. Calyx corolla ratio 1:1.60. Style 1.80 cm. long whitish 5-6 lobed stigma club shaped, blackish red purple (67 V.R/a Plate XII) Anthers picric yellow (23 yellow/d Plate IV.)	Flowering after 48 days after sowing. Flowers singly in leaf axils, spread 4.9 cm. long 3.83 cm. broad. Pedicil 1.22 cm. long, light viridine green (33' GY-G/d Plate VI) with stiff hairs. Calyx light viridine green, 2.44 cm. long. Corolla martius yellow (23' yellow/f Plate IV) on both outside and inside. Inner Corolla base pomegranate purple (71 V - RR/i Plate XII) and outer Indian lake (71 V - RR/i Plate XVI) Corolla length 2.11 cm. Calyx corolla ratio 1:1.75. Style 1.47 cm. long, sea foam yellow (25" YG - Y/i Plate XXII) with 6-8 stigmatic lobes; lobes club shaped, blackish red purple (67 V - R/a Plate XII) Anthers citron yellow (23 yellow/b Plate XVI).
Fruit character:	Fruit short, 3.93 cm. long, 1.87 cm. broad at edible stage. Colour apple green, pubescent, 5 to 6 angled, apical end straight, tough. Weight 14.4 at edible stage. Number of locules 5 to 6. Sliminess medium. Dehisces in 51.1 days. Mean number of fruits per plant 12.0.	Fruits short 3.91 cm. long, 1.58 cm. broad at edible stage, colour biscay green (27' GY/i Plate XVII), prickly 7-8 angled, apical end not curved, tough, weight 19.5 g. at edible stage, number of locules 6-8; medium sliminess. Dehisces in 51.8 days. Mean number of fruits per plant 18.5.
Seed characters:	Colour dark greenish olive (23" yellow Plate XXX) shape globose 0.497 (0.46 to 0.59) cm. long 0.50 (0.47 to 0.58) cm. broad 100 seeds weighing 5.82 g. Number of seeds per fruit 73.1 (35 to 94) Over inability good 92 %.	Colour yellowish olive (23" yellow Plate XXX) shape globose 0.488 (0.46 to 0.55) cm. long and 0.521 (0.45 to 0.58) cm. broad. Hundred seeds weighing 6.5 g. Number of seeds per fruit 93 (65 to 138). Over inability good 96 %.
General:	Medium duration, susceptible to vein clearing and fruit borer attack; poor yielder.	Medium duration, susceptible to vein clearing and fairly resistant to borer moderate yielder.

Table 1 (contd)

Characters	RED BHENDI (Plate V)	COLLEGE ORCHARD (Plate VI)
Habit:	Tall 46.6 cm. stem diameter 1.27 cm. erect 1545 sq.cm. Number of branches 2.3, branches erect.	edium tall 48.8 cm. stem diameter 1.37 cm. erect 2840 cm. Number of branches 3.8, branches erect.
Stem:	Slightly terrete, glabrous, colour bordeaux (71 V-RR/k Plate XII) internode length 7.79 cm.	round, prickly, green and purple mixture, internode length 7.83 c .
Leaf:	Lamina 9.0 (4.5 to 12.7) cm. long, 12.2 (6.0 to 19.8, cm. broad, lower leaves broadly lobed and top leaves deeply lobed, pubescent, elm green with purple blotch - (27' G-y/ Plate XVII Petiole 10.4 (5.1 to 15) cm. long pink, pubescent.	Lamina 11.76 (5.0 to 19.8) cm. long; 15.9 (5.5 to 20.5)cm. broad, moderately lobed, armed. Colour hellebore green (22' Y3/ Plate XVII) Petiole 13.1 (5.1 to 25) cm. long purplish green, prickly.
Inflorescence:	First flowering in 43.5 days after sowing. Flowers singly in leaf axils, 4.34 cm. long 3.64 cm. broad, pedicel 1.5 cm. long, corinthian purple (69" RV-R/k Plate XXXVIII), pubescent. Calyx rocellin purple (71" V-RR/b Plate XXXVIIII), 2.82 cm. long Corolla sulphur yellow with reddish streaks (25 YO/f Plate V) Corolla base colour dark maroon purple (71' V - RR/a plate XXVI) inside and Indian lake (71' V - RR/a Plate XXVI) outside. Corolla length 4.31 cm. Calyx corolla ratio 1:1.54. Style 1.48 cm, Hydranges pink (5" OOR/f Plate XXVII). Stigmatic lobes 5, dahlia purple (67 V-R/k Plate XII) Anthers picric yellow (25 yellow/d Plate IV).	Flowering in 48.8 days after flowering. Flowers singly in leaf axils, 4.58 cm. long 4.19 cm. broad. pedicil 1.86 cm. long, alderegreen (25" GG-I/b Plate XXXI). Calyx 2.54 cm. chrysolite green (27" G-Y/b Plate XXXI) Corolla martius yellow (25 yellow/f Plate IV,on either side. Corolla base peony purple (69 RV - R/a Plate XII) inside and martius yellow outside. Corolla length 4.19 cm. Calyx corolla ratio 1:1.79. Style 1.65 cm. long, whitish, 5 to 7 lobed stigmas, club shaped, blackish red purple (67 V.R./m Plate XII) Anthers picric yellow (25 yellow/b Plate IV).
Fruit characters	Fruit medium 10.75 cm. long, 1.558 cm. broad. Colour bordeaux, 5 angled, apical and straight, smooth. Weight 21.0 g. at edible stage, 5 loculed, sliminess medium. Dehisces in 51.0 days. Mean number of fruits per plant 9.9.	Fruits short 9.44 cm. long, 1.507 cm. broad at edible stage. Colour bissay green (27' G-Y/i Plate XVII) hairy, 5-7 angled, apical end slightly curved, tough. Weight 18.4 g. at edible stage. Number of locules 6-7, sliminess medium, Dehisces in 50.8 days. Mean number of fruits per plant 15.8.
Seed characters:	Colour dark greenish olive (25" yellow Plate XXX) shape globose 0.455 (0.45 to 0.55) cm. long, 0.511 (0.45 to 0.55) cm. broad.100 seeds weighing 5.4 g. Number of seeds per fruits 76.6 (42 to 100) Germinability good 95.	Colour dark greenish olive (25" yellow Plate XXX) shape, globose 0.485 (0.44 to 0.51) c . long, 0,512 (0.46 to 0.54)cm. broad, 100 seeds weighing 5.62 g. Number of seeds per fruit 78.4 (64-98) Germinability good 98.
General	Medium duration, resistant to vein clearing, susceptible to fruit borer, poor yielder.	edium duration, susceptible to vein clearing and fruit borer edium yielder.

As regards the sliminess of the fruit varieties Pusa Sawani and Indian Bhendi were comparatively more mucilagenous than other varieties. The number of loculee ranged from 5 to 9, Indian Bhendi, Pusa Sawani, Red Bhendi having 5 loculee each while, in others it ranged from 5 to 9.

The data in the description reveals that the number of seeds per fruit varied within the variety as well as among the varieties. The highest seed content was recorded in English Green and the lowest in Sabour Selection with a seed content of 93 and 73.1 respectively.

Among the varieties the seed content ranged from 61 to 93; 55 to 139; 84 to 99; 83 to 94; 46 to 107 and 42 to 100 in Indian Bhendi, English Green, College Orchard, Sabour Selection, Pusa Sawani and Red Bhendi respectively.

Regarding the seed size and weight, Pusa Sawani recorded the highest weight with 6.4 per 100 seeds. In other varieties it ranged from 5.3 to 5.88.g. Germinability was found to be good in all the varieties.

Considering the other important economic characters, Pusa Sawani was found to be highly resistant to vein clearing disease while English Green was fairly resistant to pod borer.

diameter, number of days taken for flowering, number and weight of pods are presented in Table 1 (a). The following conclusions are possible.

1) Plant height and stem diameter:

On the 75th day from sowing the variety English Green was found to be significantly taller than Pusa Sawani, Indian Bhendi and Sabour Selection but was on par with College Orchard and Red Bhendi. On a general consideration it was found that English Green and College Orchard were relatively better than the other varieties in terms of plant height (Figure II). In regard to stem diameter, however, the difference was not significant.

It was found that plant height and stem diameter are significantly influenced by seasonal conditions (Table 2). The plant height was significantly greater in monsoon season than in summer, which in turn was greater than winter season.

A study of the progressive growth rate of plants from 30th day after sowing at fortnightly intervals at different seasons, showed that the growth in terms of plant height and stem diameter was significantly higher in monsoon season in all the stages (Table 3). During the 30th and 45th day the differences between the growth rates in winter and summer were not significant. It

Table 1 (a) Varietal differences in vegetative and reproductive phases.

Variety	Mean plant height on 7th day in cm.	Mean stem diameter on 75th day in cm.	Mean number of days taken for flowering	Mean number of pods	Mean weight of pods in grams
1. Pusa Sawani	45.3	1.39	42.5	18.8	304.4
2. Indian bhendi	43.1	1.43	45.8	18.2	331.3
3. Sabour Selection.	41.1	1.31	42.6	12.0	151.8
4. English green	51.7	1.50	45.0	16.3	234.6
5. Red bhendi	46.8	1.27	43.5	9.8	151.8
6. College Orchard	46.6	1.37	45.8	15.8	223.6
Rather significant by 'F' test	yes	No	Yes	Yes	Yes
S.E.	1.03	-	0.33	1.02	16.6
C.D. at P = 0.05	3.0	-	-	-	-
p = 0.01	-	-	0.80	3.7	60.5

Conclusion:

4,6,5,1,2,3 | 6,4,2,5,3,1 | 1,2,4,6,3,5 | 1,2,4,6,3,5

Table.3: Seasonal influences on vegetative and reproductive phases.

Variety	Mean plant height on 75th day in cm.	Mean stem diameter on 75th day in cm.	Mean number of days taken for flowering	Mean number of pods	Mean weight of pods in grams
1. Winter	29.8	1.06	48.1	13.0	178.2
2. Summer	31.1	1.38	44.1	16.4	248.3
3. Monsoon	69.3	1.70	39.3	16.5	258.3
Whether significant by 'F' test	Yes	Yes	Yes	Yes	Yes
S.E.	1.29	0.05	0.16	0.73	11.7
C.D. at P = 0.05	-	0.16	.	-	-
P = 0.01	5.8	-	0.60	2.6	42.6

Conclusion:

M S W M S W M S W S I W S I W

Table 3. Interaction of stages of growth and season in respect to plant height and stem diameter.

Season / Stages.	Mean plant height in cm.			Mean stem diameter in cm.		
	Winter	Summer	Monsoon	Winter	Summer	Monsoon
1. 30th day after sowing	8.7	7.6	14.0	0.44	0.38	0.66
2. 45th day after sowing	14.6	13.4	31.1	0.64	0.64	1.19
3. 60th day after sowing	23.1	27.2	62.7	0.80	1.04	1.63
4. 75th day after sowing	29.8	59.1	69.3	1.06	1.38	1.70
Whether significant by 'F' test		Yes			Yes	
S.E.		0.83			0.025	
C.D. at p = 0.01		3.80			0.10	

Conclusion: -

30th day	M, $\overline{W, S}$	60th day	M, S, W
45th day	M, $\overline{W, S}$	75th day	M, S, W

Table 4. Interaction of varieties and stages of growth in respect to plant height and stem diameter.

Stages of crop (days)	Mean plant height				Mean stem diameter			
Varieties	30th day	45th day	60th day	75th day	30th day	45th day	60th day	75th day
1. Pusa sawani	10.1	18.2	35.5	45.3	0.42	0.69	1.45	1.39
2. Indian Bhendi	9.6	18.0	35.6	43.1	0.43	0.84	1.21	1.45
3. Red Bhendi	11.1	24.3	41.9	46.6	0.48	0.80	1.06	1.37
4. College orchard	10.3	18.7	39.0	46.6	0.49	0.83	1.15	1.37
5. Sabour Selection	9.5	20.1	34.8	41.1	0.47	0.81	1.12	1.31
6. English green	9.6	18.7	36.5	51.7	0.49	0.83	1.26	1.80
Whether significant by 'F' test		Yes				No		
S.E.		1.17				0.036		
C.D. at P = 0.01		4.5						

Conclusion:

30th day after sowing — RS, CO, PS, SS, IB, BO

45th day after sowing — RS, SS, CO, BO, PS, IB

60th day after sowing — RS, CO, BO, PS, IB, SS

75th day after sowing — BO, CO, RS, PS, IB, SS

respect of initial growth but with the progress in growth the variety Red Bhendi recorded the highest measurements upto 60th day while English Green and College Orchard took the lead thereafter in terms of mean measurements. Judged from the point of view of statistical significance the differences among the varieties were very slight, one variety being on a par with the other.

Table 5 summarises the mean internode length of the different varieties under trial. It was seen that internode length was a varietal character but was also influenced by the seasonal conditions as in case of stem height. In summer the internode lengths were comparatively less than in the monsoon the mean values being 5.20 cm. and 7.19 cm. respectively for summer and monsoon. In general, the plants which recorded highest plant height were characterised by longer internodes.

ii) Earliness: The varieties Pusa Sawani and Sabour Selection were significantly earlier than the other varieties, the differences between the other varieties being not significant (Table 7 a) The next in order of earliness was Indian Bhendi and Red Bhendi followed by English Green and College Orchard. The mean number of days from sowing to flowering in the earliest varieties ranged from 42.5 to 43.6 days, while the late ones recorded a range of 43.5 to 45.6.

Flowering was found to be significantly earlier in monsoon than during summer and winter, between the latter the summer crop flowered earlier.

iii) Number and weight of pods: The yield data in terms of number of pods, revealed that Pusa Sawani, Indian Bhendi, English Green and College Orchard were significantly superior to Sabour Selection

Table 5. Mean internode lengths of different varieties during summer and monsoon (mean of 200 internodes)

Season / Variety	Internode length in cm.		Varieties mean
	Summer	Monsoon	
1. Pusa sawani	4.09	5.57	4.83
2. Indian bhendi	4.04	5.86	4.95
3. College Orchard	6.26	8.41	7.33
4. Red bhendi	6.50	9.09	7.79
5. Sabour selection	4.19	5.62	4.90
6. English green	6.23	8.63	7.43
Seasons mean	5.09	7.19	

Table 6: Varietal and seasonal variation in yield in terms of weight of fruits per plant.

Season / Variety	Winter	Summer	Monsoon	Varieties mean
1. Pusa sawani	227.0	367.8	318.4	304.4
2. Indian bhendi	176.6	264.2	313.0	251.3
3. Red bhendi	151.6	168.9	135.7	151.8
4. College orchard	213.4	242.8	214.6	223.6
5. Sabour selection	113.3	171.1	171.1	151.8
6. English green	187.2	275.6	241.0	234.6
Mean for seasons	178.2	248.5	234.3	
Whether significant by 'F' test.		Yes		Yes
S.E.		11.7		16.6
C.D. at P = 0.01		42.6		60.5

Conclusion: Interaction between Season and varieties - Not significant.

and Red Bhendi, while in regard to weight of pods Pusa Sawani was alone superior to all but Indian Bhendi (Figure II). Between Pusa Sawani and Indian Bhendi on one hand, and among Indian Bhendi, English Green and College Orchard and again between Sabour Selection and Red Bhendi on the other, the differences were not significant. The mean number of pods ranged from 9.9 to 18.8 in these varieties while the corresponding weights ranged from 181.89 g. to 304.4 gm. (Table 1 a).

The yield during summer and monsoon was significantly superior to that in winter. Between summer and monsoon seasons, the difference was not signiricant (Table 2 and Figure II).

It can be seen from Table 6 that Pusa Sawani consistently recorded the highest yield, thus indicating its relative adaptability for all the three seasons. However, its best performance was during summer with a mean weight of 367.8 gm. Indian Bhendi seems to be equally good in monsoon along with Pusa Sawani while in summer and winter its performance was controlled.

College Orchard was found to be consistent in its bearing habit in all the three seasons, but in comparison with other varieties its performance in winter was equal to that of Pusa Sawani.

II. Influence of pruning on plant growth and yield

The data in Table 7 indicate that there was no significant difference in shoot length among the varieties tried. In regard to the number and weight of pods, the differences were significant. Pusa Sawani produced the maximum mean number of pods with a mean of 19.4 fruits followed by Indian Bhendi and Red Bhendi, Red Bhendi

Table 7. Varietal variations in relation to pruning.

Variety	Mean total shoot length in cm.	Mean number of pods	Mean weight of pods in grams
1. Pusa sawani	111.7	16.4	301.8
2. Indian bhendi	98.9	17.9	256.0
3. Red bhendi	96.9	11.4	170.4
Whether significant by 'F' test	No	Yes	Yes
S.E.	-	0.74	11.6
C.D.	-	2.1	32.1
Conclusion:	PS, IB, RB	PS, IB, RB	

Table 8. Seasonal effects on pruning treatments.

Season	Mean shoot length in cm.	Mean number of pods	Mean weight of pods in grams
1. Monsoon	115.4	16.8	251.8
2. Summer	88.6	15.7	233.5
Whether significant by 'F' test	Yes	No	No
S.E.	3.8	-	-
C.D.	10.5	-	-
Conclusion:	M S		

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being significantly poorer than the former two. As regards the weight of fruits the differences between the varieties were significant with mean values of 301.5 gm. 256.0 gm and 170.4 gm. for Pusa Sawani, Indian Bhendi and Red Bhendi respectively (Plate VII and Figure III).

The seasonal influence on the growth in the pruning treatments was similar to the observations recorded in the previous experiment, the total shoot length being significantly higher in monsoon than in summer. The yield differences were not significant between the two seasons as in the previous experiment (Table 8).

Among the three pruning treatments tried, it was seen (Table 9) that in all the characters studied namely total shoot length, number and weight of pods, there was high significant difference. In the total shoot length produced, lateral pruning was significantly poorer with a mean of 51.8 cm. than the terminal pruning and control which recorded 129.6 cm. and 126.4 cm. respectively, the latter two being on par.

Table 10 presents the number of branches in the different treatments. It is seen that in all the varieties the terminal pruning recorded higher number of branches over control, the mean differences being 0.65; 1.00; and 1.50 for Pusa Sawani, Indian Bhendi and Red Bhendi respectively. The summer crop produced more number of branches as compared to monsoon.

In terms of number and weight of pods there was significant difference among the treatments, terminal pruning being superior to lateral pruning and control. Between the latter, lateral pruning was found inferior to control, the yield being less by a mean number of 7.5 fruits.

Table 9: Influence of pruning treatments

Treatments	Mean shoot length in cm	Mean number of pods	Mean height of pods in grams.
1. Terminal pruning	129.6	22.0	317.3
2. Lateral pruning	51.5	8.6	151.0
3. Control (no pruning)	106.4	17.1	259.6
Whether significant by 'F' test	Yes	Yes	Yes
S.E.	4.7	0.74	11.6
C.D.	13.0	2.05	32.1

Conclusion: TP, C, LP. TP, C, LP TP, C, LP

Table 10. Mean number of brenches produced in each treatment (Mean of 10 plants)

Variety	Terminal pruning		Control		Lateral pruning		Increase over control (Mean of 2 seasons)
	Summer	Mon-soon	Summer	Mon-soon	Summer	Mon-soon	
Puea sawani	4.1	3.2	3.7	2.3	-	-	0.65
Indian bhendi	3.9	3.7	3.1	2.5	-	-	1.00
Red bhendi	5.0	3.7	3.1	2.0	-	-	1.30

Table 11. Interaction between season and varieties.

Season	Total mean shoot length in cm			Mean No.of pods			Mean weight of pods in grams		
	PS	IB	RB	PS	IB	RB	PS	IB	RB
Monsoon	103.8	124.3	96.3	18.3	18.6	11.6	294.5	280.0	174.1
Summer	98.7	78.5	85.3	18.6	16.1	11.3	308.1	232.0	163.2
Whether significant by F test		Yes			No			No	
S.E		6.7			-			-	
C.D.		18.6			-			-	

Conclusion: 1. Season

Monsoon	IB, PS, RB
Summer	PS, RB, IB

2. Variety.

Red Bhendi	M, S
Puea sawani	M, S
Indian bhendi	M, S

Table 12. Interaction between treatments and varieties.

Treatments	Mean total shoot length in cms.			Mean Number of pods			Mean weight of pods in grams		
	P.S.	I.B.	R.B.	P.S.	I.B.	R.B.	P.S.	I.B.	R.B.
1. Terminal pruning	133.8	120.0	125.9	26.2	23.5	16.4	384.9	325.0	242.1
2. Lateral pruning	81.0	47.0	57.4	11.0	10.0	7.8	126.5	134.4	122.1
3. Control (No pruning)	101.4	120.6	107.4	21.1	20.1	10.1	343.2	208.7	142.0
Whether significant by 'F' test	Yes			Yes			Yes		
S.E.	6.2			1.3			20.1		
C.D.	22.6			3.6			56.7		

Conclusion:

i) Variety:

Pusa sawani	C, T.P., L.P	T.P, C, L.P.	T.P, C, L.P
Indian bhendi	T.P, C, L.P	T.P, C, L.P	T.P, C, L.P
Red bhendi	T.P, C, L.P.	T.P, C, L.P.	T.P, C, L.P

ii) Treatments:

Terminal pruning	PS, IB, RB	PS, IB, RB	PS, IB, R.B.
Lateral pruning	RB, PS, IB	PS, IB, RB	PS, IB, R.B.
Control	IB, PS, RB	PS, IB, RB	PS, IB, R.B.

The interaction between season and the varieties was significant only for one character namely shoot length. Between season and pruning treatments it was not significant while between the varieties and treatments the interaction was significant for shoot length, number of pods and weight of pods (Table 11 and 12) thus indicating that (i) pruning treatments will exert the same influence regardless of the season (ii) the effect of the season and the variety will be felt only in shoot length and (iii) the varietal influence to the different pruning treatments being highly significant for all the characters.

The observations on the relationship between the shoot length and the number of fruits, revealed a high positive correlation between the two factors, 'r' being 0.722,** indicating that the higher the total shoot length the greater the yield.

III. Influence of pod maturity at harvest on growth of plants and total yield

The data in respect of this experiment are furnished in Tables 19 to 25 (Plate VIII and Figure IV). The following is the summary of results.

1) Length of pods: The pods were significantly longer in Red Bhendi than in Pusa Sawani and Indian Bhendi the latter two being on par (Table 13).

Table 14 indicates that the increase in length was significant at each successive harvests upto 11th day beyond which the increase was not found to be appreciable, the mean length of pods being 7.66 cm, 13.18 cm, 16.47 cm, 17.80 cm. 17.77 cm, 17.86 cm. and 17.78 cm. respectively for the harvests on 6th, 7th, 9th, 11th, 13th, 15th days and seed set group of plants.

** Significant at 1% level.

ii) Height of plants: With regard to the height of plants there was no significant difference among varieties, but the increase in height at successive harvests was significant. Growth of plant was significantly retarded when all the pods were kept for complete maturity and seedset, as seen from the mean height of only 30.0 cm. in plants on which the pods were allowed to set seed, while in plants on which the pods were regularly harvested at 8th day maturity, the plant height was highest with 47.67 cm. The maximum decrease in plant heights were observed after 11th day harvests after flowering (Table 19) indicating that harvest can be ignored until 11th day without any detrimental effect on plant height. Beyond this period any delay in harvests retards plant growth.

iii) Stem diameter: Among the varieties tried Indian Bhendi recorded the highest mean stem diameter followed by Pusa Sawani and Red Bhendi (Table 16).

As the pods were retained on the plants longer, the stem diameter was reduced to a significant level. The highest mean value of 1.7 cm. was recorded in plants on which fruits were picked on every 5th day after flowering. The lowest mean value of 1.165 cm. was recorded in plants from which pods were not harvested. (Table 17). This indicates that periodical harvests of pod contributes to thickening of the stem.

In the interaction between varieties and periods of harvests it was seen that in the earlier periods of harvest Indian Bhendi recorded greater stem diameter than the other two varieties (Table 18). But this difference was obliterated as the harvesting periods were delayed. The increase in stem diameter at different periods of harvests, though evident in all the varieties, has been

Table 13. Comparison of length of pod

Variety	Mean length of pod in cm.	Whether significant by F Test	S.E.	C.D. P = 0.05
1. Indian bhendi	14.630			
2. Pusa sawani	14.938	Yes	0.366	0.717
3. Red bhendi	16.749			

Conclusion: R.B. P.S., I.B.

Table 14: Comparison of length of pods at different periods of harvest.

Periods of maturity	Mean length of pods	Whether significant by 'F' test	S.E.	C.D. (P =0.05)
1. 5th day	7.659			
2. 7th day	13.185			
3. 9th day	16.470			
4. 11th day	17.603	Yes	0.559	1.094
5. 13th day	17.770			
6. 15th day	17.860			
7. Seed set	17.777			

Conclusion: 15, 13, 11, 15, 9, 7, 5

Table 15. Comparison of plant heights at successive harvests.

Periods of harvest	Mean height of plants in cm.	Whether significant by 'F' test	S.E.	C.D at p = 0.05
5th day	47.867			
7th day	45.467			
9th day	44.300			
11th day	41.700	Yes	1.693	5.299
13th day	37.100			
15th day	33.916			
Seed set	30.000			

Conclusion: 5, 7, 9, 11, 13, 15, S.S.

Table 16. Stem diameter - comparison of varieties.

Periods of harvest	Mean stem diameter in cm.	Whether significant by 'F' test	S.E.	C.D. at p=0.05
Indian bhendi	1.543			
Pusa sawani	1.472	Yes	0.022	0.04
Red bhendi	1.411			

Conclusion: I.B, P.S. R.B.

Table 17. Comparison of stem diameter - periods of maturity of fruit at harvest.

Periods of harvest	Mean stem diameter in cm.	Whether significant by 'F' test	S.E.	C.D. (P=0.05)
5th day	1.700			
7th day	1.616			
9th day	1.606			
11th day	1.515	Yes	0.035	0.063
13th day	1.444			
15th day	1.280			
S.S.	1.165			

Conclusion: 5 7 9 11 13 15 SS

Table 18. Stem diameter - Interaction of varieties and periods of harvest.

Periods	Red Bhendi	Pusa Sawani	Indian Bhendi
5th day	1.584	1.673	1.834
7th day	1.586	1.529	1.734
9th day	1.550	1.559	1.670
11th day	1.495	1.475	1.575
13th day	1.363	1.400	1.510
15th day	1.235	1.310	1.295
S.S.	1.049	1.200	1.195

Whether significant by 'F' test: Yes
S.E. 0.057
C.D. at P = 0.05 0.112

Conclusion:

1) Periods	Varieties
5th day	IB PS RB
7th day	IB RB PS
9th day	IB PS RB
11th day	IB RB PS
13th day	IB PS RB
15th day	PS IB RB
S.S.	PS IB RB

ii) Varieties	Periods
Red Bhendi	7 5 9 11 13 15 SS
Pusa Sawani	5 9 7 11 13 15 SS
Indian Bhendi	5 7 9 11 13 15 SS

best brought about in Indian Bhendi.

iv) Number of pods: In the production of pods, Red Bhendi was found to be significantly poorer than Pusa Sawani and Indian Bhendi (Table 19).

The number of fruits produced was highest in plants in which fruits were harvested regularly on the fifth day after flowering. As this period increased, the number of pods produced decreased gradually. The mean number of fruits produced in the former was 22.93 and the general decrease being 20.10; 16.87; 14.23; 11.07 and 8.60 respectively at 7th, 9th, 11th, 13th and 15th day harvests after flowering, 7th and 9th day harvests being on par (Table 20).

While the above was the trend in the mean number of fruits produced for all the varieties, in the interaction between varieties and periods of harvests the number of fruits on fifth day harvests differed markedly from variety to variety (Table 21). These differences become less pronounced in the subsequent periods though the fewer number of pods was evident throughout. The varieties did not differ markedly in yielding capacity with successive harvests.

v) Weight of pods: Among the varieties, as in case of number of fruits produced, with regard to weight of fruits also Red Bhendi has recorded significantly lesser mean weight than other two varieties which were on par (Table 22).

With regards to periods of harvests and weight of fruits per plant, the data (Table 23) showed a gradual increase in weight till the 9th day harvest group and then there was a reduction in weight of pods. The mean weights being 161.9 gm; 324.7 gm; 474.2 gm;

Table 19. Yield in terms of number of pods . Varietal difference.

Variety	Mean number of pods	Whether significant by 'F' test	S.E.	C.D. 0.05
1. Red bhendi	18.61			
2. Pusa Sawani	19.03	Yes	0.718	1.407
3. Indian Bhendi	17.96			

Conclusions: P2 P1 P3

Table 20. Yield in terms of number of pods - Production at different periods of pod maturity

Periods of harvest	Mean number of pods	Whether significane by 'F' test	S.E.	C.D. at 0.05
1. 5th day	22.93			
2. 7th day	20.10			
3. 9th day	19.87	Yes	1.015	1.989
4. 11th day	14.23			
5. 13th day	11.07			
6. 15th day	8.60			

Conclusion: 5 7 9 11 13 15

Table 21. Number of pods - Interaction between periods of harvest and variety.

Period of harvest	Red Bhendi	Pusa Sawani	Indian Bhendi	Means for periods level
5th day	16.5	28.1	24.2	22.93
7th day	14.2	24.5	21.8	20.10
9th day	13.0	20.8	21.0	18.27
11th day	11.0	16.9	14.3	14.23
13th day	8.6	13.5	11.1	11.07
15th day	6.4	10.4	9.0	8.60
Means for varieties level	12.61	19.03	17.95	

Whether significant by 'F' test Yes

S.E. 1.76

C.D. at P = 0.05 3.5

Conclusion:

1) Periods	Varieties
5th day	PS IB RB
7th day	PS IB RB
9th day	IB PS RB
11th day	PS IB RB
13th day	PS IB RB
15th day	PS IB RB

Varieties	Periods
Red Bhendi	5 7 9 11 13 15
Pusa Sawani	5 7 9 11 13 15
Indian Bhendi	5 7 9 11 13 15

Table 22. Yield in terms of weight of pods - Varietal differences

Variation	Mean weight of pods in grams	Whether significant by 'F' test	S.E.	C.D. at p =0.05
Red Bhendi	307.6			
Pusa Sawani	408.4	Yes	22.83	45.6
Indian Bhendi	369.8			

Conclusion: P2 P1 P3

Table 23. Yield in terms of weight of pods - production of different periods of pod maturity at harvest.

Periods of harvest	Mean weight of pods in grams.	Whether significant by 'F' test	S.E.	C.D. at p = 0.05
5th day	181.9			
7th day	324.7			
9th day	474.9	Yes	31.44	61.6
11th day	432.6			
13th day	417.5			
15th day	340.7			

Conclusion:

9 11 13 15 7 5

432.5 gm; 417.5 gm and 340.7 gm. for 5th, 7th, 9th, 11th, 13th and 15th day harvests respectively. The former increase in weight can be attributed to the increase in length and also the internal development of the fruit components, while the latter reduction in weight was due to the fewer number of fruits borne, even though individual fruits weighed more at these periods of harvests.

In the interaction between periods of harvests and the varieties it could be seen that there was reduction in weight of fruits as the period of harvests exceeded nine days after flower opening in Indian Bhendi and thirteen days in the others. The differences among varieties at each periods of harvests were not consistent (Table 24).

Three correlations between height and diameter of stem; height of plant and number of fruits; stem diameter and number of fruits were worked out. As seen from Table 25, there was high positive correlation in all these combinations thus indicating the balance between the vegetative growth and the reproductive growth of the plants.

IV. Quality and fruit maturity

a) Crude fibre: The percentages of crude fibre at different stages of maturity on dry basis are furnished in Table 26 from which it is seen that between summer and monsoon seasons the crude fibre development was not significantly different while in winter it was significantly lower than during summer and monsoon.

The crude fibre content at different stages of maturity from the 5th day after flowering to the 17th day after flowering was determined on every alternate day. Considering all the varieties

Table 24. Weight of pods - Interaction between periods of harvest and variety.

Period	Red Bhendi	Pusa Sawani	Indian Bhendi
5th day	183.2	191.3	201.2
7th day	273.3	389.9	332.0
9th day	364.3	487.8	600.4
11th day	330.6	532.9	433.9
13th day	424.1	488.8	345.7
15th day	298.8	416.6	308.8

Whether significant by 'F' test Yes

S.E. 64.8

C.D. at P 0.05 186.8

Conclusions:

i) Periods

5th day	IB PS RB
7th day	PS IB RB
9th day	IB PS RB
11th day	PS IB RB
13th day	PS RB IB
15th day	PS IB RB

ii) Varieties Periods

Red bhendi	13 9 11 15 7 5
Pusa Sawani	11 13 9 15 7 5
Indian Bhendi	9 11 15 7 13 5

Table 25. Correlations

Correlation between	Correlation coefficient	Significant or not	Level of significance
Height and diameter of stem	0.4770	Yes	p = 0.05
Height and number of fruits	0.4939	Yes	p = 0.05
Stem diameter and number of fruits.	0.9034	Yes	p = 0.01

Table 26. Crude fibre development - Season and varietal interaction

Seasons	Mean crude fibre per cent	Whether significane by 'F' test	S.E.	C.D
Winter	18.85			
Summer	19.01	Yes	0.19	0.54
Monsoon	19.39			

Conclusions: Monsoon, Summer, Winter

and the three seasons, crude fibre content at these stages ranged from 2.93 per cent to 34.68 per cent (Table 27).

Regarding the stages of maturity, it was observed that at every stage of growth the crude fibre development progressively increased, the mean values being 4.63 per cent at 5th day after flower opening to 30.82 per cent at 17th day after flowering. The differences between any two stages were found to be highly significant (Table 28).

During winter, crude fibre development was rather slow in the beginning but after 7th day there was a significant increase. In summer also more or less the same tendency was observed excepting that between 11th and 13th stages the developmental process slowed down. In the monsoon season at every stage, the development was significantly higher than the previous one (Table 29).

On the 5th day after flowering, the crude fibre development was practically the same irrespective of the season, the trend being maintained on the 7th day, but when the pods were harvested on the 9th day after flowering the crude fibre remained practically the same in summer and monsoon. In winter, however, the developmental rate slowed down significantly and this was maintained at all stages (Figure V a).

b) Organoleptic test: The marks scored under different attributes for all the varieties is furnished in table 30. With respect to organoleptic tests fruits in the monsoon season recorded significantly higher values than those in summer season viz., 48.8 and 45.5 respectively (Table 31).

Pusa Sawani, Indian Bhendi, Red Bhendi and Sabour Selection

Table 27. Percentage of crude fibre at different stages of pod maturity on dry basis.

Varieties	WINTER							SUMMER							MONSOON						
	5th day	7th day	9th day	11th day	13th day	15th day	17th day	5th day	7th day	9th day	11th day	13th day	15th day	17th day	5th day	7th day	9th day	11th day	13th day	15th day	17th day
1. Pusa Sawani	4.05	5.36	8.49	8.63	17.00	20.00	25.49	2.92	7.21	11.10	23.15	23.64	29.19	31.74	5.57	6.83	12.00	24.15	25.85	28.34	32.85
2. Indian Bhendi	4.19	5.66	11.84	11.92	15.80	22.70	25.79	5.83	6.55	15.38	23.06	24.10	28.95	31.83	4.65	6.92	14.56	22.20	24.25	27.76	32.25
3. Sabour Selection	5.53	6.58	10.53	14.64	16.87	21.45	24.35	5.25	5.98	16.54	22.59	24.65	27.86	34.26	4.35	6.76	14.68	22.47	25.85	28.91	34.45
4. English Green	4.22	5.85	10.96	15.86	17.25	21.53	25.46	4.84	7.15	12.55	23.90	24.55	28.92	31.54	4.45	7.25	15.43	22.67	24.55	27.53	34.69
5. Red Bhendi	5.86	5.52	9.78	12.25	15.00	20.56	24.00	4.59	6.68	15.54	22.95	24.82	28.55	32.25	5.25	7.25	12.78	23.94	25.92	28.86	34.65
6. College Orchard	4.52	5.97	11.54	15.57	16.58	21.54	24.62	4.55	6.76	14.39	21.50	23.69	28.74	32.85	4.97	7.40	15.55	21.82	25.98	28.74	34.56

Table 22. Crude fibre development - Stages and varietal interaction.

Varieties	5th day	7th day	9th day	11th day	13th day	15th day	17th day	Var. mean
Pusa sawani	13.55	19.40	31.64	55.83	66.40	77.46	95.35	17.00
Indian Bhendi	14.67	19.11	41.58	57.18	69.18	79.61	97.65	17.83
Sabour Selection.	15.11	19.13	41.65	59.63	68.25	78.82	93.06	17.71
English green	13.53	20.36	36.93	60.49	66.11	77.65	97.49	17.27
Red Bhendi	13.69	19.45	36.10	59.14	68.74	77.94	90.86	17.29
College orchard	13.84	20.13	41.78	56.69	64.95	77.02	101.83	17.86
Stages mean	4.65	6.53	13.75	19.39	21.67	26.00	30.32	

Whether significant by 'F' test — Yes — No

S.E. — 0.29

C.D. — 0.82

Conclusion — 17 13 15 11 9 7 5

Table 29. Crude fibre development - Stages and seasonal interaction
(Mean values for seasons and stages)

Seasons	5th day	7th day	9th day	11th day	13th day	15th day	17th day
Winter	4.40	5.79	10.02	12.46	16.09	21.26	26.45
Summer	4.63	6.72	13.96	22.86	24.19	29.36	32.35
Monsoon	4.67	7.07	13.78	23.88	24.77	28.57	33.65

Whether significant or not Yes

S.E. 0.51

C.D. 1.44

Conclusion: I Season Stages

Winter 17 15 13 11 9 7 5

Summer 17 15 13 11 9 7 5

Monsoon 17 15 13 11 9 7 5

II. Stages Seasons

5th day M S W

7th day M S W

9th day S M W

11th day M S W

13th day M S W

15th day M S W

17th day M S W

Table 30. Organoleptic scoring of different varieties at different stages of maturity for various attributes

A. MONSOON

	Total marks	PUSA SAWANI						INDIAN BHENDI						GABOON SELECTION						ENGLISH GREEN						RED BHENDI						COLLEGE ORCHARD					
		5th day	7th day	9th day	11th day	13th day	15th day	5th day	7th day	9th day	11th day	13th day	15th day	5th day	7th day	9th day	11th day	13th day	15th day	5th day	7th day	9th day	11th day	13th day	15th day	5th day	7th day	9th day	11th day	13th day	15th day	5th day	7th day	9th day	11th day	13th day	15th day
Flavour & aroma	15	10.5	11.6	7.5	7.5	6.8	6.5	12.8	10.8	6.8	6.8	6.4	5.8	12.4	11.5	7.4	6.5	6.5	6.8	11.8	10.2	7.4	7.2	6.8	5.6	11.6	9.8	7.0	6.0	5.8	5.0	10.9	10.6	6.7	5.6	5.4	4.6
Mucilage	15	12.2	10.9	6.8	5.4	4.9	4.8	11.4	11.2	7.2	7.0	7.0	5.5	10.8	10.7	8.5	7.5	8.0	5.8	9.4	9.5	7.8	7.2	7.0	6.2	10.4	11.7	8.4	8.2	8.0	4.5	10.5	11.5	7.2	7.2	6.8	5.8
Fibre	30	26.0	24.8	15.7	11.6	7.1	4.9	28.7	28.4	15.9	8.4	8.2	7.0	15.7	20.3	12.6	9.5	7.8	7.5	28.8	30.5	11.4	8.5	8.1	5.9	25.0	21.2	7.5	7.0	6.5	6.0	21.8	21.5	10.2	7.5	7.0	6.6
Seediness	15	10.6	9.2	7.4	7.0	6.5	5.5	12.4	10.1	6.5	6.5	6.0	4.0	11.7	10.5	1.5	6.7	6.4	5.7	11.7	10.6	7.9	6.8	6.5	6.1	12.1	10.9	6.6	6.0	5.6	4.8	11.0	11.4	6.4	5.6	5.4	5.0
Taste	25	20.3	20.0	9.5	7.5	7.0	5.9	22.4	24.0	12.5	9.4	8.6	7.7	19.7	17.9	8.8	7.0	6.5	6.5	18.5	14.8	10.8	8.5	7.5	6.4	19.5	18.6	8.3	7.1	6.8	5.9	19.2	18.9	8.7	8.0	7.2	7.2
Total	100	79.6	76.5	45.0	34.6	32.5	27.4	82.4	81.0	48.9	38.1	36.2	29.4	82.8	70.9	44.8	37.7	35.0	31.4	74.4	65.8	45.0	38.0	35.1	30.8	78.6	72.2	37.6	34.5	32.5	26.2	72.4	72.7	39.2	32.9	32.1	29.5

B. SUMMER

Flavour & aroma	15	8.4	9.0	7.0	6.0	5.4	6.0	8.6	8.8	6.4	5.2	4.4	3.0	8.2	8.2	5.6	5.0	4.0	3.6	8.8	6.8	5.0	3.6	3.2	3.0	9.2	9.4	7.0	7.2	5.8	4.0	9.2	9.2	6.0	5.8	4.4	3.8
Mucilage	15	9.8	10.6	9.6	7.6	7.6	7.8	8.4	10.8	8.0	6.8	6.2	5.4	8.1	8.8	7.2	6.0	6.0	5.0	8.8	9.8	8.4	6.6	8.2	7.6	9.4	9.6	7.6	6.0	7.0	5.6	8.8	8.6	6.6	6.6	6.6	4.2
Fibre	30	24.3	21.2	15.4	7.6	4.0	4.4	24.2	23.2	13.0	9.0	5.4	2.8	24.0	22.6	12.0	8.4	6.0	5.0	20.6	21.0	8.6	7.6	6.6	4.6	19.4	21.2	15.2	9.6	7.8	5.2	20.6	17.2	6.0	5.4	4.6	3.0
Seediness	15	10.8	9.6	7.2	4.6	4.0	3.4	12.2	11.0	7.0	5.0	3.8	1.6	10.8	10.4	7.4	6.4	5.6	3.8	9.6	8.4	5.2	5.2	4.8	5.0	10.4	9.8	7.4	6.6	5.4	3.6	9.8	9.0	6.2	4.6	4.4	2.4
Taste	25	18.0	18.0	13.8	7.4	6.4	5.4	18.4	20.2	12.4	7.6	5.8	5.0	18.6	19.6	12.4	10.2	6.8	4.8	16.2	17.2	7.2	6.2	4.6	3.8	19.2	18.2	14.4	11.0	9.4	4.4	17.0	17.4	6.4	4.8	5.4	5.2
Total	100	71.0	68.6	53.0	33.2	29.4	27.0	65.4	74.0	76.8	38.6	25.6	18.8	69.7	69.6	44.6	36.0	28.4	21.6	61.0	62.4	34.2	31.2	27.4	24.0	72.6	68.2	51.6	40.4	35.0	22.8	65.6	61.4	31.2	27.2	25.4	15.6

seem to be significantly better than English Green or College Orchard with scorings of 48.5; 47.7; 47.9; 46.5; and 44.1; 42.3 respectively. Between Sabour Selection and English Green and between English Green and College Orchard no significant difference was seen. On the whole, in respect to organoleptic attributes, Pusa Sawani lead all the other varieties, Red Bhendi and Indian Bhendi being on par (Table 32).

It is evident from table 32 that the eating quality on the 5th day is not significantly different from that on the 7th day but thereafter at every stage the quality deteriorated significantly, the corresponding marks being 71.8; 70.3; 45.5; 38.8; 31.1 and 24.9 respectively.

In the monsoon season, the variety Indian Bhendi was found to be significantly better than English Green, Sabour Selection, College Orchard and Red Bhendi but on par with Pusa Sawani. In summer, Red Bhendi was significantly better than others excepting Pusa Sawani which was on a par with Red Bhendi. Varieties Pusa Sawani, Red Bhendi and Sabour Selection did not exhibit any significant differences in quality due to seasons. As for the other varieties, their quality was significantly better in monsoon than summer (Table 33; Figure V b).

In the interaction between stages and seasons, (Table 34) it was found that upto the 7th day after flowering in both the seasons, there was no significant difference in the attributes scored viz., 73.3 and 67.3; but thereafter in case of summer the decrease in scores was highly significant but in monsoon at the 11th and 13th stages the mark scored were on par.

Table 31. Organoleptic scoring - Seasonal variation.

Season	Mean	Whether significant or not	S.E.	C.D.
Monsoon	49.8	Yes	0.50	2.1
Summer	43.5			

Conclusion. Monsoon, Summer

Table 32. Organoleptic scoring - Interaction between variety and stages of maturity.

Stages of maturity	Pusa sawani	Indian Bhendi	Sabour Selection.	English green	Red Bhendi	College orchard	Stages mean
5th day	150.6	147.8	139.0	136.4	151.2	138.8	71.9
7th day	144.9	155.0	140.5	137.7	140.4	135.1	70.3
9th day	98.0	95.7	89.2	79.4	89.8	70.4	43.5
11th day	71.8	71.7	73.7	69.2	74.7	61.1	35.2
13th day	59.7	61.5	63.4	63.5	67.5	57.5	31.1
15th day	54.4	43.2	53.0	54.2	46.0	45.1	24.9
Variety mean	46.5	47.9	46.5	44.1	47.7	42.3	
Whether significant by 'F' test			Yes				Yes
S.E.			0.9				0.9
C.D.			2.6				2.6

Conclusion: PS IB RB SS EG CO 5 7 9 11 13 15

Table 33. Organoleptic scoring - Interaction between variety and season.

Variety	Monsoon	Summer
Pusa Sawani	49.9	46.7
Indian Bhendi	52.7	43.3
Sabour selection	48.0	45.0
English green	48.3	40.0
Red Bhendi	46.9	45.4
College orchard	47.0	37.7
Whether significant by 'F' test	Yes	
S.E.	1.3	
C.D.	3.7	

Conclusion:

i) Variety — Season

Pusa sawani — M S

Indian bhendi — M S

Sabour selection — M S

English green — M S

Red bhendi — S M

College orchard — M.S.

ii) Season — Variety

Monsoon — IB PS RG SS CO RB

Summer — RB PS SS IB SG CO

Table 34. Organoleptic scoring - Interaction between season and stages of maturity

Stages of maturity	Monsoon	Summer
5th day	76.1	67.5
7th day	75.3	67.3
9th day	43.4	43.6
11th day	36.8	33.6
13th day	34.0	28.2
15th day	20.0	20.9
Whether significant by 'F' test	Yes	
S.E.	1.3	
C.D.	3.7	

Conclusions:

1) Season — Stages

Monsoon	5	7	9	11	13	15
Summer	5	7	9	11	13	15

11) Stages — Seasons

5th day	M S
7th day	M S
9th day	M S
11th day	M S
13th day	M S
15th day	M S

In respect of interaction between stages, upto the 7th day after flowering, the scorings in monsoon were significantly higher than summer but beyond that stage there was no seasonal differences

Regression of organoleptic scoring with crude fibre development

From comparisons of 36 pairs or data for the organoleptic scorings and crude fibre content at different stages of maturity for six varieties, a very high negative correlation was found to exist their value being -0.975** leading to the inference that as the pod matures is edibility is lost (Figure x).

c. Cutting strength: An instrument was designed to record the cutting strength of pods at different stages of maturity. The instrument operates on the principle of a spring balance. A blunt edge of 0.48 mm. thickness is fixed at the basal end of the spring and the top of the spring is attached to a nut and screw arrangement so that as the nut is rotated the spring is lifted up. The whole structure is fixed to a framework which facilitates the easy movement of the spring and the nut and screw arrangement with least friction. As pressure is put upon the spring by rotating the nut above, the blade moves up and cuts the fruit kept at right angles to the blade and held in position by means of two clamps. The resistance offered by the pod for the first cut is measured on a scale which is caliberated in kilograms based on the tension of the spring (Plate IX and X)

Table 35 gives the mean (mean of 25 fruits) reading of the

** Significant at 0.1 per cent level.

strength required to cut the pods at different stages of maturity. It is seen that there is no appreciable difference among the varieties, but there is difference in the cutting strength required at the different stages of maturity, the mean values for all the varieties being 1.42 kg; 2.41 kg; 4.43 kg and 6.20 kg respectively for 5th, 7th, 9th and 11th day fruits after flower opening. Beyond 11th day the blade could not cut through the pod (Fig. V C)

Regression of cutting strength with crude fibre development

Twenty four pairs of data combining the six varieties and four stages of maturity namely 5th, 7th, 9th and 11th day after flowering were compared. There was a very high positive correlation between the cutting strength and the crude fibre content at all the stages of pod maturity, the 'r' value being 0.979*** (Figure XI)

d) Specific gravity: The specific gravity of the pods at different stages of maturity was determined for all the varieties (Table 36).

Among varieties there was no significant difference in specific gravity.

There was highly significant difference between stages of maturity and specific gravity the mean range of specific gravity being 0.983; 0.817; 0.736; 0.761; 0.761 and 0.788 on the 5th, 7th, 9th, 11th, 13th and 15th day after flowering. The differences between 7th, 9th, 11th and 13th day after flowering were however not significant (Figure V d).

*** Significant at 0.1 per cent level.

Table 55. Cutting strength of pods at different stages of maturity (Kilo grams)

Varieties	5th day	7th day	9th day	11th day
1. Pusa sawani	1.44	2.90	4.72	6.40
2. Indian Bhendi	1.56	2.50	4.48	6.26
3. Red Bhendi	1.40	2.44	4.22	6.02
4. English green	1.50	2.34	4.20	6.14
5. Sabour selection	1.20	2.46	4.62	6.32
6. College orchard	1.42	2.50	4.18	6.62
Mean	1.42	2.41	4.44	6.20

Table 56. Specific gravity of fruits at different stages of maturity (Average of 15 pods)

Varieties	5th	7th day	9th day	11th day	13th day	15th day
Pusa sawani	0.911	0.617	0.760	0.744	0.754	0.750
Indian bhendi	0.976	0.609	0.766	0.757	0.764	0.716
Sabour Selection	1.201	0.651	0.746	0.762	0.766	0.717
English green	0.961	0.798	0.797	0.794	0.740	0.691
Red bhendi	0.843	0.627	0.749	0.777	0.764	0.731
College orchard	0.908	0.807	0.798	0.794	0.771	0.752
Mean	0.953	0.617	0.768	0.761	0.761	0.723

Whether significant by 'F' test: Yes

S.E. 0.023

C.D. 0.067

Conclusion: 5 7 11 13 9 15

Correlation between the specific gravity and the crude fibre

Thirty six pairs of data in respect of six varieties and six stages of maturity were compared. There was a high negative correlation between crude fibre and specific gravity the 'r' value being - 0.803**

V. Fruit maturity and composition

a. Protein: It is seen from Table 37 that as the fruit ages, the protein content gradually decreases, the highest value on the 5th day old pods being 16.81 per cent for the variety English Green and the lowest value at 15th day being 10.83 per cent for the variety College Orchard on dry weight basis.

Among the varieties, College Orchard recorded significantly higher protein content than Indian Bhendi, the former was however on par with Pusa Sawani, Red Bhendi and English Green (Table 38: Figure VII)

The protein content on 5th day and 7th day was significantly higher than the subsequent stages. Between the 9th and 11th; 11th and 13th; and 13th and 15th day the differences were not appreciable. Among the last four stages the protein content on the 9th day and 11th day were slightly higher than that of the 15th day pods. The data thus indicate the relative richness of Bhendi harvested at the vegetable stage on the 5th and 7th days, in comparison with the more mature stages (Table 38: Figure VI).

b) Starch: Unlike the protein content there was a gradual increase in the percentage of starch as the pod matured, the mean range

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** Significant at 0.1 per cent level.

Table 37. Protein content at different stages of pod growth. per cent on dry basis.

Varieties	5th day	7th day	9th day	11th day	13th day	15th day
Pusa sawani	16.08	16.32	15.79	13.90	13.21	12.46
Indian bhendi	16.46	13.92	12.35	12.11	11.90	11.30
Red bhendi	17.69	16.44	13.89	13.38	13.05	12.56
Sabour Selection	16.34	16.61	13.38	12.40	11.78	11.40
English green	18.81	19.91	14.33	13.43	12.30	12.22
College Orchard	17.71	15.08	15.83	13.43	12.68	10.89

Table 38. Protein content - comparison of varieties.

Varieties	Mean per cent of protein	Whether significant by 'F' test	S.E.	C.D. p=0.05
Pusa sawani	14.96			
Indian bhendi	13.01			
Red bhendi	14.70			
Sabour selection	13.96	Yes	0.37	1.01
English green	14.67			
College orchard	15.67			

Conclusion: 6 1 3 5 4 2

Table 39. Protein content - variation among stages of pod maturity.

Stages of pod maturity	Mean percent of protein	Whether significant by 'F' test	S.E.	C.D.
5th day	17.86			
7th day	16.86			
9th day	14.16	Yes	0.37	1.01
11th day	13.44			
13th day	12.49			
15th day	11.76			

Conclusion: 5 7 9 11 13 15

Table 40. Starch content at different stages of pod maturity per cent on dry basis.

Varieties	5th day	7th day	9th day	11th day	13th day	15th day
Pusa sawani	15.6	19.2	21.0	24.0	24.4	30.4
Indian bhendi	20.8	20.6	26.6	28.0	28.8	29.8
Red bhendi	14.8	23.2	18.8	21.2	24.6	31.6
Sabour Selection	12.8	25.2	25.4	28.6	29.8	34.4
English green	14.2	19.8	23.4	26.6	29.6	33.2
College Orchard	16.2	21.0	25.6	27.4	32.4	38.8

being 15.4 per cent on the 5th day and 33.0 per cent on the 15th day after flowering representing an increase of over 100 per cent in ten days (Table 40).

The variety College Orchard recorded significantly higher mean starch content than all the other varieties. Sabour selection and Indian Bhendi which were on a par were significantly higher than English Green, Red Bhendi and Pusa Sawani. The last three varieties were also significantly different the superiority being in the order mentioned above (Table 41; Figure VII).

It was also noted that the difference in starch content between each successive stage was highly significant. Increase in starch content was much more rapid between successive stages than the decrease in protein. For instance, between the 5th and 7th days the difference was as much as 6.1 per cent. Beyond this stage the increase was less rapid. The starch content on the 7th day (21.8 per cent) represents nearly two thirds of the maximum starch content (33.0 per cent) recorded on the 15th day (Table 42; Figure VI).

c) Ash content: Table 43 reveals the ash content of fruits for the varieties under study and at different stages of pod maturity. Variety Indian bhendi recorded the maximum mean ash content of 9.64 per cent while the minimum mean per cent of 7.33 was recorded by Pusa Sawani on dry basis. Between stages, the ash content seems to be erratic as seen from the mean percentage of 8.67; 8.69; 10.06; 8.32; 8.05 and 9.02 for fruits harvested after 5th, 7th, 9th, 11th 13th and 15th days after flowering (Figure VI and VII).

Table 41. Starch content - comparison of varieties.

Variety	Mean percent of starch	Whether significant by 'F' test	S.E.	C.D.
Pusa sawani	22.1			
Indian Bhendi	26.8			
Red Bhendi	23.4	Yes	0.10	0.29
Sabour selection	26.0			
English green	24.3			
College Orchard	26.6			

Conclusion: 6 4 2 5 3 1

Table 42. Starch content - Variation among stages of pod maturity

Stages of pod maturity	Mean percent of starch	Whether significant by 'F' test	S.E.	C.D.
5th day	18.4			
7th day	21.3			
9th day	23.0	Yes	0.10	0.29
11th day	26.0			
13th day	28.3			
15th day	33.0			

Conclusion: 15 13 11 9 7 5

Table 43. Ash content at different stages of maturity (percent on dry basis)

Varieties	5th day	7th day	9th day	11th day	13th day	15th day	Mean
Pusa sawani	5.52	7.26	8.29	8.68	7.54	12.00	7.33
Indian bhendi	8.24	9.96	8.69	12.64	8.73	9.47	9.64
Red bhendi	6.19	12.56	7.76	8.03	5.99	8.46	8.50
Sabour Selection	5.85	7.73	14.14	7.17	6.79	8.65	8.05
English green	7.58	8.75	14.58	6.63	5.56	6.26	7.68
College Orchard	6.72	7.98	9.74	9.31	6.69	8.67	8.05
Mean	6.67	8.69	10.06	8.92	6.92	8.92	

VI. Morphology and developmental anatomy of the fruit

a) Morphology of fruit growth: In all the varieties studied the rate of growth of fruits was rather at a slow phase in the beginning upto about fifth day after flowering (Table 44). This was followed by a quick growth phase for another three to four days and then a gradual fall upto 13th to 15th day after flowering. Thereafter there was no external indications of growth either in length or diameter. Among the three seasons, however, in winter the highest growth rate occurred between seventh and ninth days after flowering while in summer and monsoon, this phase was earlier i.e., from 5th to 7th day after flowering (Table 45).

After having reached the maximum length the fruit remains in that condition for about three days after which it tends to shorten slightly owing possibly due to loss of moisture (Plates XI to XIII; Figure VIII).

In the study of comparison of fruit length among varieties, as well as the seasons, the following results were observed (Table 46). The mean pod lengths at seven days after flowering were 10.02; 10.23; 10.60; 9.02; and 9.00 and 8.90 cm. for varieties Pusa Sawani, Indian Bhendi, Red Bhendi, Sabour Selection, College Orchard and English Green respectively. Pod lengths of Pusa Sawani, Indian Bhendi and Red Bhendi remained almost the same while those of Sabour Selection, College Orchard and English Green were on par. However, the fruit lengths of the first three varieties were significantly higher than the other varieties (Fig.IX).

The mean pod lengths of all the varieties for winter, summer and monsoon were 6.96 cm; 9.89 cm. and 12.17 cm. respectively. It

Table 44. Pod growth in terms of length and diameter from flowering to pod dehiscence

1. PUSA SAWANI

		Number of days after flower opening												
		1	2	3	4	5	6	7	8	9	10	15	20	25 Day before dehiscence
WINTER	Length	0.97	1.65	2.57	3.41	4.51	5.438	6.77	7.76	10.20	11.90	13.64	13.57	13.53	13.43
	Diameter	0.92	1.02	1.11	1.16	1.22	1.26	1.30	1.42	1.46	1.55	1.84	1.81	1.76	1.68
SUMMER	Length	1.23	2.17	3.41	4.65	5.95	7.76	9.90	11.45	12.94	13.39	13.78	13.71	13.67	13.60
	Diameter	0.90	1.03	1.11	1.18	1.28	1.38	1.46	1.56	1.69	1.78	1.84	1.84	1.84	1.83
MONSOON	Length	1.45	2.38	3.25	4.85	6.65	10.28	13.51	14.01	15.45	16.64	17.58	17.50	17.35	17.29
	Diameter	1.13	1.22	1.30	1.37	1.43	1.48	1.58	1.69	1.76	1.92	2.04	1.99	1.95	1.92
2. INDIAN BHENDI														
WINTER	Length	1.14	1.82	2.87	3.92	4.95	6.22	7.56	9.19	11.62	12.93	14.09	13.73	13.70	13.70
	Diameter	0.84	0.94	1.08	1.14	1.19	1.27	1.30	1.40	1.50	1.60	1.84	1.85	1.84	1.76
SUMMER	Length	1.13	2.31	3.55	4.79	6.47	8.31	10.22	11.28	12.17	12.27	12.55	12.65	12.65	12.55
	Diameter	0.83	0.96	1.01	1.08	1.22	1.32	1.41	1.60	1.72	1.76	1.83	1.88	1.85	1.78
MONSOON	Length	1.95	3.22	4.60	5.92	7.94	10.58	13.86	14.00	15.79	16.05	16.66	16.68	16.37	16.20
	Diameter	1.21	1.24	1.30	1.37	1.45	1.54	1.65	1.81	1.91	2.03	2.11	2.08	1.98	1.89
3. RED BHENDI														
WINTER	Length	1.14	1.68	2.56	3.74	4.78	5.94	7.60	8.88	10.88	12.45	14.10	14.11	14.01	13.94
	Diameter	0.99	1.04	1.13	1.21	1.25	1.29	1.38	1.44	1.50	1.58	1.77	1.79	1.75	1.66
SUMMER	Length	1.07	1.96	3.07	4.52	6.00	7.91	10.59	11.92	13.06	13.51	13.59	13.30	13.20	13.13
	Diameter	0.89	1.05	1.16	1.26	1.34	1.42	1.53	1.64	1.73	1.79	1.91	1.89	1.78	1.76
MONSOON	Length	1.70	3.01	4.45	5.94	8.27	11.24	13.99	16.16	16.17	18.84	19.43	19.47	19.20	19.20
	Diameter	1.21	1.35	1.43	1.48	1.54	1.61	1.72	1.92	1.92	2.05	2.17	2.09	2.01	1.90

Table 44 (Contd)

4. SABOUR SELECTION

WINTER	Length	0.95	1.40	2.13	2.93	3.71	4.52	5.53	6.28	6.19	9.30	11.55	11.56	11.50	11.46
	Diameter	0.79	0.92	0.96	1.07	1.12	1.16	1.19	1.30	1.33	1.38	1.39	1.65	1.62	1.61
SUMMER	Length	1.18	2.34	3.49	4.67	6.25	9.24	10.41	11.75	12.74	13.91	13.05	12.99	12.98	12.93
	Diameter	0.88	0.99	1.07	1.17	1.23	1.35	1.46	1.61	1.72	1.79	1.89	1.91	1.89	1.66
MONSOON	Length	1.43	2.37	3.40	4.51	6.04	8.47	10.98	13.78	14.20	15.28	16.01	15.97	15.86	15.80
	Diameter	1.14	1.21	1.29	1.33	1.38	1.48	1.57	1.68	1.78	1.98	2.03	1.99	1.92	1.89

5. ENGLISH GREEN

WINTER	Length	1.12	1.75	2.53	3.73	4.58	5.92	7.70	9.63	11.03	12.08	13.45	13.45	13.39	13.30
	Diameter	0.90	1.02	1.11	1.22	1.27	1.33	1.50	1.55	1.66	1.74	2.06	2.06	1.99	1.93
SUMMER	Length	1.15	1.91	2.75	3.77	5.18	6.53	8.71	10.19	11.40	11.54	11.78	11.78	11.71	10.67
	Diameter	0.90	1.05	1.11	1.19	1.33	1.46	1.56	1.66	1.86	1.90	2.07	2.09	2.07	2.02
MONSOON	Length	1.40	2.25	3.02	4.23	5.94	8.23	10.31	12.16	13.68	14.89	15.00	15.19	15.06	14.93
	Diameter	1.05	1.20	1.32	1.39	1.49	1.57	1.69	1.85	2.01	2.16	2.31	2.28	2.22	2.08

6. COLLEGE ORCHARD

WINTER	Length	0.95	1.52	2.30	3.10	3.90	4.98	6.21	7.93	9.93	11.23	13.33	13.31	13.12	12.98
	Diameter	0.82	0.95	1.05	1.12	1.19	1.23	1.30	1.39	1.51	1.62	1.91	1.98	1.89	1.83
SUMMER	Length	1.20	2.14	3.16	4.35	6.18	8.25	10.37	11.89	13.41	13.67	13.45	13.76	13.75	13.73
	Diameter	0.89	1.01	1.11	1.18	1.29	1.38	1.49	1.60	1.73	1.81	2.01	2.04	1.98	1.96
MONSOON	Length	1.69	2.76	3.91	5.21	6.89	9.57	11.65	14.15	15.92	16.81	16.73	16.76	16.61	16.55
	Diameter	1.17	1.28	1.34	1.37	1.41	1.51	1.63	1.81	1.93	2.09	2.19	2.16	2.09	2.05

Table 45. Frequency of growth rate of pods

	Pusa Sawani			Indian Bhendi			Sabour Selection			English Green			Red Bhendi			College Orchard		
	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M
First five days	0.90	1.19	1.33	0.95	1.29	1.69	0.75	1.25	1.21	0.93	1.08	1.19	0.95	1.20	1.65	0.79	1.23	1.38
Next two days	1.13	1.58	5.42	1.80	1.63	2.46	0.93	2.08	2.46	1.82	1.79	2.19	1.51	2.19	2.68	1.10	2.04	2.48
Next two days	1.71	1.62	0.97	1.01	0.97	1.46	1.28	1.18	1.68	1.78	1.84	1.79	1.82	1.88	2.09	1.86	1.07	2.05
Next six days	0.56	0.81	0.35	0.41	0.05	0.14	0.57	0.05	0.80	0.37	0.60	0.22	0.84	0.05	0.21	0.67	0.29	0.13
At the time of dehiscence	-0.11	-0.18	-0.23	-0.27	-0.01	-0.45	-0.09	-0.10	-0.21	-0.15	-0.11	-0.27	-0.16	-0.21	-0.13	-0.55	-0.01	-0.17

is interesting to note that the maximum pod length was achieved in monsoon followed by summer and winter. The monsoon and summer crops produced significantly higher pod length as compared to winter while the pod lengths of monsoon crop was significantly higher than both summer as well as winter crops (Table 47 and Plates XIV and XV; Figure IX).

The total duration taken for the pod to mature and dehisce on the plant itself from the day of flower opening were 33.6; 30.5; and 29.6 days in winter, summer and monsoon respectively. It is seen that in winter the time taken for maturity was significantly higher than the other two seasons. There was no significant difference between summer and monsoon seasons.

Irrespective of the seasons, the variation among the varieties in the total number of days required for pod dehiscence was not significant (Table 48).

Relationship of number of seed and pod length: From thirty pairs of data taken on the seventh day after flowering, the correlation between number of seeds and length of pod has been worked out. There was a positive correlation ranging from high to very high in varieties Indian Bhendi, Pusa Sawani and Sabour Selection, the 'r' values being 0.461**, 0.673*** and 0.369* respectively. There was no correlation in varieties Red Bhendi, College Orchard and English Green.

Relationship of length of pod and weight of pod: Fifteen pairs of data for weight of fruit and length of fruit were studied on the

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*** Significant at 0.1 per cent level.
** Significant at 1.0 per cent level.
* Significant at 5.0 per cent level.

Table 46. Pod length at 7th day maturity among different varieties.

Variety	Mean length in cm.	Whether significant by 'F' test	S.E.	C.D
1. Pusa sawani	10.08			
2. Indian bhendi	10.25			
3. Sabour selection	9.02	Yes	0.33	1.01
4. English green	8.90			
5. Red bhendi	10.01			
6. College orchard	9.00			

Conclusions: 5 2 1 3 6 4

Table 47. Pod length at 7th day maturity - comparison of seasons.

Seasons	Mean length in cm.	Whether significant by 'F' test	S.E.	C.D.
Winter	8.96			
Summer	9.89	Yes	0.25	0.72
Monsoon	12.17			

Conclusions: M S W

Table 40. Period taken for total maturity of pods.

Variety	Winter	Summer	Monsoon
1. Pusa sawani	34.6	30.8	29.7
2. Indian bhendi	35.9	30.7	29.4
3. Sabour selection	34.3	31.0	28.9
4. English green	32.8	30.0	30.1
5. Red bhendi	33.5	30.1	29.4
6. College orchard	32.8	30.2	30.0

Comparison of seasons:

Season	Mean No. of days	Whether significant by 'F' test	S.E.	C.D
Winter	33.8			
Summer	30.5	Yes	0.31	0.90
Monsoon	29.8			

Conclusion: W S M

seventh day after flowering. There was a positive correlation between length of pod and weight of pod in all the six varieties studied in spite of variations in pod diameter among different varieties, the 'r' values being 0.930*** ; 0.780** , 0.838*** , 0.936*** , 0.884*** and 0.814*** for Pusa Sawani, Indian Bhendi, Red Bhendi, Sabour Selection, College Orchard and English Green respectively.

b) Anatomy of the fruit:

The fruit (Plate XVI) is angular in outline and is usually five ridged and five loculed. The pericarp is pubescent and is about 1148 to 1705.2 microns in thickness at the age of three days after flower opening.

Epidermis is uniseriate consisting mostly of tabular cells. Cuticle is very thin and the outer tangential wall is slightly thickened.

The epidermal hairs are long, multicellular and multiseriate. The basal cell is the largest and with a bulbous foot. The cell immediately above this is considerably narrow and slightly constricted. Both these cells possess less dense protoplasm at young stages of maturity. The remaining length of the hair is made up mostly of cells which are longer than broad and are arranged in several rows, the rows gradually reducing in number towards the attenuating apex. Few of the top most cells are uniseriate with the apical cell being rounded.

The remaining portion of the pericarp to the innermost layer

*** Significant at 0.1 per cent level.
** Significant at 1.0 per cent level.

lining the locule is made up of thin walled parenchymatous cells. The sub-epidermal layer of the parenchymatous cells is compactly arranged and made up of cells, most of which are somewhat radially elongated. Four to nine succeading layers of parenchymatous cells are isodiametric and compactly arranged without any intercellular spaces. Following these are layers of parenchymatous cells which, except the last two to three layers of cells abutting the locule and a few layers lying immediately above, are comparatively bigger and radially elongated with very small intercellular spaces. It is in these layers that the innumerable lysigenous mucilage cavities are found scattered all over.

In addition to these mucilage canals or cavities, a large number of small vascular bundles occur scattered all over. The size of the bundles near the periphery is comparatively small while the bundles gradually increase in their size in the subsequent layers. The bundles are collateral, open and endarch. Phloem is well developed while the xylem is made up of a few vessels which are irregularly arranged and spirally thickened.

The innermost three to four layers of cells are periclinally elongated. The few layers of cells above these are compactly arranged and are smaller in size.

While the above is the structural or anatomical features of the pericarp for most of its parts, in regions lying opposite to the middle portion of the locule, the pericarp exhibits entirely different type of arrangement of tissues. In this region the vascular bundles present certain peculiarities not only in their mode of arrangement but also in the orientation. They are

exarch, two to three bundles, comparatively very large and show a tendency to coalesce together and form radially elongated and club shaped strips. The bundles orient themselves through an angle of 90° with the xylem of the opposite bundles facing each other and lying in periclinal direction. The strips that are formed thus in this region are two in number and are separated by a narrow band of parenchymatous cells of variable sizes. The parenchymatous cells, three to four layers abutting the xylem are comparatively larger and somewhat radially elongated, while the core consisting five to six layers is considerably smaller in size. The cells of this core extending from the hypodermis (subepidermal) to nearly one third the radial length of the pericarp are distinctly elongated towards the anticlinal direction. The mucilagenous cavities as well as intercellular spaces are characteristically absent in this region. The pericarp is continuous with the axis, through the septa, separating the locules. At the junction of the pericarp with the septum, the considerably large vascular bundle coalesces to form an arc of collateral and endarch vascular bundle extending from near about one locule to the adjuscent locule, separated only by a few layers of parenchymatous cells lining the locule. The core of the septum consists of parenchymatous cells and mucilageous cavities. The cells lining the locule are anticlinally elongated.

The axis becomes furrowed on either side of the septa due to the disintegration of the club shaped cells ingrowth, observed in the ovary. The base of the septa as well as the placenta are very broad, supplied with traces arising from an irregular arc of vascular bundles which are medullated and

situated opposite the septum, with a pith in the centre, separated and surrounded by thin walled parenchymatous cells. The xylem of the outer arc is endarch while that of the inner arc is exarch. The core of the arc consists mostly of thin walled parenchymatous cells. The cells of the parenchymatous tissue in the peripheral region as well as the central region are considerably small and compactly arranged. In the remaining portions they are bigger in size with large intercellular spaces. Five to six vascular bundles are arranged in the form of a ring in the central region. The xylem of these bundles undergo orientation in different directions. In a few bundles they are exarch, in some they are endarch and in others they are lateral. A few mucilaginous cavities lye scattered in this region.

A majority of cells contain starch grains while a few of them possess sphaerocrystals of calcium oxalate. The starch grains are bigger in size.

The above description deals with a typical anatomical structure of the fruit. The changes taking place as the fruit ages with special reference to the maturity and fibre formation are given below (Plates XVII to XXXI).

The ovary: Epidermis is uniseriate with a number of multicellular, uniseriate or multiseriate hairs. The pericarp is made up of thin walled parenchymatous cells which are considerably smaller in size. Majority of the cells contain starch grains. A large number of cells contain small stellate or sphaerocrystals of calcium oxalate. The pericarp abounds in

mucilage cavities of lysigenous type. Parenchymatous cells are all isodiametric except those lining the lysigenous cavities which are periclinally elongated. In the region opposite to the middle portion of the locule the cells are all radially elongated and somewhat bigger in size. The vascular bungles arrangement is similar to those described already.

The axis or core is somewhat pentagonal in outline with five radiating septa arising at its angles. In between the septa there is a club shaped ingrowth of distinct and compactly arranged homogenous parenchymatous cells which are very rich in protoplasmic contents. In between these two adjacent club shaped structures are seen two lysigenous mucilage cavities situated towards the base of septum. Each septum is broad and contains a large mucilage cavity or similar type. Situated between the basal two cavities and the large septal cavity is the medullated vascular bundle. The remaining portion of the axis presents typical description.

Although the seeds are developed only in five rows in the mature fruit, there are actually two ovules in each locule (Plate XIX) but they get arranged one above the other, thus falling in a line in the developed fruit.

Fifth day: The cell wall of the hairs and the epidermal cells become cutinised and slightly thick. The xylem vessels of the bundles are also considerably thickened. Parenchymatous cells become larger in size while those lying opposite the middle portion of the locule remain smaller in size. The lysigenous cavities also appear to be diminished in size. The septal wall

becomes elongated together with large cavity situated in it, the cavity becoming narrow. The contents of the sieve elements become less dense.

7th day: The walls of the sieve elements become considerably thickened due to deposition of lignin, with their contents disappearing. Slight thickening of the septal wall is also observed. The parenchymatous cells become larger.

9th day: The walls of the elements of the defunct phloem tissue and the associated cells become considerably thickened to form the fibres of the phloeic origin. At this stage, in the development of the fibre it is only the smaller bundles that are situated in the pericarp take prominent part. In other words the fibres are developed only from the smaller vascular bundles situated in the pericarp though the components of phloem tissue of the larger and the radially elongated bundles situated in the pericarp, opposite to the middle portion of the locule as well as the bundles lying opposite the septal wall in the pericarp also undergo slight thickening. In the core or axis the defunct phloem also show slight thickening and the vascular bundles tend to coalesce together. The septal walls become somewhat more thickened.

11th day: The deposition of lignins on the walls of the defunct phloem cells continues and the cells become distinctly thickened. The bigger vascular bundles also get lignin coated. Apart from this some of the parenchymatous cells abutting the functional phloem of the bundles in the axis also become sclerenchymatous and form fibres of extraphloeic origin.

15th day: At this stage the lignin deposition on all the phloem cells is very great and as a result the walls become very thick, in both the larger vascular bundles and the smaller ones. The secondary thickening of the parenchymatous tissues abutting the active phloem is very distinct. Thickening of the cells continue in a similar manner during the next few days.

17th day: Apart from the usual activity of lignin deposition, a few air spaces develop just above the vascular bundles situated opposite to the locule wall. In the subsequent stages the air spaces already formed increase in size while new air spaces are produced inside the pericarp in between each of the small vascular bundles scattered along the pericarp. After 23rd day after flowering, along with increase in the size of the air spaces, the locule wall just below the two radially elongated large vascular bundles seem to get weakened.

25th day: The locule wall below the corners of the fruit slightly degenerates. Air spaces become enlarged and the parenchymatous cells surrounding the vascular bundles also disintegrates forming large cavities inside the fruit. The smaller parenchymatous cells in between the two radially situated vascular bundles also get weakened as indicated by the darkening of these cells. The increase in air spaces continues upto the 27th and 28th day after flower opening and at this stage the contraction of the cells both in the vascular bundles as well as in the parenchymatous region is very distinct. The cells to a greater extent are devoid of water and the cell contents adhere to the cell wall.

31st day. Actual dehiscence of the pod takes place due to extreme desiccation and contraction of the cells. The plane of dehiscence falls in between the two radially situated vascular bundles, opposite the middle portion of the locule wall, where the parenchymatous cells have already become weak. The mechanism of dehiscence can be explained as mainly due to loss of water and contraction of the cells.

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CHAPTER V

DISCUSSION

The morphological description of the varieties have brought out certain differences among the varieties and have also indicated that environmental conditions exert an influence on the plant characters. Classification of the bhendi varieties based on their economic characters is important from the points of view of both the consumer as well as the grower, especially in view of the growing quality consciousness. On the basis of studies of different varieties of bhendi, Venkatramani (1948), Thompson and Kelly (1957) suggest the classification based on plant height and pod length. The present studies reveal that these characters are greatly influenced by environmental conditions such as temperature, humidity, rainfall etc., It may be pertinent to mention in this connection, the criticism of Rao Narasinga (unpublished) on the classification of Venkatramani (1948). The main characters on which Rao attempted classification are, stem colour and spininess. In the present studies, only six varieties were described and it is observed that although there are variations in the different characters studied, the differentiation on the basis of stem colour, spininess and other morphological characters, as suggested by Rao (unpublished) seems to be extremely difficult. In view of the limited number of varieties studied, no attempt has been made here for arriving at a key for classification. However, it appears that the number of locules, number of ridges on the fruit and colour of fruit along with other morphological characters may be given importance in arriving at a key for classification.

Growth is affected by a number of factors some of which may

prove limiting under certain conditions. Apart from the varietal influences, the part played by the season is quite evident as seen from the results. Emphasising the influence of climatic conditions Hildebrandt states "no successful method has yet been brought forward by which the value of climatic complex to produce growth in any plant may be deduced from instrumental data". The word growth has been used for various purposes. It is used to denote the continual laying down of new differentiated cells from the undifferentiated meristematic tissue which constantly occur in a rapidly developing plant resulting in increase in height or elongation and finally increase in mass or dry weight. The rate of flowering and fruiting has got a direct bearing on the vegetative growth and hence the importance of the study of the growth behaviour.

From the results obtained in this study it is apparent that growth and bearing are significantly influenced by the season apart from the genetical growth pattern of a particular variety in question. Pal et al (1966) have also recorded similar findings in respect of Pusa Makhmali variety of bhendi in which the vegetative growth as well as bearing was prolonged in the monsoon than in summer. But from the observations reported in this study, it seems likely that some other factors have also been responsible for the seasonal variations, since the crop was raised under irrigated conditions. The next important factor is the temperature. The influence of temperature has been studied at length in cotton. Studies by Balls (1916) revealed that growth of stem in cotton is influenced by temperature and the best continuous temperature for growth of the cotton plant is reported to be 90°F. It has been also shown that temperature above 90°F accelerated growth for a

short time but later on, the growth is retarded. Perhaps the optimal temperature has got its action on the assimilation, photosynthesis, absorption of nutrients, respiration, enzyme activity, protein synthesis etc., as well as the rate of cell division. It has already been proved in several horticultural crops, that the best growth takes place at certain levels of temperature, below or above which the growth is retarded or completely suspended. Summarising the temperature influences on plant growth, Gardner et al (1988) state "Functional activity and growth of any kind in a plant have definite temperature requirements. Within the limit between which the growth processes can proceed development is slowest near each extreme - that is close to the lower and close to the upper limit. Growth is most rapid at an optimal temperature, somewhere between the two extremes, but usually nearer the upper than the lower limit. Furthermore the optimum for certain growth processes is quite different from that for others within the same plant and the extremes may be different for different activities".

The above statement provides a possible explanation for the marked growth increase noted in the monsoon in the present study, as also the adverse influence of winter on growth. Similar observations have been made in beans, peas and tomatoes (Went 1944, 45; Igawa 1959). The different varieties under trial have shown significant differences in growth which may be attributed to the inherent differences in the genetical make up of each variety. The genetic constitution of a given plant sets definite limits to the type of development of which the plant is capable beyond which no environmental conditions carry it.

Whether growth is expressed as the increase in dry weight or the increase in height of plant, there is a fairly constant relationship between the measure of growth employed and time. Tisdale and Nelson (1961) explain this general pattern as one of initial small increase in size, followed by a rapid increase in growth and last by a period during which the size of the plant increases only slowly or not at all. This general pattern was observed in the present study. However, while all the varieties show a gradual increase in size, variety English Green, showed somewhat an accelerated pace of growth at the period when other varieties showed decline in height. This may be a varietal characteristic which suggests that this variety may demand a different cultural and manurial treatment, such as the later application of manures, than for the other varieties.

The effect of temperature is also seen in the flower bud initiation. It is seen from the results that flowering is significantly delayed in winter than during summer and monsoon, the difference between the latter being negligible. Gardner et al (1962) reported that flower bud initiation is inhibited in many plants by high, and in the same and other plants by low, growing season temperatures. They quote that the tomato sets freely when the day temperatures range from 70° to 90°F but is inclined to abort when they exceed 90°F, due in part to temperature and in part to high transpiration rate. As evident from the findings in cotton by Balls (1916) the date of flowering is again influenced by the corresponding growth of the main stem during the preceding 28 days. The seasonal variation in the square and boll period, reported to be independent of cultural operations and manuring also supports the view that seasonal conditions,

especially temperature are directly related to flower bud initiation (Ludwig 1931). However, Igawa (1959) reported that high temperature prolonged the period of flowering in beans.

It is obvious from the works of Swingle (1904) and Hodgson (1948) as quoted by Gardner et al (1952) that temperature influences flowering and fruiting in dates as well as pine apple. Swingle's work makes it clear that at temperature below 64.4°F, dates neither flower nor fruit. Similarly in pine apple for profuse flowering night temperature should fall below 62°F while higher temperature generally favours fruit set.

From the results obtained in the present studies it is clear that winter has a retarding influence not only on growth but also on flowering and fruiting while summer and monsoon seasons favour higher flowering and fruit production. Thus it seems likely that it is the temperature that counts much in fruit production in bhendi. The findings of Bastur (1950) in cotton and Went (1944) in tomato also support this view, while in beans and peas it has been recorded that fruit set was smaller even though flowering was profuse at higher temperatures (Saki 1956; 1957 and Lambert and Linck 1950). The exact temperature at which the fruit set was retarded has not been specified.

Thus it is clear that bhendi requires a very favourable environment, specially temperature for the full expression of growth and reproductive phases. It would be worthwhile to record the lowermost and the upper limits of temperature requirements below or above which the growth, flowering and fruiting habits get impaired.

Pruning in relation to growth and yield does not appear to

and other vegetable crops appreciable work has been done in the past. Results of these experiments reveal both decrease as well as increase in yield due to pruning under different conditions. In cotton, although pruning treatments did not result in increased yield of pods, in several cases, there is clear indication that vegetative growth is enhanced as a result of pruning. However, pruning is reported to be a usual practice in U.S.S.R. to improve yield and quality of bolls (Bedding and Kimbrough 1936; Ayres 1931; Templeton 1931; Venkatraman and Jagannatha Rao, 1933; Joshi et al 1941; Christidis and Harrison 1955; Guruswami Raja and Neelakantan 1959 and Sikka and Avtar Singh 1961).

The growth and bearing habits are entirely different aspects in cotton in which case the sympodial growth is responsible for higher boll production and the end products namely the lint is of importance. Thus the increased vegetative growth which has been reported to be late in the season may delay the production of sympodial branches, exposing the bolls to the vagaries of the season. In bhendi, on the other hand, the bearing is on the axillary position of leaf and except for the first few nodes every other seems to be reproductive. Further it is not the end products as in case of cotton that concerns the grower, but in the initial production namely edible green fruits. Hence the increased vegetative growth as seen in the results due to pruning might be of value in production of increased fruits. Further it is seen that the number of branches in terminal pruning is definitely higher than control while the increase in total shoot length is slight but is to a significant level. It can be inferred that with a higher manurial doses along with terminal pruning may increase the yield to a greater tune.

In vegetable crops such as beans, musk melon, tomatoes the beneficial effects of different types of pruning have been recorded while a few have also recorded negative results.

The results obtained in this study, clearly indicate the beneficial effects of the pruning the terminal bud forty five days after sowing treatments. Both in shoot length, number of pods and weight of pods, terminal pruning was found to be significantly superior over control while lateral pruning has got an adverse effect on yield. Review of literature in muskmelon and tomatoes reveal positive results due to different pruning treatments such as single stem pruning; single stem with two or four side shoots being retained; single stem with shoots below the first inflorescence being retained etc., (Wolf and Hartmann, 1942; Memphill and Furnook 1946; Sayre 1948; Smerda 1949; Kerr 1949; Maley and Jamieson 1950; Peterson and Bremer 1953; Cooper 1956; Dabska and Koslowska 1959; McEwen 1961). While in beans Sugiama's (1944) finding is that by pinching the apex, there was inducement of vegetative growth but no increase in fruit production was recorded. Topping was also found to be inferior to removal of laterals in tomatoes (McEwen 1961). It may be inferred from the results that due to terminal pruning the apical dominance in growth is cut down thereby inducing the lateral branches to produce early increase in length. The mean number of branches also was higher in this treatment over control. The reduced yields in the lateral pruning treatment may be attributed to the loss in leaf area and therefore a possible reduction in photosynthesis. Supporting this view the importance of leaf area in apples and grapes has been stressed for obtaining regular bearing and uniform ripening etc.,

(Haller and Magness 1925; Harley et al 1932; Mohanakumaran (unpublished).

The time of pruning may also influence the vegetative growth and yield (Sverdz 1949 and Christidis and Harrison 1955) which is a factor worthy of further investigation, because the time required for the vegetative growth of the subsidiary shoots should be enough for their full expression.

Even though the terminal pruning increased the shoot length, number of pods and weight of pods in general, the season and the varietal influences were still obvious. However data on interactions of different factors in respect of three characters under study indicated that the influence of season is independent of that of pruning treatments and vice versa in influencing the shoot length and yield. On the other hand season and varieties are inter-dependent so for as the total shoot length is concerned. Varieties and pruning treatments seem to be highly inter dependent in influencing the expression of all the three characters.

Further trials seems to be necessary to investigate the responses of other varieties to the different levels of pruning done at different stages of the crop.

The influence exerted by the growing pod on the plant growth as well as further production of fruits is very interesting. It is evident from the results that both plant growth as well as the yield are retarded when the pods were retained on the plant for full maturity, the reduction being in proportion to the age of pod at harvest.

Work in the past both in bhendi as well as other crops as

cited in the review also reveal that when the harvest of fruits were made while still young, the growth of the plant continues for several weeks and acts as a stimulus for further growth and flower production (Beattie 1905; Harvey 1931; Joshi et al 1941; Lachman 1948; Perkins et al 1952; Rao 1953 and Parthakar and Barooah 1961). The statement 'Bhendi plant possesses an extremely delicate balance between vegetative and reproductive activity" by Harvey (1931) seems to be very apt in this connection. The reason is obvious that the nutrients absorbed by the plant is completely utilized by the growing fruit. But the degree of plant growth and yield reduction has not been recorded so far and as such we do not know how far a fruit can be retained on the plant without any retarding effect on plant growth and yield.

The differences in plant height, apparently remain the same till the 11th day harvest, thereafter the plant height is reduced considerably. The stem on the other hand recorded a more gradual fall even though the initial stem diameter was the maximum on the fifth day than those plants on which no harvesting was done. As regards the number of fruits and their weight per plant it is seen that the maximum number of fruits were borne in plants where harvests were carried out at every fifth day after flowering, with a progressive reduction afterwards. But the weight of the fruits at this stage is very low and this can be attributed to the smaller size of the fruits. In plants where harvests were done seventh day and ninth day intervals the number of fruits borne is almost the same while there is significant difference in their corresponding weights. At these harvest periods the difference in length of pods is not appreciable - no doubt the ninth day pods are slightly longer - but this difference is not in proportion with the

increase in weight in pods harvested at nine days after flowering does not seem to be due to increase in size but due to the internal development of the pods. This is evident in the study of the anatomical structure and development of fruits discussed elsewhere, in which it was recorded that the fibrous development is due to lignin deposition and cell enlargement, taking place between seventh and ninth day after flowering. This quick internal development also makes the fruit, fibrous and inedible as seen from the maturity studies.

After 9th day harvests - 11th day, 13th day, 15th day harvests after flowering as well as in plants allowed to mature seed - the pod length remaining almost same the total weight of fruits produced is gradually reduced to a significant level. In these cases the reduction in total weight is not due to the lack of internal development in the pod, but due to the lesser number of pods produced on these sets of plants. Thus it is clear that in terms of maximum pod weight and plant growth, harvest at ninth day after flowering have been found to be the highest but at this stage the pod is inedible due to fibre formation. Therefore the best quality, yield and plant growth are obtained around the seventh day. The farmer by dint of his experience has been found to harvest his produce about this time possibly because of the maximum number of fruits of the optimum maturity obtained at this stage. A slight delay no doubt impairs the quality but within a period of 10 days the pods still have an external look to enable their getting mixed up in produce of five to seven days old. Upto the 10th day therefore the economics of the farmer does not suffer appreciably due to the over maturity of a part of his crop. However beyond this stage it would be rather easy to distinguish an overmature fruit and so everyone is served by retaining the crop

except for seed.

Several workers have recommended the harvest of bhendi fruit when they attain four to seven days of age after flowering. The recommendations were mainly based on external texture of pod and perhaps the organoleptic tests but the reasons for arriving at these recommendations have not been specified. Moreover the recommendations have not been specified. Moreover the recommendations vary to a great extent from person to person which might be due to the conditions prevailing at a particular place or season (Beattie 1905; Godfrey 1930; Caldwell et al 1945; Purewal and Randhawa 1947; Boswell 1951; Rao 1955; Parthakur and Saroosh 1961 and Boswell and Reed 1962). Hence attempts were made in this study to arrive at the exact harvesting date based on crude fibre development and organoleptic tests and at the same time bearing in mind the economic characters such as length of pod, weight of pod etc., so as to get the maximum returns without any loss of edibility.

It is observed from the results that crude fibre goes on increasing as the pod ages. The crude fibre development in winter is seen to be at a lower rate than in summer and monsoon, thus indicating the seasonal influence on quality. This is in accordance with the results obtained by Maitrow (1927) Crowther (1944) and Sethi et al (1960). Whatever may be the other assets of the fruit, once it develops fibreness then it loses its edibility and hence the market value. Therefore fibre development is the major factor that decides the quality in bhendi and it is interesting to note that this factor being influenced by season, while the varieties among themselves do not show any variation. Now it is the question how far one can tolerate the fibre or at what stage of pod growth the fibre is intolerable. From the data it is clear that the

seventh day after flowering the crude fibre content suddenly shoots up and this figure is supported by the accumulation of lignin and thickening of cells especially that of vascular bundles as evidenced by the anatomical development discussed elsewhere.

Organoleptic tests also indicate that irrespective of varieties, fruits beyond seventh day become quite inedible. Monsoon fruits were found to be superior to those of summer. These tests for two seasons also indicate that seventh day after flower opening is the best as far as edibility is concerned and at this stage the mean crude fibre contents were 6.72 per cent and 7.07 per cent respectively for summer and monsoon. Hence it is clear that the optimum quality and maturity of the pods are obtained on the seventh day after flowering in summer and monsoon while in winter a delay of about a day may perhaps be possible in view of the slower rate of maturity.

The length of pods, number of fruits obtained and the weight of fruits gathered at harvests done on seventh day after flowering as already discussed, reveal the fact that the maximum number, length and weight of fruits, without any detriment to quality, is obtained at this stage. It has also been shown that harvesting fruits on every seventh day after flowering does not influence the vegetative growth of the plant to any significant level.

Since crude fibre determines the edibility of bhendi and considering the fact that this is subject to seasonal influences it seems desirable that this aspect should be studied in different environments.

The correct edibility in the field is determined by arbitrary methods. Snapping the tips of fruits is a common practice but very

tender fruits may easily give way to this test, thus reducing the yields due to shortness of the pods. Although pod length is another factor which may give a fair indication of the correct maturity, it varies with the season and varieties. The pod length is characteristic of each variety subject to of course to slight variations, due to seasons but the familiarity with the variety would no doubt enable the farmer to determine the exact stage. A cracking sound when the pods are slightly pressed in between the thumb and forefinger can also be taken as an indication of proper edibility. Beyond the seventh day, this sort of cracking sound may not be evident.

Where canning has been greatly developed for vegetables several devices have been designed to measure the maturity and quality of a given sample, such as texturometer, tenderometer, crushing tests etc., (Sayre et al 1961; Martin 1937; Linch and Mithel 1950 and 1950 b; Kramer and Asmlid 1953). Objective measurements of maturity have been shown to be comparable to organoleptic tests (Schneider 1955). The device for finding out the cutting strength was therefore developed. The cutting strength was highly correlated with crude fibre development. It is felt that this would be of use for judging the percentage of overmature fruits in a given sample.

The specific gravity at different stages of pod maturity was investigated with a view to finding its value in expressing the maturity of pod. However it was seen that even though there is a gradual decrease in specific gravity as the pod matures, the differences in specific gravity for different stages being so small, this could not be taken as an indication of maturity. Moreover due to the individual variation in pod size a large number of pods

are required to arrive at the correct specific gravity.

The composition of any feeding stuff is very important in its expression of quality. Proteins, carbohydrates, minerals and vitamins constitute the foremost in nutritive values of vegetables. The percentage of various constituents in bhendi at edible stage has been reported by Boswell (1955) and Purewal and Randhawa (1944). In the present studies the percentage of protein, starch and ash content were estimated on dry basis at different levels of maturity of pods and the results have indicated a bearing on the quality of pods. Protein content shows a progressive reduction as the pod matures, but without any significant difference between the fifth and the seventh day old pods. Gardner et al (1955) quote Pleiffer that nitrogen of the apple fruit measured in percentage of dry weight, decreases throughout development which is attributed to the increase in dry matter as the fruit enlarges. Thus the indication in the present studies is in accordance with findings in apple by Pleiffer. In contrast to the protein content, starch showed progressive increase as the pod matured. However, it is evident that nearly two thirds of the total starch content is attained on the seventh day after flowering and hence the loss of starch by early harvest is considerably less. In tomatoes, Andreotti and Cool (1956) reported a gradual rise in reducing sugars while starch content decreased, and finally disappeared at ripeness. This may be the case in fruits that ripen at the edible stage and supporting this view, Nitsch (1953) recorded that the starch, the common form of sugar storage in plants, is found in the actively growing fruits during the time when carbo-hydrate material enters this organ in quantity. As growth slows down and maturation sets it, starch rapidly disappears.

While the above phenomenon may be true in fruit crops, in a vegetable like bhendi one is interested in the maximum starch content that is obtained at edible maturity without any loss in edibility and not in the ripening of the fruit. In bhendi this is achieved on the seventh day after flowering.

It is seen from the results that ash content does not follow any definite trend as the pod matures. Absorption and transport of the inorganic nutrients in plants is influenced by several factors such as soil conditions, type of colloids, soil reaction etc., (Robertson 1951) while Fried and Shapiro (1961) cite evidences in support of the fact that mineral uptake is directly related to soil solution concentration.

Discussing the mineral nutrition in fruit plants Gardner et al (1952) reported that there exists striking variations in total mineral content as well as different kinds of mineral constituents in different tissues of plant body. They cite an experiment that in equal rye plots the potassium content of the grain ranged from 1.5 per cent to 5.5% per cent.

Studies in apple and pear by Pleiffer (1875) as quoted by Gardner et al (1952) also reveal that ash content gradually decreases as the fruit matures. However this trend was not observed in the present study wherein the results were erratic. It seems possible that soil water, available salt supply and temperature conditions at the sampling period have influenced to a great extent the mineral contents of the pods.

Hence it is clear from the observations on the composition of fruits at various levels of maturity, that harvesting the pods at seventh day after flower opening, not only ensures fibre free

pods but also confers the benefits of a high amount of protein and starch, while in the case of minerals its concentration at edible stage appears to depend on the cultural operations and environment.

In bhendi fruit attains its maximum length in 15 days after flower opening, this being in accordance with the findings of Purewal and Randhawa (1947). For total maturity the time taken ranges from 29.4 to 35.9 days. These two factors are again influenced by the environmental conditions to a remarkable degree as seen from the seasonal variations both in total length of pods as well as the number of days taken for total maturity. Here again it is believed that temperature has got much to do with the pod development. Even though the total length of fruit is governed by the varietal nature the pattern of growth seems to be influenced by the seasonal conditions. It is likely that the conditions prevailing in monsoon are very conducive for the cell differentiation from the meristematic tissues.

From the results it can also be inferred that nearly three fourths of the total growth of the pod is completed by about a weeks time after flower opening.

The growth pattern of many fruits have been studied. (Tukey and Young 1939; Simmonds 1963 b; Sinnot 1943; Schroeder 1958; Soundararajan 1960). In most of the fruit growth curves studied, there are three different phases of growth namely i) initial rapid growth (ii) a slow phase (iii) period of rapid growth of flesh to maturity. But in bhendi it is seen that in the initial stage of development there is a slow phase of growth followed by a rapid growth and then again it slows down. The seasonal variations in the expression of these phases are also

evident in the present studies i.e., in winter the rapid phase occurs between six to nine days after flowering while in summer and monsoon the rapid phase is only during five and seven days after flowering irrespective of the variety.

In the development of the fruit after fertilization the ovules themselves enlarge very rapidly and simultaneously the tissues of the ovary and adjacent organs enter on a period of renewed growth resulting in the formation of the fruit. The growth taken place chiefly as a result of enlargement of cells already present in the ovary before fertilization as well as by cell division the later being to a limited extent (Nitsch J.P. 1953; Tukey 1954).

However the varying frequency of growth at different stages of pod development may be due to the different levels of auxin produced in the ovary as well as the developing seeds. In this connection the findings of Luckwill (1948) are of special interest. His work with tomato has shown that the rate of growth of a fruit and the final size attained is governed by the available supply of auxin and this is supported by the close correlation obtained between seed number and the fruit size. He further adds that in fruits having high seed content, this sort of correlation will not be quite apparent. The fact that some varieties showed a high correlation while some others failed is explained by the above statement.

The anatomical observations reported in this study show that the structure of the fruit can be divided into i) epidermis with a single layer of cells ii) the parenchymatous tissue interspresd with fibrovascular bundles, air spaces, and lycigenous cavities iii) endodermis forming the lining of ovarian cavity enclosing the

ovule or seed (v) pith or axis consisting of a ring of vascular bundles and parenchymatous tissues.

Though in the mature fruit apparently it looks like single ovuled, actually each locule consists of two ovules as seen from the C.S. of ovule which as the seeds grow, get arranged one over the other alternatively so as to accomodate the growing seed in the locule. The observations on development of fibre and the tissues that contribute to fibre formation are interesting. It is seen that only the defunct cells of the phloeic origin contribute much to the fibre formation as such the number of the vascular bundles inside the cortex and the pith or axis may be a deciding factor in the accumulation of fibre. Upto seventh day after flower opening the cells of the vascular bundles are very thin and the thickening of the cell wall due to lignin deposition starts somewhere on eighth day or ninth day after flowering since the anatomical observation on ninth day reveals a fair amount of thickening of vascular cells.

At a later date viz., 15th day some of the cells other than that of phloeic origin also contribute to the fibre development as seen from the secondary thickening of cells on either sides of the vascular bundles situated as a circular ring in the pith region. Thickening of the endodermis at this stage gradually adds to the fibrous material. The fact that vascular bundles contribute to the fibre development in bhendi is of special value in isolation of variety which develop vascular system at a slower pace or having fewer number of vascular bundles. In this connection the findings of Rogalev (1967) that phosphorus nutrition stimulates the formation of fibrovascular bundles in several cron plants indicates that by

regulating the nutritional dosage may help in reducing fibre content of bhendi pods. The present investigation has also thrown some light on the mechanism of dehiscence of fruits, which is in agreement with the dehiscence mechanism in cotton reported by Paranjape et al (1956).

CHAPTER VI

SUMMARY

The investigations were carried out at the Agricultural College and Research Institute, Coimbatore with six varieties of bhendi over a period of three seasons in 1962-63.

I. Varietal description and observations on growth

1. The six varieties under study were described according to a descriptive blank prepared for the purpose, and the varietal differences in the morphological characters have been brought out.

2. Apart from the differences among the varieties the seasonal influence on plant growth was highly significant, monsoon being the most conducive.

3. In winter the flowering was found to be late while in monsoon it was significantly early. The varietal differences though significant were not very appreciable.

4. Regarding yield, both in terms of number and weight of pods, variety Pusa Sawani was found to be the best followed by Indian Bhendi. The yield during summer and monsoon were significantly superior to that in winter. Pusa Sawani consistantly recorded the highest yield indicating its relative adaptability for all the three seasons. Indian bhendi seems to be equally good in monsoon as compared with Pusa Sawani while in summer and winter its performance was controlled.

II. Influence of pruning on plant growth and yield

1. Lateral pruning treatment was significantly inferior to terminal pruning and control, (No pruning) as far as the total shoot length produced, the latter two being on a par. However, the number of branches produced in the terminal pruning treatment was definitely higher than that of control and lateral pruning.

2. The seasonal response in total shoot length was highly significant, monsoon being superior to summer.

3. In terms of number and weight of pods the terminal pruning treatment was significantly superior to lateral pruning treatments.

4. Shoot length and number of fruits per plant revealed high positive correlation.

III. Influence of pod maturity at harvest on growth of plants and total yield.

1. Retaining the pods to mature on the plant checked plant growth, the decrease being significantly felt, when the pods were kept on the plants for more than 11 days after flowering. A similar reduction in stem diameter was also observed.

2. The number of pods produced was highest in plants in which fruits were harvested on the fifth day after flowering. As this period increased, the number of pods produced gradually decreased.

3. There was a gradual increase in weight till the ninth

day harvest group in regard to weight of fruit per plant and then there was a reduction in the weight of pods.

IV. Quality and maturity

1. The crude fibre development progressively increased as the pods matured, the mean values being 4.63 per cent at the fifth day after flowering to 30.62 per cent at the 17th day after flowering. The difference between any two stage was highly significant.

2. The rate of crude fibre development was rather slow in winter than in summer and monsoon.

3. With respect to organoleptic scorings, fruits in the monsoon recorded significantly higher values than those in summer.

4. Considering all the varieties, Pusa Sawani led the rest with respect to organoleptic attributes.

5. Eating quality was reduced after the seventh day after flowering fifth and seventh being on a par in both the seasons.

6. A high negative correlation was found to exist between crude fibre and organoleptic scorings.

7. An instrument was devised to evaluate the tenderness in a given sample of bhendi. Its description is given.

8. There was a high positive correlation between crude fibre development and cutting strength as recorded by the instrument.

9. Specific gravity of fruits was found to go down as the pods matured.

10. There was a negative correlation between crude fibre and specific gravity of pods.

V. Fruit maturity and composition

1. The protein content gradually decreased with the increasing age of the fruit. The protein percentage on 5th and 7th days after flowering being significantly higher with a mean value of 17.86 per cent and 16.86 per cent than during the subsequent stages.

2. Starch content recorded gradual increase with pod maturity, at a higher rate than the decrease in protein. The starch content on the 7th day was nearly two thirds of the maximum which was recorded on the 15th day, with a mean value of 21.6 per cent.

3. The ash content in pods determined at different stages of maturity did not show consistent trends. It varied from 6.67 to 10.06 among the stages of maturity.

VI. Morphology and developmental anatomy of the fruit

1. The fruit development consisted of three phases namely an early slow rate, quick growth and again a slow growth phase.

2. The fruit completed its growth in about 15 days after flower opening.

3. At edible stage the fruit length among different varieties under study ranged from 8.00 cm. to 10.88 cm.

4. Pod length was influenced to a significant level by season. The lowest pod length was attained in winter and the highest in the monsoon.

5. There was no varietal variation in the time taken from flowering to pod dehiscence but as in case of pod length the seasonal effects were marked.

6. The relation between length of pods and number of seeds was apparent only in three varieties, namely Pusa Sawani, Indian Bhendi and Sabour Selection. There was a very high correlation between length and weight of pods in all the varieties.

7. The anatomical structure and development of the fruit from preanthesis stage to pod dehiscence has been studied.

8. It was observed that the fibro vascular bundles in the fruit are responsible for fibre development though at a later stage a few extra phloeic cells also contribute to fibreness.

9. Thickening of the vascular cells started after the seventh day of flower opening.

10. The mechanism of dehiscence has been attributed to loss of moisture from cells followed by the contraction of vascular bundles.

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LITERATURE CITED

* AMBROSOTTI, R., and D.CECI. 1956 Investigations on carbohydrate metabolism and on changes in acidity during the process of ripening of the tomato. Ind. Cons. 30: 249-253. Hort. Abstr. 28: 1831.

* AMBROSOTTI, R. 1956 Investigations on nitrogen metabolism and on changes in content of mineral substances during the process of ripening of the tomato. Ind. Cons. 31: 305-308. Hort. Abstr. 28: 1532.

* ANON. 1955 Tomato Research: Effect of pruning on yield and quality. A.R. Cawthron Inst. 1954-55, 26-27. Hort. Abstr. 26: 711.

* ------- 1957 Tomatoes. A.R.Glasshouse crops Res. Inst. 1954-55 Littlehampton, 27-36. Hort. Abstr. 28: 496.

AYKROYD, W.R. 1936 The nutritive value of Indian foods and the planning of satisfactory diets. Health bulletin No. 23. Manager of Publications, Govt. of India, Delhi.

AYRES, A.S. 1921 Cotton experiments. Miscl. Agrl. Exp. Sta. Cir. 42-46.

BEATTIE, W.R. 1905 Okra: its culture and uses. U.S. Agr. Dep. Farmers' Bull. No. 232.

BOSWELL, V.R. 1931 Okra culture and use. Leafl. U.S. Dept. Agric. No. 108.

------, and L.B.REED. 1932 Okra culture. Leafl. U.S. Dept. Agric. No. 449.

BASU, P.P., and D.GHOSH. 1943 Availability of calcium in lady's finger. Part II. Indian J. med. Res. 31: 57-59.

BROWN, H.B. 1938 Cotton
McGraw-Hill Book Company, Inc.
New York.

BAILEY, M.A., and T.TRAUGHT. 1927 Growth, bud shedding and flower production in Egyptian cotton.
Technical and Scientific Service Bull. No. 65. Govt. Press, Cairo.

BAILEY, L.H. 1932 The standard cyclopedia of Horticulture.
3: 2332-2335.
The Macmillan Company, New York.

BALLS, W.L. 1916 The influence of natural environmental factors upon the yield of Egyptian cotton.
Phil. Trans. Roy. Soc., London Ser. B. 208: 157-223.

BELL, K.E. 1934 Cellular development of Golden Delicious apple from blossom to maturity.
Diss. Abstr. 14: 213-214.
Hort. Abstr. 24: 2260.

BOYSTON, D., and E.H.WILDE. 1939 Development of the black raspberry fruit I. Seasonal increases in gross volume, dimensions and dry weight.
Proc. Amer. Soc. hort. Sci. 75: 158-163.

CULPEPPER, C.W., and H.H.Moon. 1945 Differences in the composition of the fruits of cucurbita varieties at different ages in relation to culinary use.
J. agric. Res. 71: 111-136.

------ and ------ 1951 The growth and composition of fruit of okra in relation to eating quality.
U.S.D.A. Bull. No. 595.

CALDWELL, J.S., C.W.CULPEPPER, M.C.HUTCHINS, E.D.BELL and M.S. WILCOX. 1945 The dehydration of okra; Variety and stage of maturity as factors in determining quality.
Canner 101: 14-16, 22-24, 26.

CARR, D.J., and K.C.M. SYKES. 1961 Diauxie growth curves of seeds with special reference to French beans (Phaseolus vulgaris L.).
Aust. J. biol. Sci. 14: 1-12.

CHIPMAN, E.W. 1963 The effect of time of seeding and plant topping on production of early and total yields of ripe tomatoes.
Proc. Amer. Soc. hort. Sci. 77: 483-486.

CHRISTIDIS, B.G., and G.J.HARRISON. 1955 Cotton growing problems. McGraw-Hill Book Company, New York.

* COOPER, A.J. 1958 Observations on the effect of the retention of selected axillary shoots on the cropping of potentate variety of tomato. A.R.Glasshouse crops Res. Instt. 1956. Littlehampton, 1958, 33-39. Hort. Abstr. 28: 3756.

CROWTHER, F. 1944 Studies on growth analysis of the cotton plant under irrigation in Sudan. III A comparison of plant development in Sudan, Gezira and Egypt. Ann. Bot., Lond. 8: 213-278.

DANIELSON, C.E. 1936 Starch formation in ripening pea seeds. Physiol. Plant. 9: 213-219.

DASTUR, R.H. 1950 Physiological comparison of American cotton plant in the Punjab and Sind. Indian Cott. Gr. Rev. 4: 1-25.

* DEBSKA, I., and F. KOZLOWSKA. 1959 Various methods of pruning tomatoes. Biul. Warzyw. 4: 103-116. Hort. Abstr. 30: 1578.

* ENACHESCU, G., O. JORDACHESCU, and R.MARINESCU. 1959 The study of the changes in certain physical properties and in the principal chemical components of green peas during ripening. Lucr. Sti. Inst. Cerc. horti-vitic. 1959-60, 175-186. Hort. Abstr. 32: 4916.

FRIED, M., and R.E.SHAPIRO. 1961 Soil plant relationships in ion uptake. Annu. Rev. Pl. Physiol. 12: 91-112.

FREEMAN, J.A., and C.G.WOODBRIDGE. 1960 Effect of maturation, ripening and truss position on free aminoacid content in tomato fruits. Proc. Amer. Soc. hort. Sci. 76: 518-523.

GARDNER, V.R., F.C. BRADFORD and H.D. HOOKER. 1952 The fundamentals of fruit production. McGraw-Hill Book Company, New York.

GUYER, R.B., A.KRAMER and L.E. IDE. 1950 Factors affecting yield and quality measurements of raw and canned green and wax beans - a preliminary report. Proc. Amer. Soc. hort. Sci. 56: 303-314.

GUTHRIWAMIRAJA, V.D. and L.VENKATAPATHAM. 1956 A preliminary note on topping of 'Desi' (G.arboreum race indicum) cotton. Madras agric. J. 45: 236-237.

HALSEY, L.H., and F.C.JANISCH. 1950 Yields of tomato varieties harvested at two stages of maturity from staked and unstaked plants. Proc. Amer. Soc. hort. Sci. 56: 335-336.

HALLER, M.H., and J.R.MAGNESS. 1928 The relation of leaf area to the growth and composition of apples. Proc. Amer. Soc. hort. Sci. 23: 189-196.

HARVEY, R.M. 1931 A preliminary report on the vegetative growth of okra in relation to production of varying amounts of reproductive tissue. Ore. Agr. Exp. Sta. Bull. 248: 1-16.

HARLEY, C.P., H.P. MAGNE and J.R.MAGNESS. 1932 Effects of leaf area, nitrate of soda and soil moisture on fruit bud formation in the Delicious apple. Proc. Amer. Soc. hort. Sci. 29: 193-197.

HEADDILL, E.D., and A.E.MURNEEK. 1940 More tomatoes per stem. Market Gr. J. 77: 31-32.

HORWITZ, W. 1955 Official methods of analysis of the association of official agricultural chemists. Association of Official Agricultural Chemists, Washington.

HOOVER, M.W., and R.A. DAMMISON. 1933 The correlation of stages of maturity with certain physical measurements in Southern pea (Vigna sinensis). Proc. Amer. Soc. hort. Sci. 62: 391-396.

JOSHI, N.V., P.B.GODE and A.F.SHAW. 1941 A monograph on studies in physiology of Broach cotton plant, 52, 230-247. Indian Central Cotton Committee, Bombay

* KARWOWSKA, T. 1950 The stringiness of runner beans in relation to age of pod and variety. Rocz. Nauk. Roln. 54: 315-334. Hort. Abstr. 23: 1583.

KERR, E.A. 1949 Effect of extra foliage on greenhouse tomato production. Rep. Vineland Hort. Exp. Stat., Ontario 1949-50, 28-29.

KRAMER, A., and K.AARELID. 1933 The shear press an instrument for measuring the quality of foods. III. application to peas. Proc. Amer. Soc. hort. Sci. 61: 477-483.

LACHMAN, W.H. 1948 Some effects of blossom removal on vegetative development and defoliation in determinate tomato plants. Proc. Amer. Soc. hort. Sci. 51: 341-348.

LAWRENT, R.C., and A.J.LINCK. 1958 Effects of high temperature on yield of peas. Plant physiol. 33: 347-350.

LESLIE, W.R., and W.GODFREY. 1939 Vegetables for Prairie farms. Dominion of Canada - Dept. of Agriculture publication 663; Farmers' Bull. 83.

LUCKWILL, L.C. 1948 A method for the quantitative estimation of growth substances based on the response of tomato ovaries to know amounts of β-Naphthoxyacetic acid. J. Hort. Sci. 24: 19-31.

LUNTO, C.A. 1931 Some factors concerning earliness in cotton. J. Agric. Res. 43: 647.

* LYNCH, L.J., and R.S.MITCHEL. 1950 Physical measurement of quality in canning peas. Bull. Coun. Sci. Industr. Res., Australia 234: 35. Hort. Abstr. 21: 3886.

* ------., and ------. 1953 The definition and prediction of the optimal harvest time of pea canning crops. Bull. Coun. Sci. Industr. Res., Australia 273: 43. Hort. Abstr. 24: 1356.

MACK, H.J., and E.R.LANING JR. 1950 Basal defoliation effects on pole beans. Proc. Amer. Soc. hort. Sci. 74: 597-600.

MARTIN, W.M. 1937 The tenderometer an apparatus for evaluating tenderness in peas. Canner 84: 108.

MASON, T.G. 1922 Growth and abscission in sea island cotton. Ann. Bot., Lond. 36: 457-484.

McEWEN, J. 1961 Review of work on tomatoes. 1957-61. Ghana Fmr. 5: 112-114.

MOHANASUNDARAM, N. 1963 Influence of leaf area and age of wood on the yield and quality of some varieties of grapes. Dissertation submitted to the University of Madras.

MONSELISE, S.P., and F.W. WENT. 1950 Effects of temperature on growth and drymatter accumulation of peas. Plant Physiol. 33: 372-374.

MOORE, J.F. 1950 Use of para-chlorophenoxyacetic acid spray and two pruning systems to increase yield and fruit size of field grown tomatoes in Western Washington. Proc. Amer. Soc. hort. Sci. 56: 299-302.

MITCH, J.P. 1953 The physiology of fruit growth. Annu. Rev. Pl. Physiol. 4: 199-236.

* OTTOSSON, L. 1956 Growth and maturity of peas for canning and freezing. Vartodling 9: 113. Hort.Abstr.28. 3587.

PAL, B.P., S.K.SIKKA, and H.B.SINGH. 1955 Improved pusa vegetables. Indian Frg. 13: 64-73.

PAPTHAKUR, B., and S.BAROOAH. 1961 Marketting okra in Assam. Indian Frg. 11 (8): 35.

PARANJAPE, V.N., B.S. BHATT, and C.O.BISEN. 1956 Investigations into boll opening of cotton. Seventh conference on cotton growing problems in India. Nov. 1956, 56-67.

* PERSSON, A.R., and A.N.PERSSON. 1953 Experiments on outdoor tomatoes. A. Experiments on outdoor tomatoes 1947-52. B. Temperature and cultivation of outdoor tomatoes. Forskn. Landsurk. 4: 293-316, 317-327. Hort. Abstr. 24: 1633.

PERKINS, D.Y., J.C.MILLER and S.L.DALLYN. 1952 Influence of pod maturity on vegetative behaviour of okra. Proc. Amer. Soc.hort.Sci. 60: 311-314.

PRIT, S.J., and W.J.WHEALAN. 1951 The determination of starch by acid hydrolysis. J. Sci. Food. Agri. 2: 334-338.

PURSWAL, S.S. 1944 Lady's finger, Vegetable gardening in the Punjab. Superintendent, Government Printing, Punjab, Lahore.

-------., and G.S.RANDHAWA. 1947 Studies in Hibiscus esculentus (Lady's finger) 1. Chromosome and pollination studies. Ind. J. agric. Sci. 17: 129-136.

RAO, V.N.M. 1953 Certain aspects of harvest in relation to crop maturity in Bhindi (H.esculentus L.). Madras agric. J. 10: 433-444.

RAO, U.N. Preliminary studies in the classification of Bhendi. (Unpublished)

REDDING, C.J., and J.M. KINGBROUGH. 1906 Cotton culture. Georgia Agrl. Expt. Stat. Bull. 75.

REUTHER, W., T.W.EMBLETON, and W.W. JONES. 1958 Mineral nutrition in tree crops. Annu. Rev. Pl. Physiol. 9: 175-206.

RIDGWAY, R. 1912 Color standards and color nomenclature. Published by Author, Washington, D.C

ROSS, E., J.E. MRSKKE, and J.F. MOORE. 1956 The objective evaluation of some green bean varieties used for processing in the North West. Proc. Amer. Soc. hort. Sci. 67: 398-411.

* ROGALEV, I.E. 1957 Differentiation of fibrovascular bundles and xylem vessels as affected by phosphorus nutrition of plants. Doklady Akad. Nank. S.S.S.R., 115: 1206-1208. Hort.Abstr. 28:1063. 1958

ROBERTSON, R.N. 1951 Mechanism of absorption and transport of inorganic nutrients in plants. Annu. Rev. Pl. Physiol. 2: 1-24.

SALUNKHE, D.K., L.H. POLLARD, and E.W. TAYLOR. 1957 Evaluation of maturity of peas and utilization of over mature peas by deep fat freezing. Indian J. Hort. 14: 83-86.

SAYRE, C.B. 1948 Early and total yields of tomatoes as affected by time of seeding, topping the plants and space in the flats. Proc. Amer. Soc. hort.Sci. 51: 367-370.

------ 1954 Comparison of the tenderometer and maturometer for measuring the quality of raw peas. Proc. Amer. Soc. hort. Sci. 63: 371-377.

------., J.J. WILLAMAN, and Z.I. KERTOZ. 1931 Factors affecting the quality of commercial canning peas. Tech. Bull. No. 176. Published by New York State Agrl. Expt. Stat. under authority of Cornell University.

SETHI, B.L., S.N.SIKKA, R.D.DASTUR, P.D.GADKARI, R.BALASUBRAMANYAN, P.MAHESHWAR, N.S.RANGASWAMY and P.N.JOSHI. 1960 Cotton in India (A monograph) Indian Central Cotton Committee, Bombay.

* SCHROEDER, C.A. 1956 Growth and development of avocado fruit. Year. b. Calif. Avoc. Soc. 114-118. Hort. Abstr. 29: 1781.

* SCHNEIDER, A. 1955 On the course of ripening in garden peas and the determination of optimum picking date with the aid of texture meter. Zuchter 25: 302-309. Hort. Abstr. 26: 612.

* SHEWFELT, A.L., and W.P. MOHR. 1957 Effect of harvesting frequency on yield and canning quality of yellow snap beans. Abstr. in Rep. Canad. Cttee. Fruit Veg. Preserv. 1956, 1957-12. Hort. Abstr. 28: 452.

* ------., and ------ 1957 Bean size as an indication for canning quality. Abstr. in Rep. Canad. Cttee. Fruit Veg. Preserv. 1956, 1957 - 13. Hort. Abstr. 28: 452.

SHANMUGASUNDARAM, A. 1950 Variation in the fruiting habit of Bhendi.
Mezhichelvam, 2 (8): 10.

SIKKA, S.K., and A.SINGH. 1961 Cotton research in U.S.S.R.
Report of the delegation of cotton research workers to U.S.S.R. 26-29 Indian Central Cotton Committee, Bombay.

SIMMONDS, N.W. 1936b The development of banana fruit.
J. exp. Bot. 4: 87-105.

SINGH, B.N. 1950 Studies in growth, senescence and rejuvenescence in plants.
J. Ind. Bot. Soc. 7: 17-21.

SINGH, K.P. 1951b Preliminary growth rate studies of Chikoo fruit.
Indian J. Hort. 8: 17-21.

SINNOTT, E.W. 1946 The relation of growth to size in cucurbits.
Amer. J. Bot. 32: 439-446.

SISTRUNK, W.A., L.G. JONES and J.C.MILLER. 1960 Okra pod growth habits.
Proc. Amer. Soc. hort. Sci. 76: 486-491.

* SMERDA, V. 1949 The effect of pinching out shoots of tomato plants on the quality of seed, on earliness of cropping and on yield.
Sbornik ceskoslov. Akad. Zemedel. 21: 140-148. Hort.Abstr. 19: 3161.

SOUNDARARAJAN, S. 1960 Studies on certain aspects of growth flowering and fruiting in some varieties of sapota (Achras zapota L.) Dissertation submitted to the University of Madras (Unpublished).

STRYDOM, E. 1955 Is it necessary to prune tomato plants?
Fmg. S. Afr. 30: 349-350.

* STRACHAN, G., and W.E. THOMPSON. 1952 Maturity studies of vegetables in Alberta.
Rep. Proc. 8th annu. Mtg. West. Canad. Soc. Hort. 19-22.
Hort. Abstr. 23: 1696.

* SUGIYAMA, T., S.NISHI and T.KATO. 1949 Fruiting habit of broad bean (Japanese) J.hort. Ass.,Japan 18: 138-149. Hort. Abstr. 21: 591.

SUNDARARAJ, D.D. 1956 A contribution to the morphology of fruits - the edible banana. South Indian Hort. 4: 13-18.

TEMPLETON, J. 1931 The effects of topping Egyptian cotton plants. Min. Agric. Egypt. Tech. Sci. Ser. Bull. 103: 9.

TISDALE, S.L., and W.L. NELSON. 1956 Soil fertility and fertilizers. The Macmillan Company, New York.

THOMPSON, H.C., and W.C.KELLY. 1957 Vegetable crops. McGraw-Hill Book Company, New York.

* TORRASON, W.E., I.L. WONNACOTT and G.STRACHAN. 1956 An evaluation of objective methods for determining the maturity of canning peas. Canad. J. agric. Sci. 36: 247-264. Hort. Abstr. 26: 3771.

TUKEY, H.B. 1954 Plant Regulators in Agriculture. John Wiley and Sons, Inc., New York.

------., and J.O.YOUNG. 1939 Histological study of the developing fruit of sour cherry. Bot. Gaz. 100: 723-747.

* UEKI, K. 1956 Varietal differences in flowering and fruiting responses of broad bean to changes in night temperature II. Effect of night temperature on flower differentiation and seed ripening in broad bean. Tech. Bull. Kagawa agric. Coll. 8: 15-24. Hort. Abstr. 28: 2858.

* ------ 1957 Varietal differences in flowering and fruiting responses of broadbean to changes in night temperature. III. Influence of high night temperature on growth and fruiting. Tech. Bull. Kagawa agric. Coll. 9: 1-10. Hort. Abstr. 28: 2885.

* ------., and M.IGAWA. 1959 The ecological difference in broad bean varieties as shown by high temperature by day and by night. Tech. Bull. Kagawa agric. Coll. 10: 112-120. Hort. Abstr. 31: 2447.

VENKATARAMAN, K., and C.J.RAO. 1953 The relation of size and shape of plant to yield of cotton. Madras agric. J. 21: 51-63.

VENKATRAMANI, K.S. 1945 Preliminary studies on bhendi (Hibiscus esculentus). Madras agric. J. 33: 201-207.

------ 1953 Some observations on blossom biology and fruit formation in Hibiscus esculentus. J. Madras Univ. Sect. B. 23:1-14.

WARD, K.M. 1956 Temperature and fruit set in tomatoes. Qd. agric. J. 82: 641-644.

WENT, F.W. 1944 Plant growth under controlled conditions. III. correlation between various physiological processes and growth in tomato plant. Amer. J. Bot. 31: 597-618.

------ 1945 Plant growth under controlled conditions. V. The relation between age, light, variety and thermo-periodicity of tomatoes. Amer. J. Bot. 32: 469-479.

WOLF, E.A., and J.D.HARTMAN. 1940 Plant and fruit pruning as a means of increasing fruit set in muskmelon breeding. Proc. Amer. Soc. hort. Sci. 40: 475-480.

YAMAGUCHI, M., F.D. HOWARD, E.S.LUH and S.J. LEONARD. 1960 Effect of ripeness and harvest dates on the quality and composition of fresh canning tomatoes. Proc. Amer. Soc. hort. Sci. 76: 561-567.

ZAITZEW, G.S. 1927 The effect of temperature on the development of the cotton plant. Emp. Cott. Gr. Rev. 4: 272-273.

* Original not seen.

APPENDIX I

a) Variations in yield (weight of pods)

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Plants	9	124800.0	13866.7	-
Seasons	2	162019.2	81009.6	9.8**
Varieties	5	528501.8	105719.4	12.8
Plants x Seasons	18	91942.0	5107.9	-
Plants x Varieties	45	313791.6	6973.1	-
Seasons x Varieties	10	100394.7	10039.5	-
Error	90	741582.1	8239.8	
Total	179	8071121.4		

b) Variations in yield (Number of pods)

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Plants	9	382.7	42.5	-
Seasons	2	431.5	215.7	6.9**
Varieties	5	1874.0	374.8	12.0**
Plants x seasons	18	446.9	24.8	
Plants x varieties	45	1098.7	24.4	
Seasons x varieties	10	387.8	38.7	
Error	90	2819.4	31.3	
Total	179	7411.1		

c) Earliness

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Plants	9	23.9	2.7	-
Seasons	2	2354.3	1177.2	745.0**
Varieties	5	263.1	52.6	33.3**
Plants x Seasons	18	46.8	2.6	-
Plants x varieties	45	68.6	1.5	-
Seasons x varieties	10	271.1	27.11	17.2**
Error	90	142.5	1.58	
Total	179	3170.3		

d) Plant height

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Stages	3	14823.03	4084.6	991.4**
Seasons	2	9158.14	4592.6	1120.1**
Varieties	5	200.56	40.0	9.8**
Stages x seasons	6	2944.87	490.8	119.7**
Stages x varieties	15	212.22	14.0	3.4**
Seasons x varieties	10	100.51	10.05	2.4*
Error	30	123.22	4.107	
Total	71	27560.55		

APPENDIX II

a) Pruning trial - Number of fruit production

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Seasons	1	57.6	57.6	1.74
Varieties	2	2247.2	1123.6	33.84**
Seasons x varieties	2	30.6	15.3	-
Treatments	2	4668.4	2334.7	70.26**
Seasons x treatments	2	26.3	13.2	-
Varieties x treatments	4	277.6	69.4	2.04*
Error	166	5513.3	33.2	
Total	179	12918.2		

b) Pruning trial - weight of fruits produced.

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Seasons	1	15125	15125	1.97
Varieties	2	332103	166052	20.56**
Seasons x varieties	2	23204	11602	1.44
Treatments	2	856096	428048	53.01**
Seasons x treatments	2	15252	7626	-
Varieties x treatments	4	113945	28486	3.53**
Error	166	1340450	8075	
Total	179	2696174		

c) Pruning trial - Total shoot length

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Seasons	1	30160.88	30160.55	22.65**
Varieties	2	7813.03	3906.51	2.9
Seasons x varieties	2	17384.03	8692.03	6.53**
Treatments	2	234483.42	117241.71	88.05**
Seasons x treatments	2	1013.77	506.39	-
Varieties x treatments	4	14359.80	3589.45	2.65*
Error	166	221053.86	1331.55	
Total	179	526217.49		

APPENDIX III

Influence of pod maturity on plant growth and yield - a) Length of pods

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	2	182.65	91.325	19.568**
Periods of maturity	6	2620.62	436.770	93.587**
Varieties x periods	12	39.79	3.316	
Error	189	883.92	4.677	
Total	209	3726.98		

b) Height of plants

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	2	162.20	81.10	1.908
Periods of maturity	6	7756.46	1292.743	30.418**
Varieties x periods	12	881.56	73.463	1.728
Error	189	8033.02	42.503	
Total	209	16833.23		

c) Stem diameter

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	2	0.6135	0.30675	18.982**
Periods of maturity	6	6.7400	1.12333	69.515**
Periods x varieties	12	0.4034	0.03361	2.079*
Error	189	3.0542	0.01616	
Total	209	10.8111		

d) Number of pods

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	2	1755.8	877.9	56.814**
Periods of maturity	5	4563.9	912.8	59.073**
Periods x varieties	10	302.9	30.29	1.960*
Error	162	2503.2	15.452	
Total	179	9125.8		

e) Weight of pods

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	2	310436	155218	10.466**
Periods of maturity	5	1647686	329537.2	22.22**
Varieties x periods	10	416906	41690.6	2.812**
Error	162	2402565	14830.7	
Total	179	4777593		

APPENDIX IV

Fruit maturity and quality - (a) Crude fibre development

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	5	11.46	2.29	1.49
Seasons	2	794.64	397.32	258.34**
Varieties x seasons	10	27.96	2.80	1.81
Stages of maturity	6	10420.64	1736.78	1129.49**
Varieties x stages	30	75.20	2.51	16.31
Seasons x stages	12	349.85	29.15	18.81**
Error	60	92.77	1.54	
Total	135	11772.49		

b) Organoleptic tests

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Seasons	1	499.3	499.3	53.56**
Varieties	5	456.1	69.2	7.36**
Seasons x varieties	5	292.7	58.5	6.16**
Stages of maturity	5	24558.5	5911.7	622.33**
Seasons x stages	1	163.0	163.0	17.16**
Variety x stages	25	406.9	16.3	1.72
Error	29	273.2	9.5	
Total	71	16641.5		

c) Specific gravity of pods.

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	5	0.0185	0.0037	1.19
Periods	5	0.2071	0.0414	13.35**
Varieties x periods	25	0.0765	0.0031	
Total	35	0.3021		

APPENDIX V

Fruit maturity and composition - a) Protein content at different stages of maturity

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	5	20.21	4.04	4.67*
Periods	5	177.83	35.59	41.08**
Varieties x periods	25	20.71	0.83	
Total	35	218.83		

b) Starch content at different stages of maturity.

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	5	1.12	0.22	3.67*
Periods	5	10.99	2.20	35.00**
Varieties x periods	25	1.41	0.06	
Total	35	13.52		

APPENDIX VI

Morphology and developmental anatomy of the fruit.

a. Length of pods at 7th day after flowering.

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	5	28.77	5.76	5.27**
Seasons	2	245.47	122.74	112.61**
Variety x Season	10	22.26	2.23	2.05
Error	36	39.14	1.09	
Total	53	335.64		

b. Period taken for total maturity of the fruit.

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Varieties	5	9.49	1.90	1.11
Seasons	2	176.54	88.27	51.39**
Variety x Season	10	20.51	2.05	1.19
Error	36	62.01	1.72	
Total	53	268.55		

** Significant at 1 per cent level.

* Significant at 5 per cent level.

APPENDIX VII

Descriptive blank for Mhendi

1. Name of the Variety.
2. Habit
   1) a. Height in cm. (tall, medium, dwarf)
      b. Spread in square cm. (erect or spreading or bushy)
   11) Branching
      a. Number of branches
      b. Crawling, spreading or erect
3. Stem
   a. Round or terrate
   b. Clothing (glabrous, tomentose, pubescent, pricky or armed)
   c. Colour (Purple, green, green and purple mixed together)
4. Leaf
   a. Lamina 1) Length at the broadest place along the midrib
      11) Breadth at the broadest place.
   b. Shape (moderately lobed, entirely lobed, entire)
   c. Clothing (stellate, armed, pubescent or glabrous)
   d. Colour (Red, purple, green or mixture of purple and green)
   e. Petiole 1) Length in cm.
      11) Pigmentation
      111) Clothing
5. Inflorescence
   a. Number of flowers
   b. Clothing armed or not
   c. Measurements (1) Length (11) Breadth

d. Flowers:

i. Pedicil length in cm.

Colour

Clothing

ii. Calyx length

Colour

Clothing

iii. Corolla - colour (inner and outer)

Corolla base colour (inner and outer)

Corolla length

Calyx corolla ratio.

iv. Style and stamens

Length of style

Colour of style

Number of stigmatic lobes

Colour of stigma

Anther colour.

6. Fruit characters:

a. Length (long medium short)

b. Size at edible stage (length in cm. excluding stalk and width of broadest point)

c. Colour (Red, purple, green, shades of purple green etc.)

d. Hairiness (Smooth, pubescent, pricky etc.,)

e. Number of angles

f. Apical end (curved or not)

g. Weight of fruit

h. Toughness of the fruit (smooth, tough etc.,)

i. Edible stage of the fruit

j. Number of locules

k. Mucilage (Sliminess, high, medium, little)

l. Time taken from flowering to pod burst).

7. Seed characters

a) Colour

b) Shape

c) Size (length and breadth)

d) Weight of 100 seeds

e) Number of seed per fruit

f) Germinability.

8. General characters.

a) Duration or the crop (early, medium or late)

b) Resistance to pests and diseases

c) Any special agronomic characters like heavy yield drought resistance etc.,

ILLUSTRATIONS

Fig.I. PROGRESSIVE GROWTH RATE OF PLANT

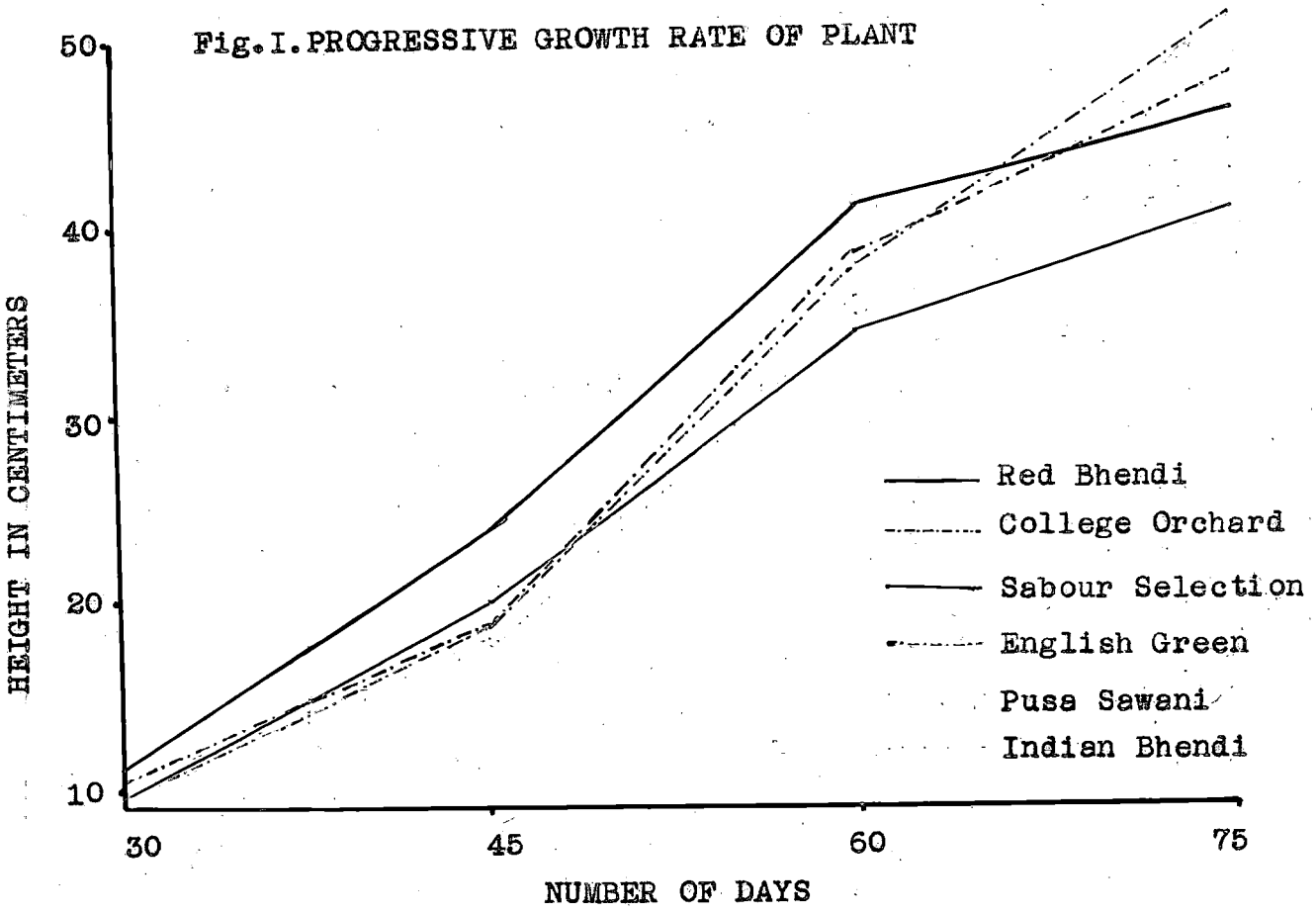


Fig.II. VARIETAL AND SEASONAL VARIATION IN YIELD
(Weight of pods per plant)

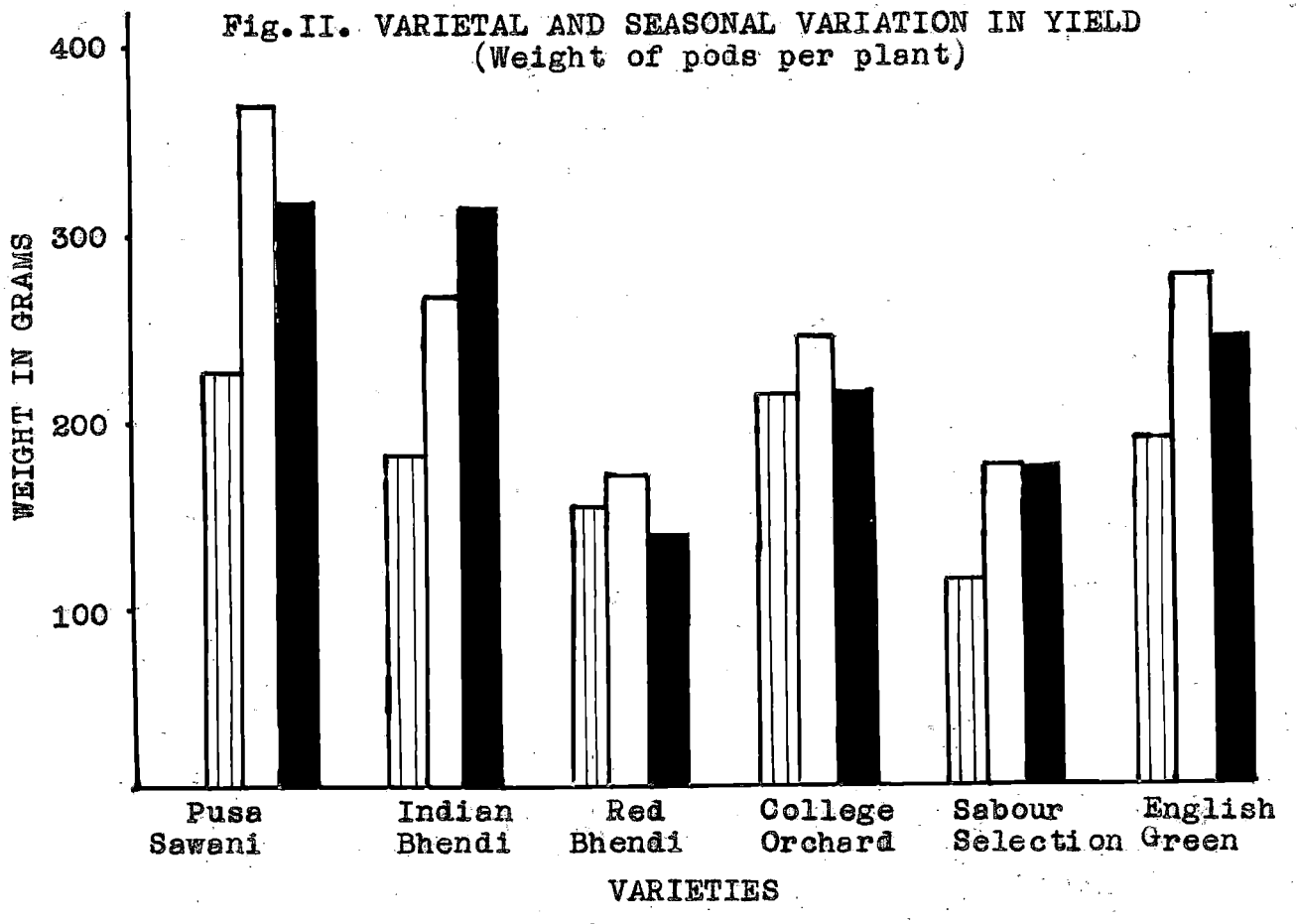


Fig.III. VARIETAL AND SEASONAL VARIATIONS IN SHOOT LENGTH, NUMBER AND WEIGHT OF PODS UNDER DIFFERENT PRUNING TREATMENTS

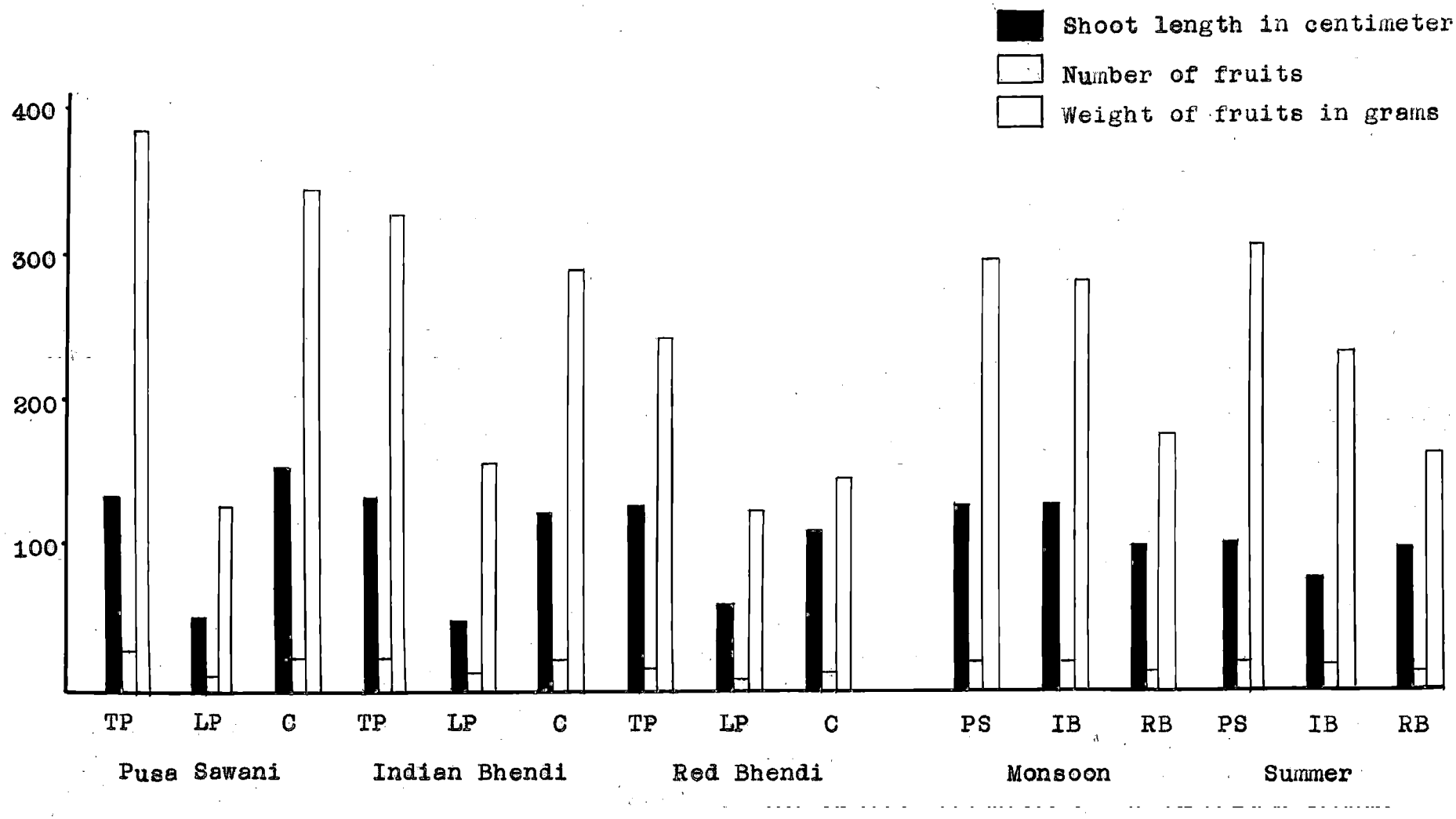


Fig.IV. INFLUENCE OF POD MATURITY AT HARVEST ON PLANT AND POD CHARACTERS

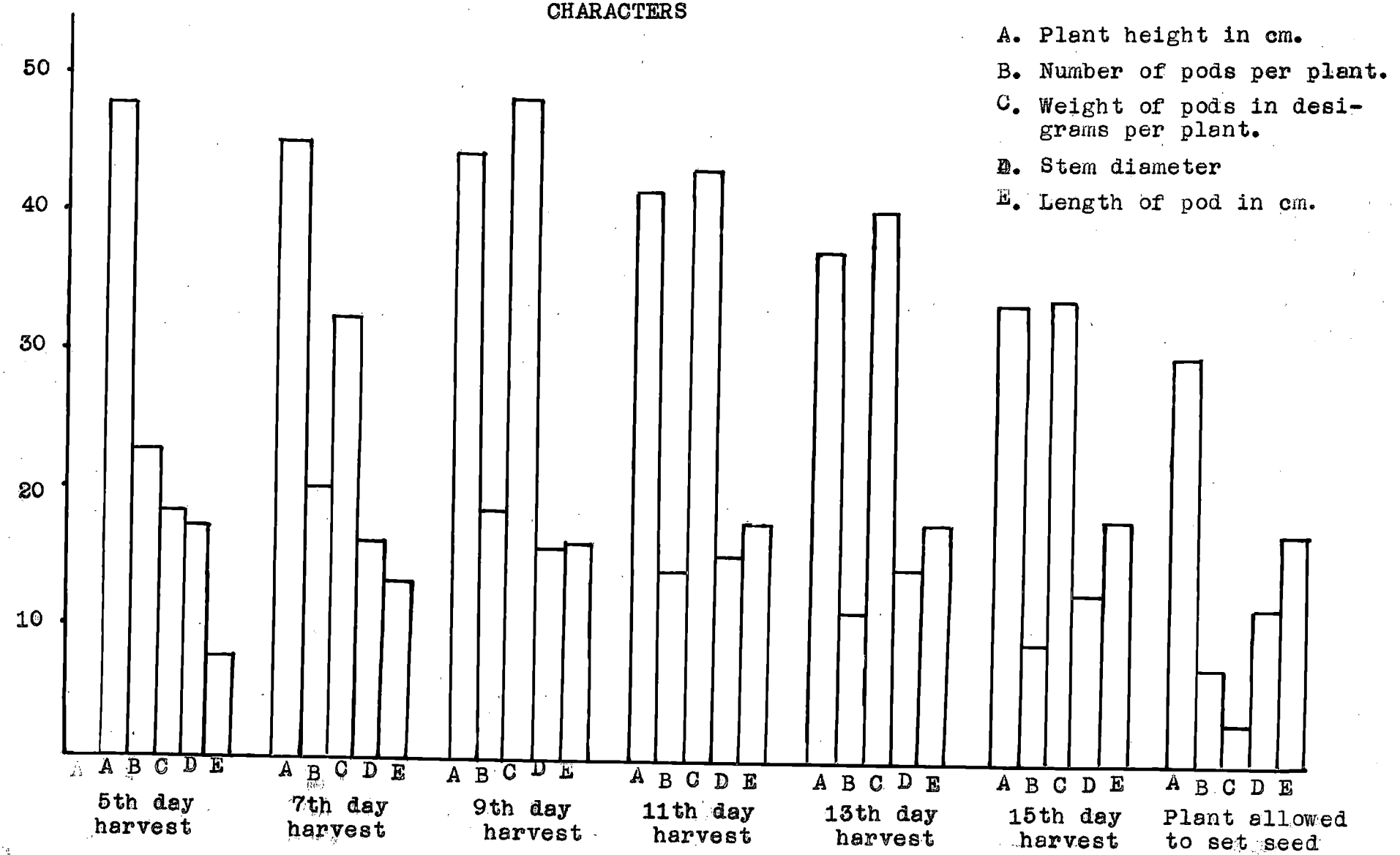
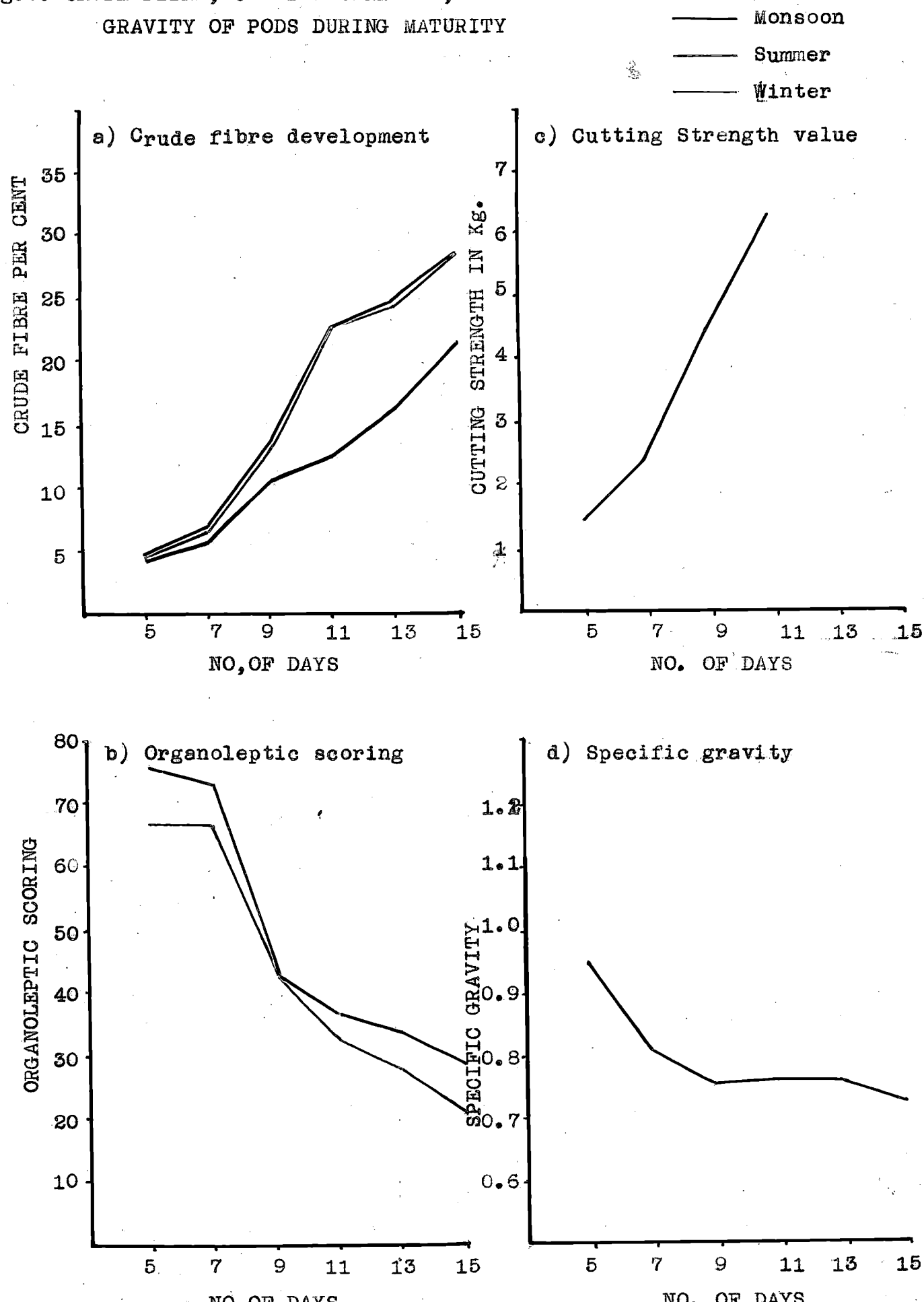


Fig.V. CRUDE FIBRE, CUTTING STRENGTH, ORGANOLEPTIC SCORING AND SPECIFIC GRAVITY OF PODS DURING MATURITY



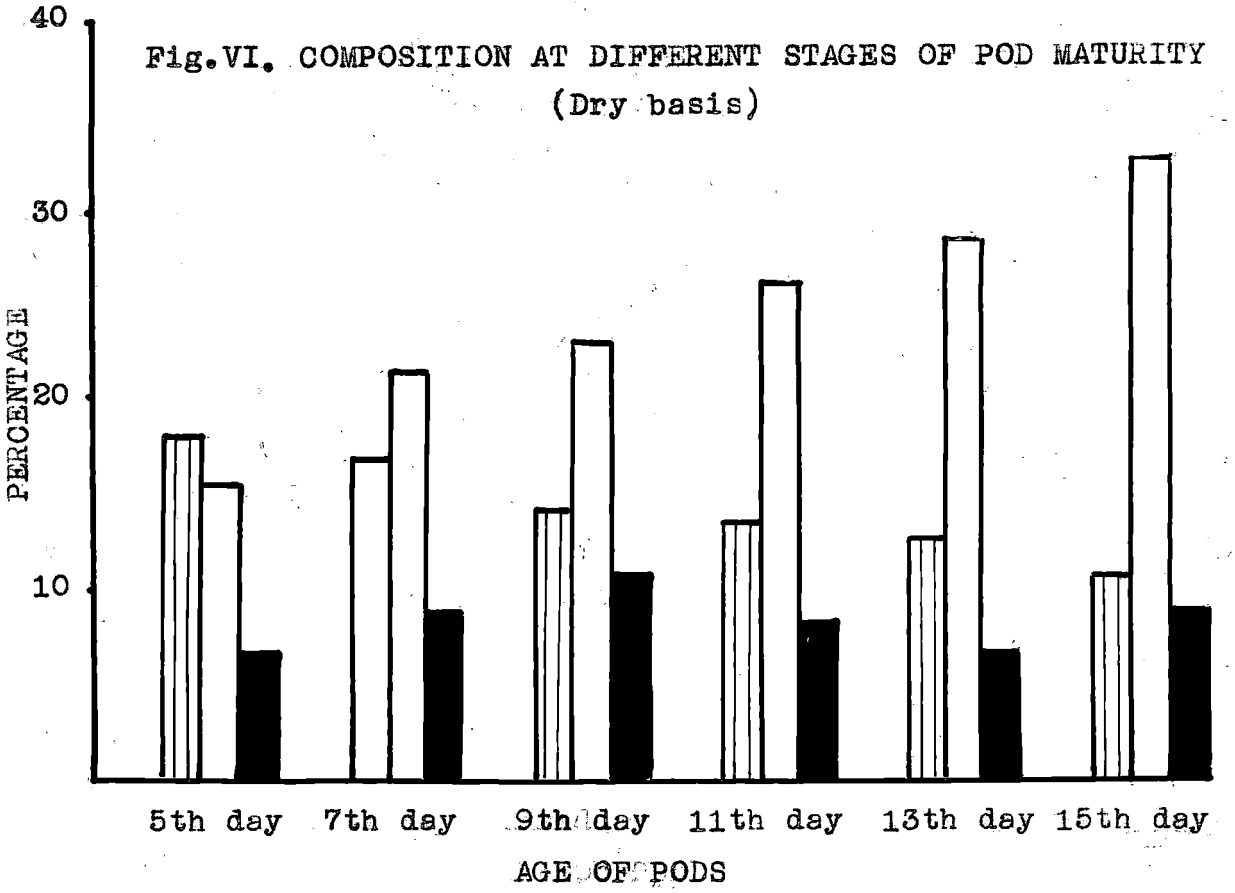


Fig.VI. COMPOSITION AT DIFFERENT STAGES OF POD MATURITY
(Dry basis)

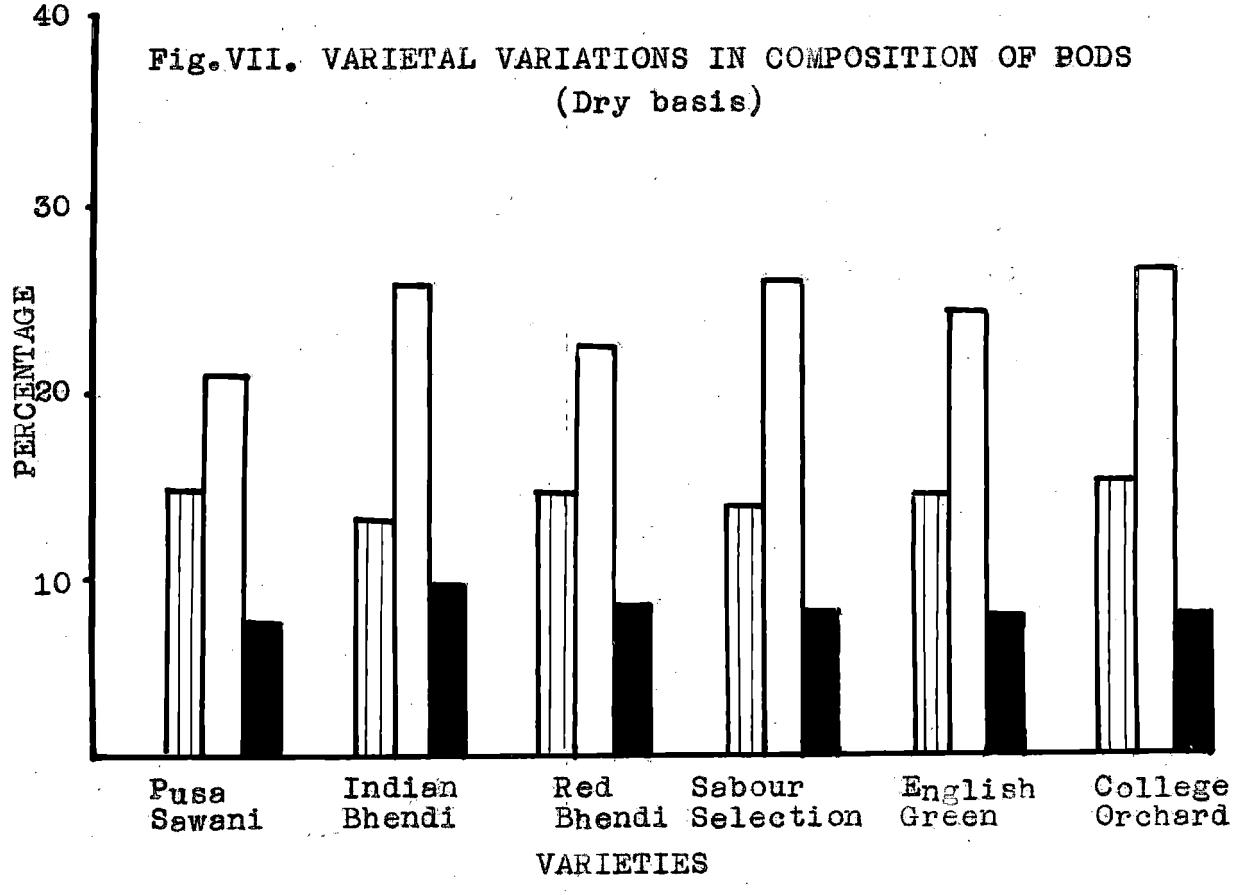


Fig.VII. VARIETAL VARIATIONS IN COMPOSITION OF PODS
(Dry basis)

Fig.VIII. PROGRESSIVE GROWTH CURVE OF PODS IN DIFFERENT SEASONS
(Length and diameter)

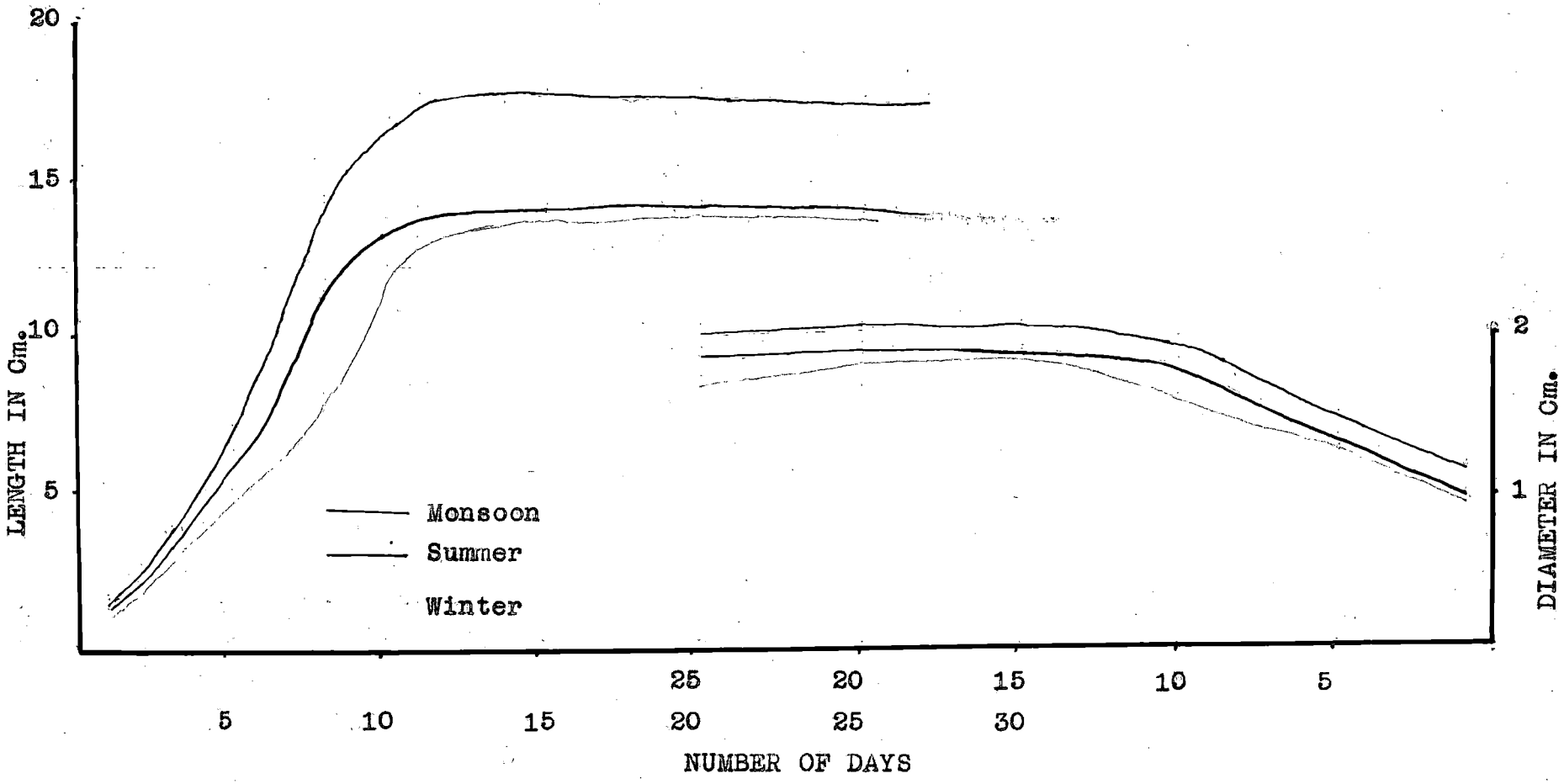


Fig.IX. SEASONAL AND VARIETAL VARIATIONS IN LENGTH AND DIAMETER OF PODS AT EDIBLE STAGE (Seventh day after flowering)

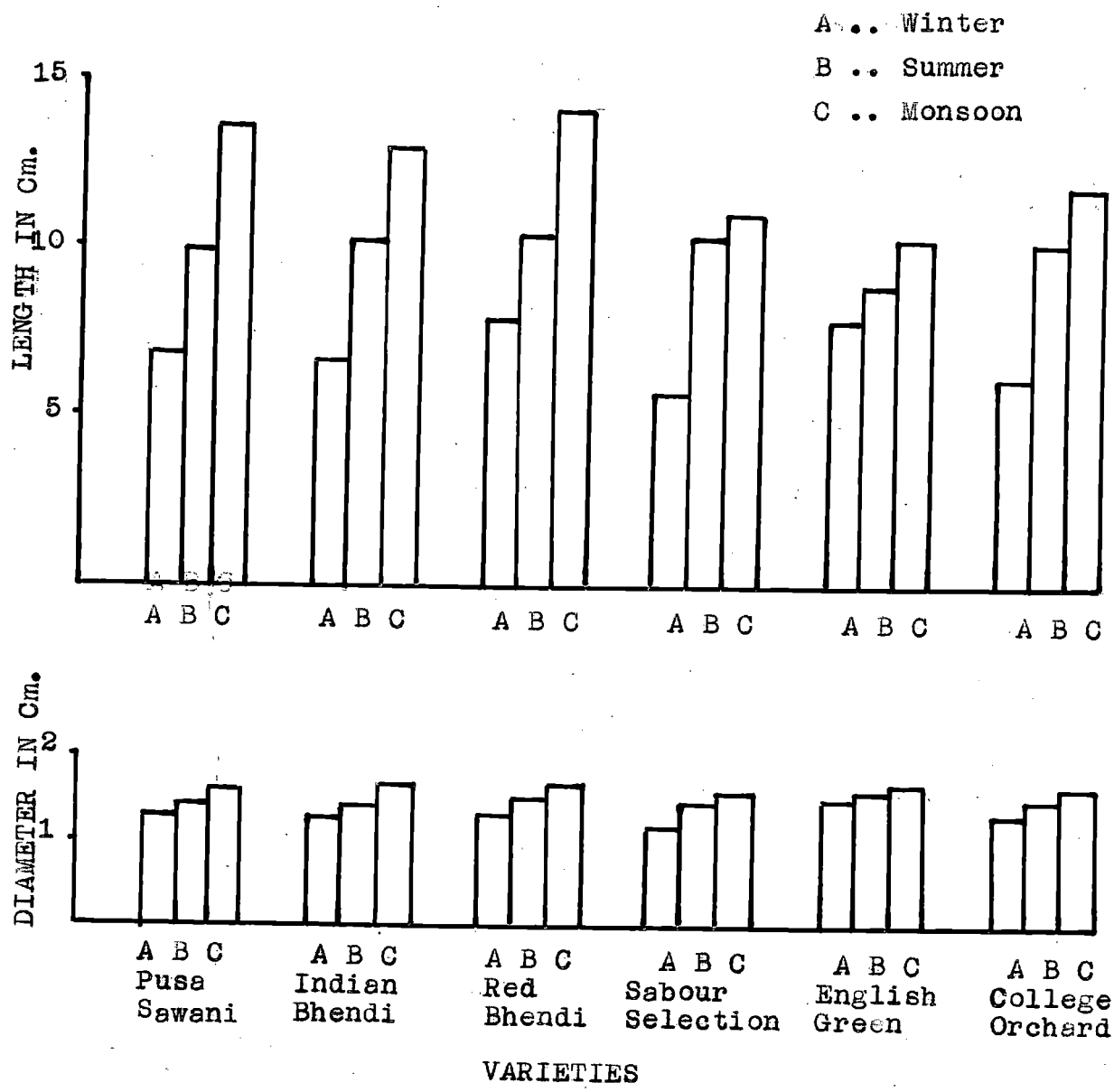


Fig.X. CRUDE FIBRE-ORGANOLEPTIC SCORING RELATIONSHIP

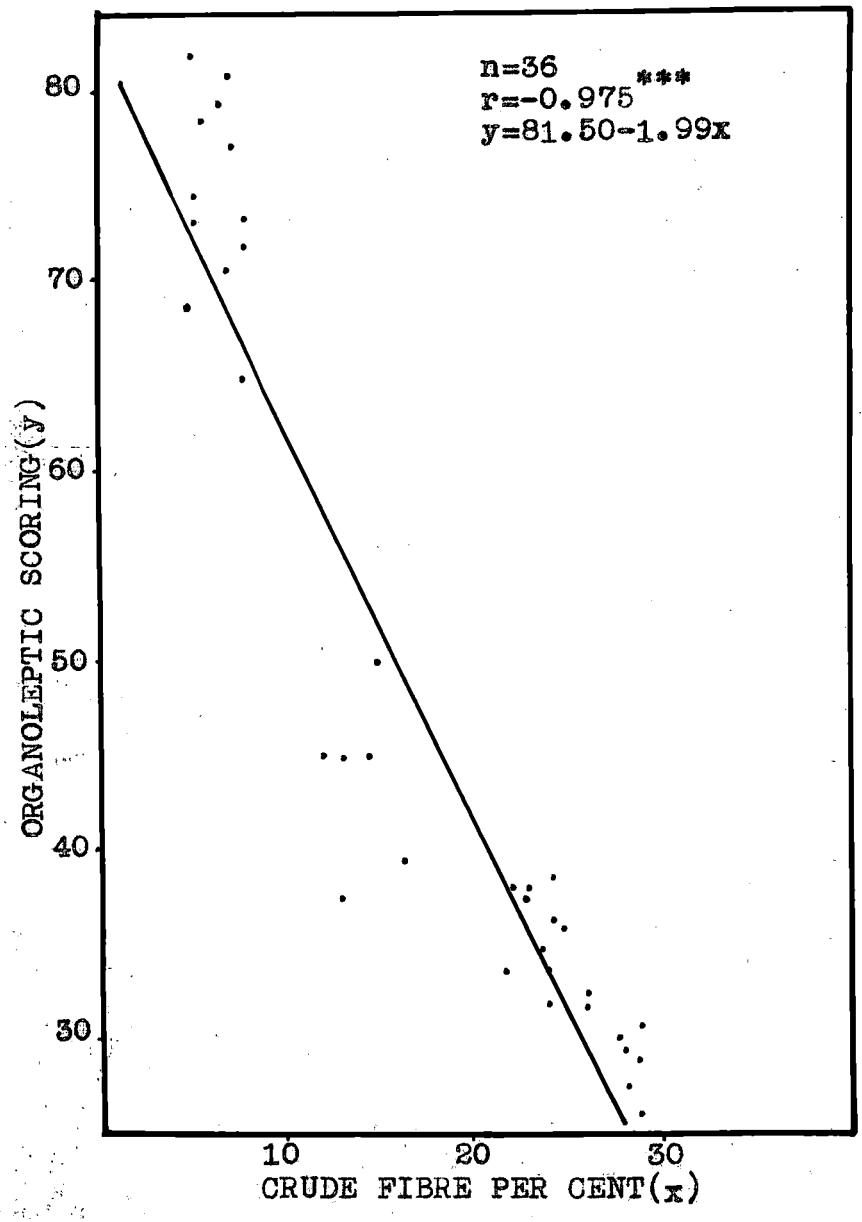


Fig.XI. CRUDE FIBRE-CUTTING STRENGTH RELATIONSHIP

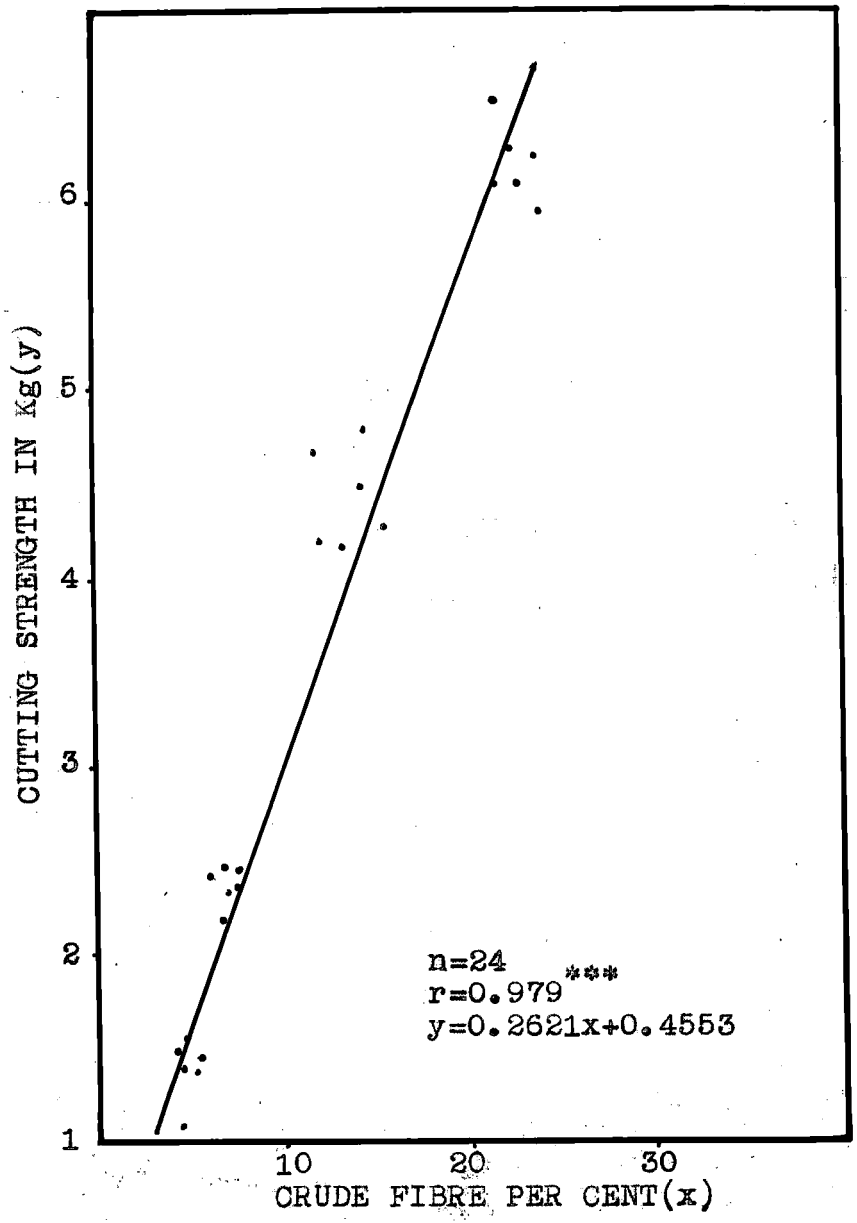


Plate I.

A typical plant of variety Pusa Sawani

Plate II

A typical plant of variety Indian Bhendi

Plate III

A typical plant of variety Sabour Selection

Plate IV

A typical plant of variety English Green

Plate I

Plate II

Plate III

Plate IV

Plate V.

A typical plant of variety Red Bhendi

Plate VI.

A typical plant of variety College Orchard.

Plate VII

Influence of pruning treatments.

Control

Terminal pruning

Lateral pruning

Plate V

Plate VI

Plate VII

Plate VIII

Pod maturity at harvest and growth of plants

1. Plant on which harvesting was done at every 5th day after flower opening

2. Plants which were allowed to mature seed.

Plate IX

Devise for finding out the cutting strength of the fruits to predict maturity.

Plate X Plan of the cutting devise.

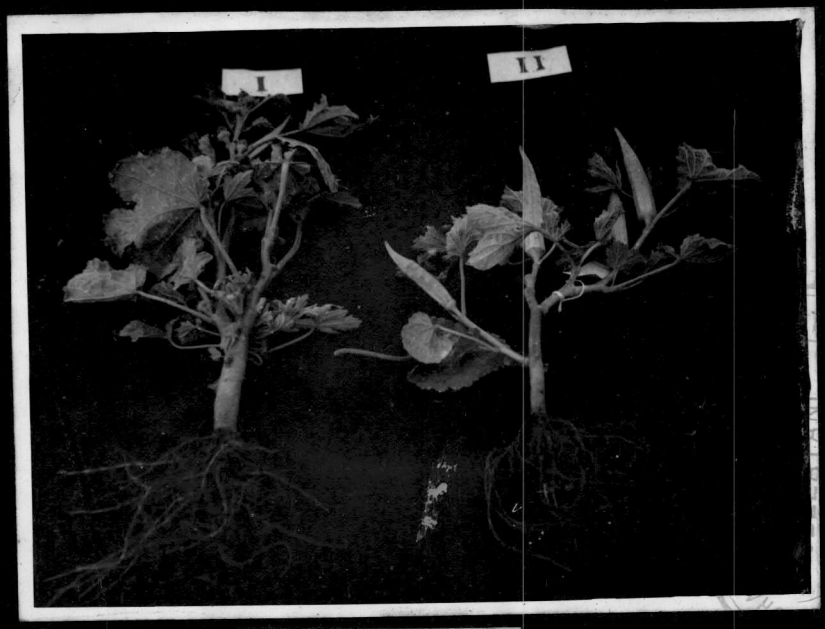


Plate VIII

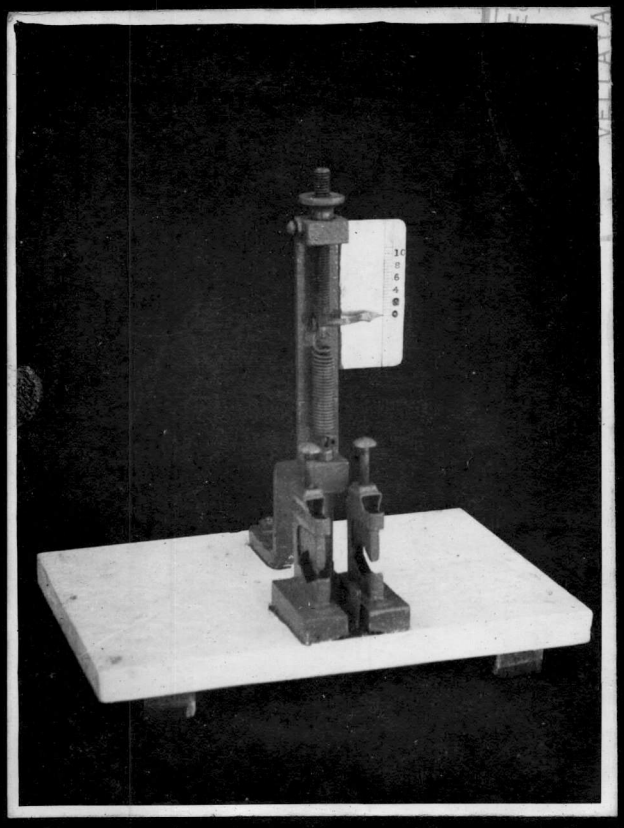


Plate IX

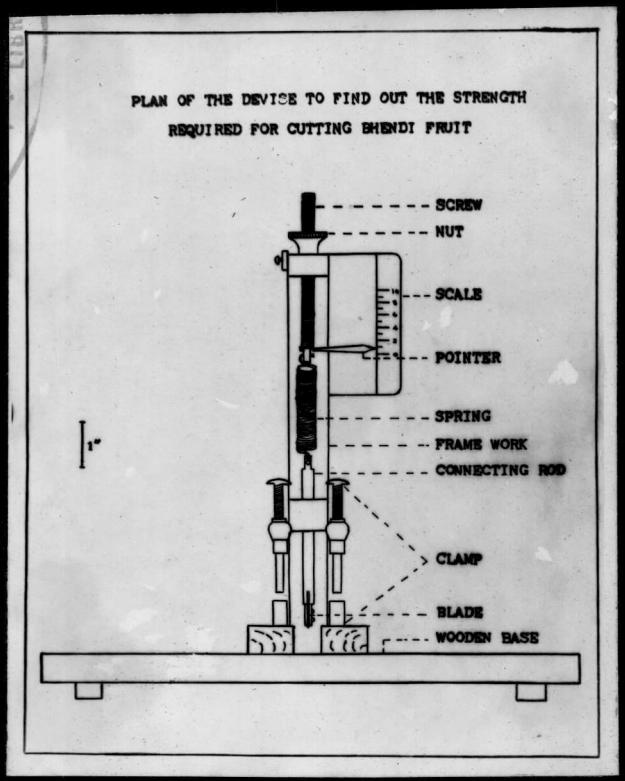


Plate X

Plate XI Pod length at the 5th, 7th, 9th, 11th 13th, 15th and 17th day after flower opening.

Pusa Sawani and Red Bhendi

Plate XII Pod length at the 5th, 7th, 9th, 11th 13th, 15th and 17th day after flower opening.

Indian Bhendi and College Orchard.

Plate XIII Pod length at the 5th, 7th, 9th, 11th 13th, 15th and 17th day after flower opening.

English Green and Sabour Selection

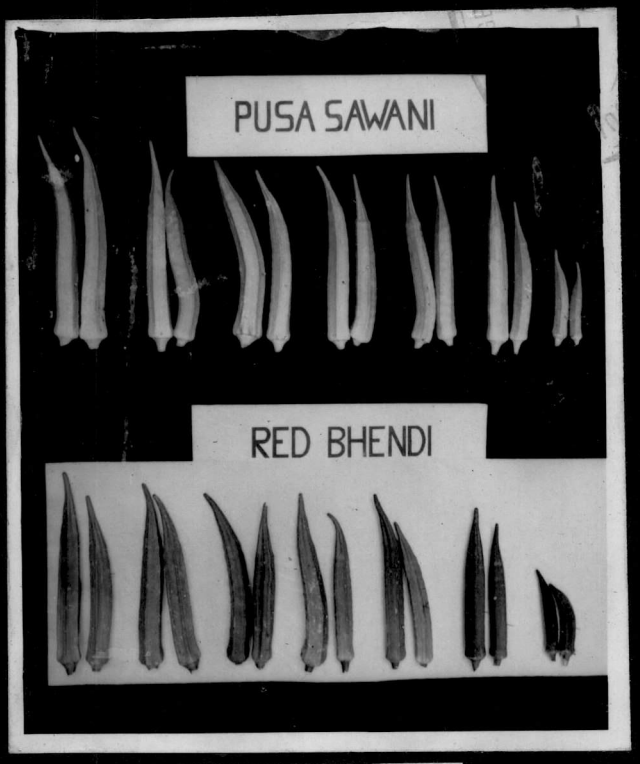


Plate XI

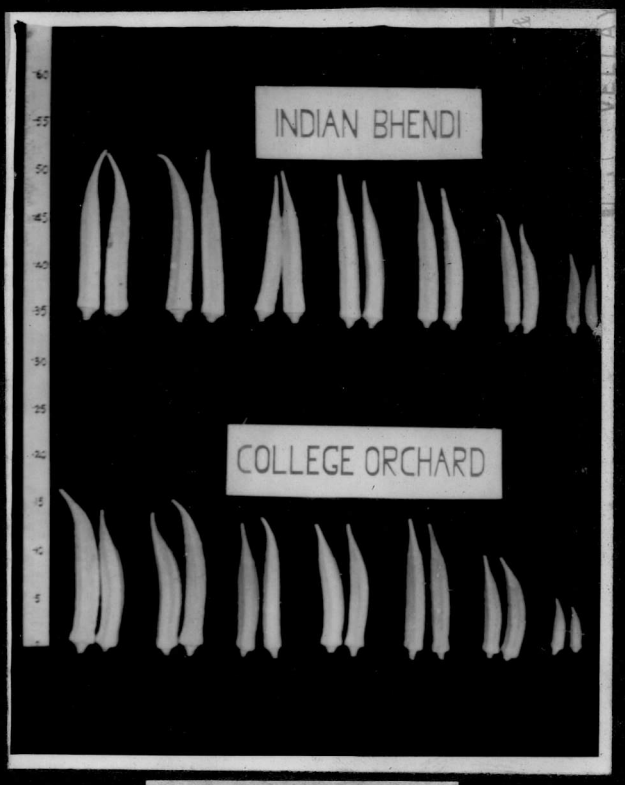


Plate XII

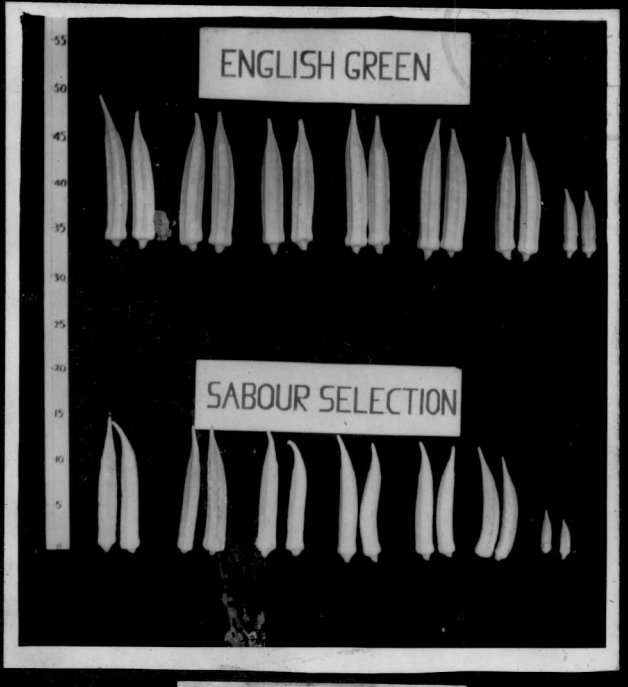


Plate XIII

PlateXIV and XV.

Varietal variation in pod length on any day after flower opening.

From left to right Red Bhendi

Pusa Sawani

Indian Bhendi

English Green

Sabour Selection

College Orchard

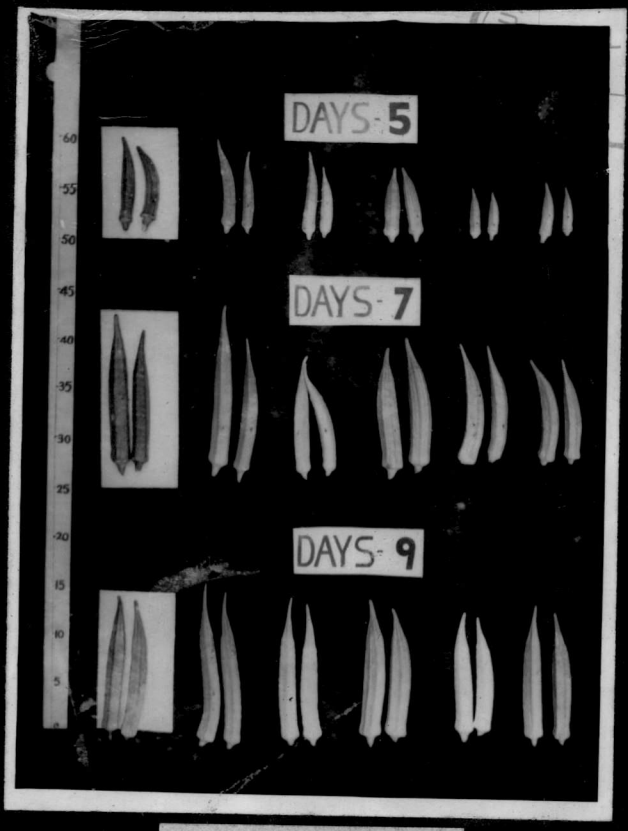


Plate XIV

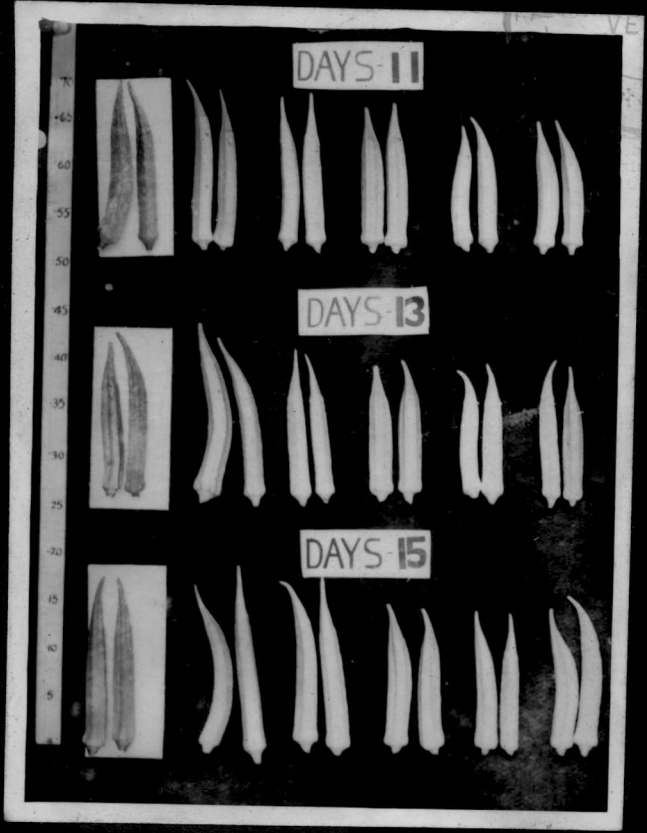
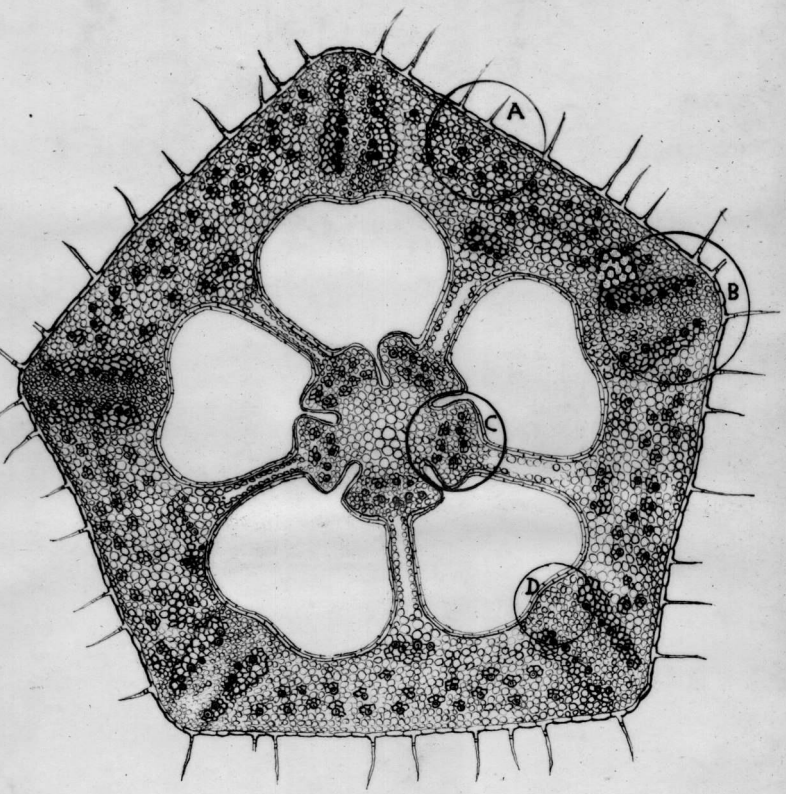


Plate XV

Plate XVI Diagramatic representation of the cross section of bhendi pod.

C·S· OF BHENDI FRUIT (SCHEMATIC)

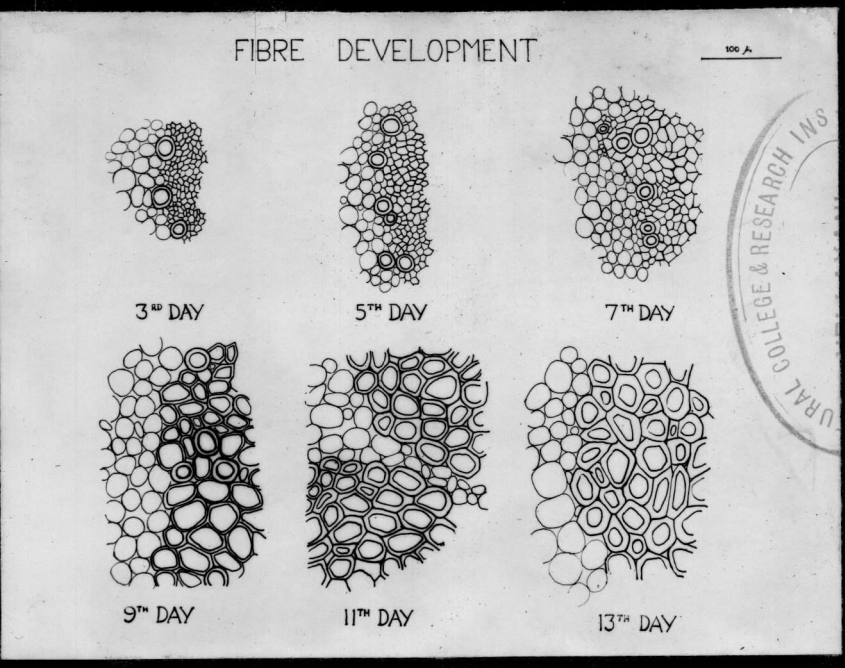


A .. VIDE PLATES 22, 25, AND 30
B .. VIDE PLATES 17, 21, 23, 24, 26, 28, AND 31
C .. VIDE PLATES 18, 20, AND 27
D .. VIDE PLATE 29

PLate XVI

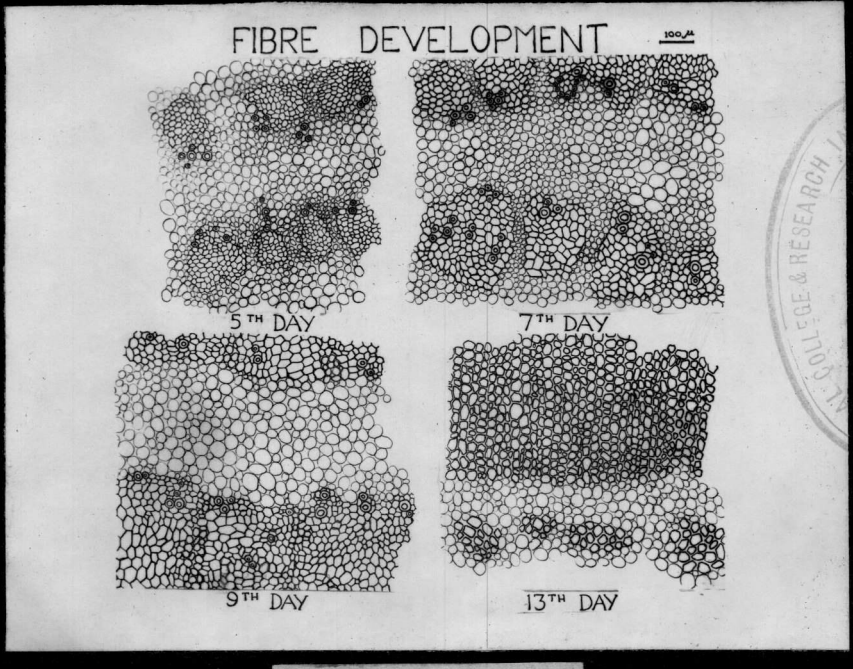
Plate XVII Camera-lucida drawings of fibre development in the vascular bundles situated at the ridges of the fruit.

Plate XVIII Camera-lucida drawings of fibre development in the vascular bundles situated in the Central region of the fruit.



URAL COLLEGE & RESEARCH INS

Plate XVII



COLLEGE & RESEARCH

Plate XVIII

Plate XIX C.S. of the fruit before anthesis showing the ovules and pericarp.

Plate XX C.S. of the fruit after 3 days after flowering showing a portion of the pericarp at the ridge.

Plate XXI C.S. of the fruit after 3 days after flowering showing a portion of the centrally located vascular bundles

Plate XXII C.S. of the fruit after 3 days after flowering showing the epidermis and the epidermal hairs.

Plate XIX

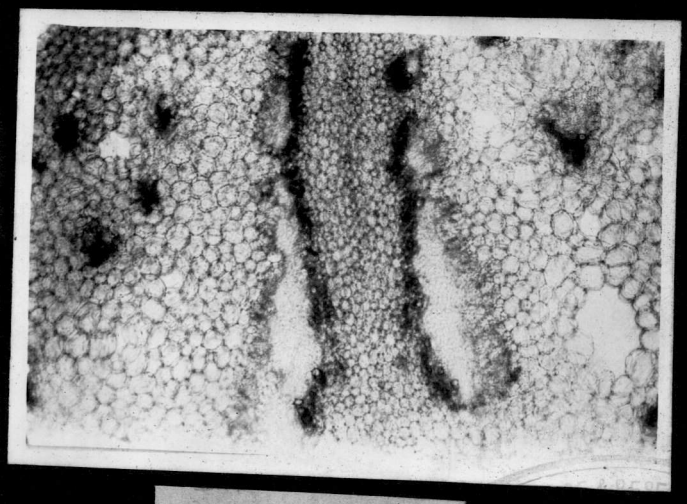


Plate XX

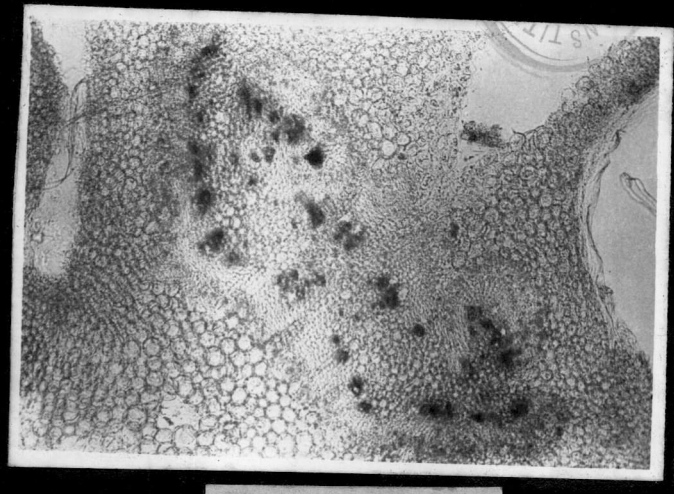


Plate XXI

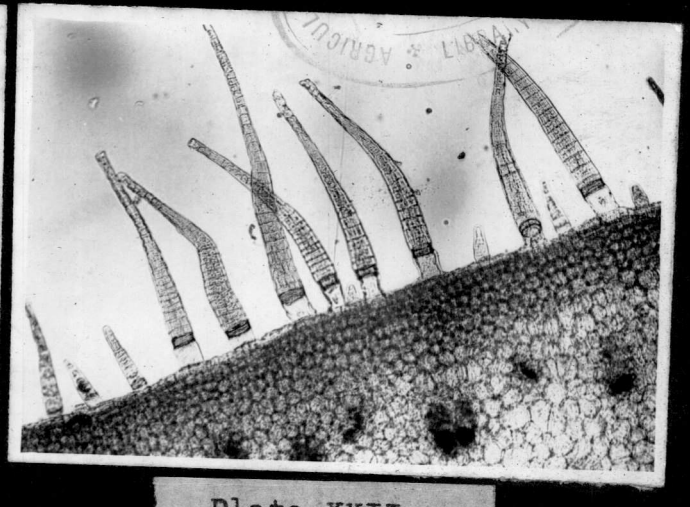


Plate XXII

Plate XXIII

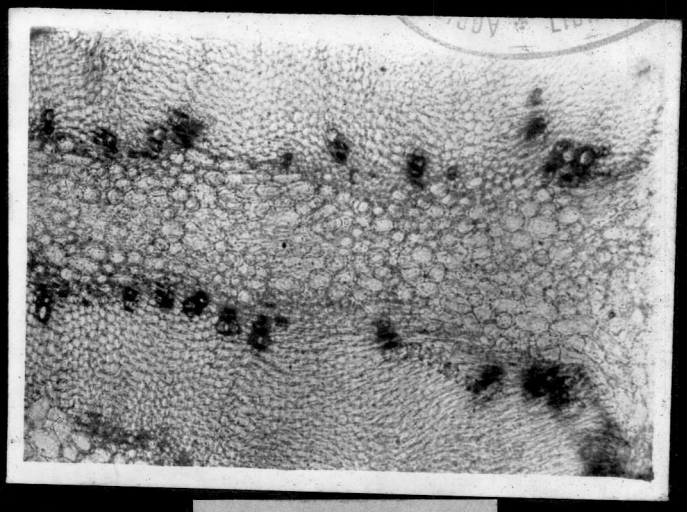


Plate XXIV

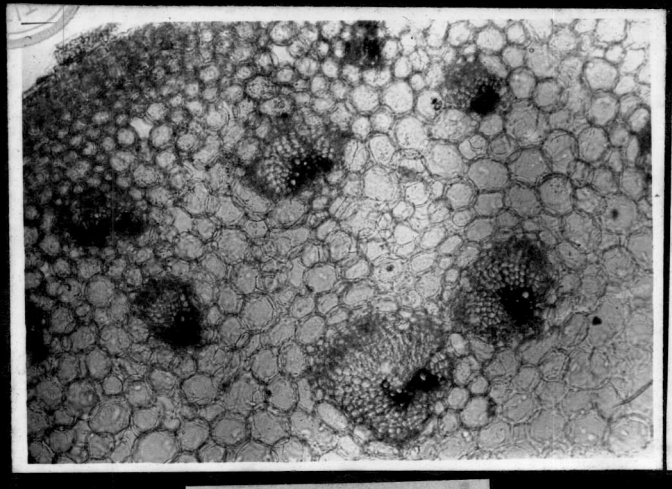


Plate XXV

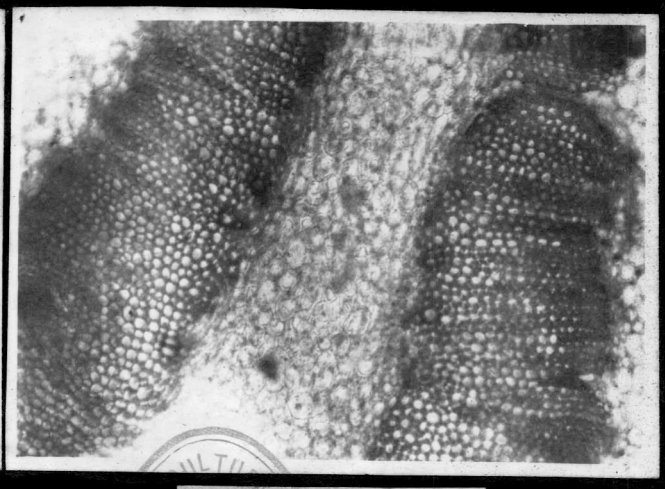


Plate XXVI

Plate XXVII C.S. of the fruit, 13 days after flowering showing the centrally located vascular bundles and secondary thickening of tissues.

Plate XXVIII C.S. of the fruit, 29 days after flowering showing the rupture of tissues in between the vascular bundles at the ridge.

Plate XXIX C.S of the fruit, 29 days after flowering showing the rupture of the locule wall.

Plate XXX C.S. of the fruit, 29 days after flowering showing the development of air spaces in the pericarp.

Plate XXXI C.S. of the fruit, 31 days after flowering showing the dehiscence of the pod at the ridge.

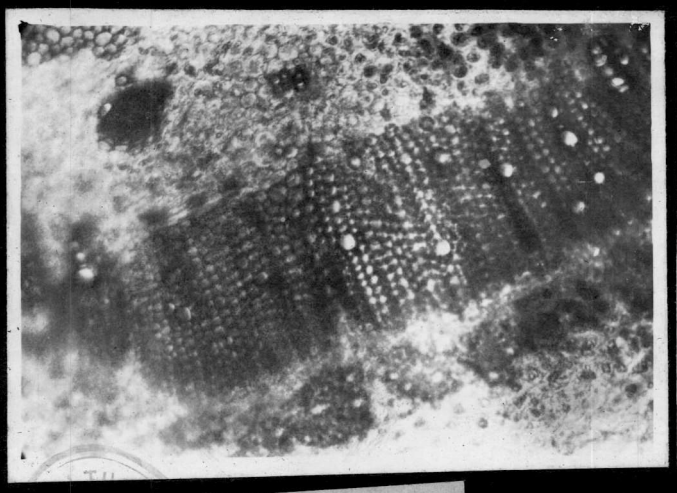


Plate XXVII

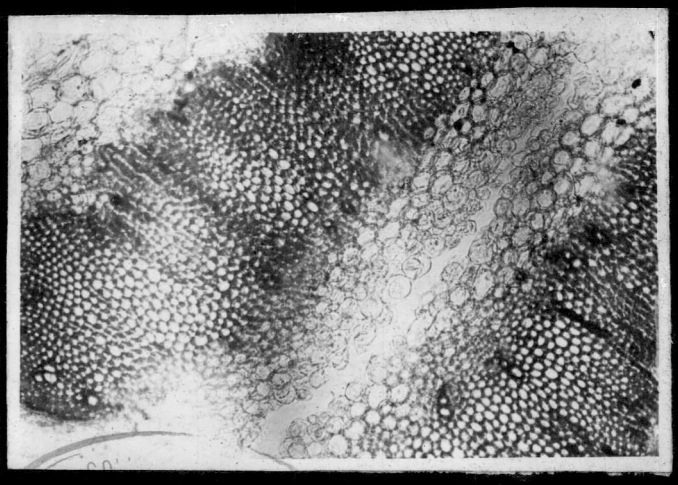


Plate XXVIII

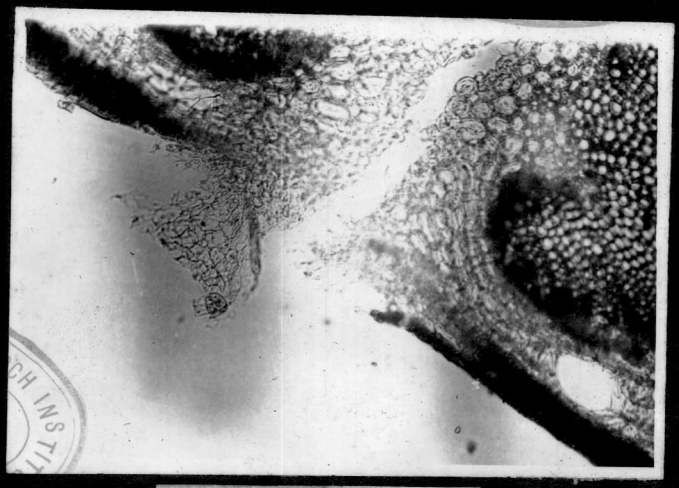


Plate XXIX

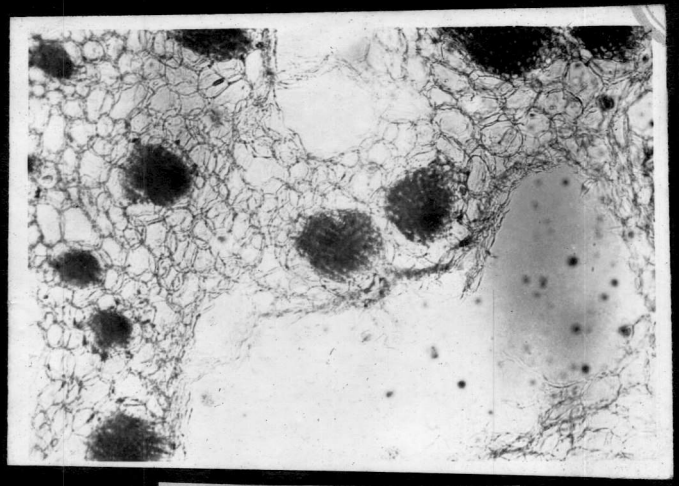


Plate XXX

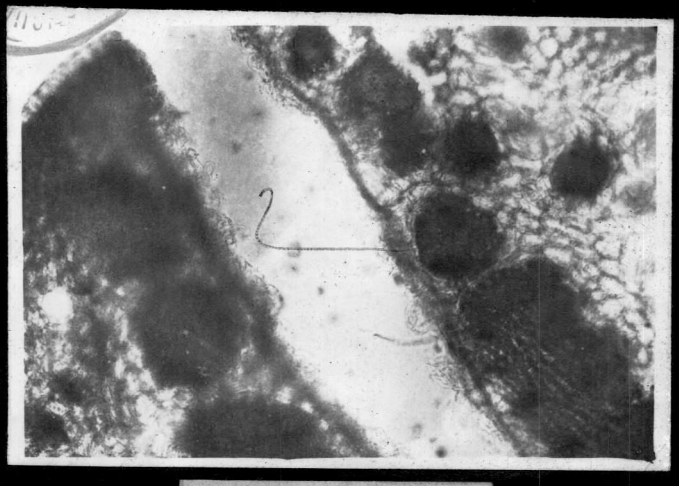


Plate XXXI