STUDIES ON GENETIC RESOURCES OF JACKFRUIT (*Artocarpus heterophyllus* LAMK.) IN WEST BENGAL

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By

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Dedicated to My Beloved Parents & Benevolent Teachers

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CERTIFICATE

This is to certify that the work recorded in the thesis entitled **"Studies on genetic resources of jackfruit (Artocarpus heterophyllus Lamk.) in West Bengal"** submitted by Sri Chandan Suravi Maiti in partial fulfilment of the requirements for the award of the Degree of Doctor of Philosophy (Horticulture) in Fruits and Orchard Management, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, is a faithful and bonafide research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received from various sources during the course of investigation have been duly acknowledged.

(S. K. MITRA)
Chairman, Advisory Committee

CERTIFICATE OF APPROVAL

We, the undersigned, having been satisfied with the performance of Sri Chandan Suravi Maiti in the viva-voce Examination, conducted today, the 6 December 2001 recommended that the thesis be accepted for the award of the Degree of Doctor of Philosophy (Horticulture) in Fruits and Orchard Management of Bidhan Chandra Krishi Viswavidyalaya.

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(C. S. Maiti)

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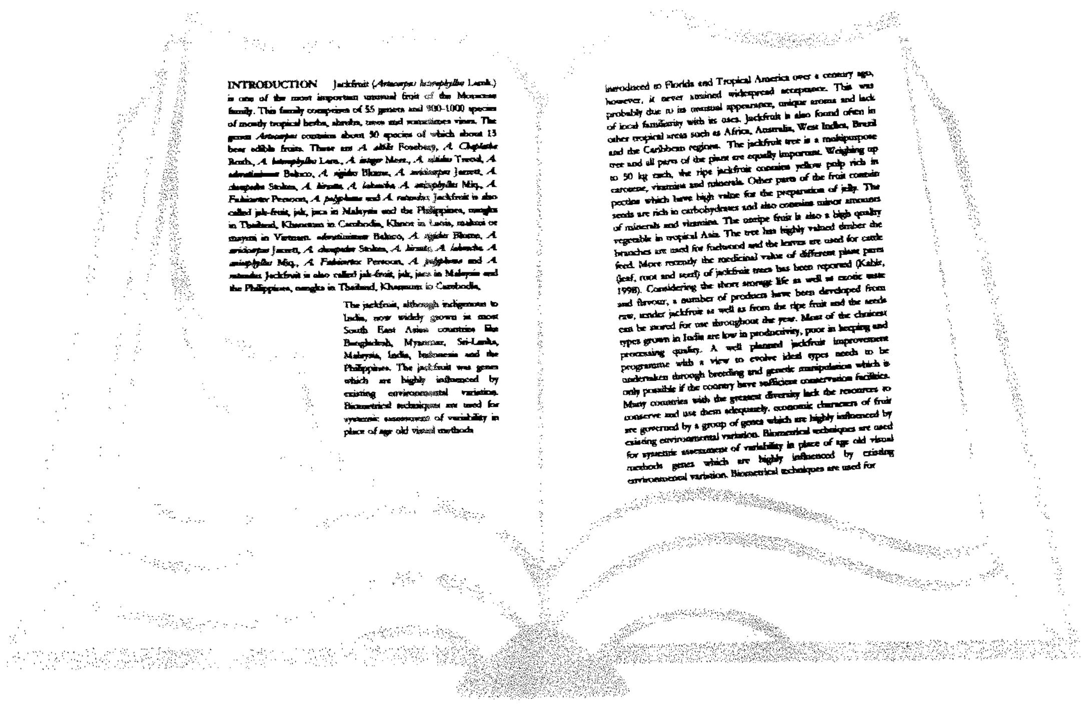


INTRODUCTION

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lamk.) is one of the most important unusual fruit of the Moraceae family. This family comprises of 55 genera and 900-1000 species of mostly tropical herbs, shrubs, trees and sometimes vines. The genus *Artocarpus* contains about 50 species of which about 15 bear edible fruits. These are *A. altilis* Fosebery, *A. Chaplasha* Roxb., *A. heterophyllus* Lam., *A. integer* Merr., *A. nitidus* Trecul, *A. odoratissimum* Balnco, *A. rigidus* Blume, *A. sericicarpus* Jarrett, *A. chempeden* Stokes, *A. hirsuta, A. lakoocha, A. anisophyllus* Miq., *A. Fulvicortex* Persoon, *A. polyphema* and *A. rotundus.* Jackfruit is also called jak-fruit, jak, jaca in Malaysia and the Philippines, nangka in Thailand, Khannum in Cambodia, Khnor in Laois, makmi or maymi in Vietnam.

The jackfruit, although indigenous to India, now widely grown in most South East Asian countries like Bangladesh, Myanmar, Sri-Lanka, Malaysia, India, Indonesia and the Philippines. The jackfruit was introduced to Florida and Tropical America over a century ago, however, it never attained widespread acceptance. This was probably due to its unusual appearance, unique aroma and lack of local familiarity with its uses. Jackfruit is also found often in other tropical areas such as Africa, Australia, West Indies, Brazil and the Caribbean regions.

The jackfruit tree is a multipurpose tree and all parts of the plant are equally important. Weighing up to 50 kg each, the ripe jackfruit contains yellow pulp rich in carotene, vitamins and minerals. Other parts of the fruit contain pectins which have high value for the preparation of jelly. The seeds are rich in carbohydrates and also contains minor amounts of minerals and vitamins. The unripe fruit is also a high quality vegetable in tropical Asia. The tree has highly valued timber the branches are used for fuelwood and the leaves are used for cattle feed. More recently the medicinal value of different plant parts (leaf, root and seed) of jackfruit trees has been reported (Kabir, 1998). Considering the short storage life as well as exotic taste and flavour, a number of products have been developed from raw, tender jackfruit as well as from the ripe fruit and the seeds can be stored for use throughout the year.

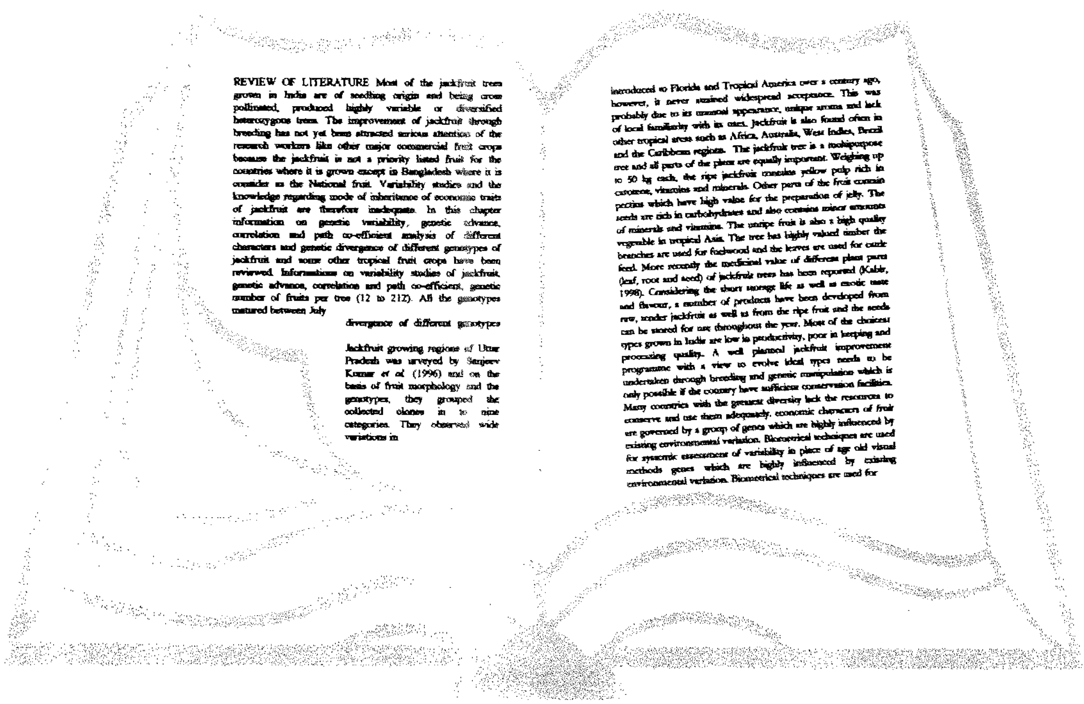
Most of the choicest types grown in India are low in productivity, poor in keeping and processing quality. A well planned jackfruit improvement programme with a view to evolve ideal types needs to be undertaken through breeding and genetic manipulation which is only possible if the country have sufficient conservation facilities. Many countries with the greatest diversity lack the resources to conserve and use them adequately. Conversely, many countries with the best conservation facilities and advanced scientific research institutions have less indigenous genetic diversity. The term 'genetic resources' came into common usage at the FAO International Technical Conference in 1967. The scientific principles underlying strategies and methodologies for collecting, conserving, evaluating and documenting genetic resources were comprehensively addressed for the first time. In 1983, FAO developed a voluntary legal framework, the International Undertaking on Plant Genetic Resources, aimed at formalizing arrangements for the conservation, access, and use of Plant Genetic Resources. The Commonwealth Science Council organised a workshop at Bangladesh in 1992 on the Utilization of Traditional and Underutilized Fruits and Nuts in Asia where fruits like jackfruit, ber, bael, jamun, tamarind, karonda were considered for commercialization in Asian countries. For any crop improvement programme, the knowledge about genotypic variations of the economic characters is a prerequisite and is considered to be the key point to take a crop improvement programme either by selection or by hybridization and exploited hybrid vigour and high yielding characters may be perpetuated through vegetative propagation. The chances of success of any crop improvement programme increases to a greater extent due to genetic divergences within the available germplasm. Thus the greater variability in the initial material will ensure evolution of desirable recombination by using suitable breeding methods. Most of the economic characters of fruit are governed by a group of genes which are highly influenced by existing environmental variation. Biometrical techniques are used for systemic assessment of variability in place of age old visual methods (Frey, 1966).

There are following biometrical techniques, *viz.*, simple measures of variability (range, mean, standard deviation, variance, standard error, co-efficient of variation), variance component analysis, D^2 statistics which are used for the assessment of variability in selection of germplasm programmes. The efficiency of selection is generally more effective for characters with high heritability. Selection is made on the basis of phenotype, although phenotypic superiority is not solely dependent on gene action as it is produced by the interaction of genotypes and environment and improvement in the performance of selected lines over the original population is expressed through genetic advance (Johnson *et al.,* 1955a).

Where direct selection is not sufficient, it may require indirectly in case of characters with low heritability. Some biometrical analysis provide information about relative contribution of various traits. These techniques include, correlation and path analysis. Correlation measures the mutual relationship of types and helps in selection based on determination of yield components. Path analysis further splits the correlation coefficient into the measures of direct and indirect effects of types on yield (Dewey and Lu, 1959).

Jackfruit is a highly heterozygous, cross pollinated fruit and as such seedlings exhibits a wide range of variations which aids in the selection of the superior desirable types. Due to cross pollination and predomination of seed propagation over a large period of time, species diversity and genetic diversity with in the species by their influence on the evolutionary process of extinction, selection, gene drift, gene flow and mutation, increasing the diversity in the existing population. Wide variations were observed in sweetness, acidity, flavour, taste, size, shape and bearing habit. Narasinhan (1990) stated that there are different cultivated types of jackfruit which vary widely in size, shape appearance and taste. Researchers at the International Centre for Underutilized Crops, UK in collaboration with the Bangladesh Agricultural Research Institute have made significant progress in characterizing of the genetic diversity of the jackfruit trees of Bangladesh (Azad and Haq, 1998). In West Bengal wide variations of jackfruit types were observed (Mitra and Mani, 1998) which needs in depth evaluation for selection of superior genotypes to use in future breeding programme. The present investigation was taken up to study the genetic resources of jackfruit grown in different district of West Bengal.

CHAPTER II



REVIEW OF LITERATURE

REVIEW OF LITERATURE

Most of the jackfruit trees grown in India are of seedling origin and being cross pollinated, produced highly variable or diversified heterozygous trees. The improvement of jackfruit through breeding has not yet been attracted serious attention of the research workers like other major commercial fruit crops because the jackfruit is not a priority listed fruit for the countries where it is grown except in Bangladesh where it is consider as the National fruit. Variability studies and the knowledge regarding mode of inheritance of economic traits of jackfruit are therefore inadequate. In this chapter information on genetic variability, genetic advance, correlation and path co-efficient analysis of different characters and genetic divergence of different genotypes of jackfruit and some other tropical fruit crops have been reviewed. Informations on variability studies of jackfruit, genetic advance, correlation and path co-efficient, genetic divergence of different genotypes of jackfruit are not available like other fruit crops.

Variability studies:

Jackfruit:

Jackfruit growing regions of Uttar Pradesh was surveyed by Sanjeev Kumar *et al.* (1996) and on the basis of fruit morphology and the genotypes, they grouped the collected clones in to nine categories. They observed wide variations in number of fruits per tree (12 to 212). All the genotypes matured between July and August except one genotypes which matures between March and May, There was also variability in chemical composition of the pulp, with total soluble solids ranging from 14 to 20.5% and ascorbic acid content from 23.8 to 32.0 mg/100 g. The best genotype was considered as No. 7, with moderate yields, large fruits (> 15 kg) and bulbs (about 20 g), small cylinders, high pulp/cylinder ratio and average fruit quality. However, they were not assessed systematically by biometrical techniques. Hossain and Haque (1977) evaluated the jackfruit types of Bangladesh. The average fruit weight in selected 10 types ranged from 3.24 – 7.39

kg, the weight of pulp and seed being 0.57 and 0.39 kg respectively, in the smallest fruit and 2.70 and 1.01 kg in the largest fruit. Skin colour ranged from yellow and pale-green to brown.

Vilasachandran *et al.* (1982) also evaluated the jackfruit types from different locations on the basis of pectin contents in all parts of the fruits. Mitra (1998) identified 28 genotypes of jackfruit clones of West Bengal which showed wide variability in yields, fruit weight, fruit shape, skin colour, number of spines, pulp colour, number of segments, pulp weight, texture of pulp, TSS, total sugar and acidity contents of fruit. Wide variability in yield (14 – 325 fruits/plant), fruit weight (2.1 – 10.2 kg), fruit shape (oblong, roundish and conical), skin colour (greenish, light-brown, dark-brown, yellow and yellowish-brown), number of tubercles in skin (5 – 27/cm^2), pulp colour (yellow, whitish, reddish – yellow and pinkish-yellow), number of segments (34 – 380/fruit), number of stones (32-362/fruit), texture of segments (soft, moderately soft and hard)), pulp weight (361 – 3,648 g), total soluble solids (15.4 – 29.6%), total sugar (12.9 – 26.6%) and acidity (0.10 – 0.31%) were observed among the genotypes. The growth, bearing (twice a year in some types) and maturity (June – August) of fruits also showed variation among the genotypes. A comparative study was carried out on yellow bulbs, light yellow bulb and orange bulb types of jackfruit to identify the elite type by Guruprasad and Thimaraju (1989). The light-yellow type had the highest seed weight (7.66 g), seed length (3.23 cm), seed breadth (2.10 cm) and average total weight of seeds per fruit (913.21 g). The yellow type had more seeds per fruit (124.6) and the highest pulp to seed ratio (4.24). Mitra and Maity (2000) studied nearly 1460 trees from different district of West Bengal and have identified 35 superior clones. They observed wide variability in yield (14 – 1200 fruits/plant), fruit weight (2.0 – 16.0 kg), fruit shape (oblong, roundish, conical), peel colour, pulp colour, number of flakes (30 – 380/fruit), number of seeds (30 – 365/fruit), texture of pulp, pulp weight, total soluble solids (15 – 30%), total sugar (13.0 – 27.09%) and acidity (0.10 – 0.33%) among the genotypes. The growth, bearing (twice a year in some types) and maturity (June – September) of fruits showed variations among the genotypes. Alagiapillai *et al.* (1996) selected PPI 1, a new variety of *A. heterophyllus* as a clonal selection from the Kazhukupala type at Tamil Nadu. The variety is high yielding and comes to first fruiting in 5 years. They conducted a trial at Mulagumoodu during 1980-94 and observed that PPI 1 gave an average yield of 107 fruits per tree each weighing 16.99 kg. Sarma *et al.* (1997) identified 12 different genotypes from the lower Brahmaputra valley zone of Assam. They noted significant variations in yield and chemical composition of fruits of the different genotypes. Fruit yield (60 fruits/tree) and Brix values were highest in KJF 3, while the lowest acidity (0.6%) was recorded in type KJF 12. However, Singh and Srivastava (2000) identified 18 clones from eastern UP and observed wide variations in fruit weight, shape and size, number of bulbs/fruit, TSS, acidity yield (12 – 400 fruits/tree), fruit bearing (some bore fruit twice a year) and fruit maturity.

The Mekarsari Fruit Garden of Indonesia and Fairchild Tropical Garden in south Florida have collected different *Artocarpus* sp. from the various regions. Mekarsari Garden of Indonesia maintained two important jackfruit cultivars *viz.* Kandel and Mini (Tirtawinata, 2000). Many new superior cultivars were imported and planted at Fairchild Tropical Garden, Florida. Among the cultivars Black Gold, Golden Nugget, J-31, Honey Gold and Lemon Gold have been reported as most precocious. These cultivars vary greatly in their size, shape, flesh characteristics, taste and ripening time. Fruit ripening mainly concentrated in July and August in most of the cultivars, but J-31 matures in late May and early June and black Gold ripens in middle of September (Campbell and McNaughton, 1994).

Banana:

Nayar *et al.* (1980) evaluated thirteen yield components in twenty two indigenous and exotic varieties of banana. Analyses on phenotypic and genotypic variances, phenotypic and genotypic coefficients of variations, heritability and genetic advance showed a wide range of variation among the characters studied.

They estimate that the high heritability values along with high genetic advance with high genetic coefficient of variation for number of fruits per bunch (94%, 1003.89, 551.51, respectively), weight of hands (99%, 2591.85, 1461.23, respectively) and fruit length of pedicel (99%, 443.01, 250.31, respectively), girth of plant (99%, 1130.00, 640.00, respectively) and number of leaves (100%, 713.00, 404.00, respectively) per plant. It was suggested that further improvement is possible in these characters through proper selection. In an experiment with twelve desert and six culinary varieties of banana, very little difference between genotypic and phenotypic coefficient of variations were observed. However, culinary varieties showed high GCV values for number of fruits, hands per bunch and bunch weight (Shree Rangaswamy *et al.,* 1980). Rajeevan and Geetha (1984) noted a significant variation for plant and bunch characters of ratoon crops in ten banana cultivars. Chundawat *et al.* (1988) observed high estimates of GCV for bunch weight, plant height, fingers per bunch, hands per bunch and days to ripening among the different cultivars of banana. Rekha and Prasad (1993) evaluated genetic variability and character association among 170 genotypes of banana for 14 yield components. They observed, high estimates of genetic coefficients of variation, heritability and genetic advance for number of hands/bunch, number of fingers/bunch, finger weight and bunch weight and between most other yield components, while number of hands/bunch and fingers/bunch showed either non-significant positive correlations or highly negative correlation with most of the yield components. They concluded that the important selection criteria of banana for improvement were bunch and finger weight. Osuji *et al.* (1997) studied the possible association among different quantitative traits in cultivar groups and subgroups in the *Musa* germplasm. They found that fruit traits, number of neutral flowers, total number of leaves, plant girth at 50 cm, and days to flowering and harvest were major discriminating traits in the different germplasm. Ortiz (1997) made univariate and principal component analysis (PCA) to identify the most important descriptors to characterise and classify *Musa* germplasm collections. The most important quantitative morphological descriptors included pseudostem girth, height of tallest sucker, number of fruits and fruit size and the most important qualitative morphological descriptors were persistance of male bud and hermaphrodite flowers, pigmentation in pseudostem, foliage, petiole and male flower, pseudostem blotching and waxiness and leaf orientation. These quantitative descriptors showed a high heritability (> 80%), high repeatability (> 20%) and low coefficient of variation (9 – 15%) with the exception of height of the tallest sucker.

Ortiz and Vuylsteke (1998) evaluated sixteen quantitative characters of 75 plantation and 18 banana cultivars during several production cycles. The extent of variation in quantitative characteristics and phenotypic correlations between them were analysed and observed that most of the variation was significantly affected by the specific genotype of the *Musa* accessions. The most productive cultivars were the Cavendish bananas and the Giant French plantation (3730 t ha^{-1} $year^{-1}$). They also noted that five phenotypic correlations were common to all known texonomic *Musa* groups. Short cycling cultivars showed early flowering, whereas tall cultivars had wide plant girth and many leaves. The number of fruits/bunch was significantly associated with the number of hands. They concluded that, index descriptor may be useful for selection of *Musa* cultivars which showed a high coefficient of variation.

Sirisena and Senanayake (2000) in trials with diverse accessions of *Musa* cv. Mysore for a three year production period, investigated the possibilities for genetic improvement through within clone selection. They studied the phenotypic and genotypic variability, broad-sense heritability (h^2), phenotypic coefficient of variation (PCV), and genotypic correlation of variation (GCV), expected genetic advance (EGA) and phenotypic and genotypic indirect effects of some selected characters on yield. From the PCV, GCV, h^2, EGA and genotypic and phenotypic correlations, it was found that the pseudostem girth, fruit maturity period, bunch weight, total fruit weight, average fruit weight and fruit circumference in the second comb had high genotypic variation and genotypic correlations which would be beneficial for crop yield improvement through within clone selection. Fruit maturity period had a significant negative correlations with yield and yield components. High levels of correlated responses in improvement of bunch weight could be obtained when selection was made for average fruit weight and pseudostem girth. Selection for average fruit weight was likely to improve total fruit weight. Selection for a short fruit maturity period was found beneficial since fruit maturity period had negative correlated responses for improving bunch weight and its components. The correlated response of the selected characters on improvement of average fruit weight was very low. Selection for total fruit weight had a high response in improvement of fruit circumference in the second comb. Path analysis revealed that average fruit weight had a positive direct effect on bunch weight while fruit circumference in the second comb, pseudostem girth and fruit maturity period had high indirect effects on bunch weight via average fruit weight. Thus, a useful path diagram to show the relationship of average fruit weight, pseudostem girth, fruit circumference in the second comb and fruit maturity period to bunch weight has been proposed.

Citrus:

Prasad and Rao (1989) studied variability of acid lime fruits for morphological and biochemical characteristics of twenty seven genotypes. The estimates of GCV and PCV were higher in characters like fruit rind thickness, juice weight, juice volume and fruit volume. Jature and Chakrawar (1989) studied eleven different elite types or clones of Kagzi lime and variability for yield components and certain fruit characters. The variability was found significantly high for the characters like yield of fruits per tree, fruit weight, fruit shape, number of seeds per fruit, seed shape, rind thickness, percentage of juice and acidity. Thangaraj *et al.* (1992) observed that the growth of 100 Rangpur lime (*Citrus limonia*) seedling had a high degree of genetic variability and recommended for adoption only vigorous growth characteristics seedling for improved nursery technology. Badiyala *et al.* (1993) observed wide variations among nineteen strains of galgal for characters like yield and physic-chemical characters and number of seeds. Desai *et al.* (1993) recorded high genetic variability among 217 clones of acid lime for various characters (fruit weight, juice percentage, total soluble solids, fruit acidity and skin thickness) grown in western Maharastra.

Guava:

Thimmappaiah *et al.* (1985) noted higher coefficient of variation among fruit characters like fruit weight, fruit volume and acidity in five guava cultivars. Kahlon *et al.* (1993) studied the variability in fruit characters of 177 mixed seedlings progeny of guava and noted high coefficient of variations for fruit yield. However, the variability was low for maturity period, fruit length and fruit diameter. High estimates of GCV and PCV were recorded for fruit volume and fruit weight among eight cultivars of guava by Bandopadhyay *et al.* (1992).

Kahlon *et al.* (1997) carried out an experiment on 170 guava seedlings to determine the pattern of variability with respect to various fruit characters (fruit yield, fruit weight, fruit shape, pulp colour, surface colour, seed numbers/fruit, TSS, total sugar and vitamin C). They noted that the fruit yield/tree ranged from 5.0 to 50.4 kg and 1.5 kg to 48.1 kg during rainy and winter season, respectively. The fruit weight ranged from 58.6 to 148.3 g and 68.7 g to 179.2 g; seed number/fruit from 110-581, TSS from 7.8% to 14.4% and 8.0% to 14.8%; total sugar from 48.82% - 8.77% and 5.24 - 9.29% and vitamin C from 82 - 196 mg and 114 – 299 mg/100 g during rainy season and winter season, respectively. They also observed that the existence of high level of variability with respect to fruit shape (roundish, roundish ovate, ovate), surface colour (greenish yellow, straw yellow, saffron yellow), pulp colour (white and pink) indicates better chances for improvement in these characters in the existing cultivars through seedling selection.

Mango:

Prasad (1987) studied the variability of mango under a widely divergent collection of forty varieties. He recorded high GCV for fruit weight, fruit volume, reducing sugar and ascorbic acid content of fruit. Lal and Gupta (1993) observed wide range of variation in number of fruits per plant, fruit weight, skin colour, shape, size, sweetness, juiciness of pulp, ripening period and maturity among sixty four genotypes of mango. Singh *et al.* (1993) also recorded a great range of variation in fruit weight (32.40 to 192.40 g), pulp percentage (32.02 to 84.84%), stone weight (17.57 to 48.28 g), total sugar (12.45 to 18.24%) and titrable acidity (0.16 to 0.40%) among fifteen genotypes of mango. Samanta *et al.* (1999) noted significant difference for all the studied characters (leaf length, leaf breadth, petiole length, average number of leaves/twig, number of scaffold branches, number of tertiary branches, internodal length, chlorophyll-a and chlorophyll-b contents) among the twenty five genotypes of mango.

Attri *et al.* (1999) studied the genetic variability and correlation among various fruit characters of 14 mango collections. The genetic and phenotypic coefficients of variance, heritability, genetic advance and coefficient of correlation were estimated for 15 fruit characters which included length, breadth, peel, pulp, stone TSS, sugar, ascorbic acid, carotenoids and overall quality. A remarkable variability was observed among collections for these characters. All the characters showed high estimates of broad sense heritability (ranges between 85.3% to 99.9%) whereas genetic advance was recorded very high in carotenoids (324.95%), fruit weight (266.23%), fruit volume (269.03%) and ascorbic acid (77.36%). They also reported that fruit weight, fruit length, fruit breadth, fruit pulp and overall quality were the effective relation indices. Samanta *et al.* (1999) studied twenty five genotypes of mango for estimating genetic variability. Difference between PCV and GCV were found to be low only in fruit volume (46.48, 43.49), fruit weight (42.95, 40.44) and pulp weight (49.59, 47.00), respectively, indicating less influence of environment. High heritability along with high genetic advance was found for the fruit volume (87.17, 154.26), fruit weight (88.66, 155.61) and pulp weight (89.87, 135.03) respectively, indicating presence of additive gene actions where selection would be effective.

Papaya:

Magdalita *et al.* (1984) evaluated 100 papaya accessions of local and foreign origin. They observed wide range of variation in fruit weight, fruit volume, cavity volume and latex yield per fruit. Ghanta and Modnal (1992) studied seven cultivars of papaya and recorded high GCV for height of the plant, days required to first flowering, spread of the plant, fruit yield per plant and number of leaves per plant. The genotypic variances were high for seed weight per fruit, number of fruits per plant, number of seeds per fruit, fruit yield, fruit weight and pulp weight (Modnal and Ghanta, 1993; Dwivedi *et al.*, 1995).

Aonla:

Prasad *et al.* (1980) studied phenotypic, genotypic and environmental variances and coefficient of variation for yield and other thirteen traits related to flowering and fruit set in twenty cultivars. They observed wide range of variations in different fruit characters. Genetic diversity of thirty-three genotypes of aonla was explored by Rai *et al.* (1993). They observed wide range of variability in fruit length, diameter, average weight, TSS, acidity, vitamin C and tannin content. They also observed that phenotypic variances were high for vitamin C, average fruit weight and TSS content.

Heritability and genetic advance:

Heritability and genetic advance are the most important selection parameter. Heritability is the ratio of genotypic variance to the phenotypic variance and it is expressed in percentage. It is a good index to understand the transmission of any character from parents to their offspring in the next generation (Falconer, 1981). Genetic advance is the genotypic value of selected plants over the base population and it is the measure of genetic gain under selection. The genetic advance under selection depends on the following important factors (i) genetic variability among the different plants in the base population, (ii) the heritability of characters under selection and (iii) the intensity of selection (Allard, 1960). So, genetic advance and heritability are very important component for selection of any genetic resources.

Singh and Uppal (1977) observed that heritability for the nut weight in all the groups of almond was quite high and also recorded high genetic gain. Prasad *et al.* (1980) studied the heritability and genetic advance for yield and thirty economic traits in twenty cultivars of aonla related to flowering and fruit set was high. Shree Rangaswami *et al.* (1980) estimated high heritability and genetic advance for number of fruits per bunch, bunch weight and number of days to flowering in twelve dessert type of banana and for number of fruits per bunch and number of days to flowering in six culinary varieties. Rajeevan and Geetha (1994) also confirmed these findings and observed that finger numbers per bunch, finger weight and height and circumference of the pseudostem at flowering had high values of heritability and genetic advances.

High estimates of heritability was observed for sugar content in *Citrus tankan* (Li, 1981); fruit weight, fruit volume, fruit diameter, rind thickness, juice weight, TSS, acidity and ascorbic acid in acid lime (Prasad and Rao, 1989). High heritability along with high genetic advance for fruit weight, fruit volume, fresh and dry pulp weight, and seed weight in nine varieties of litchi was recorded by Sarkar *et al.* (1991). Bandopadhyay *et al.* (1992) recorded high heritability and high genetic advance for fruit volume and fruit weight in guava. Mondal and Ghanta (1993) reported that the fruit characters of papaya like, seed weight per fruit, number of seeds of fruit, fruit weight, number of fruits per plant, pulp weight per fruit and yield per hectare had high heritability along with high genetic advance. High heritability along with high genetic advance were recorded for average number of leaves per twig indicating presence of additive gene action leaf length, leaf breadth, petiole length, internodal length thickness of one year shoot, chlorophyll-a and chlorophyll-b content of twenty five genotypes of mango showed high heritability and low genetic advance indicating presence of non additive gene actin (Samanta *et al.,* 1999).

Correlation studies:

To find out the degree and direction of relationship between two and more variables are known as correlation coefficient. Correlation coefficient analysis measures the mutual relationship between various plant character and determines the component characters on which relation can be based for improvement in yield (Johnson *et al.,* 1955b). In genetic analysis, phenotypic, genotypic and environmental correlation plays vital role. Correlation studies provide information about yield components which helps plant breeder during selection.

Kumar *et al.* (1986a, 1986b) and Shamasundaran *et al.* (1993) observed that all phenotypic correlations of the economic traits with yield of banana were positive. Number of hands per bunch and number of fingers per hand were positively correlated with yield. Rai *et al.* (1993) noted that fruit length and fruit diameter in aonla positively correlated with average fruit weight but fruit acidity had negative correlation with fruit length, diameter and average fruit weight. Prasad (1987) studied the correlations of growth behaviour and fruit characters with yield components in different mango cultivars. Plant height showed positive and significant association with number of fruits per tree and yield per tree. Both the characters showed positive and significant association at both genotypic and phenotypic levels. Fruit weight was found to have positive and significant correlation with fruit volume, TSS and reducing sugar content of fruit. The ascorbic acid content of fruit with reducing sugar and number of fruits with yield per plant also showed highly significant relation at both genotypic and phenotypic levels. Singh *et al.* (1990) recorded highly significant and positive correlation between reducing sugar content in mango fruit and pulp : stone ratio and edible : non-edible ratio. However, Balakrishna *et al.* (1993) observed that average fruit weight had positive and significant relationship with fruit size whereas TSS and ascorbic acid content were negatively associated with fruit size in mango. Chadha (1992) noted positive correlation between fruit weight, fruit size and sugar content in sapota. The correlation studies between the pairs of physical characters in litchi revealed that fruit weight, fruit volume and the amount of aril content had highly significant and positive correlation with breadth of the fruit. Highly significant and positive correlation were also found between fruit weight and fruit volume, fruit weight and pulp weight, fruit volume and pulp weight and peel weight (Bandopadhyay *et al.,* 1990). Bandopadhyay *et al.* (1992) studied correlation for different fruit characters in guava and found highly significant and positive correlation between fruit weight and fruit volume; fruit weight and fruit diameter; fruit weight and fruit length; fruit volume and fruit diameter; fruit diameter and fruit length as well as fruit volume and fruit length. Dwivedi and Mitra (1995a) in studies with eleven litchi cultivars found that TSS/acid ratio was positively correlated with the sugar/acid ratio and negatively with fruit acidity. Dwivedi (1997) studied correlation and regression of fruit weight and its five component traits in litchi. Fruit weight was found to be significantly and highly positively correlated with fruit length (0.776) and diameter (0.913) and aril weight (0.952) and regression study revealed that an increase of one centimeter in fruit length and diameter increased fruit weight by 8.92 and 13.04 g, respectively, while an increase of 1 g in peel, aril and stone weight increased the fruit weight by 0.47, 1.19 and 1.16 g, respectively.

Dwivedi (1998) studied correlation and regression of fruit weight and its components in papaya. He noted that fruit weight was significantly and positively correlated with fruit diameter (0.875), peel weight (0.987), pulp weight (0.993) and pulp thickness (0.889). He suggested that selection indices based on higher fruity diameter and pulp weight and thickness are the most important criteria to identify a plant type bearing fruits with higher fruit weight in papaya.

Path coefficient analysis and genetic divergence:

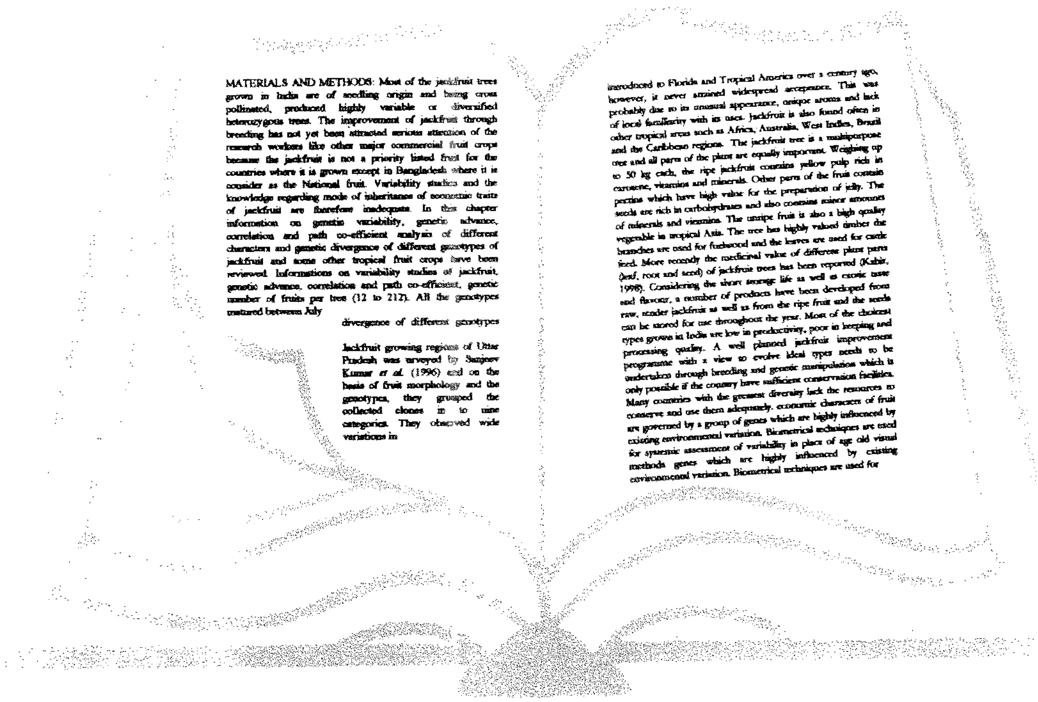
Path coefficient analysis measures the contribution of independent variable on dependent variable and it helps in determining the yield components. It is simply a standardised regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects. The concept of path analysis was originally developed by Wright (1921) and Dewey and Lu (1959) which was subsequently used by different worker for selection of new cultivar.

Genetic diversity in selecting the desirable parents for a further breeding programme measures by the most important technique of genetic divergence, which is measuring by D^2 statistics. Mahalanobis (1936) originally developed this concept but Rao (1952) suggested the application of this technique for the assessment of genetic diversity. D^2 statistics measures the forces of differentiation thus helps in the selection of genetically divergent parents. This technique also determines the relative contribution of each component traits to the total divergence.

Path analysis of twelve dessert and six culinary varieties of banana indicated that bunch weight, number of fruits and stem girth had positive direct effect on bunch weight in dessert cultivars whereas, in culinary types number of hands per bunch, weight and number of hands per bunch and tree height had negative direct effect (Shree Rangaswami *et al.,* 1980). Kurian *et al.* (1985) observed that finger numbers, hands weight and hand numbers exerted maximum direct effects towards yields of banana. Path analysis for rind thickness in acid lime showed that polar diameter, fruit shape index, fruit volume, juice weight and TSS had positive direct effects on rind thickness, whereas, equatorial diameter, fruit weight, percentage of juice, acidity, TSS and acid ratio, ascorbic acid and number of seeds had negative direct influences (Prasad and Rao, 1998). Brar and Sarowa (1993) also studied path analysis of sweet orange cv. Jaffa on growth characters and yield of fruit. Path analysis of the data on eight fruit quality characters in eleven litchi cultivars indicted that selection for higher sugar-acid ratio and higher reducing sugar content would increase the TSS/acid ratio (Dwivedi and Mitra, 1995b).

Dwivedi and Mitra (1995b) assessed genetic diversity of eleven litchi cultivars on the basis of eight fruit quality traits. The study revealed enormous diversity in the material as indicated by the wide range of D^2 values from 85.06 to 26088.03. The cultivars was grouped into two clusters, one accommodating nine cultivars and the other with two cultivars. They noted the intra cluster distance 1672.41 for cluster I and 4213.32 for cluster II, being lower than the solitary inter cluster distance of 11262.05.

CHAPTER III



MATERIALS AND METHODS

MATERIALS AND METHODS

The experimental materials used and methods followed during the period of investigation (1997 to 1999) were as follows.

Experimental Area:

Survey work was carried out throughout West Bengal ($21^{0}31^{/}$ to $27^{0}41^{/}$ N latitude and $85^{0}91^{/}$ to $89^{0}93^{/}$ E longitude) for selection of elite plants. The selected types were propagated and planted at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya.

Experimental materials:

After studying nearly 2000 trees, forty four genotypes representing a fairly wide spectrum of variability of various characters were selected which were taken as experimental materials and further evaluated. The different types and their source of collection, soil type and elevation of the location from where it was collected are tabulated in Table 1. Bearing habits, leaf characters, morphological characters of fruit were studied.

The following survey schedule was developed and used for selection.

Survey schedule:

1. District	:
2. Village/City	:
3. Name and address of the grower	:
4. Plot details	:
i) Elevation of the location	: Low land/mid land/high land
ii) Elevation of the plot	: High/medium/plain
Iii) Maintenance	: Good/average/poor
iv) Soil type	: Alluvial/sandy loam/ lateritic/ coastal/ sandy/terai
v) Stand of crop	: Single planting/equal spacing
vi) Irrigation	: Irrigated/rainfed

5. Details of planting materials	:
i) Source of seedlings	:
ii) Numbers planted	:
iii) Number of plant living	:
iv) Number of plant in bearing	:
6. Morphological characters of tree	
i) Age of the tree	:
ii) Bearing	: Regular/irregular
iii) Age at first flowering	:
vi) Type of inflorescence and branching	: Single/cluster
v) Leaf size	: Leaf blade length (cm) × leaf blade width (cm)
vi) Leaf shape	:
a) Leaf blade shape	: Obovate/Elliptic/Oblong/Wavy
b) Leaf apex shape	: Acute/Acuminate/Retuse/Obtuse
c) Leaf base shape	: Oblique/rounded/cuneate/attanuate
vii) Flowering time	:
viii) Yield/ plant (No. of fruits/ plant)	:
ix) Harvesting time	:
7. Morphological characters of fruit	:
i) Shape	: Obloid/Spheroid/Broadly ellipsoid/ Ellipsoid/Clavate/Oblong/ Irregular/ Slender/Oval/ Round/ Reniform/ Twisted/Cordate
ii) Skin colour	: Mature/Immature (Recorded with the help of RHS Colour Chart)
iii) Numbers of tubercles/3 cm^2 (at maturity)	:
iv) Colour of the pulp	: Recorded at the ripe stage with the help of RHS Colour Chart
8. Physical characters of fruits	:
i) Average fruit weight (g)	:
ii) Flake colour	: Recorded at the ripe stage with the help of RHS Colour Chart
iii) Texture of pulp	: Soft/Firm/Melting
iv) Weight of edible part (g)	:
v) Rind weight (g)	:
vi) Rachis weight (g)	:
vii) Stone weight (g)	: 10 seed weight
viii) Stone shape	: Spheriod/ Ellipsoid/ Elongate/ Oblong/ Reniform/ Irregular
ix) Stone colour	: Recorded with the help of RHS Colour Chart

x) Stone size : Average of 10 stone length (cm) × average of 10 stone width (cm)

xi) No. of flakes/fruit :

xii) No. of stone/fruit :

xiii) Rind/flake ratio :

9. Bio-chemical composition of fruits :

i) TSS (^{0}Brix) :

ii) Total sugar (%) :

iii) Acidity (%) :

iv) Ascorbic acid content (mg/100 g of juice)

v) TSS/acid ratio :

Experimental Methods:

(a) Survey, selection and identification of bearing trees.

(b) Collection of fruits from identified tree for studying the physico-chemical properties:

Three typical fruits from each of the selected elite type were collected for three consecutive years *i.e.* 1997, 1998 and 1999 and fruits were then brought to the laboratory for physico-chemical analysis. The mean data of each quantitative traits in each year were replicated three times and year was considered as a replication for statistical analysis.

(c) Observations recorded:

A number of observations consisting of some morphological and quantitative characters of trees and fruits like, age of the tree, bearing habits, flowering time, harvesting time, leaf characters (leaf size, leaf base shape, leaf apex shape, leaf blade shape), fruit characters (fruit colour, fruit weight, fruit shape, flake number, weight of edible part, rind weight, rachis weight, stone number, stone colour, stone size, stone shape, stone weight, flake colour, flake texture, spine density per 3 cm^2, rind/flake ratio, total soluble solids, titrable acidity, total sugar, vitamin C and TSS/acid ratio) were recorded.

I. Morphological characters of tree:

Age of the tree:

The information about the age of the tree was collected from the grower.

Bearing habits:

Bearing habits of the selected elite genotypes were studied for three years and were then grouped as (i) regular – single bearing habit, (ii) regular - cluster bearing habit and (iii) number of bearing – once or twice a year.

Leaf characters:

The leaf size was determined by measuring the distance of the length and breadth of the leaves with the help of a graduated measuring scale and the mean value was recorded in centimeter (cm).

The length of the leaf was measured form the base of the tip of the leaf blade and breadth was measured at the widest portion of the leaf blade from six fully expanded leaf of the each type. The shape of the leaf base, leaf apex and leaf blade were also studied and recorded for each of the selected type and classified as per schedule.

Yield/tree (number of fruits):

Yield was calculated by counting the number of fruits produced in each tree/year.

Flowering time:

Flowering time of the selected genotypes were recorded by observing the individual tree.

Harvesting time:

Harvesting time for all the selected clones were recorded.

II. Morphological characters of fruits:

Fruit shape:

The shape of the fruit was recorded and were classified as obloid, spheroid, ellipsoid, clavate, oblong, broadly ellipsoid, irregular, round, slender, oval, reniform, twisted and cordate.

Fruit skin (rind) colour:

The skin (rind) colour of mature fruit was recorded with the help of colour chart (RHS Colour Chart, 1986).

Spine density:

Spine density on the rind was recorded in 3 cm^2 area at the base of the fruit at maturity.

III. Physical characters of fruit:

Fruit weight:

Ten representative fruits were weighed by a simple pan balance and their average weights were determined an expressed in g.

Pulp colour:

The pulp colour (flake) of mature fruit was noted with the help of colour chart (RHS Colour Chart, 1986)

Flake texture:

The texture of flakes was recorded organoleptically (with a panel of 5) and were classified as melting, smooth and crisp flake.

Weight of edible part:

The edible portion of the fruit was measured by substracting the rind, stone and rachis weight from the fruit weight and was expressed in g.

Rind weight:

The rind weight of the fruit was determined after carefully removing the rachis and flakes and were measured with the help of a pan balance and expressed in g.

Rachis weight:

Rachis were separated carefully from the ripe fruit and the total weight was determined with the help of a pan balance.

Stone weight:

The stones were removed from the flakes of ripe representative fruit and the average weight of the ten (10) stones per fruit of each type was measured with the help of a pan balance and their mean values were recorded in g.

Stone shape:

Stone shapes were studied and were classified as spheroid, ellipsoid, elongate, oblong, reniform and irregular.

Stone colour:

Stone colour was noted after extraction of stone from fruits and drying under shade with the help of RHS Colour Chart (1986).

Stone size (cm^2):

The length of the stone was obtained by measuring maximum distance between the apical and basal point of the five average size stones with the help of a slide caliper and the mean value was expressed in centimeter (cm). The breadth of the stone was also determined by measuring the distance between the two shoulders with the help of a slide caliper and the mean value was recorded in centimeter (cm). The stone size was calculated [stone size (cm^2) = length (cm) × breadth (cm)].

Number of flakes per fruit:

The number of flakes in each of the replicated fruit was counted after carefully extraction from the ripe fruit.

Number of seeds per fruit:

The number of seeds in each of the replicated fruit was counted after carefully removing the seeds from flakes.

Rind/flake ratio:

Rind/flake ratio were calculated by dividing the rind weight with flake weight.

IV. Biochemical composition of fruits:

Biochemical composition of fruits were estimated after extracting the juice from the flakes of fully-ripe fruits and strained with a fine moslin cloth.

Total soluble solids (TSS):

The total soluble solids content of fruit juice was determined with the help of a hand refractometer calibrated at 0^0 Brix.

Titrable acidity:

Titrable acidity of the extracted juice was determined by titrating against N/10 NaOH solution using phenolphthelene as an indicator and expressed as percentage in terms of citric acid (AOAC, 1984).

Total sugar:

The total sugar content of the fruit juice was determined with the help of Fehlings' solution by copper reduction method using the methelene blue as an indicator and expressed as percentage (AOAC, 1984).

Vitamin C:

Vitamin C content of fruit were estimated by using 2, 6-dichlorophenol indophenol dye titration method (Ranganna, 1977) and values were expressed as mg/100 g juice.

TSS/acid ratio:

Total soluble solids and acid ratio were calculated by dividing the value of total soluble solids with titrable acidity content of the juice.

V. Biometrical Analysis:

Mean, range of variation, standard error of mean and critical difference for each quantitative characters were worked out by the method of analysis of variance using Randomized Block Design (Panse and Sukhatme, 1989). The different characters were further statistically analysed to study the genetic variability concerning with genotypic and phenotypic variance (Burton and De Vane, 1953), Phenotypic and genotypic coefficient of variability (Burton, 1952), heritability (Allard, 1960), genetic advance (Lush, 1949 and Johnson *et al.,* 1955a), correlation coefficient of different pairs of characters (Johnson *et al.,* 1955b; and Jibouri *et al.,* 1958), path coefficient of different characters on fruit weight (Dewey and Lu, 1959) and genetic divergence of different genotypes were confirmed by D^2 statistics derived by Mahalanobis (1936) and grouping or clustering of genotypes was done in accordance with the Tocher's method as described by Rao (1952).

Genotypic and phenotypic variability:

The variability of genotypic and phenotypic for various characters were calculated in accordance with the suggestion by Burton and DeVane (1953).

The genotypic and phenotypic variance were calculated as

$$\text{Genotypic variance } (\sigma g^2) = \frac{MSg - MSe}{r}$$

$$\text{Phenotypic variance } (\sigma p^2) = \sigma g^2 + \sigma e^2$$

Where, MSg and MSe represents mean sum of squares of genotypic and error respectively in an analysis of variance table and r, σg^2 and σe^2 represents number of replications, genotypic variance and error variance respectively.

Genotypic and phenotypic coefficient of variation:

According to Burton (1952), the genotypic and phenotypic coefficient of variation were calculated from the following formulae.

$$\text{Genotypic coefficient of variance (GCV)} = \frac{\sqrt{\sigma g^2}}{\bar{x}} \times 100$$

$$\text{Phenotypic coefficient of variance (PCV)} = \frac{\sqrt{\sigma p^2}}{\bar{x}} \times 100$$

Where, σg^2, σp^2 and $\bar{x}$ represents the genotypic, phenotypic variance and general mean for the character respectively.

Heritability:

Allard (1960) suggested to estimate the heritability (h^2) of the different characters by using $h^2 = \sigma g^2/\sigma p^2$, where, h^2, σg^2 and σp^2 represents as heritability, genotypic and phenotypic variance respectively.

Genetic advance:

Genetic advance was estimated by the aid of formula derived from (Lush, 1949).

$$\text{Genetic advance (GA)} = \frac{\sigma g^2}{\sigma p^2} \times k \sqrt{\sigma p^2}$$

Where, σg^2 and σp^2 represents genotypic and phenotypic variance respectively and K is the standardised selection differential at particular intensity. The value of K at 5% selection intensity is 2.06 in term of normal distribution curve.

Correlation coefficients:

To study the genotypic and phenotypic correlation between various pairs of characters, the data were computed as per method suggested by Johnson *et al.* (1955b) and Jibouri *et al.* (1958). The correlation were calculated as

$$\text{Genotypic correlation } [r_g (x, y)] = \frac{COV_g (x, y)}{\sqrt{\sigma g^2 x \times \sigma g^2 y}}$$

$$\text{Pehnotypic correlation } [r_p (x, y)] = \frac{COV_p (x, y)}{\sqrt{\sigma p^2 x \times \sigma p^2 y}}$$

Where, COV_g (x, y) and COV_p (x, y) are the gentypic and phenotypic covariance between the characters x and y respectively. σg^2 x, σg^2 y, σp^2 x and σp^2 y are the genotypic variance and phenotypic variance of the corresponding characters x and y respectively.

Analysis of path coefficients:

Direct and indirect effects of various component characters on fruit weight per tree was calculated, Wrights (1921) path coefficient were computed using by correlation coefficients as suggested by Dewey and Lu (1959).

$$\begin{bmatrix} P_1 \\ P_2 \\ - \\ - \\ P_n \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ - & - & \cdots & - \\ - & - & \cdots & - \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{bmatrix}^{-1} \begin{bmatrix} r_{y1} \\ r_{y2} \\ - \\ - \\ r_{yn} \end{bmatrix}$$

Where, r_{11} to r_{nn} represents the correlation coefficients among independent variables, r_{y1} to r_{yn}, are correlation coefficient between dependent and independent variables, and P_1 and P_n are direct paths. Indirect paths for the first variable are $r_{11} \times P_1$, $r_{12} \times P_2$, ... $r_{1n} \times P_n$.

$$\text{Residual effect} = \sqrt{1 - P_1 \times r_{y1} - P_2 \times r_{y2} - \ldots - P_n \times r_{ym}}$$

Genetic divergence:

Genetic divergence of different genotypes was computed by D^2 statistics derived by Mahalanobis (1936) which was find out by the Tocher's method as described by Rao (1952). The generalised distance between any two populations or genotypes is defined as

$$D^2 = (\lambda_{ij})\ \delta_i\ \delta j$$

Where, (λ_{ij}) is the reciprocal matrix to the common dispersion matrix, δ_i is the difference between the mean values of the two populations for i^{th} character and δ_j is the difference between the mean values of the two population for the j^{th} character.

Thus, the formula for computation requires the inversion of the matrix of fourteen order transformation of the original correlated unstandardised character means to standardised uncorrelated variables was done to simplified the computational procedure. This transformation was affected by pivotal condensation method (Rao, 1952). Thus significance of D^2 values was tested by treating them as χ^2 values and (V-1) P degrees of freedom at the significance level of $p = 0.05$. Where, V is the number of types and P is the number of variables.

The grouping of genotypes was done according to Tocher's method as described by Rao (1952). The producer used for clustering was that any two types belonging to the same cluster at least on an average should have a smaller D^2 value than those belonged to the different clusters. The average inter and intra cluster divergences were calculated by taking into consideration all the component of D^2 values possible between the number of two cluster.

Table 1. Different jackfruit types identified after survey

Genotype	Location		Elevation of the location	Maintenance	Soil type	Stand of crop	Irrigation practices
	Post	District					
T_{1}	Mohanpur	Nadia	Mid land	Poor	Alluvial	Single planting	Rainfed
T_{2}	Kalyani	Nadia	Mid land	Average	Alluvial	Single planting	Rainfed
T_{3}	Kalyani	Nadia	Mid land	Poor	Alluvial	Single planting	Rainfed
T_{4}	Kalyani	Nadia	Mid land	Poor	Alluvial	Single planting	Rainfed
T_{5}	Nagarukhra	Nadia	Mid land	Poor	Alluvial	Single planting	Rainfed
T_{6}	Barasat	24 Parganas (N)	Mid land	Average	Alluvial	Single planting	Rainfed
T_{7}	Majipara	24 Parganas (N)	Mid land	Average	Alluvial	Single planting	Rainfed
T_{8}	Haringhata	Nadia	Mid land	Average	Alluvial	Single planting	Rainfed
T_{9}	Maniktala	Nadia	Mid land	Poor	Alluvial	Single planting	Rainfed
T_{10}	Krishma	Nadia	Mid land	Average	Alluvial	Single planting	Rainfed
T_{11}	Majipara	24 Parganas (N)	Mid land	Average	Alluvial	Single planting	Rainfed
T_{12}	Kalyani	Nadia	High land	Average	Alluvial	Single planting	Rainfed
T_{13}	Kalyani	Nadia	High land	Average	Alluvial	Single planting	Rainfed
T_{14}	Palasi	24 Parganas (N)	High land	Average	Alluvial	Single planting	Rainfed
T_{15}	Palasi	24 Parganas (N)	High land	Average	Alluvial	Single planting	Rainfed
T_{16}	Palasi	24 Parganas (N)	High land	Average	Alluvial	Single planting	Rainfed
T_{17}	Palasi	24 Parganas (N)	High land	Average	Alluvial	Single planting	Rainfed
T_{18}	Alaipur	Nadia	Mid land	Poor	Alluvial	Single planting	Rainfed
T_{19}	Mollabaria	Nadia	Mid land	Poor	Alluvial	Single planting	Rainfed
T_{20}	Alaipur	Nadia	Mid land	Poor	Alluvial	Single planting	Rainfed
T_{21}	Alaipur	Nadia	Mid land	Poor	Alluvial	Single planting	Rainfed
T_{22}	Alaipur	Nadia	Mid land	Average	Alluvial	Single planting	Rainfed
T_{23}	Alaipur	Nadia	Mid land	Average	Alluvial	Single planting	Rainfed
T_{24}	Madanpur	Nadia	High land	Average	Alluvial	Single planting	Rainfed
T_{25}	Alaipur	Nadia	Mid land	Average	Alluvial	Single planting	Rainfed
T_{26}	Alaipur	Nadia	High land	Poor	Alluvial	Single planting	Rainfed
T_{27}	Bero (Raghunathpur)	Purulia	High land	Poor	Lateritic	Single planting	Rainfed
T_{28}	Haripur, Santipur	Nadia	High land	Average	Alluvial	Single planting	Rainfed
T_{29}	Alaipur	Nadia	High land	Average	Alluvial	Single planting	Rainfed
T_{30}	Patharpratima	24 Parganas (S)	Mid land	Poor	Coastal sandy	Single planting	Rainfed
T_{31}	Madhavnagar	24 Parganas (S)	Mid land	Poor	Coastal sandy	Single planting	Rainfed
T_{32}	Rajeshswarpur	24 Parganas (S)	Mid land	Average	Coastal sandy	Single planting	Rainfed
T_{33}	Gurudashpur	24 Parganas (S)	Mid land	Poor	Coastal sandy	Single planting	Rainfed
T_{34}	Gayeshpur	Nadia	High land	Average	Alluvial	Single planting	Rainfed
T_{35}	Gayeshpur	Nadia	Mid land	Average	Alluvial	Single planting	Rainfed
T_{36}	Borashlbari	Coochbehar	Mid land	Average	Terai	Single planting	Rainfed
T_{37}	Borashalbari	Coochbehar	Mid land	Average	Terai	Single planting	Rainfed
T_{38}	Borashalbari	Coochbehar	Mid land	Average	Terai	Single planting	Rainfed
T_{39}	Chhat Fulbari	Coochbehar	Mid land	Average	Terai	Single planting	Rainfed
T_{40}	Andaran Flubari	Coochbehar	Mid land	Average	Terai	Single planting	Rainfed
T_{41}	Andaran Fulbari	Coochbehar	Mid land	Average	Terai	Single planting	Rainfed
T_{42}	Karkai	Midnapore	High land	Average	Sandy loam	Single planting	Rainfed
T_{43}	Barasat	24 Parganas (N)	Mid land	Average	Alluvial	Single planting	Rainfed
T_{44}	Barasat	24 Parganas (N)	Mid land	Average	Alluvial	Single planting	Rainfed

Descriptions of different selected types

T_1 : A regular bearing type, flowers in December – January and the fruits ripen by June – July. The skin colour of the fruit is rusty-brown at maturity. The fruits are broadly-ellipsoid in shape and bears singly, flakes melting, yellow coloured, stone oblong in shape, white in colour, leaf glabrous, elliptic in shape, leaf apex cuspidate and base attanuate. The tree produces an average of 20 – 30 fruits, each weighing more than 9 kg (average 9812.50 g). Each fruit contained 346 – 350 flakes. The flakes are sweet (19.4% TSS and 17.7% total sugar), rind/flake ratio (0.93) and the edible portion is 39.54 per cent. Selected for high average fruit weight.

T_2 : Regular bearer, flowers in December – January and the fruits matures in June – July, fruit obloid in shape, skin colour ivory at maturity, flakes smooth, yellow in colour, stones spheriod in shape, ivory coloured. The leaf glabrous, elliptic in shape, leaf apex cuspidate and base attanuate. The tree produces an average of 50 – 55 fruits in a year each weighing (4950 – 5015 g). The TSS, total sugar contents of flakes and edible portion of the fruit are 18.5%, 14.7% and 41.14% respectively with a TSS/acid ratio of 123.70. Selected to use as table fruit.

T_3 : Golden yellow coloured, broadly ellipsoid fruit with smooth flake texture which are yellow in colour. Fruit matures in June – July, stone ellipsoid in shape, whitish in colour. The leaf blade is lanceolate in shape. Cuneate and cuspidate in shape of leaf base and leaf apex respectively. The tree produces 42 - 50 fruits/year and each fruit weight 5590.0 g. The fruit have 52 – 62 flakes, 40% edible part and sweet (18.4% TSS, 15.7% total sugar). Selected for medium size fruit to use as table fruit.

T_4 : Regular bearer, fruits borne in cluster, flowers in December – January and the fruits matures in June – July. Leaves lanceolate, base oblique, apex acute, fruit skin colour golden yellow, spheroid in shape, flake melting, yellow colour, stones ivory, elongate in shape. Tree produces about 50 fruits each weighing 3200 g – 3920 g of which 32.65% is edible. Each fruit contain 35 –

42 flakes with 21.0% TSS and 19.5% total sugar, vitamin C content of 4.46 mg/100 g juice. Selected for good fruit quality.

T_5 : Regular bearer, fruits mature in June – July. Fruits are greenish yellow in colour, oblong in shape, flakes crispy, yellow colour, stone reniform in shape, cream in colour. The leaves are lanceolate in shape, apex acute, base oblique, surface glabrous. The tree produces an average of 35 – 40 fruits each weighing 3315 g. Each fruit contain 40 – 42 flakes. The TSS, total sugar of flake and edible portion contents are 17.7%, 14.2% and 40.0% respectively with a TSS/acid ratio of 55.31. Selected to use as table fruit.

T_6 : Regular bearer, fruits matures in May – June, flowers appears in November – December, fruits are spheriod in shape, skin colour creamy yellow at maturity, flakes pinkish-red in colour, melting, stones elongate in shape, cream colour, leaves usually lanceolate in shape, oblique at base and acute at apex. The tree produces an average of 50 fruits in a year each weighing 1200 – 1400 g with 40.0% of edible portion. The TSS and total sugar contents of flakes are 16.0% and 13.0% respectively with a TSS/acid ratio of 30.19. Selected for unusual and attractive pinkish-red colour of flakes.

T_7 : This type of tree flowers in the month of December – January and fruits matures in July – August. The leaves are obovate in shape, apex cuspidate, base rounded, surface glabrous. Fruits are small in size, irregular in shape, beige-pink in colour at maturity. The tree produced an average 70 – 75 fruits/year, each weighing 3227.5 g. Each fruit have about 30 – 34 flakes which are very low in TSS (11.9%), total sugar (9.4%) and 43.37% of edible portion. Selected for processing purpose.

T_8 : Fruit size medium, each weight 3800 g to 3892.5 g and have 30 – 32 flakes. Fruits are clavate in shape, green in colour at maturity, flakes melting and whitish, stones white and oblong. Leaves are usually obovate in shape, obtuse at apex and at base. The fruit have 40% of edible portion. The flake composition shows 16.0% TSS, 14.5% total sugar and 0.31% titrable acidity. Selected for unusual clavate shape of fruit.

T_9 : The tree flowers early (August – September), and matured in June – July. Fruits are ellipsoid, remain green at maturity. Flakes melting, whitish in colour, regular bearer, fruits borne singly. Leaves are glabrous, elliptic in shape, base attanuate and apex acute. The tree produces an average size of fruit (4396.2 g), large number of flakes (75 – 78), 37.75% edible portion which have 18.0% TSS and 15.5% total sugar and 8.23 mg vitamin C/100 g. Selected to use as table fruit.

T_{10} : Regular and early bearer, fruit matures in March – April, slender in shape, greenish – yellow colour. Leaves are glabrous, elliptic in shape, base attanuate and apex acute. Average fruit weight varies between 6900 g to 7415.17 g, bears 25 – 30 fruits/year. Each fruit have 38.72% edible portion, 150 – 170 flakes, smooth, light yellow colour, stones reniform, white, TSS and total sugar content are 16.0% and 13.0% respectively. Selected for higher fruit weight and early bearing.

T_{11} : Tree bears regularly and fruit matures in March – April. Fruits are ellipsoid in shape, skin yellow, average fruit weight 8030 g. Leaves are glabrous, elliptic, oblique in base and acute in apex. The tree produces 20-25 fruits/year, each having 80 – 85 flakes, flakes crispy, yellow, stones reniform, white. Flakes are insipid in taste with 12% TSS, 9.5% total sugar and very less in vitamin C (4.5 mg) content. The fruit contents 38.6% edible matter. Selected for very high average fruit weight and as an early bearer.

T_{12} : Regular bearer, fruits born in cluster, flowers in November – December, matures in last week of April. Leaves are glabrous, elliptic, oblique in base and cuspidate in leaf apex. The tree produces 50 – 55 fruits/year with an average weight 1671 g, has 90 to 95 number of flakes and about 41.41% edible portion. Fruits are round in shape, yellow in skin colour, flakes melting, yellow colour, 11.0% TSS, 9.5% total sugar and 8.06 mg/100 g vitamin C. Stones elongate, ivory in colour. Selected to use as culinary purpose.

T_{13} : Regular bearer, fruits mature in last week of August. Leaves are lanceolate, surface glabrous, apex acute and base oblique. Fruits are greenish-yellow in colour, slender in shape, flakes crispy, yellow colour, stones irregular in shape, brown in colour. The tree produces an average of 20 – 25 fruits/year, each weighing more than 12 kg (average 12200 g) but fruit content only 41.06% edible portion. Each fruit contain 250 – 255 flakes. The flakes are moderate in taste (14.6% TSS, 12.8% total sugar, vitamin C 6.4 mg/100 g and TSS/acid ratio about 91.25). Selected for very high average fruit weight and to use in processing.

T_{14} : Regular bearer, fruits matures in August. Fruit are greenish yellow in colour, oblong in shape, flakes melting, light yellow colour, stones reniform in shape, cream in colour. The leaf surface is glabrous, apex acute, base oblique and lanceolate in shape. The tree produces an average of 44 – 50 fruits each weighing more than 17 kg (average 17299.75 g), the fruit have 39.11% edible flakes, 210 – 220 flakes per fruit. The flakes are moderately sweet (15.1% TSS and 11.6% total sugar) with pleasant aroma. Selected for very high average fruit weight and to use in processing industry.

T_{15} : Regular bearer, fruit matures late in June, ellipsoid in shape, skin colour light yellow at maturity, flakes melting, light-yellow colour, stone oblong in shape, white colour. The leaf surface is glabrous, elliptic in shape, apex acute, base oblique. The tree produces an average of 25 fruits in a year, each weighing 2025.25 g with 34.56% edible matter. The TSS and total sugar content of flakes were 19.0% and 17.5% respectively with TSS/acid ratio of 90.61. Selected to use as vegetable in the month of January.

T_{16} : The tree bears regularly, single in a spike, fruits mature late in July, spheroid in shape, rusty-brown colour at maturity. The leaves are obovate in shape, apex cuspidate, base oblique, surface glabrous. Flakes melting, yellow in colour, stones oblong in shape, white in colour. The tree produces an average of 30 – 35 fruits per year, each weighing 3955.40 g with about 40.45% edible matter. The flakes are sweet (18.2% TSS and 14.5% total sugar) with good aromatic pulpy juice. Selected to use as a table fruit.

T_{17} : Bears twice a year (April – May and December). Fruits obovate in shape, rusty-brown in colour, flakes melting, bold, light yellow. Stones oblong and off-white. Leaves usually elliptic in shape, oblique at base and cuspidate at apex. The tree produces an average of 70 – 75 fruits in a year each weighing 2968 g with 39.08% edible portion. The fruit has 30 – 35 flakes, sweet (16.1% TSS), rich flavour. Selected to use as vegetable in the month of January – February and October.

T_{18} : Regular bearer, flowers in December – January, fruits matures in July. Fruits ellipsoid in shape, skin light green in colour at maturity, flakes smooth, yellow coloured, stones oblong in shape, white in colour. The leaves are glabrous, elliptic in shape, apex obtuse, base oblique. The tree produces an average 40 – 45 fruits having 90 – 95 flakes in each fruit. Average fruit weight 1904.20 g. The flakes content 14.2% and 12.1% TSS and total sugar respectively. Total edible portion of each fruit is 40.22%. Selected to use as vegetable.

T_{19} : Selected for bearing twice a year (April – May and December) to use as vegetable. Fruits are broadly – ellipsoid in shape, flakes melting, yellow in colour, stones off white, reniform in shape. The leaves are glabrous, lanceolate, apex acute, base oblique. The tree is very productive (145 – 150 fruits in a year), each weighing 6703 g. Each fruit have 100 – 120 flakes *i.e.* about 43.48% of the total fruit weight, which are sweet in flavour. The chemical composition of flakes shows 15.6% TSS and TSS/acid ratio of about 42.

T_{20} : Regular bearer, flowers in December – January and the fruit ripens in June – July. The fruits are oblong in shape, light green coloured at maturity, bears singly. The leaves are glabrous, lanceolate in shape, apex cuspidate, base cuneate. The tree produces an average 75 – 80 fruits, each weighing 4832.50 g. Each fruit having 220 – 225 flakes (30.87% edible portion), sweet (17.10% TSS and 15.60% total sugar) with high vitamin C content (8.00 mg/100 g). Selected to use as table fruit.

T_{21} : Tree bears regularly, fruits remain light green in colour at maturity, broadly ellipsoid in shape, flakes melting, light yellow when ripe, stones spheroid, cream in colour. Leaves are broadly elliptic in shape, obtuse at apex and rounded at base. Tree produces an average of 50 – 60 fruits, each weighing 4839.5 g. Tree flowers in December – January and fruits ready for harvest in May – June. Ripe fruit have 360 – 380 flakes with a rind/flake ratio of 1.16. The flake content of 16.0% TSS and 14.5% total sugar and TSS/acid ratio of 72.72. Selected for good fruit quality and higher number of flakes/fruit.

T_{22} : Regular bearer, flowers in December – January and fruits matures in July – August. Fruits are irregular, slightly flat in shape, light green in colour. Leaves are glabrous, obovate in shape, base rounded and apex obtuse. The tree produces 25 – 30 fruits/year and each fruit has 25 – 30 flakes. Flakes melting, yellow colour, stones roundish in shape, white in colour. Flakes content 17.0% TSS and 15.5% total sugar and moderate quantity of acidity (0.31%) and 35.24% edible portion of the total fruit weight. Selected for good fruit quality.

T_{23} : Regular and early bearer (harvesting time April), very high yielder (1450 fruits in a year) with average fruit weight of 1340 g. Leaves are elliptic in shape, cuspidate at apex, oblique at base and leaf surface is glabrous. Mature fruits are rusty-yellow colour, ellipsoid in shape, flakes crispy, light-yellow in colour, having a strong aroma, TSS content 16.6 – 17.4% and TSS/acid ratio of 75 – 80 but total edible portion is very low (12.68%). Selected for high yield and for use as table fruit.

T_{24} : Bears twice in a year (April – May and September – October). Fruits reniform in shape, yellow in colour, flakes crispy, light yellow, stones oblong and off white. The leaves are glabrous, oblong in shape, apex obtuse, base shortly attanuate. The tree produces an average of 750 – 800 fruits in a year each weighing 2001.50 g. The fruit contains 75 – 80 flakes (42.49%), sweet (17.0% TSS), good flavour. Selected to use as vegetable in the month of January – February and October.

T_{25} : Regular bearer, produces slender shaped fruits, mature fruits are light green in colour. Flowers in December – January and ready for harvest in the middle of June. The leaves are glabrous, obovate in shape, apex obtuse and base cuneate. The tree is very productive (320 – 400 fruits in a year each weighing 6631 g.). Each fruit having 100 – 120 flakes that are rich and sweet in flavour. The flakes have 14.0% TSS and 43.5 TSS/acid ratio. The total edible portion of each fruit is about 38.87%. Selected for regular high yielding characters.

T_{26} : Regular bearer, flowers in December – January and the fruits are ready for harvest in July – August. The leaves are glabrous, oblong in shape, apex retuse, base oblique. The tree produces 75 fruits/year each weighing 4670 g. Each fruit contain 90 – 95 flakes. Fruits are ellipsoid in shape, skin yellow in colour. Flakes smooth and yellow, stones reniform, white. Flakes having very high TSS (23.0%) and total sugar (18.0%), comparatively low in acidity (0.27%) and 38.11% edible portion. Selected for use as table fruit.

T_{27} : Cluster bearing habits, regular, fruits matures in the middle of July. The leaves are glabrous, broadly elliptic, apex obtuse, base cuneate. The tree produces 90 – 100 fruits each weighing about 2299.75 g. Each fruit contain 60 – 65 flakes (31.78%). Fruits are broadly ellipsoid, light-green in colour, flakes melting, light-yellow, stones elongated, whitish. Flakes sweet (18.4% TSS, 16.2% total sugar) and have a good aroma. Selected for good quality fruits.

T_{28} : Dwarf tree, regular bearer, leaves are glabrous, lanceolate in shape, apex retuse, base oblique. Fruit matures in July, skin colour light-green, spheroid in shape, flakes melting, small, yellow coloured, stones creamy, reniform. Tree produces 75 – 80 fruits each weighing 1661.25 g and content 29.64% edible portion. Each fruit contain45 – 50 flakes of excellent quality (TSS 26.0%, total sugar 22.5% and TSS/acid ratio 173.8). It has a mild aroma. Selected for good fruit quality.

T_{29} : This type was selected for an average fruit weight (6198 g) and good quality. Tree bears regularly in cluster. Fruits are ellipsoid in shape, light-green colour. The leaves are glabrous, broadly elliptic in shape, apex obtuse and leaf base rounded, flakes melting, yellow, stones shortly-elongated in shape, white in colour. The fruits mature in late July – August, producing 45 – 50 fruits. The flakes content 20.9% TSS and 22.5% total sugar and 37.10% of edible portion in each fruit.

T_{30} : This was also selected for its excellent fruit quality(25.0% TSS, 22.0% total sugar and TSS/acid ratio 100.00), however, it is a poor yielder (15 – 20 fruits/year).Tree bears regularly, leaves are elliptic in shape, apex cuspidate, leaf base cuneate and leaf surface glabrous in nature. Fruits are light green in colour, flakes smooth, yellow colour, stones white and reniform in shape. The tree flowers in October – November and fruits mature in June – July, each fruit weighing 2795 g of which 34.34% is edible.

T_{31} : This type was selected for its excellent fruit quality (TSS 27.1%, total sugar 23.6% and TSS/acid ratio 100.47). The leaves are glabrous, lanceolate in shape, apex cuspidate and leaf base rounded. Tree bears regularly. Fruits are greenish in colour, flakes smooth, golden yellow coloured, stones whitish and oblong in shape. The fruit matures in mid June, however, producing only 14 – 16 fruits each weighing 2896.5 g. Each fruit contain 100 – 115 flakes (43.67%). It has the ability to stand severe drought condition.

T_{32} : Regular bearer, flowers in February – March and fruits matures in late August. Fruits are oblong curve shaped, greenish in colour, flakes melting, yellow, stones whitish and spheroid in shape. The leaves are glabrous, lanceolate in shape, apex acute, base oblique. Tree produces 35 – 40 fruits each weighing 2325.0 g. Each fruit contain 45 – 50 flakes (42.68% edible portion) of good quality (24.3% TSS, 22.5% total sugar and TSS/acid ratio 127.89). Selected for good fruit quality.

T_{33} : Regular bearer, tree flowers in December – January in cluster and fruits ready for harvest in June – July. The leaves are glabrous, lanceolate in shape, apex cuspidate, base shortly attanuate. Fruits are spheroid in shape, greenish in colour at maturity, flakes melting, yellow, stones ellipsoid, whitish. Tree produces an average of 20 fruits each weighing 2180 g. Fruit contained 30 – 36 flakes with rind/flake ratio of 1.12. The fruit quality is excellent (28.0% TSS, 23.0% total sugar and 127.27 TSS/acid ratio). Selected for good fruit quality.

T_{34} : Regular and late maturing type. Fruits are twisted in shape, light green coloured. Tree produces an average of 50 fruits/year each weighing 7191 g. The leaves are glabrous, lanceolate in shape, apex cuspidate and leaf base shortly attanuate. Fruit contain 240 – 250 flakes with a rind/flake ratio of 0.96. Fruit quality is medium (TSS 9.1% and total sugar 7.6%) but it content 43.40% edible matter. Selected for processing industry.

T_{35} : Regular bearer, flowers in November – December and fruits are ready for harvest in August. Fruits oval in shape, yellow, flakes smooth, whitish, stone oblong, white, leaves are glabrous, elliptic in shape, apex cuspidate and leaf base oblique. Tree produces an average of 50 – 55 fruits each weighing 9170 g. Each fruit having 400 – 425 flakes (42.68% edible portion) with a rind/flake ratio of 0.86. It has sweet flavour and aroma and a TSS/acid ratio of 104.73. Fruit contain high vitamin C (11.11 mg/100 g juice). Selected for very stable yield and higher fruit weight.

T_{36} : Regular bearer, flowers twice a year (October – November and June – July) and fruits matures in March – April and November – December respectively. The leaves are glabrous, obovate in shape, apex obtuse and leaf base cuneate. The tree produces 40 – 55 fruits/year each weighing 4041 g. 40 – 42 number of flakes per fruit *i.e.* 39.51% edible portion. Fruits are oblong, yellowish in skin colour, flakes smooth, light yellow colour, stones creamy white, oblong in shape. Fruits are sweet (20.0% TSS and 17.5% total sugar). Selected for bearing twice in a year with good fruit quality.

T_{37} : Regular bearer, fruits ellipsoid, yellow in colour, flakes smooth and yellow, stones irregular, whitish in colour. The leaves are glabrous, elliptic in shape, apex cuspidate and leaf base cuneate. Tree produces 70 – 80 fruits/year each fruit weighing 4867 g. Fruit contain 90 – 110 flakes, good quality (22.9%, 20.4%, 120.52 and 40.27% TSS, total sugar, TSS/acid ratio and edible portion respectively).

T_{38} : Regular bearer, cluster in bearing habit, flowers appears in January – February and fruits matures in June – July. The leaf surface is glabrous, broadly elliptic in shape, apex obtuse and leaf base rounded. Ripe fruits rusty-brown in colour, oval in shape, flakes melting, yellow in colour, stones spheroid, white. Tree produces 160 – 175 fruits/year each weighing 2450.5 g of which 39.17% is edible. Flakes contain 19.0% TSS and 17.0% total sugar with very high TSS/acid ratio (173.68). Selected for average fruit weight to use as table fruit.

T_{39} : Regular bearer, flowers in January – February and mature in June – July. Fruits oblong with curve in shape, skin colour rusty-brown at maturity, flakes melting, yellow in colour, stones oblong in shape, white in colour. The leaves are glabrous, elliptic in shape, apex cuspidate and leaf base oblique. The tree produces an average of 45 – 50 fruits in a year each weighing 3066.75 g. The TSS and total sugar content of flakes are 22.0% and 18.0% respectively with a TSS/acid ratio of 88.0. Fruits have very high per cent of edible matter (69.78%). Selected to use as table fruit.

T_{40} : Fruits are clavate shaped with melting flakes, yellow in colour, fruit matures in June – July, stones oblong in shape, whitish in colour. The leaves are glabrous, oblong in shape, apex retuse and base oblique. The tree produces 20 – 24 fruits/year and average fruit weight 4280.57 g. The fruit contain 130 – 135 flakes (39.27%), flakes having 18.0%, 13.5% and 100.20 TSS, total sugar and TSS/acid ratio respectively. Selected to use as table fruit.

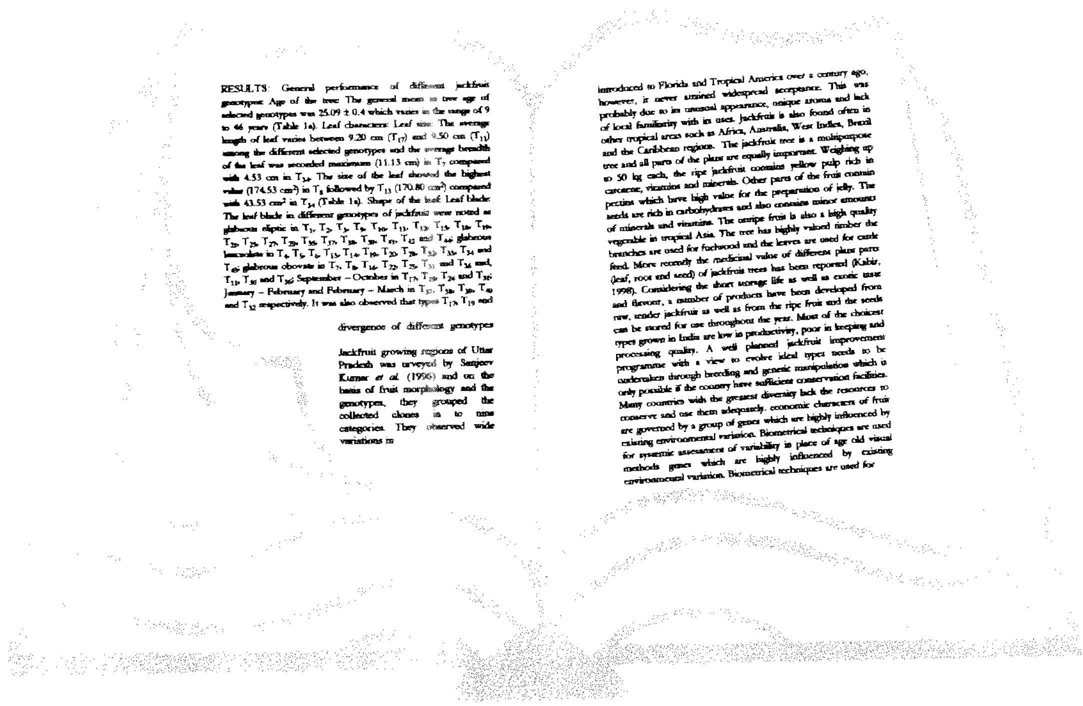
T_{41} : A regular bearing type, flowers in December – January and the fruits matures in June – July. The skin colour is yellowish at maturity. The leaves are glabrous, broadly elliptic in shape, apex obtuse and base rounded. The fruits are ellipsoid and bears singly, flakes melting, yellow colour, stone ellipsoid in shape, creamy white. The tree produces an average of 200 – 225 fruits each weighing 2135 g. Fruit contain 60 – 65 flakes (36.58% edible portion). The flakes are excellent in quality (25.9% TSS and 21.9% total sugar) and a rind/flakes ratio of 1.19. Selected for high yielding nature.

T_{42} : Regular bearer, late fruiting, matures in late July – August. Fruits are cordate in shape, yellowish in colour. Average fruit weight 5050 g, bears 120 – 125 fruits year. The leaves are glabrous, elliptic in shape, apex cuspidate and leaf base oblique. Each fruit contain 45 – 50 flakes, flakes are crispy, light yellow coloured, stones irregular, white in colour. TSS and total sugar content 22.09% and 20% respectively in flakes. Fruit content 39.95% edible portion (flakes).Selected for stable, high yield.

T_{43} : Regular bearer, tree flowers singly in December – January and fruits ready for harvest in June – July. Fruits are round in shape, rusty-brown in colour at maturity, flakes smooth, yellow, stones ellipsoid, brownish, the leaves are glabrous, lanceolate in shape, apex acute and leaf base oblique. Tree produces an average of 20 – 25 fruits each weighing 5510 g. Fruit contain 80 – 90 flakes with rind/flake ratio 0.51. Fruit content higher percentage of edible portion (59.02). The fruit is sweet (20.3% TSS, 18.2% total sugar and 105.05 TSS/acid ratio). Selected for use as table fruit.

T_{44} : The tree bears regularly, single in a spike, fruit harvesting time late in July. The leaves are glabrous, elliptic in shape, apex cuspidate and leaf base oblique. Fruits are irregular shaped, rusty-brown in skin colour at maturity, flakes smooth, yellow in colour. Stones oblong in shape, brownish in colour. The tree produces an average of 50 – 65 fruits per year each weighing 2340 g. The flakes are sweet, content 40% edible-portion but produces unacceptable irregular shaped fruit. Selected for processing purpose.

CHAPTER IV



RESULTS

RESULTS

General performance of different jackfruit genotypes:

Age of the tree:

The general mean in tree age of selected genotypes was 25.09 ± 0.4 which varies in the range of 9 to 46 years (Table 1a).

Leaf characters:

Leaf size:

The average length of leaf varies between 9.20 cm (T_{17}) and 9.50 cm (T_{11}) among the different selected genotypes and the average breadth of the leaf was recorded maximum (11.13 cm) in T_7 compared with 4.53 cm in T_{34}. The size of the leaf showed the highest value (174.53 cm^2) in T_8 followed by T_{13} (170.80 cm^2) compared with 43.53 cm^2 in T_{34} (Table 1a).

Shape of the leaf:

Leaf blade:

The leaf blade in different genotypes of jackfruit were noted as glabrous eliptic in T_1, T_2, T_3, T_9, T_{10}, T_{11}, T_{12}, T_{15}, T_{18}, T_{19}, T_{21}, T_{23}, T_{27}, T_{29}, T_{35}, T_{37}, T_{38}, T_{39}, T_{41}, T_{42} and T_{44}; glabrous lanceolate in T_4, T_5, T_6, T_{13}, T_{14}, T_{19}, T_{20}, T_{28}, T_{32}, T_{33}, T_{34} and T_{43}; glabrous obovate in T_7, T_8, T_{16}, T_{22}, T_{25}, T_{31} and T_{36} and glabrous oblong in T_{24}, T_{26} and T_{40} (Table 2; Fig. 5).

Leaf apex:

The shape of the leaf apex were noted as cuspidate (T_1, T_2, T_3, T_7, T_{12}, T_{16}, T_{17}, T_{20}, T_{23}, T_{30}, T_{31}, T_{33}, T_{35}, T_{37}, T_{39}, T_{42} and T_{44}), acute (T_4, T_5, T_6, T_9, T_{10}, T_{11}, T_{13}, T_{14}, T_{15}, T_{19}, T_{32} and T_{43}), retuse (T_{26}, T_{28}, T_{40}) or obtuse (Table 2; Fig. 4).

Leaf base:

The leaf base shape was noted attanuate (T_1, T_2, T_9, T_{10}, T_{24}, T_{33} and T_{34}) cuneate (T_3, T_8, T_{20}, T_{25}, T_{27}, T_{30}, T_{36}, T_{37}), rounded (T_7, T_{21}, T_{22}, T_{29}, T_{31}, T_{38} and T_{41}) and in other types as oblique (Table 2; Fig. 3).

Bearing:

The bearing habits showed that all the selected genotypes were regular in bearing.

Type of inflorescence:

The different selected types showed either single (T_1, T_2, T_3, T_5, T_7, T_8, T_9, T_{10}, T_{11}, T_{13}, T_{20}, T_{22} – T_{26}, T_{28}, T_{34} – T_{37}, T_{39}, T_{41} – T_{44}) or cluster (T_4, T_6, T_{12}, T_{21}, T_{27}, T_{29}, T_{30}, T_{31}, T_{32}, T_{33}, T_{38} and T_{40}) types of inflorescence (Table 2).

Flowering time:

The flowering time showed variations among the selected genotypes (Table 2; Fig. 1). Most of the selected types flowered during December – January (T_1 to T_5, T_7, T_{13}, T_{14}, T_{15}, T_{16}, T_{18}, T_{20}, T_{21}, T_{22}, T_{23}, T_{25} to T_{29}, T_{33}, T_{34} and T_{41} – T_{44}) while T_6, T_8, T_{12} and T_{35} flowered in November – December; August – September in T_9; October – November in T_{10}, T_{11}, T_{30} and T_{36}; September – October in T_{17}, T_{19}, T_{24} and T_{31}; January – February and February – March in T_{37}, T_{38}, T_{39}, T_{40} and T_{32} respectively. It was also observed that types T_{17}, T_{19} and T_{24} flowered twice a year between April and May and again between September and October and T_{36}, between October and November and June and July.

Fruit yield:

The number of fruits produced per plant showed wide variations among the different selected genotypes (Table 1a). The fruit yield varies as low as 15 per plant in T_{31} to as high as 1450 per plant in T_{23}.

Table 1a. Plant and leaf characters of different selected jackfruit genotypes

Genotype	Age of the tree (year)	Leaf length (cm)	Leaf breadth (cm)	Leaf size (cm^2)	Fruit yield/plant (number of fruits)
T_1	36.0	13.1	6.33	82.97	29.00
T_2	26.0	14.3	6.13	87.70	562.33
T_3	26.0	11.3	7.13	80.60	45.67
T_4	36.0	13.2	7.53	99.43	50.00
T_5	31.0	18.1	9.13	165.30	37.00
T_6	41.0	10.7	5.33	57.07	49.00
T_7	16.0	7.7	11.13	85.73	72.33
T_8	16.0	18.7	9.33	174.53	77.33
T_9	15.0	13.8	7.93	109.50	35.00
T_{10}	19.0	11.1	6.33	70.30	32.33
T_{11}	16.0	19.5	8.67	169.03	22.33
T_{12}	15.0	14.6	6.23	91.03	52.33
T_{13}	21.0	18.7	9.13	170.80	22.33
T_{14}	31.0	18.5	8.53	157.90	50.00
T_{15}	21.0	13.2	7.93	104.73	25.00
T_{16}	26.0	14.1	8.13	114.70	31.00
T_{17}	26.0	9.2	6.53	60.10	72.33
T_{18}	19.0	12.3	4.93	60.70	42.33
T_{19}	31.0	13.1	6.53	85.60	145.00
T_{20}	16.0	18.1	8.73	158.10	75.67
T_{21}	31.0	10.6	8.13	86.23	55.00
T_{22}	29.0	14.0	8.53	119.50	27.33
T_{23}	26.0	12.2	7.13	87.03	1450.00
T_{24}	36.0	15.6	8.63	134.73	775.00
T_{25}	26.0	13.1	7.40	96.93	360.00
T_{26}	36.0	12.6	5.83	73.53	75.00
T_{27}	36.0	12.1	7.63	92.40	95.00
T_{28}	31.0	16.1	8.00	128.80	72.33
T_{29}	36.0	14.5	6.63	96.20	47.33
T_{30}	10.0	12.5	7.13	89.20	17.33
T_{31}	16.0	10.3	6.23	64.23	15.00
T_{32}	46.0	13.4	6.73	90.27	37.33
T_{33}	13.0	11.5	5.63	64.80	20.00
T_{34}	41.0	9.6	4.53	43.53	50.00
T_{35}	31.0	15.3	7.53	115.30	52.33
T_{36}	9.0	16.7	7.23	120.80	46.67
T_{37}	21.0	17.2	8.23	141.60	75.00
T_{38}	18.0	14.9	6.53	97.37	167.33
T_{39}	21.0	12.7	5.33	67.73	50.00
T_{40}	11.0	14.6	6.83	99.80	21.00
T_{41}	23.0	13.1	7.13	93.47	212.33
T_{42}	26.0	13.5	6.53	88.23	125.00
T_{43}	21.0	13.4	7.63	102.30	17.33
T_{44}	26.0	14.6	7.63	111.50	57.33
S.Em (±)	0.44221	0.04321	0.08766	1.60516	8.67288
C.D. (P=0.05)	0.73540	0.07186	0.14578	2.66938	14.42301

Table 2. Flowering and leaf characters of different jackfruit genotypes

Genotype	Bearing habit	Type of inflorescence	Flowering time	Harvesting time	Leaf shape		
					base	apex	blade
T_1	Regular	Single	December – January	June - July	Attenuate	Cuspidate	Glabrous, elliptic
T_2	Regular	Single	December – January	June – July	Attenuate	Cuspidate	Glabrous, elliptic
T_3	Regular	Single	December – January	June – July	Cuneate	Cuspidate	Glabrous, elliptic
T_4	Regular	Cluster	December – January	June – July	Oblique	Acute	Glabrous, lanceolate
T_5	Regular	Single	December – January	June – July	Oblique	Acute	Glabrous, lanceolate
T_6	Regular	Cluster	Mid November – December	May – June	Oblique	Acute	Glabrous, lanceolate
T_7	Regular	Single	December – January	July – August	Rounded	Cuspidate	Glabrous, obovate
T_8	Regular	Single	November – December	June - July	Cuneate	Obtuse	Glabrous, obovate
T_9	Regular	Single	August – September	June - July	Attenuate	Acute	Glabrous, elliptic
T_{10}	Regular	Single	October – November	March – April	Attenuate	Acute	Glabrous, obovate
T_{11}	Regular	Single	October first week	March – April	Oblique	Acute	Glabrous, lanceloate
T_{12}	Regular	Cluster	November – December	Last week of April	Oblique	Cuspidate	Glabrous, obovate
T_{13}	Regular	Single	December – January	Last week of August	Oblique	Obtuse	Glabrous, obovate
T_{14}	Regular	Single	December – January	August	Oblique	Acute	Glabrous, elliptic
T_{15}	Regular	Single	December – January	Last week of June	Oblique	Acute	Glabrous, elliptic
T_{16}	Regular	Single	December – January	Last week of July	Oblique	Acute	Glabrous, elliptic
T_{17}	Regular	Single	(i) April – May (ii) September – October	(i) December (ii) April – May	Oblique	Cuspidae	Glabrous, elliptic
T_{18}	Regular	Single	December – January	July	Oblique	Cuspidate	Glabrous, elliptic
T_{19}	Regular	Single	(i) April – May (ii) September – October	(i) December (ii) April – May	Oblique	Obtuse Acute	Glabrous, lanceloate
T_{20}	Regular	Single	December – January	June – July	Cuneate	Cuspidate	Glabrous, lanceloate
T_{21}	Regular	Cluster	December – January	May – June	Rounded	Obtuse	Glabrous, broadly elliptic
T_{22}	Regular	Single	December – January	July – August	Rounded	Obtuse	Glabrous, obovate

Contd…………………..

Table 2. Contd.....................

Genotype	Bearing habit	Type of inflorescence	Flowering time	Harvesting time	Leaf shape		
					base	apex	blade
T_{23}	Regular	Single	December - January	July – August	Oblique	Cuspidate	Glabrous, elliptic
T_{24}	Regular	Single	(i) April – May (ii) September – October	April – May	Shortly attenuate	Obtuse	Glabrous, oblong
T_{25}	Regular	Single	December - January	Mid of June	Cuneate	Obtuse	Glabrous, obovate
T_{26}	Regular	Single	December – January	July – August	Oblique	Retuse	Glabrous, oblong
T_{27}	Regular	Cluster	December – January	Mid July	Cuneate	Obtuse	Glabrous, broadly ellpitic
T_{28}	Regular	Single	December – January	Mid July	Oblique	Retuse	Glabrous, lanceolate
T_{29}	Regular	Cluster	October - November	July – August	Rounded	Obtuse	Glabrous, broadly elliptic
T_{30}	Regular	Cluster	September – October	June – July	Cuneate	Cuspidate	Glabrous, elliptic
T_{31}	Regular	Cluster	September – October	Mid June	Rounded	Cuspidate	Glabrous, lanceolate
T_{32}	Regular	Cluster	February – March	August	Oblique	Acute	Glabrous, lanceolate
T_{33}	Regular	Cluster	December – January	June – July	Shortly attenuate	Cuspidate	Glabrous, lanceolate
T_{34}	Regular	Single	December – January	Mid August	Shortly attenuate	Cuspidate	Glabrous, lanceolate
T_{35}	Regular	Single	November – December	July – August	Oblique	Cuspidate	Glabrous, elliptic
T_{36}	Regular	Single	(i) October – November (ii) June – July	(i) March – April (ii) November	Cuneate	Obtuse	Glabrous, obovate
T_{37}	Regular	Single	January – February	June – July	Cuneate	Cuspidate	Glabrous, elliptic
T_{38}	Regular	Cluster	January – February	June – July	Rounded	Obtuse	Glabrous, broadly elliptic
T_{39}	Regular	Single	January – February	June – July	Oblique	Cuspidate	Glabrous, elliptic
T_{40}	Regular	Cluster	January – February	June – July	Oblique	Retuse	Glabrous, oblong
T_{41}	Regular	Single	December – January	June – July	Rounded	Obtuse	Glabrous, broadly elliptic
T_{42}	Regular	Single	December – January	July – August	Oblique	Cuspidate	Glabrous, elliptic
T_{43}	Regular	Single	December – January	June – July	Oblique	Acute	Glabrous, lanceolate
T_{44}	Regular	Single	December – January	June – July	Oblique	Cuspidate	Glabrous, elliptic

Harvesting time:

Like flowering time, the maturity of fruits also showed variations among the selected genotypes. The fruits of the types T_1 to T_5, T_8, T_9, T_{15}, T_{16}, T_{18}, T_{20}, T_{30}, T_{31}, T_{33}, T_{37} to T_{41}, T_{43} and T_{44} matures in June – July; July – August in T_7, T_{14}, T_{16}, T_{22}, T_{23}, T_{26}, T_{27}, T_{28}, T_{29}, T_{32}, T_{34}, T_{35} and in T_{42}; March – April in T_{10} and T_{11} and twice a year *viz.,* December and April – May in T_{17}, T_{19} and T_{24} and in T_{36} the fruits matures twice in March – April and in November (Table 2; Fig. 2).

Fruit characters:

Fruit shape:

The shape of the fruit in different selected genotypes showed wide variations. The different shapes of the fruits recorded were broadly ellipsoid (T_1, T_3, T_{19}, T_{21}, T_{27}, T_{31}), ellipsoid (T_9, T_{11}, T_{15}, T_{18}, T_{23}, T_{26}, T_{29}, T_{30}, T_{37} and T_{41}), spheroid (T_4, T_6, T_{16}, T_{28} and T_{33}), oblong (T_5, T_{14}, T_{20}, T_{32}, T_{36} and T_{39}), clavate (T_8, T_{40}) slender (T_{10}, T_{13}, T_{25}), round (T_{12}, T_{43}), oval (T_{35}, T_{38}), irregular (T_7, T_{22} and T_{44}), reniform (T_{24}), twisted (T_{34}), obloid (T_2) and cordate (T_{42}) (Table 3; Fig. 6).

Fruit skin colour:

The skin colour of fruit was found rusty - brown (T_1, T_{16}, T_{17}, T_{19}, T_{23}, T_{38}, T_{39}, T_{43} and T_{44}), ivory (T_2), golden-yellow (T_3, T_4), greenish - yellow (T_5, T_{10}, T_{13}, T_{14}), yellow (T_{11}, T_{12}, T_{24}, T_{26}, T_{36}, T_{37}, T_{40}, T_{41} and T_{42}), green (T_8, T_9), light-green (T_{18}, T_{20}, T_{21}, T_{22}, T_{25}, T_{28} and T_{34}), pale-green (T_{27}, T_{29}, T_{30}, T_{31}, T_{32} and T_{33}), light-yellow (T_{15}), cream (T_6) and beige-pink (T_7) in different selected genotypes (Table 3).

Tubercles density:

The number of spines (tubercles) per 3 cm^2 was recorded 80.33 in the fruit of T_{30} type compared with only 17.00 per 3 cm^2 in T_{37} type (Table 4).

Table 3. Physical characters of fruit of different jackfruit genotypes

Geno -type	Fruit shape	Fruit colour at maturity	Flake texture	Flake colour	Stone shape	Stone colour
T_1	Broadly ellipsoid	Rusty-brown	Melting	Yellow	Oblong	Whitish
T_2	Obloid	Ivory	Smooth	Yellow	Spheroid	Ivory
T_3	Broadly ellipsoid	Golden-yellow	Smooth	Yellow	Ellipsoid	Whitish
T_4	Spheroid	Golden-yellow	Melting	Yellow	Elongate	Ivory
T_5	Oblong	Greenish-yellow	Crisp	Yellow	Reniform	Cream
T_6	Spheroid	Cream	Melting	Pinkish	Elongate	Ivory
T_7	Irregular	Beige-Pink	Melting	Light-yellow	Oblong	White
T_8	Clavate	Green	Melting	Whitish	Oblong	White
T_9	Ellipsoid	Green	Crisp	Whitish	Oblong	Brownish
T_{10}	Slender	Greenish-yellow	Smooth	Light-yellow	Reniform	White
T_{11}	Ellipsoid	Yellow	Crisp	Yellow	Reniform	Brownish
T_{12}	Round	Yellow	Melting	White	Elongate	Ivory
T_{13}	Slender	Greenish-yellow	Crisp	Yellow	Irregular	Brown
T_{14}	Oblong	Greenish-yellow	Melting	Light-yellow	Reniform	Cream
T_{15}	Ellipsoid	Light-yellow	Melting	Light-yellow	Oblong	White
T_{16}	Spheroid	Rusty-brown	Melting	Yellow	Oblong	White
T_{17}	Obovate	Rusty	Melting	Bright yellow	Oblong	Whitish
T_{18}	Ellipsoid	Light-green	Smooth	Yellow	Oblong	White
T_{19}	Broadly ellipsoid	Rusty-brown	Melting	Yellow	Reniform	White
T_{20}	Oblong	Light-green	Melting	Ivory	Oblong	Brown
T_{21}	Broadly ellipsoid	Light-green	Melting	Light-yellow	Spheroid	Cream
T_{22}	Irregular, slightly flat	Light-green	Melting	Yellow	Roundish	White
T_{23}	Elliproid	Rusty yellow	Crisp	Light-yellow	Spheriod	White
T_{24}	Reniform	Yellow	Crisp	Yellow	Oblong	Cream
T_{25}	Slender	Light-green	Melting	Light-yellow	Oblong	Whitish
T_{26}	Ellipsoid	Yellow	Smooth	Yellow	Reniform	White
T_{27}	Broadly ellipsoid	Medium green	Melting	Light-yellow	Elongate	Whitish
T_{28}	Spheroid	Light-green	Melting	Yellow	Reniform	Cream
T_{29}	Ellipsoid	Medium green	Melting	Yellow	Shortly elongate	White
T_{30}	Ellipsoid	Medium green	Smooth	Yellow	Reniform	White
T_{31}	Broadly ellipsoid	Medium green	Smooth	Yellow	Oblong	White
T_{32}	Oblong with curved	Medium green	Melting	Yellow	Spheroid	Whitish
T_{33}	Spheroid	Medium green	Melting	Yellow	Ellipsoid	Whitish
T_{34}	Twisted	Light-green	Melting	Whitish	Oblong	White
T_{35}	Oval	Yellow	Smooth	Whitish	Oblong	White
T_{36}	Oblong	Yellow	Smooth	Light-yellow	Oblong	Creamy
T_{37}	Ellipsoid	Yellow	Smooth	Yellow	Irregular	White
T_{38}	Oval	Rusty-brown	Melting	Yellow	Spheriod	White
T_{39}	Oblong with curved	Rusty-brown	Melting	Yellow	Oblong	White
T_{40}	Clavate	Yellow	Melting	Yellow	Oblong	Whitish
T_{41}	Ellipsoid	Yellow	Melting	Yellow	Ellipsoid	Creamy white
T_{42}	Cordate	Yellow	Crisp	Yellow	Irregular	Whitish
T_{43}	Round	Rusty-brown	Smooth	Yellow	Ellipsoid	Brownish
T_{44}	Irregular	Rusty-brown	Smooth	Yellow	Oblong	Brownish

Flake colour:

The colour of the flakes were mostly yellow to light-yellow in ripe fruits (Table 3) however, in types T_8, T_9, T_{12}, T_{13}, T_{34} and T_{35} both white and whitish colour flakes were observed. Flake colour were noted pinkish, and ivory in T_6 and T_{20}, respectively.

Fruit weight:

The average fruit weight varies between 1220.00 g and 17299.75 g. The fruit weight were higher in T_{14} (17299.75 g), T_{13} (12200.00 g), T_1 (9812.50 g) and T_{35} (9170.00 g) compared with 1220.00 g in T_6, 1340.00 g in T_{23} and 1560.50 g in T_{22}.

Flake texture:

The flake texture were either melting or smooth, however, crisp (T_5, T_9, T_{11}, T_{13}, T_{23}, T_{24}, T_{42}) flakes were also observed in certain types (Table 3).

Weight of edible part without stone:

The weight of edible part or flakes weight without stone was recorded maximum in the fruits of T_{14} (6766.00 g) followed by T_{13} (5010.00 g) compared with 170.00 g, 488.00 g, 492.50 g, 550.00 g and 692.00 g inT_{23}, T_6, T_{28}, T_{22} and T_{12} respectively (Table 4).

Skin (rind) weight:

The skin weight of different genotypes varies between 403.00 g and 6386.00 g among the 44 genotypes (Table 4), which was recorded maximum in fruit from T_{14} plant followed by T_{13} (4732.33 g) and T_1 (3608.00 g) and lowest in T_{39} (403.00 g).

Rachis weight:

The average rachis weight was recorded maximum (2808.00 g) in fruit of T_{14} followed by T_{11} (1380.00 g) and T_{25} (1320.00 g) compared with only 72.33 g in T_{22} (Table 4).

Table 4. Morphological characters fruit of different genotypes

Genotype	Fruit weight (g)	Weight of edible part without stone (g)	Rind weight (g)	Rachis weight (g)	Number of flakes/fruit	Number of stones /fruit	Spines number /3cm^2	Stone weight (g/10stones)	Stone length (cm)	Stone breadth (cm)	Stone size (cm^2)	Rind flake ratio
T_1	9812.50	3880.00	3608.00	692.00	348.00	326.33	43.33	49.50	3.30	1.30	4.30	0.93
T_2	4982.50	2050.00	2235.00	250.67	89.33	89.33	36.33	50.00	2.60	1.30	3.40	1.09
T_3	5590.00	2236.00	2705.00	193.00	57.00	57.00	33.00	79.00	2.80	1.70	4.80	1.21
T_4	3920.00	1280.00	1774.00	542.00	40.33	40.33	24.33	80.00	2.70	1.90	5.13	1.39
T_5	3315.00	1326.00	1572.00	212.00	41.00	41.00	41.00	49.00	3.40	1.90	6.50	1.07
T_6	1220.00	488.00	479.00	165.00	11.00	11.00	23.33	79.50	2.50	1.80	4.50	0.98
T_7	3227.50	1400.00	1462.00	203.33	32.33	32.33	29.33	50.00	2.20	1.70	3.73	1.04
T_8	3892.50	1557.00	1325.00	860.33	30.00	30.00	31.00	50.00	2.00	1.90	3.80	0.85
T_9	4396.20	1660.00	1933.87	313.33	77.00	72.00	30.00	65.50	2.30	2.00	4.63	1.17
T_{10}	7415.17	2838.00	2733.50	1240.00	159.33	151.00	27.00	41.00	2.40	1.40	3.40	0.96
T_{11}	8030.00	3100.00	2997.33	1380.00	81.33	79.00	25.00	70.00	2.60	1.90	4.93	0.97
T_{12}	1671.00	692.00	512.00	97.67	92.33	92.33	28.33	40.00	2.60	1.70	4.40	0.74
T_{13}	12200.00	5010.00	4732.33	1210.00	253.00	249.33	54.00	49.50	3.00	2.10	6.30	0.95
T_{14}	17299.75	6766.00	6386.00	2308.00	216.33	216.33	56.00	84.50	2.20	1.50	3.30	0.94
T_{15}	2025.25	700.07	459.00	364.70	125.33	125.33	36.33	39.00	2.70	1.10	3.00	0.68
T_{16}	3955.40	1600.00	1825.27	215.00	75.00	75.00	43.33	41.00	3.00	1.40	4.20	1.14
T_{17}	2968.00	1160.00	1340.00	308.00	32.00	32.00	42.00	50.00	3.50	1.30	4.57	1.16
T_{18}	1904.20	766.00	530.67	125.00	96.33	96.33	36.00	50.00	3.00	1.30	3.90	0.69
T_{19}	6703.00	2915.00	2581.27	363.00	111.00	111.00	53.00	75.50	3.20	2.00	6.40	0.89
T_{20}	4832.50	1492.00	1866.00	581.00	223.33	223.33	29.00	39.00	3.40	1.40	4.80	1.26
T_{21}	4839.50	1505.00	1730.00	490.00	372.33	371.33	55.00	29.50	3.00	1.20	3.60	1.16
T_{22}	1560.50	550.00	860.00	72.33	26.00	26.00	56.33	30.00	2.20	1.30	2.90	1.58

Contd.....

Table 4. Contd.................

Genotype	Fruit weight (g)	Weight of edible part without stone (g)	Rind weight (g)	Rachis weight (g)	Number of flakes/fruit	Number of stones/ fruit	Spines number /3cm²	Stone weight (g/10stones)	Stone length (cm)	Stone breadth (cm)	Stone size (cm²)	Rind flake ratio
T_{23}	1340.00	170.00	881.00	99.33	21.00	21.00	34.00	88.00	2.60	1.70	4.40	5.20
T_{24}	2001.50	849.00	629.83	125.00	79.33	79.33	36.00	50.00	3.20	1.50	4.80	0.75
T_{25}	6631.00	2578.00	2220.00	1320.00	117.00	114.00	30.00	45.00	2.10	1.80	3.80	0.86
T_{26}	4670.00	1780.00	2121.33	392.97	94.00	94.00	41.00	40.00	2.70	1.10	3.00	1.19
T_{27}	2299.75	731.00	1033.83	191.27	62.33	62.33	55.00	54.50	2.10	1.80	3.80	1.41
T_{28}	1661.25	492.50	787.30	120.03	47.33	47.33	41.00	55.00	3.40	1.40	4.80	1.60
T_{29}	6198.00	2300.00	2087.33	1200.00	111.00	111.00	51.00	53.50	2.60	1.30	3.40	0.92
T_{30}	2795.00	960.00	1351.73	245.60	123.00	119.00	80.33	21.17	2.30	1.00	2.33	1.41
T_{31}	2896.50	1265.00	1033.83	200.20	115.00	115.00	61.00	30.00	2.90	1.40	4.10	0.82
T_{32}	2325.00	992.50	757.17	318.00	46.00	46.00	35.00	50.00	2.60	1.50	3.90	0.77
T_{33}	2180.00	908.00	1019.00	105.00	33.33	33.33	56.33	39.00	1.90	1.40	2.70	1.12
T_{34}	7191.00	3121.00	2967.67	384.00	244.00	239.33	30.00	30.00	3.30	2.10	6.93	0.96
T_{35}	9170.00	3914.00	3359.33	1102.50	425.00	397.00	31.00	24.00	3.20	0.90	2.90	0.86
T_{36}	4041.00	1597.00	1945.00	196.00	40.33	38.00	32.00	74.00	2.70	1.40	3.83	1.22
T_{37}	4867.00	1960.00	2092.00	423.00	100.33	98.00	17.00	40.00	1.90	1.30	2.47	1.07
T_{38}	2450.50	960.00	1113.33	180.67	66.00	65.33	32.00	30.00	2.50	1.30	3.30	1.16
T_{39}	3066.75	2140.00	403.00	243.30	83.00	80.33	28.00	35.50	2.70	1.10	3.00	0.19
T_{40}	4280.57	1681.13	1527.27	305.00	135.00	130.00	39.33	59.50	2.10	1.30	2.73	0.91
T_{41}	2135.00	781.00	921.67	120.00	64.33	62.33	43.00	50.00	3.10	1.30	4.03	1.19
T_{42}	5050.25	2018.07	2417.10	270.00	46.00	46.00	42.00	73.50	2.70	1.90	5.13	1.20
T_{43}	5510.00	3252.33	1647.93	201.47	89.33	81.33	31.67	50.00	2.90	1.90	5.53	0.51
T_{44}	2340.00	936.00	937.00	323.33	20.33	19.00	46.00	46.50	2.60	1.30	3.40	1.00
SEm (±)	125.42760	82.57785	132.7790	15.89549	2.11239	2.26491	0.86108	1.05371	0.08690	0.04655	0.25059	0.12315
C.D. (P=0.05)	208.5861	137.32696	220.81148	26.4342	3.51291	3.76655	1.43199	1.75232	0.14452	0.07741	0.41674	0.20480

Stone weight:

The data presented in Table 4 reveals that the weight of ten (10) stones varies between 21.17 g and 88.00 g among different genotypes which was recorded maximum (88.00 g) in fruit of T_{23} and minimum (21.17 g) in T_{30}.

Stone shape:

The shape of the stones were mostly oblong, however, reniform ellipsoid, elongate, spheroid and roundish shaped stones were also observed (Table 3; Fig. 7).

Stone colour:

The colour of the stones were white in T_1, T_3, T_7, T_8, T_{10}, T_{15}, T_{16}, T_{17}, T_{18}, T_{19}, T_{22}, T_{23}, T_{25}, T_{26}, T_{27}, T_{29}, T_{30}, T_{31}, T_{32}, T_{33}, T_{34}, T_{35}, T_{36}, T_{37}, T_{38}, T_{39}, T_{40}, T_{42} and brownish in T_9, T_{11}, T_{43}, T_{44}. However, ivory (T_2, T_4, T_6 and T_{12}), creamy (T_5, T_{14}, T_{21}, T_{24} and T_{28}) and creamy white colour of stones (T_{36} and T_{41}) were also observed (Table 3).

Stone size:

The length of the stone was recorded highest in T_{17} (3.50 cm) and lowest in T_{37} (1.90 cm), while the breadth of the stone was maximum in T_{13} and T_{34} (2.10 cm) respectively. The maximum size of the stone was recorded in the fruit of T_{34} (6.93 cm^2) compared with 2.33 cm^2 in T_{30} (Table 4).

Number of flakes per fruit:

The number of flakes per fruit varies between 11.0 and 425.00 in different selected genotypes (Table 4). Fruits of T_1, T_{11}, T_{14}, T_{13}, T_{15}, T_{19}, T_{20}, T_{21}, T_{25}, T_{29}, T_{30}, T_{31}, T_{34}, T_{37}, T_{40} and T_{41} contained more than 100 flakes per fruit compared with only 11.00 flakes per fruit in T_6.

Number of stones per fruit:

Marked variation was recorded in number of stones per fruit (Table 4). It was recorded maximum (397.00/fruit) in fruit of T_{35} followed by T_1

(326.33/fruit), T_{13} (249.33/fruit) and T_{34} (244.00/fruit) compared with 11.00 per fruit in T_6.

Rind/Flake ratio:

The rind : flake ratio differ widely among the genotypes and variations was noted between 0.19 and 5.20. The rind : flake ratio was highest in T_{23} compared with the 0.19 in T_{39} (Table 4).

Total Soluble Solids:

The flakes of T_4, T_{26}, T_{28}, T_{29}, T_{30}, T_{31}, T_{32}, T_{33}, T_{37}, T_{41} and T_{42} types showed higher Total Soluble Solids (20.0% to 27.1%). The average range of Total Soluble Solids varies between 9.1 to 28.0 ^{0}Brix among the selected genotypes (Table 5).

Total sugar:

Like the TSS, the flakes of the of T_{31} showed the highest total sugar (23.60%) content followed by inT_{33} (23.0%) compared with 7.6% in T_{34} (Table 5).

Titrable acidity:

The acidity content of flake showed wide variations among the different types studied. The flake of T_6 showed the highest acidity (0.53%) while it was lowest 0.11% inT_{38} (Table 5).

Vitamin C:

The vitamin C content of immature jackfruit is higher than mature ripe jackfruit. It was varies between 4.45 mg to 11.11 mg per 100 g of fruit juices among the different genotypes studied. The flakes of T_{35} showed higher vitamin C content (11.11 mg/100 g of juice) followed by T_{43} (10.14 mg/100 g juice), and T_{37} (10.12 mg/100 g of juice) types compared with 4.45 mg in T_{26} (Table 5).

Table 5. Fruit quality of different selected jackfruit genotypes

Genotype	TSS °Brix	Total sugar (%)	Titrable acidity (%)	Vitamin C mg/100 g juice	TSS : acid ratio
T_1	19.43	17.70	0.34	9.08	57.44
T_2	18.50	14.75	0.15	8.51	123.70
T_3	18.40	15.70	0.26	8.40	70.02
T_4	21.00	19.50	0.26	4.46	80.76
T_5	17.70	14.20	0.32	8.34	55.31
T_6	16.00	13.00	0.53	5.25	30.19
T_7	11.90	9.40	0.16	4.53	72.93
T_8	16.00	14.50	0.31	5.00	51.65
T_9	18.00	15.50	0.32	8.23	56.25
T_{10}	16.00	13.00	0.42	5.06	38.15
T_{11}	12.00	9.50	0.21	4.51	56.27
T_{12}	11.00	9.50	0.37	8.06	29.69
T_{13}	14.60	12.80	0.16	6.40	91.25
T_{14}	14.10	11.60	0.44	7.07	32.04
T_{15}	19.00	17.50	0.21	6.18	90.61
T_{16}	18.20	14.50	0.21	6.18	86.76
T_{17}	16.10	14.60	0.25	7.00	64.40
T_{18}	14.20	12.10	0.30	6.80	47.33
T_{19}	15.60	10.70	0.37	8.07	41.78
T_{20}	17.10	15.60	0.27	8.00	63.40
T_{21}	16.00	14.50	0.22	7.10	72.72
T_{22}	17.00	15.50	0.31	6.20	54.87
T_{23}	12.00	10.00	0.32	5.41	37.50
T_{24}	17.00	14.50	0.41	7.10	41.48
T_{25}	14.00	12.00	0.32	6.30	43.50
T_{26}	23.00	18.00	0.27	4.45	85.26
T_{27}	18.30	16.20	0.25	5.25	72.25
T_{28}	26.00	22.50	0.15	4.46	173.85
T_{29}	20.90	17.40	0.49	7.08	42.67
T_{30}	25.00	22.00	0.25	6.51	100.00
T_{31}	27.10	23.60	0.27	5.50	100.47
T_{32}	24.30	22.50	0.19	8.50	127.89
T_{33}	28.00	23.00	0.22	9.06	127.27
T_{34}	9.10	7.60	0.15	8.00	60.87
T_{35}	19.90	17.90	0.19	11.11	104.73
T_{36}	20.00	17.50	0.25	9.20	80.00
T_{37}	22.90	20.40	0.19	10.12	120.52
T_{38}	19.00	17.00	0.11	8.15	173.68
T_{39}	22.00	18.00	0.25	9.24	88.00
T_{40}	18.00	13.50	0.18	8.10	100.20
T_{41}	25.90	21.90	0.16	7.80	161.87
T_{42}	22.00	20.00	0.19	9.22	115.78
T_{43}	20.30	18.20	0.19	10.14	105.05
T_{44}	16.00	14.00	0.12	6.26	133.33
S.Em (±)	0.16569	0.89770	0.006433	0.11292	2.97828
C.D. (P=0.05)	0.27555	1.49288	0.010690	0.18779	4.95287

TSS : acid ratio:

The flakes of the fruit of under T_{28}, T_{38}, T_{41}, T_{44}, T_{32}, T_{33}, T_{37}, T_{42}, T_{43} and T_{35} type were found comparatively higher in TSS : acid ratio than the other types. The TSS : acid ratio of flakes varies between 29.69 to 173.85 among the different types studied (Table 5).

Variability studies:

Variability studies of different tree characters:

Age of the tree:

The selected genotypes differed significantly with regard to the age of the tree. The general mean in tree age was 25.09 ± 0.4 which varies in the range of 9.00 to 46.00 years. The genotypic and phenotypic variance were observed in both the cases were 82.44 and 82.72 respectively, but the differences between genotypic and phenotypic variances were considerably low. Genotypic coefficient of variation (GCV) was 36.19 while the phenotypic coefficient of variation (PCV) was observed as 36.25 (Table 6). The heritability in broad sense, was as high as 99.60 per cent whereas, genetic advance and genetic advance as percentage of mean were 18.67% and 74.41% respectively.

Length of leaf:

The mean value of leaf length was recorded 13.80 ± 0.04 and the range of leaf length among the different genotypes varies between 9.20 cm and 19.50 cm. It was observed that genotypic variance and phenotypic variance with regard to leaf length in both the cases were 7.35. Genotypic coefficient of variation and phenotypic coefficient of variation with regard to leaf length in both situation showed the value of 19.65 while heritability per cent was very high in value (100%) (Table 6). Genetic advances expressed in percentage of mean exhibited a fairly low value which was 40.50 per cent.

Breadth of the leaf:

General mean of leaf breadth was 7.28 ± 0.08 cm which varied in the range of 4.53 cm to 11.13 cm among the different genotypes studied. The value of genotypic and phenotypic variances were observed as 1.69 and 1.70 respectively. GCV and PCV values for the leaf breadth were 17.89 and 17.95 respectively. The percentage of heritability showed as high as 99.30 (Table 6). However, genetic advance and genetic advance as percentage of mean were found considerably low (2.67 and 36.67% respectively).

Size of the leaf:

Among the different genotypes, the leaf size differed significantly. The general mean value was 102.07 ± 1.70 cm^2. The range of variation for the leaf size were noted from 43.53 cm^2 to 174.53 cm^2. The genotypic and phenotypic variances were found 1088.94 and 19092.32 respectively (Table 6). The difference between genotypic and phenotypic variances were high to a greater extent. The values of GCV and PCV were 213.94 and 214.15 respectively. Variations between two parameters were considerably low. The heritability expressed in percentage was found higher and was recorded 99.60%. The values of genetic advance and genetic advance estimated on the basis of percentage of mean were 67.85 and 66.47% respectively.

Yield per tree:

Significant difference was observed in yield per tree among the different genotypes. The general mean value was recorded as 112.25 ± 8.67. The range of variation with regard to fruit number varies between 15.00 and 1450.00. The magnitude of genotypic and phenotypic variances were noted 57670.89 and 57784.16 respectively. The values of GCV (213.94) and PCV (214.15) were more or less similar. High heritability was noted (99.80%), while the values of genetic

Table 6. Variability in tree characters among different selected genotypes

Sl. No.	Character	General mean	Range	Variance		Coefficient of variation		Heritability per cent (Broad sense)	Genetic advance	Genetic advance as percentage of mean
				Genotypic	Phenotypic	Genotypic	Phenotypic			
1.	Age of the tree (year)	25.09 ± 0.44	9.00 – 46.00	82.44	82.72	36.19	36.25	99.60	18.67	74.41
2.	Leaf length (cm)	13.80 ± 0.04	9.20 – 19.50	7.35	7.35	19.65	19.65	100.00	5.59	40.50
3.	Leaf breadth (cm)	7.28 ± 0.08	4.53 – 11.13	1.69	1.70	17.89	17.95	99.30	2.67	36.67
4.	Size of the leaf (cm^2)	102.7 ± 1.60	43.53 – 174.53	1088.94	1092.32	32.33	32.38	99.60	67.85	66.47
5.	Yield/tree (number of fruits)	112.25 ± 8.67	15.0 – 1450.00	57670.89	57784.16	213.94	214.15	99.80	494.25	440.31

Table 7. Variability in physical characters of fruit among different selected genotypes

Sl. No.	Character	General mean	Range	Variance		Coefficient of variation		Heritability per cent (Broad sense)	Genetic advance	Genetic advance as percentage of mean
				Genotypic	Phenotypic	Genotypic	Phenotypic			
1.	Fruit weight (g)	4565.01 ± 125.42	1220.00 – 17299.75	9869906.60	9892860.50	68.82	68.90	99.80	6463.87	141.59
2.	Weight of edible part without stone (g)	1826.30 ± 82.57	170.00 – 6766.00	1681360.80	1691796.50	71.00	71.22	99.40	2663.09	145.81
3.	Rind weight (g)	1793.20 ± 132.77	403.00 –6386.00	1389686.30	1416449.40	65.74	66.37	98.10	2405.79	134.16
4.	Rachis weight (g)	460.29 ± 15.89	72.33 – 2308.00	217840.68	218227.55	101.40	101.49	99.89	960.63	208.70
5.	Spine density/(3 cm^2)	39.21 ± 0.86	17.00 – 80.33	153.81	154.98	31.63	31.75	99.30	25.47	64.95
6.	Stone weight/10 number	50.69 ± 1.05	21.17 – 88.00	287.49	289.22	33.55	33.5	99.40	34.84	68.73
7.	Numbers of stones	105.60 ± 2.26	11.00 – 397.00	8403.63	8392.02	86.71	86.75	99.90	188.55	178.55
8.	Stone length (cm)	2.69 ± 0.08	1.90 – 3.50	0.18	0.20	16.17	16.65	94.40	0.87	32.34
9.	Stone breadth (cm)	1.51 ± 0.04	0.90 – 2.10	0.09	0.10	20.68	21.02	96.80	0.64	42.38
10.	Size of the stone (cm^2)	4.10 ± 0.25	2.33 – 6.93	1.16	1.26	26.37	27.40	92.60	2.15	52.43
11.	Number of flakes	108.01 ± 2.11	11.00 – 425.00	9067.15	9073.32	88.16	88.19	99.90	196.09	181.54
12.	Rind : flake ratio	1.11 ± 0.12	0.19 – 5.20	0.4532	0.4756	60.65	62.13	95.30	1.36	122.52

advances and genetic advance as percentage of mean were 494.25 and 440.31 respectively (Table 6).

Variability studies on different fruit characters:

Fruit weight:

The genotypes differed significantly with regard to different fruit characters among the different types studied. The general mean for fruit weight was 4565.01 ± 125.42 g among the different genotypes (Table 7). The fruit weight varied between 1220.00 g and 17299.75 g. The higher magnitude of genotypic and phenotypic variances were observed as 9869906.60 and 9892860.50 respectively. The differences between genotypic and phenotypic variances were considerably high in magnitude. The GCV and PCV were 68.82 and 68.90 respectively. The differences between GCV and PCV were, however, considerably low. Heritability was as high as 99.80% and genetic advance and genetic advances estimated as percentage of mean also showed higher values, which were 6473.87 and 14.59% respectively.

Weight of edible part:

The genotypes under study also differed significantly for weight of edible part without stone. The mean values was 1827.30 ± 82.57 g (Table 7). The range for this characters were from 170.00 to 6777.00 g. The magnitude of phenotypic variance of this character was more (1691796.50) than the genotypic variance (1681360.80). The genotypic coefficient of variation were more or less similar. The values of GCV and PCV were 71.00 and 71.22 respectively. The heritability value (99.40) was higher for this character. The values of genetic advance and genetic advances as percentage of mean were found 2663.09 and 145.81% respectively.

Rind weight:

There was significant difference for rind weight among different genotypes. The mean rind weight was 1793.209 ± 132.77 g and ranged from

403.00 g to 6386.00 g. The genotypic and phenotypic variances were found 1389686.30 and 1416449.40 respectively (Table 7). A moderate values of GCV (65.74) and PCV (66.37) were estimated. The heritability was as high as 98.10%, while the genetic advance and genetic advance as percentage of mean were recorded for this character were 2405.79 and 134.17 respectively.

Rachis weight:

The selected genotypes differed significantly with respect to rachis weight. The mean value of rachis weight was 460.29 ± 15.89 g and the values varied from 72.33 g to 2308.00 g. the genotypic and phenotypic variance were 217840.68 and 218227.55 respectively. The values of GCV and PCV were found to be higher (101.40 and 101.49 respectively) but the values were more or less similar. High value of heritability (99.80%) was recorded but the values of genetic advance and genetic advance as percentage of mean were estimated higher than heritability percentage (960.63 and 208.70 % respectively) (Table 7).

Tubercles density:

The general means of tubercles density per three square centimeter was 39.21 ± 0.86 and range of variation for this character was between 17.00 and 80.33. The genotypic and phenotypic variances were recorded 153.81 and 154.98 respectively. The GCV and PCV values were 31.63 and 81.75 respectively but the variations between two parameters were, however, considerably low. The value of heritability was estimated 99.30%, however, the values of genetic advance and genetic advance estimated on the basis of percent of mean showed low values of 25.47 and 64.95% respectively (Table 7).

Stone weight:

The value of mean stone weight (per 10 in number) was 50.69 ± 1.05 which ranged from 21.17 g to 88.00 g. the genotypic and phenotypic variance were noted 287.49 and 289.22 respectively for the character (Table 7). However, there appears to be no remarkable differences between these two parameters in variability. Very close values of 33.45 and 33.55 for GCV and PCV respectively were recorded while high heritability of 99.40 per cent was recorded. The genetic advance value of 34.84 was considerably low in magnitude. The value of genetic advance as percentage of mean was estimated as 68.73%.

Number of stones:

The general mean of stone numbers was estimated 105.60 ± 2.25. The range of variation in this character was recorded 11.00 to 397.00 (Table 7). the genotypic and phenotypic variance were found 8403.63 and 8392.02 respectively. The estimates of GCV and PCV for the character were found to be 86.71 and 86.75 respectively. The variations between the two parameters were considerably low. The heritability percentage was, however, high to a greater extent being 99.90%. The genetic advance as well as genetic advance as percentage of mean were also recorded high in magnitude being 188.55 and 178.55% respectively.

Stone length:

The different genotypes showed significant differences among themselves in stone length. The general mean was 2.69 ± 0.08 cm and the values ranged from 1.90 cm to 2.10 cm (Table 7). The genotypic and phenotypic variances were more or less similar in magnitude (0.18 and 0.20 respectively). The values of GCV and PCV were noted as 16.17 and 16.65 respectively. The estimates of heritability was recorded 94.40 per cent. The genetic advance was found appreciably low (0.87) for the character but the genetic advance expressed as percentage of mean was considerably higher (32.34%).

Stone breadth:

There were significant difference among all the genotypes for the character of stone breadth (Table 7). The values of mean was 1.51 ± 0.04 cm and it ranged from 0.90 cm to 2.10 cm. The genotypic and phenotypic variance showed minimum differences (0.09 and 0.10 respectively). The extent of GCV and PCV were found to be more or less similar, the values being 20.68 and 21.02 respectively. The value of heritability for this character was as high as 96.80% but the genetic advance and genetic advance as percentage of mean were very low (0.64 and 42.38% respectively).

Stone size:

The mean value of stone size was recorded 4.10 ± 0.25 cm^2. The value of stone size varied from 2.33 cm^2 to 6.93 cm^2. The values of genotypic and phenotypic variances (1.16 and 1.26, respectively) were less but the heritability for the character was 92.60%. The GCV and PCV values were 26.37 and 27.40 respectively, however, the value of genetic advance was considerably low (2.15) and genetic advance as percentage of mean was recorded 52.43% (Table 7).

Number of flakes:

Significant difference was found with regard to number of flakes per fruit among the different genotypes (Table 7). The general mean value for this character was 108.01 ± 2.11 which ranged from 11.00 to 425.00. The values of genotypic and phenotypic variances were recorded as high as 9067.15 and 9073.32 respectively. However, a closer magnitude of GCV and PCV (88.16 and 88.19, respectively) were observed. Considerably high value of heritability (99.90%) accompanied with high value of genetic advance (196.09) were estimated. The value of genetic advance as percentage of mean was noted 181.54%.

Rind : flake ratio:

The general mean value of rind : flake ratio was noted 1.11 ± 0.12 and the values ranged between 0.19 and 5.20 (Table 7). The values of genotypic and phenotypic variance were, however, considerably low in magnitude (0.4532 and 0.4756 respectively). The values of GCV and PCV were 60.65 and 62.13, respectively, but considerably high value of heritability (95.30%) accompanied with low value of genetic advance (136) were estimated. The genetic advance as percentage of mean was recorded 122.52% for the character.

Variability studies of different biochemical characters of fruits of different genotypes:

Total Soluble Solids (TSS):

Significant difference was observed for this character among all the genotypes under study (Table 8). The general mean value of total soluble solids was recorded as 18.37 ± 0.16 ^{0}Brix which was with in the range of 9.10 ^{0}Brix to 28.00 ^{0}Brix. Although, the genotypic and phenotypic variance were low (19.38 and 19.42, respectively) but the value of heritability was as high as 99.80%. The GCV and PCV values for this character were almost similar (23.97 and 23.99, respectively). The value of genetic advance (9.06) and the genetic advance as percentage of mean were 49.31% observed to be low.

Total sugar:

The mean value for this character was recorded 15.75 ± 0.89 per cent which ranged from 7.60% to 23.60%. The genotypic and phenotypic variance were estimated 15.91 and 17.11 respectively. The GCV and PCV were observed to be 25.33 and 26.27 respectively which were also more or less similar in magnitude. A high value of heritability (92.90%) accompanied with low genetic advance (7.93) were noted for this character (Table 8). The genetic advance as percentage of mean was noted 50.34 per cent.

Titrable acidity:

There was a significant difference among the genotypes for this character (Table 8). The titrable acidity content had mean value of 0.26 ± 0.0064% which ranged between 0.11% and 0.53%. Both the genotypic and phenotypic variances were considerably very low (0.0093). The values for GCV and PCV were found to

Table 8. Variability in chemical composition of fruit among different selected genotypes

Sl. No.	Character	General mean	Range	Variance		Coefficient of variation		Heritability per cent (Broad sense)	Genetic advance	Genetic advance as percentage of mean
				Genotypic	Phenotypic	Genotypic	Phenotypic			
1.	Total soluble solids (°Brix)	18.37 ± 0.16	9.10 – 28.00	19.38	19.42	23.97	23.99	99.80	9.06	49.31
2.	Total sugar (%)	15.75 ± 0.89	7.60 – 23.60	15.91	17.11	25.33	26.27	92.90	7.93	50.34
3.	Titrable acidity (%)	0.26 ± 0.0064	0.11 – 0.53	0.0093	0.0093	37.12	37.24	99.30	0.20	76.92
4.	Vitamin C (mg/100g)	7.16 ± 0.11	4.45 – 11.11	3.0072	3.0271	24.22	24.30	99.40	3.57	49.86
5.	TSS : acid ratio	80.99 ± 2.97	29.69 – 173.85	1431.14	1444.03	46.71	46.92	99.10	77.57	95.77

be 37.12 and 37.24 respectively which were also more or less same. The character had heritability value of 99.30% with very low genetic advance (0.20). The genetic advance as percentage of mean was recorded 76.92% for the character.

Vitamin C:

The genotypes under study with regard to vitamin C content was found to differ significantly among the character. The general mean for this character was 7.16 ± 0.11 mg per 100 g of juice, with the range of variation were 4.45 mg to 11.11 mg per 100 g. Very low genotypic (3.0072) and phenotypic (3.0271) variances with about similar magnitude of GCV (24.22) and PCV (24.30) were noted for this character. The heritability (99.40%) was found to be very high along with very low genetic advance (3.57). The genetic advance as percentage of mean was also moderately good (49.86%).

TSS : acid ratio:

A significant difference was noted for this character (Table 8). The TSS : acid ratio had general mean value of 80.99 ± 2.97 which ranged from 29.69 to 173.85. Genotypic and phenotypic variances were observed as 1431.14 and 1444.03 respectively. The GCV and PCV values were 46.71 and 46.92 respectively with more or less similar magnitude. High heritability (99.10%) with a fairly good genetic advance (77.57) and genetic advance as percentage of mean of 95.77% were estimated.

Correlation studies:

Genotypic correlation coefficient among different fruit characters:

Genotypic correlation coefficient among the fifteen fruit characters under study during the period of investigation was presented in Table 9. It was found that spine density showed significant and positive correlation with TSS (0.312), followed by total sugar (0.283) and stone weight which was although significant but negative correlation was observed (-0.222). Stone weight showed positive and

Table 9. Genotypic correlation coefficient among different fruit characters

Sl. No.	Character	Spine density	Stone weight	Number of stones	Weight of edible part	Rind weight	Rind : flake ratio	Rachis weight	Number of flakes	Fruit yield/tree	Fruit weight	TSS	Total sugar	Titrable acidity	Vitamin C	TSS : acid ratio
1.	Spine density	1.000														
2.	Stone weight	-0.222*	1.000													
3.	Number of stones	0.141	-0.354**	1.000												
4.	Weight of edible part	0.046	0.137	0.594**	1.000											
5.	Rind weight	0.107	0.234**	0.567**	0.940**	1.000										
6.	Rind/flake ratio	0.055	0.349**	-0.192*	-0.284**	-0.105	1.000									
7.	Rachis weight	0.008	0.143	0.470**	0.794**	0.785**	-0.173*	1.000								
8.	Number of flakes	0.130	-0.354**	0.999**	0.597**	0.566**	-0.192*	0.468**	1.000							
9.	Fruit yield/tree	-0.109	0.301**	-0.167	-0.234**	-0.179*	0.776**	-0.127	-0.167	1.000						
10.	Fruit weight	0.083	0.177**	0.625**	0.980**	0.976**	-0.203*	0.851**	0.625**	-0.200*	1.000					
11.	TSS	0.312**	-0.214	-0.150	-0.234**	-0.250**	-0.134	-0.278**	-0.142	-0.231**	0.261**	1.000				
12.	Total sugar	0.283**	-0.249**	-0.110	-0.250**	-0.262**	-0.129	-0.268**	-0.101	-0.232**	-0.269**	0.985**	1.000			
13.	Titrable acidity	0.016	0.332**	-0.024	0.099	0.087	0.023	0.296**	-0.026	-0.175*	0.139	-0.220*	-0.259**	1.000		
14.	Vitamin 'C'	-0.109	-0.154	0.298**	0.253**	0.148	-0.259**	-0.111	0.311**	-0.142	0.167	0.215*	0.231**	-0.183*	1.000	
15.	TSS : acid ratio	0.103	-0.296	-0.117	-0.209**	-0.210*	-0.078	-0.328**	0.111	-0.201*	-0.246**	0.657**	0.669**	-0.787	0.227**	1.000

* and ** significant at P = 0.05 and P = 0.01 respectively

significant association with rind weight (0.234), rind/flake ratio (0.349), fruit yield/tree (0.301) and titrable acidity (0.332) followed by fruit weight (0.177). But stone weight had negative and significant correlation with stone numbers (-0.354), flake numbers (-0.354), TSS (-0.214), total sugar (-0.249) and TSS/acid ratio (-0.296).

Stone numbers also showed significant and very high positive correlation with number of flakes (0.999) followed by weight of fruit (0.625), weight of edible part (0.594) and rind weight (0.567). Vitamin C and rachis weight also showed significant positive correlation (0.298 and 0.470, respectively) with the number of stones. All other characters exhibited negative correlation with number of stones. Weight of edible part showed very high positive significant correlation with fruit weight (0.980) and rind weight (0.940) followed by rachis weight (0.794) and number of flakes (0.597). Rind/flake ratio (-0.284), fruit yield/tree (-0.234), TSS (-0.234), total sugar (-0.250) and TSS : acid ratio were, however, showed negative correlation with weight of edible part except vitamin C content (0.253). The rind weight showed significant and positive correlation with the fruit weight (0.976) followed by rachis weight (0.785) and number of flakes (0.566) but other characters showed negative correlation with the rind weight.

Fruit weight showed significant and negative correlation with TSS (-0.261), total sugar (-0.269) and TSS/acid ratio (-0.246) but titrable acidity and vitamin C (0.139 and 0.167) showed non-significant and positive correlation. Flake numbers per fruit showed significant and very high positive correlation with the fruit weight (0.625) followed by vitamin C (0.311). Others characters were non-significant but negatively correlated with flake numbers. The rachis weight had significant and highly positive correlation with fruit weight (0.851) followed by flake numbers (0.468) and titrable acidity (0.296). The TSS, total sugar and TSS : acid ratio were negatively correlated with rachis weight. It was also observed that TSS content of fruit had significant and very high positive correlation with total sugar (0.985) followed by TSS : acid ratio (0.657). Vitamin C showed positive and significant correlation with TSS : acid ratio (0.227) but titrable acidity showed negative

Table 10. Phenotypic correlation coefficient among different fruit characters

Sl. No.	Character	Spine density	Stone weight	Number of stones	Weight of edible part	Rind weight	Rind : flake ratio	Rachis weight	Number of flakes	Fruit yield/tree	Fruit weight	TSS	Total sugar	Titrable acidity	Vitamin 'C'	TSS : acid ratio
1.	Spine density	1.000														
2.	Stone weight	-0.220*	1.000													
3.	Number of stones	0.141	-0.353**	1.000												
4.	Weight of edible part	0.046	0.135	0.592**	1.000											
5.	Rind weight	0.105	0.233**	0.562**	0.924**	1.000										
6.	Rind/flake ratio	0.055	0.342**	-0.187*	-0.285**	-0.079	1.000									
7.	Rachis weight	0.009	0.142	0.470**	0.792**	0.777**	-0.168	1.000								
8.	Number of flakes	0.130	-0.353**	0.999**	0.595**	0.561**	-0.187*	0.467**	1.000							
9.	Fruit yield/tree	-0.108	0.300**	-0.167	-0.233**	-0.178*	0.759**	-0.127	-0.167	1.000						
10.	Fruit weight	0.082	0.176*	0.624**	0.977**	0.971**	-0.193*	0.850**	0.624**	-0.199*	1.000					
11.	TSS	0.310**	-0.213*	-0.149	-0.233**	-0.248**	-0.132	-0.278**	-0.142	-0.230**	-0.260**	1.000				
12.	Total sugar	0.271**	-0.240**	-0.103	-0.240**	-0.247**	-0.109	-0.259**	-0.096	-0.222*	-0.257**	0.951**	1.000			
13.	Titrable acidity	0.016	0.330**	-0.024	0.099	0.087	0.023	0.295**	-0.026	0.174*	0.140	-0.218*	-0.249**	1.000		
14.	Vitamin 'C'	-0.109	-0.153	0.297**	0.252**	0.142	-0.260**	-0.111	0.310**	-0.143	0.165	0.214*	0.222*	-0.183*	1.000	
15.	TSS : acid ratio	0.102	-0.294	-0.116	-0.207	-0.206*	-0.075	-0.327**	-0.110	-0.200*	-0.244**	0.654**	0.646**	-0.786**	0.227**	1.000

* and ** significant at P = 0.05 and P = 0.01 respectively

correlation with vitamin C (-0.183) and TSS : acid ratio (-0.787). The total sugar content of fruit was highly significant and showed positive correlation with the TSS : acid ratio (0.669) however, it showed negative correlation with the titrable acidity (-0.259).

Phenotypic correlation co-efficient among different fruit characters:

The weight of edible part showed highly significant, positive phenotypic correlation with rind weight (0.924) and fruit weight (0.977) followed by rachis weight (0.792) and number of flakes (0.595) and it showed negative correlation with rind/flake ratio (-0.285), fruit yield (-0.233), TSS (-0.233), total sugar (-0.240) and TSS : acid ratio (-0.207). The TSS showed significant and positive correlation co-efficient with total sugar (0.951) followed by TSS : acid ratio (0.654). Vitamin C had positive correlation coefficient with TSS, but titrable acidity (-0.249) showed, negative correlation with total sugar. Fruit weight was negatively correlated with total soluble solids (-0.260), total sugar (-0.257) and TSS : acid ratio (-0.244) while other characters were non-significant but positively correlated with fruit weight (Table 10).

Stone weight exhibited positive and significant correlation with rind weight (0.233), rind/flake ratio (0.342), fruit yield/tree (0.300) and titrable acidity (0.330) content of fruit. The other characters were, however, negatively correlated and weight of edible part, rachis weight and vitamin C were non-significant with stone weight. Stone numbers per fruit showed highly significant, positive and strong correlation with number of flakes (0.999). Stone numbers also had positive, significant correlation with fruit weight (0.624), rind weight (0.562) and weight of edible part (0.592). Fruit yield per tree, however, showed negative correlation with TSS (-0.230), total sugar (-0.222), TSS : acid ratio (-0.200) and fruit weight (-0.199).

Number of flakes per fruit was found to have positive and significant correlation with fruit weight (0.624) followed by vitamin C (0.310) while other characters were negatively correlated but non-significant with number of flakes. The phenotypic correlation coefficients were found positive and significant correlation between vitamin C and TSS : acidity ratio (0.277). However, titrable acidity was found negative correlation with TSS : acid ratio (-0.786) and vitamin C (-0.183). Rind weight of fruit was significant and positively correlated with fruit weight (0.971) followed by rachis weight (0.777) but other characters mostly showed significant and negative correlation.

Path co-efficient analysis:

Genotypic path coefficient of different fruit characters for fruit weight:

Genotypic path co-efficient analysis of different fruit characters in relation to fruit weight showed that stone numbers had the maximum high positive direct effect (0.490) among the different characters, while the positive indirect effect was observed with weight of edible part (0.273), rind weight (0.214), rachis weight (0.066), TSS (0.005) and spine density (0.002) in relation to fruit weight, which was genotypically correlated with the stone numbers (0.625). Among the different components of fruit, stone numbers showed highly positive direct effect on fruit weight followed by weight of edible part (0.459) and rind weight (0.377) which was found to be genotypically highly correlated with fruit weight (0.980 and 0.976 respectively). The other direct effects of fruit components like spine density (0.014), stone weight (0.038), rachis weight (0.140), flake numbers (-0.406), fruit yield per tree (0.004), and fruit quality parameters like TSS (-0.032), total sugar (0.024), titrable acidity (0.021) vitamin C (-0.003) and TSS : acid ratio (0.019) were considerably low (Table 12). However, the positive indirect effects through stone numbers was seen only for number of flakes (0.489) followed by weight of edible part (0.291), rind weight (0.277), and rachis weight (0.230) which contributes towards fruit weight. The indirect effects of TSS (-0.073) through stone numbers influencing towards fruit weight was only (-0.261) and was negative in nature. The effect of residual factor over fruit weight was however, negligible (0.0013).

Table 11. Phenotypic path coefficient analysis of different fruit characters for fruit weight

Sl. No.	Character	Spine density	Stone weight	Number of stones	Weight of edible part	Rind weight	Rind : flake ratio	Rachis weight	Number of flakes	Fruit yield/tree	TSS	Total sugar	Titrable acidity	Vitamin 'C'	TSS : acid ratio	Phenotypic correlation with fruit weight
1.	Spine density	**0.014**	-0.008	0.064	0.021	0.040	-0.001	0.001	-0.048	0.000	-0.004	0.002	0.000	0.000	0.002	0.082
2.	Stone weight	-0.003	**0.038**	-0.159	0.061	0.090	-0.004	0.020	0.129	0.001	0.003	-0.002	0.006	0.000	-0.005	0.176*
3.	Number of stones	0.002	-0.013	**0.451**	0.267	0.216	0.002	0.067	0.366	-0.001	0.002	-0.001	0.000	-0.001	-0.002	0.624**
4.	Weight of edible part	0.001	0.005	0.267	**0.451**	0.356	0.003	0.113	-0.218	-0.001	0.003	-0.002	0.002	0.000	-0.004	0.977**
5.	Rind weight	0.001	0.009	0.253	0.416	**0.385**	0.001	0.111	-0.206	-0.001	0.003	-0.002	0.002	0.000	-0.004	0.971**
6.	Rind/flake ratio	0.001	0.013	-0.084	-0.128	-0.031	**-0.011**	-0.024	0.069	0.003	0.002	-0.001	0.000	0.000	-0.001	-0.193*
7.	Rachis weight	0.000	0.005	0.212	0.357	0.299	0.002	**0.143**	-0.171	0.000	0.004	-0.002	0.006	0.000	-0.006	0.850**
8.	Number of flakes	0.002	-0.013	0.451	0.268	0.216	0.002	0.067	**-0.366**	-0.001	0.002	-0.001	0.000	-0.001	-0.002	0.624**
9.	Fruit yield/tree	-0.001	0.011	-0.075	-0.105	-0.068	-0.009	-0.018	0.061	**0.003**	0.003	-0.001	0.003	0.000	-0.003	-0.199*
10.	TSS	0.004	-0.008	-0.067	-0.105	-0.096	0.002	-0.040	0.052	-0.001	**-0.014**	0.006	-0.004	0.000	0.011	-0.260**
11.	Total sugar	0.004	-0.009	-0.047	-0.108	-0.095	0.001	-0.037	0.035	-0.001	-0.013	**0.007**	-0.005	0.000	0.011	-0.257**
12.	Titrable acidity	0.000	0.012	-0.011	0.045	0.034	0.000	0.042	0.010	0.001	0.003	-0.002	**0.019**	0.000	-0.013	0.140
13.	Vitamin C	-0.001	-0.006	0.134	0.114	0.055	0.003	-0.016	-0.114	0.000	-0.003	0.001	-0.003	**-0.002**	0.004	0.165
14.	TSS : acid ratio	0.001	-0.011	-0.052	-0.093	-0.080	0.001	-0.047	0.040	-0.001	-0.009	0.004	-0.015	0.000	**0.017**	-0.244**

Residual effect = 0.0014, Diagonal values are direct effects; * and ** significant at P = 0.05 and P = 0.01 respectively.

Table 12. Genotypic path coefficient analysis of different fruit characters for fruit weight

Sl. No.	Character	Spine density	Stone weight	Number of stones	Weight of edible part	Rind weight	Rind : flake ratio	Rachis weight	Number of flakes	Fruit yield/tree	TSS	Total sugar	Titrable acidity	Vitamin C	TSS : acid ratio	Genotypic correlation with fruit weight
1.	Spine density	**0.014**	-0.009	0.069	0.021	0.040	-0.001	0.001	-0.053	0.000	-0.010	0.007	0.000	0.000	0.002	0.083
2.	Stone weight	0.003	**0.038**	-0.173	0.063	0.088	-0.004	0.020	0.144	0.001	0.007	-0.006	0.007	0.000	-0.006	0.177*
3.	Number of stones	0.002	-0.014	**0.490**	0.273	0.214	0.002	0.066	-0.405	-0.001	0.005	-0.003	-0.001	-0.001	-0.002	0.625**
4.	Weight of edible part	0.001	0.005	0.291	**0.459**	0.355	0.003	0.111	-0.242	-0.001	0.007	-0.006	0.002	-0.001	-0.004	0.980**
5.	Rind weight	0.001	0.009	0.277	0.431	**0.377**	0.001	0.110	-0.230	-0.001	0.008	-0.006	0.002	0.000	-0.004	0.976**
6.	Rind/flake ratio	0.001	0.013	-0.094	-0.130	-0.040	**-0.011**	-0.024	0.078	0.003	0.004	-0.003	0.000	0.001	-0.001	-0.203*
7.	Rachis weight	0.000	0.005	0.230	0.365	0.296	0.002	**0.140**	0.190	0.000	0.009	-0.006	0.006	0.000	-0.006	0.851**
8.	Number of flakes	0.002	-0.014	0.489	0.274	0.213	0.002	0.066	**-0.406**	-0.001	0.005	-0.002	-0.001	-0.001	-0.002	0.625**
9.	Fruit yield/tree	-0.002	0.012	-0.082	-0.107	-0.068	-0.009	-0.018	0.068	**0.004**	0.007	-0.006	0.004	0.000	-0.004	-0.200*
10.	TSS	0.004	-0.008	-0.073	-0.108	-0.094	0.001	-0.039	0.058	-0.001	**-0.032**	0.024	-0.005	-0.001	0.013	-0.261**
11.	Total sugar	0.004	-0.010	-0.054	-0.114	-0.099	0.001	-0.038	0.041	-0.001	-0.031	**0.024**	-0.005	-0.001	0.013	-0.269**
12.	Titrable acidity	0.000	0.013	-0.012	0.046	0.033	0.000	0.041	0.011	0.001	0.007	-0.006	**0.021**	0.001	-0.015	0.139
13.	Vitamin C	-0.002	-0.006	0.146	0.116	0.056	0.003	-0.016	-0.126	-0.001	-0.007	0.006	-0.004	**-0.003**	0.004	0.167
14.	TSS : acid ratio	0.001	-0.011	-0.057	-0.096	-0.079	0.001	-0.046	0.045	-0.001	-0.021	0.016	-0.017	-0.001	**0.019**	-0.246**

Residual effect = 0.0013, Diagonal values are direct effects; * and ** significant at P = 0.05 and P = 0.01 respectively.

Phenotypic path co-efficient analysis of different fruit characters for fruit weight:

Among the different components of fruit, number of stones (0.451) and weight of edible part (0.451) showed high positive direct effect on fruit weight followed by rind weight (0.385), whereas, spine density (0.014), stone weight (0.038), rachis weight (0.143), titrable acidity (0.019), TSS : acid ratio (0.017), total sugar (0.007) and fruit yield per tree (0.003) showed very low values of positive direct effects, yet, rind : flake ratio (-0.011), flake numbers (-0.036), TSS (-0.014) and vitamin C (-0.002) showed negative direct effects. Weight of edible part (0.267 and 0.267), rind weight (0.253 and 0.416), rachis weight (0.212 and 0.347), number of flakes (0.451 and 0.268), vitamin C (0.134 and 0.114) exerted positive indirect effects through number of stones and weight of edible part, respectively. The TSS (-0.014) showed negative indirect effects via number of stones (-0.067) and weight of edible part (-0.105). The indirect effects of other characters were either positive or negative in nature but had very negligible values (Table 11). The residual effect on fruit weight was also negligible (0.0014).

Genetic divergence:

The 44 genotypes selected were grouped into 13 clusters (Table 13). The clusters VI consisted of largest number of eight genotypes followed by the cluster III, which included seven genotypes but clusters VII, VIII and X had only five genotypes each. On the other hand cluster II included three, cluster I, IV, V and IX contained two and XI, XII and XIII had only one genotypes each.

Intra and inter cluster D^2 values showed that the intra cluster distance was zero for cluster (I, IV, V); (XI, XII and XIII) as they consisted of double and single genotypes respectively. Average values of intra cluster distance was highest in cluster X (172.728) and lowest in cluster IX (71.745). However, maximum values of inter cluster distance was observed between cluster III and IV (14319.137) followed by cluster 2 and 4 (11744.343) and cluster I and IV (10335.649). Minimum values of inter cluster divergence was recorded between clusters I and II (153.511) followed by those between clusters XI and X (218.117) (Table 14).

Table 13. Clustering pattern of 44 genotypes

Cluster	Number of genotypes	Name of genotypes	Source of genotypes
I	2	T_{6}, T_{30}	24-Pargana (S)
			24-Pargana (S)
II	3	T_{34}, T_{33}, T_{40}	Nadia
			24-Pargana (S)
			Coochbehar
III	7	T_{7}, T_{8}, T_{11}, T_{31}, T_{20},	24-Pargana (N)
		T_{12}, T_{9}	Nadia
			24-Pargana (N)
			24-Pargana (S)
			Nadia
			Nadia
			Nadia
IV	2	T_{32}, T_{38}	24-Pargana (S)
			Coochbehar
V	2	T_{36}, T_{26}	Coochbehar
			Nadia
VI	8	T_{42}, T_{3}, T_{2}, T_{16}, T_{17},	Midnapore
		T_{44}, T_{25}, T_{23}	Nadia
			Nadia
			24-Pargana (N)
			24-Pargana (N)
			24-Pargana (N)
			Nadia
			Nadia
VII	5	T_{27}, T_{4}, T_{29},	Purulia
		T_{24}, T_{1}	Nadia
			Nadia
			Nadia
			Nadia
VIII	5	T_{39}, T_{43}, T_{15}	Coochbehar
		T_{37}, T_{13}	24-Pargana (N)
			24-Pargana (N)
			Coochbehar
IX	2	T_{18}, T_{10}	Nadia
			Nadia
X	5	T_{5}, T_{28}, T_{19}, T_{21}, T_{14}	Nadia
			Nadia
			Nadia
			Nadia
			Nadia
			24-Pargana (N)
XI	1	T_{35}	Nadia
XII	1	T_{22}	Nadia
XIII	1	T_{41}	Coochbehar

Table 14. Intra and inter clusters average distances (D^2) values

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I	0.000												
II	153.511	140.387											
III	1996.678	1643.876	128.204										
IV	10355.649	11744.343	14319.137	0.000									
V	1606.478	1677.514	1655.404	2550.776	0.000								
VI	2025.669	1909.498	1441.182	1927.271	1788.833	95.561							
VII	5923.848	5033.173	2212.352	6653.759	2085.644	1094.043	117.699						
VIII	1753.841	1508.087	588.748	1941.951	1488.163	549.586	1633.091	84.878					
IX	1827.616	1534.729	374.016	2086.189	1528.126	767.459	1853.573	240.306	71.745				
X	1785.498	1815.272	1668.476	1534.108	1746.294	559.376	563.492	1090.542	1311.012	172.728			
XI	1810.065	1848.304	1727.856	1538.679	1781.546	631.323	532.701	1149.853	1370.247	218.117	0.000		
XII	1723.519	1705.203	1455.783	1559.931	1641.771	344.153	764.126	877.920	1098.383	249.729	345.006	0.000	
XIII	1703.899	18512.707	804.736	1813.847	1479.762	334.220	1414.803	231.995	449.957	874.585	938.317	658.674	0.000

Figure 1. Flowering time of different selected jackfruit genotypes

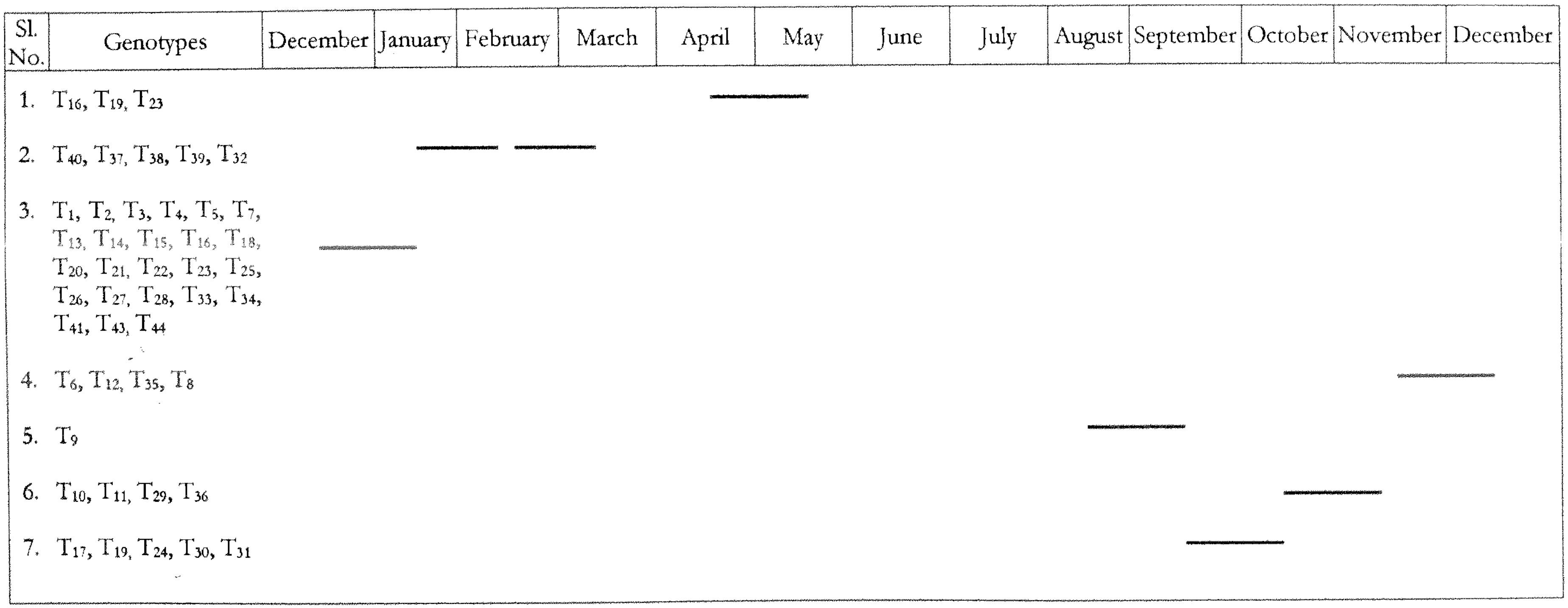
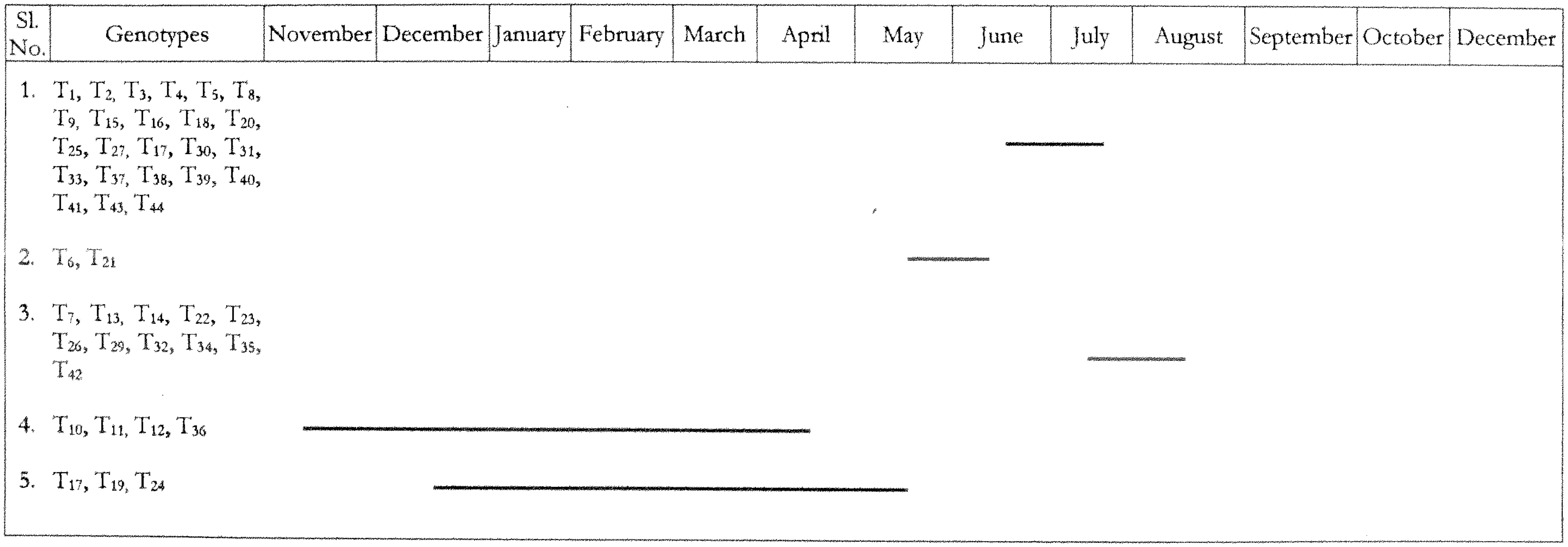


Figure 2. Harvesting time of different jackfruit genotypes



LEAF BASE SHAPE

Fig. No. 3

LEAF APEX SHAPE

Fig. No. 4

LEAF BLADE SHAPE

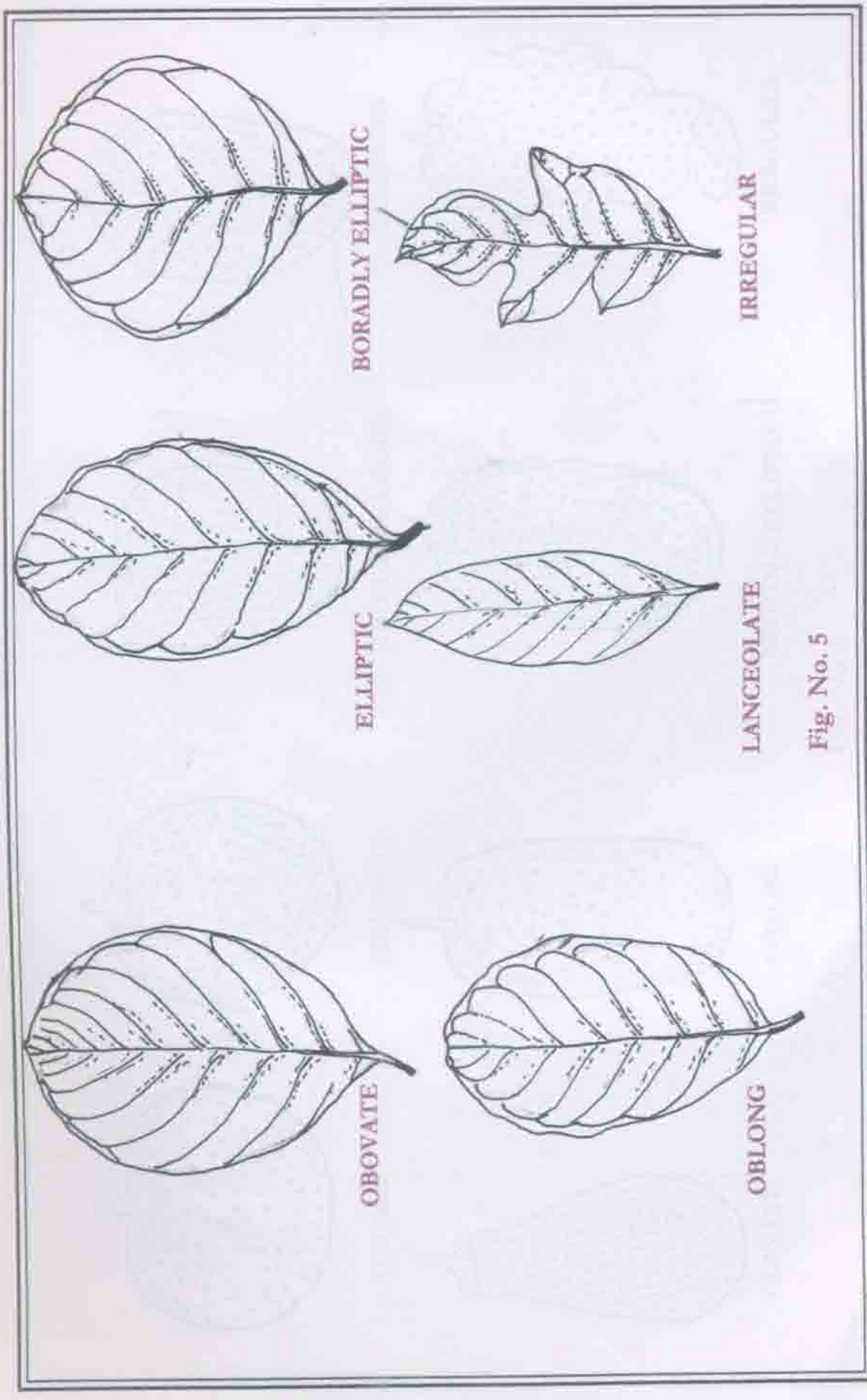


Fig. No. 5

FRUIT SHAPE

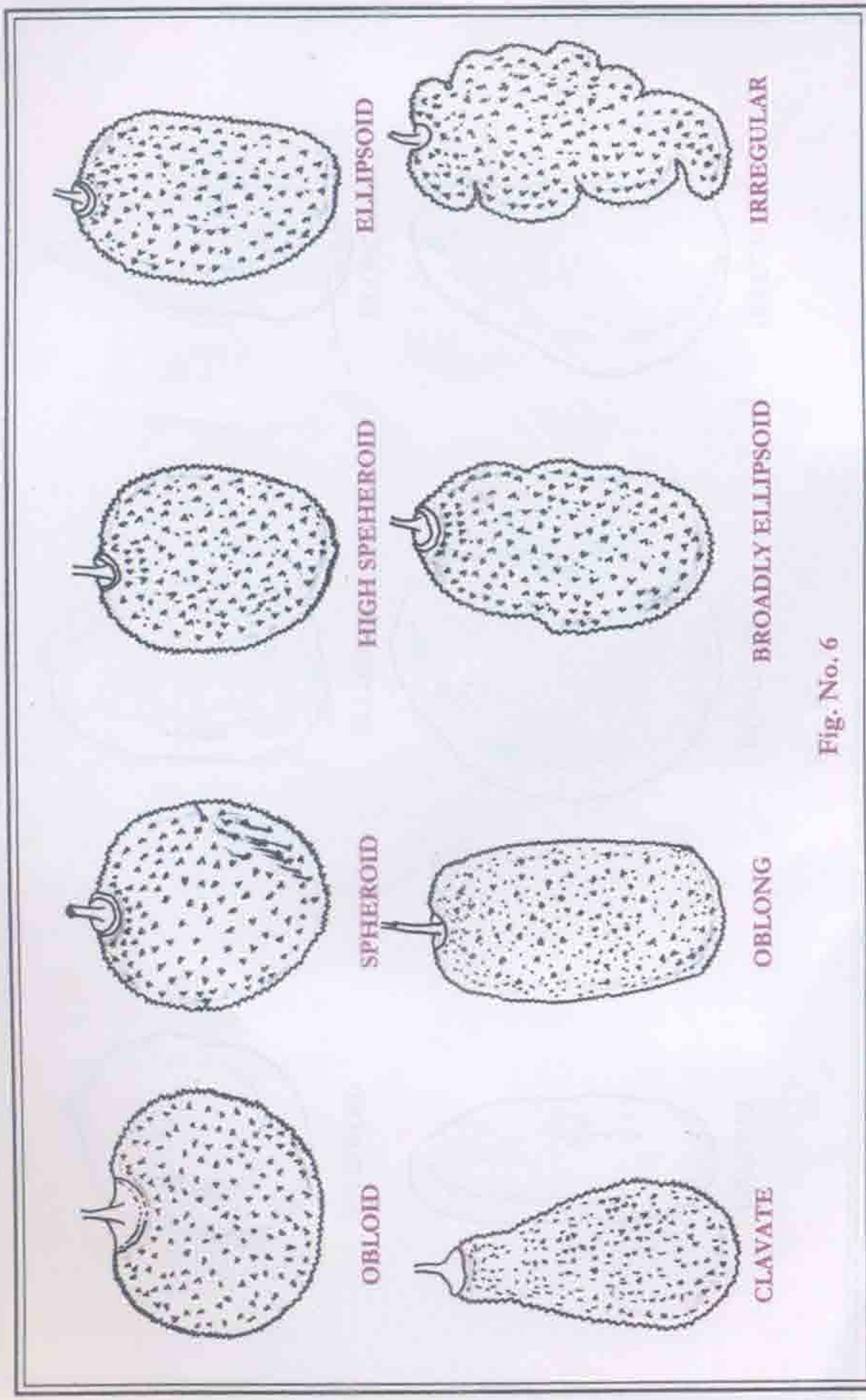


Fig. No. 6

SEED SHAPE

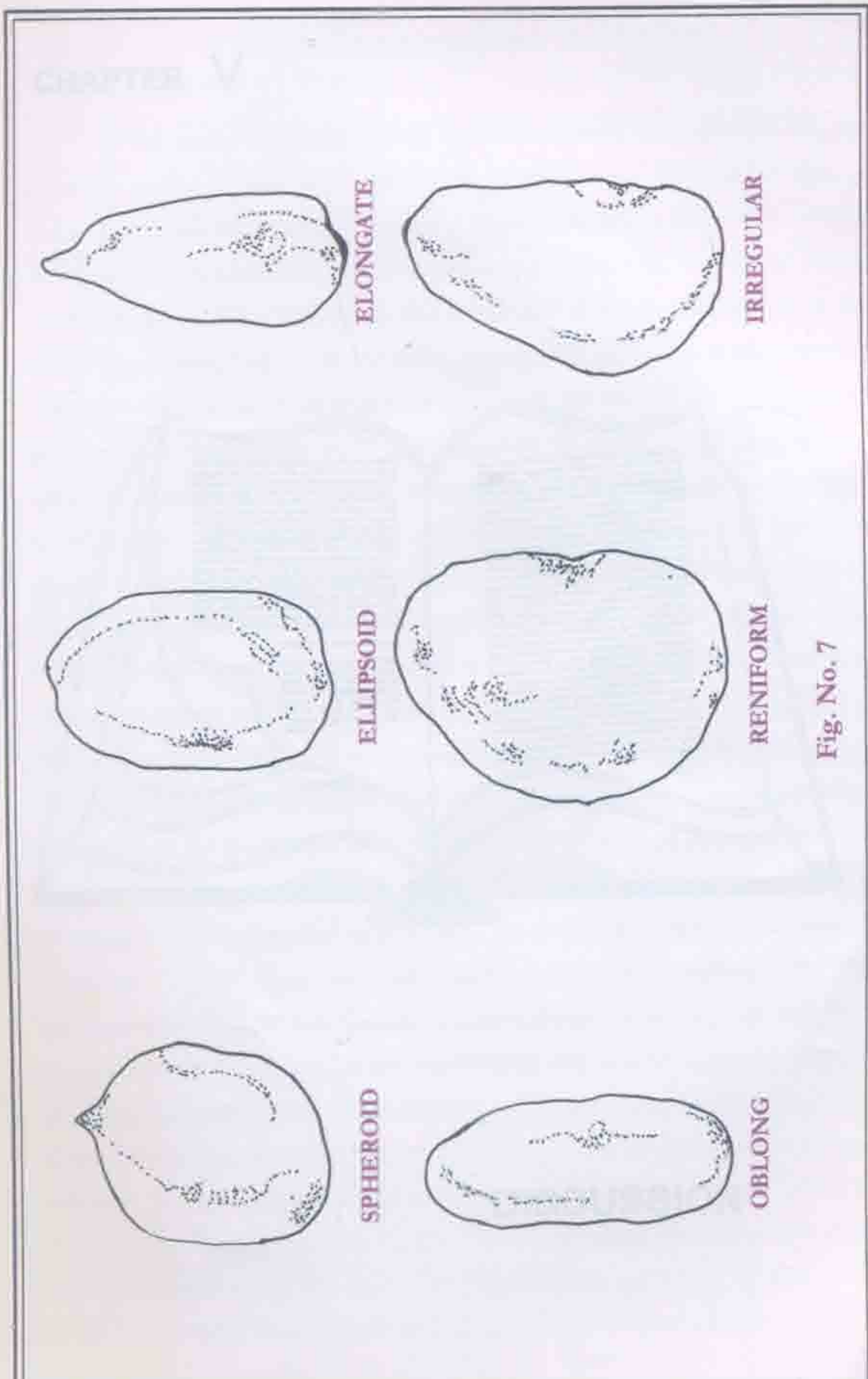
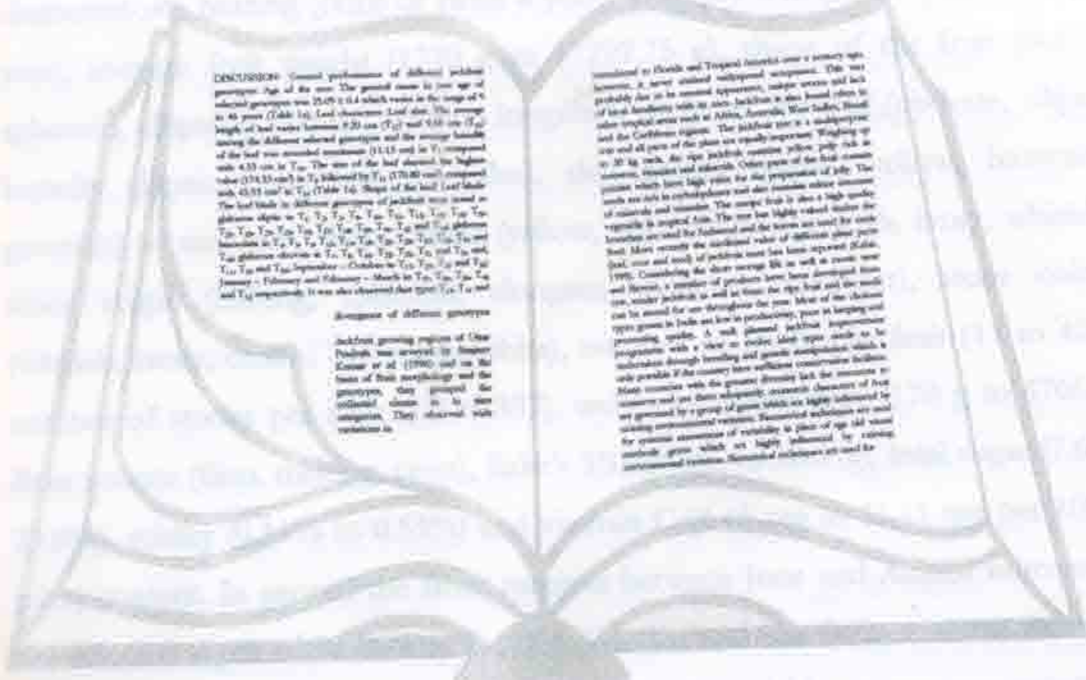


Fig. No. 7

CHAPTER V



DISCUSSION

DISCUSSION

In the present investigation, 44 types of jackfruit were selected. All the types are regular in bearing. However, the different types differ widely among themselves in tree characters, leaf size, leaf shape, fruit weight, fruit shape, colour, flowering and maturity time, yield, spine density in the rind, number of flakes, texture of flakes, stone size, shape and colour and chemical composition of the flakes. It appears that great variability exists with regard to many desirable characters *viz.* bearing (once or twice a year), yield per tree (15 to 1450 fruits per year), average fruit weight (1220 g to 17299.75 g), shape of the fruit (obloid, spheroid, ellipsoid, clavate, oblong, irregular), shape of the leaf (obovate, elliptic, broadly elliptic, lanceolate, irregular), skin colour (green, yellow, brownish, greenish) at maturity, flake colour (yellow, light-yellow, pinkish, ivory, whitish), stone shape (oblong, spheroid, elongate, reniform, irregular), stone colour (whitish, ivory, cream, brownish, white), number of flakes per fruit (11 to 425), number of stones per fruit (11 to 397), weight of edible part (170 g to 6766 g) flake texture (firm, melting, crisp), flake's TSS (9.1% to 28.0%), total sugar (7.6 to 23.6%), acidity (0.11% to 0.53%) and vitamin C (4.45 mg to 11.11 mg per 100 g juice) content. In general the fruits matures between June and August in most of the selected types while in T_{10}, T_{11}, T_{17}, T_{19}, T_{24} and T_{36} fruits matures twice in November – December and April – May. The fruit yield per year was recorded highest in T_{23} (1450 fruits/year) which produced fruits each weighing about 1340 g compared with 17300 g in T_{14}. The T_{14} types however, produced only 50 fruits in a year. The types T_{12} and T_{43} produced round shaped fruits. The very attractive golden-yellow colour fruits was found in T_3 and T_4 types. The flakes of the fruit of T_6 was found unusual pinkish in colour which was normally found yellow to light-yellow in most of the types. Crisp flake texture was observed in fruits of T_5, T_9, T_{11}, T_{13}, T_{23}, T_{24} and T_{42}. The T_{14} types which produced the larger sized fruits (each weighing > 17 kg), also showed the highest edible part (> 6.7 kg, about 40% of the fruit weight). Stone weight, size, shape and colour showed wide variations.

The stone weight was recorded as high as 88.0 g in the fruits of T_{23} compared with about 21.0 g in the fruits of T_{30}. The fruits of T_6 which has the pinkish colour flakes, showed only 11.0 flakes per fruit compared with 425.0 flakes per fruit in T_{35}. The fruits of the types, T_{28}, T_{32}, T_{33}, T_{38}, T_{41} and T_{43} were very high in TSS and total sugar content and also showed higher TSS/acid ratio at harvest. The vitamin C content of fruit was comparatively higher in fruits of T_1, T_{33}, T_{35}, T_{36}, T_{37}, T_{39}, T_{42} and T_{43}.

Hossain and Haque (1977), Guruprasad and Thimaraju (1989), Sanjeeb Kumar *et al.* (1996), Alagiapillai *et al.* (1996), Sarma *et al.* (1997), Mitra (1998), Mitra and Mani (1998), Azad and Haq (1998), Singh and Srivastava (2000) and Mitra and Maity (2000) identified superior clones of jackfruit in different agro-climatic conditions in the past on the basis of physico-chemical characters of the fruits.

Variability studies:

Variability studies of tree characters:

The size of leaf and yield/tree varied due to high genotypic and phenotypic factors than that of low genotypic and phenotypic variance values for the characters like leaf length and breadth. All the attributes showed significant differences and wide range of variation. The higher range of values were also reflected on coefficient of variation (GCV and PCV) which was recorded highest for yield/tree (213.94 and 214.15 respectively) followed by age of the tree and size of the leaf. The higher genetic variabilities in the character (yield/tree) indicated the scope for improvement in these types by selection. Nayar *et al.* (1980), Shree-Rangaswamy *et al.* (1980) and Chundawat *et al.* (1988) observed similar genetic variabilities for number of fruits in banana, Bandopadhyay *et al.* (1992) in guava and Gupta (1993) and Samanta *et al.* (1999) in mango.

High estimates of heritability (broad sense) were noted in all the recorded tree characters. Therefore, these high heritability were implicating a close contribution between genotype and phenotype due to relatively a smaller contribution of environment to the phenotype. Size of the leaf and yield/tree showed high genetic advance and genetic advance as percentage of mean. High heritability with high genetic advance determine the more reliable predicting gain for selection of these types than heritability alone (Johnson *et al.,* 1955a). Due to additive gene effects, for the characters leaf size and yield/tree, very high estimate of heritability with high genetic advance and high GCV were observed (Panse, 1957). Hence, scope for selection of these types exists for improvement of above mentioned characters. Similar results were reported in banana and mango for yield/tree as well as leaf size by Shree Rangaswamy *et al.* (1980) and Samanta *et al.* (1999) respectively.

Variability studies of different physical characters of fruit:

All the selected genotypes showed significant difference for physical characters of fruit. The estimates of general mean and range for different physical characters revealed that there was a great scope for improvement of these types by selection. Among all the desirable characters *viz.* fruit weight, weight of edible part, flake numbers, stone numbers and rind : flake ratio; very wide range of variability were observed. These results are in agreement with those of Hossain and Haque (1977), Vilasachandran *et al.* (1982), Sanjeev Kumar *et al.* (1996), Azad and Haq (1998) and Mitra and Maity (2000) in jackfruit. Among the physical characters studied, higher magnitude of genotypic and phenotypic variances were observed for fruit weight followed by weight of edible part and rind weight and rachis weight. The highest coefficients of variations (GCV and PCV) were recorded for rind weight followed by number of flakes and stones, weight of edible part and fruit weight which indicated existence of higher genetic variabilities as well as high estimates of heritability for all the recorded characters. Maximum estimates of heritability were observed for number of stones and flakes followed by other characters. Most of the characters showed a close relation between genotypes and phenotypes due to relatively smaller contribution of environment to the phenotypes. Fruit weight, weight of edible part, rind weight, rachis weight, number of flakes and stones and rind/flake ratio showed very high genetic advance and genetic advance as percentage of mean. According to Johnson *et al.*

(1955a), heritability and genetic advance determine the heritable portion of variation. They also reported that high heritability along with higher genetic advance are more reliable index. Similar results were reported by Prasad and Rao (1989) in acid lime, in litchi by Sarkar *et al.* (1991) and Mitra and Maity (2000) in jackfruit.

Variability studies on chemical composition of fruits:

Chemical composition *viz.* TSS, total sugar, titrable acidity, vitamin C as well as TSS/acid ratio showed significant variations among the selected types. The estimates of general mean and the range for above said characters showed great variations indicating presence of high heritability with respect of selection of these types. The genotypic and phenotypic variances were low but the value of heritability was high. It was found that except TSS : acid ratio and titrable acidity, other quality components of fruit showed very low genetic advance which might be due to non additive gene effects. It may be suggested that for quality improvement of jackfruit types it may not be effective but wide variation in physico-chemical compositions of fruits have wide scope for breeding to develop desirable traits (Mitra and Maity, 2000).

Correlations studies:

Phenotypic and genotypic correlation coefficient among fruit characters:

All the genotypic correlation coefficient and phenotypic correlation coefficient between various pairs of characters showed higher values in most characters than phenotypic correlation coefficient or vis-versa. Correlation of a particular character with fruit weight, either negative or positive, is considered for selection. It was observed that spine density showed significantly positive correlation with TSS followed by total sugar. However, fruit weight was found negatively correlated with TSS and total sugar in both the genotypic and phenotypic correlation coefficient.

Number of flakes per fruit also had very high positive correlation with stone numbers per fruit followed by fruit weight, weight of edible part and vitamin C content at phenotypic and genotypic level but none of the qualitative characters exhibited positive association with fruit weight. It was also observed that weight of edible part had a very high positive and significant correlation (genotypic and phenotypic) with fruit weight and rind weight followed by rachis weight and flake numbers but yield/tree depends significantly negative correlation with fruit weight and chemical composition of the fruit.

Titrable acidity had significant correlation with fruit yield/tree, stone weight and rachis weight at both the genotypic and phenotypic levels. On the contrary, TSS had significant but negative correlation with titrable acidity which indicated that the mentioned characters had complementary influence to each other to a greater extent and not a single character influence the fruit weight. Magdalita *et al.* (1984) and Ghanta and Mondal (1992) in papaya, Thimmappaiah *et al.* (1985) in guava and Shamsundram *et al.* (1993) in banana also observed similar correlation with fruit weight and other characters.

Therefore, it is concluded that improvement of jackfruit types or selection of elite superior clones may be dependent on these characters and the phenotypic expression of correlation may be reduced under the influence of environment as well as genotypic factors.

Path coefficient analysis:

Fruit weight is a product of interaction of component traits which are either positively or negatively correlated with each other. For better understanding of direct and indirect influences of various characters on variable fruit weight of different selected types would, however, emerge from the path analysis which showed that number of stones, weight of edible part and rind weight had comparatively high positive direct effect on fruit weight with significantly high positive correlation. It indicated that these characters were of great importance for variations in fruit weight among the different types. The direct effect of flake numbers was negative but showed significant positive correlation (genotype and phenotype) with fruit weight, could be due to high positive direct effect of stone numbers, weight of edible part and rind weight. The results showed that spine density, stone, weight, rachis weight, total sugar and titrable acidity had very low positive association on fruit yields. It was also found that the residual effect was only (G = 0.0013, P = 0.0014) which infer that almost equal to zero of the variability in fruit weight has been governed by the fruit weight traits covered. When correlation and path analysis are viewed together, it indicated that stone numbers and weight of edible part as well as rind weight were important characters which had maximum direct and indirect effects on fruit weight and it helps in selecting the superior genotypes.

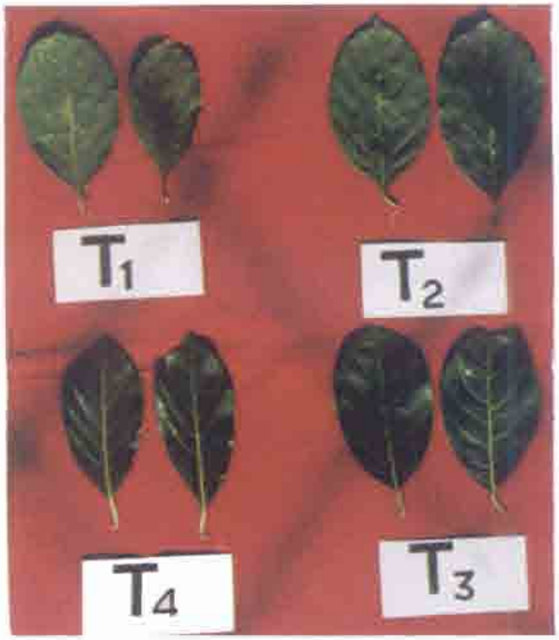
Genetic divergence:

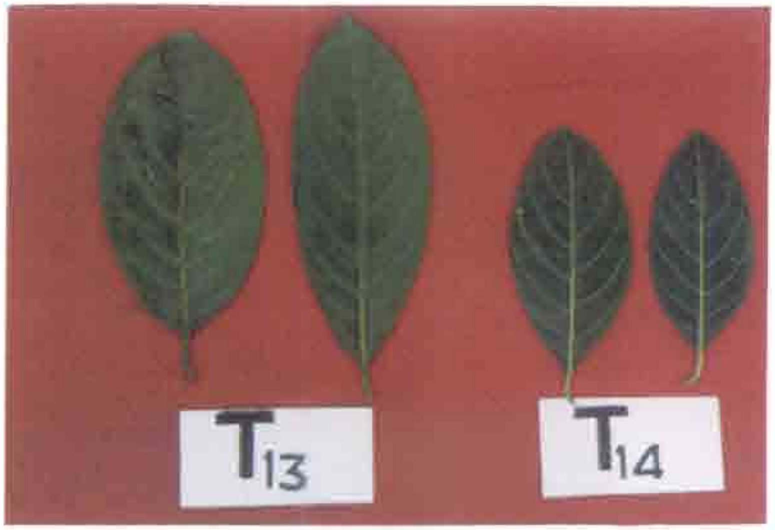
Information on the nature and degree of divergence is useful in selecting the desirable parents for a further breeding programme. Hence, the present study was undertaken to assess the amount of genetic diversity. The multivariate analysis of genetic divergence using D^2 statistics was carried out by Tocher's method as described by Roy (1952). The 44 genotypes selected were grouped into 13 clusters indicating that there exits no close correspondence between geographic diversity and genetic diversity. Single genotype in each cluster from XI to XIII was included and the maximum number of genotypes was in cluster VI (8) followed by cluster III (7) and five genotypes in each of the clusters VII, VIII, and X. The clustering pattern of genotypes also showed that the genotypes from the same area did not necessarily belong to the same cluster. The genotypes from 24 Pargana (N), 24 Pargana (S), Nadia, Coochbehar were distributed indifferent clusters whereas, the genotypes belonging to different areas were grouped in the same cluster. From the study of genetic divergence among 44 genotypes, it appear that genetic drift and natural selection under different environmental conditions could cause considerable diversity than geographical distance.

Average inter cluster distance analysis revealed maximum distance between cluster III and cluster IV followed by cluster II and IV an cluster I and cluster IV and minimum between cluster I and II followed by cluster XI and X. The intra-cluster distance ranged from zero to 172.728, the maximum being in cluster X. Those genotypes included in clusters with maximum inter cluster distance are obviously genetically more divergent. Hence, it would be logical to incorporate genotypes from these clusters in breeding programme or selection for new genotypes.

The information collected from the selected clones of jackfruit revealed that, the genotypes from the same area did not necessarily belong to the same group. On the other hand, the genotypes selected from different areas were grouped in the same cluster. It implicated that the genetic diversity was not always directly related to geographical diversity and therefore, it was not an adequate index for genetic variation. The genetic drift and natural selection under different environmental conditions within a country could cause considerable diversity than geographical distance. Jackfruit being cross pollinated and mostly seed propagated environment variability in tree as well as fruit characters were observed. Due to free exchange among the different regions of propagating materials influencing the character for a particular regions had lost their individuality and produces new genotypes effecting by the environment or by the phenotypic variation. In jackfruit, fruit weight is an important yield component. The relationship of fruit weight to its quality attributing traits is of great importance for effective selections.

LEAF SHAPE OF DIFFERENT GENOTYPES

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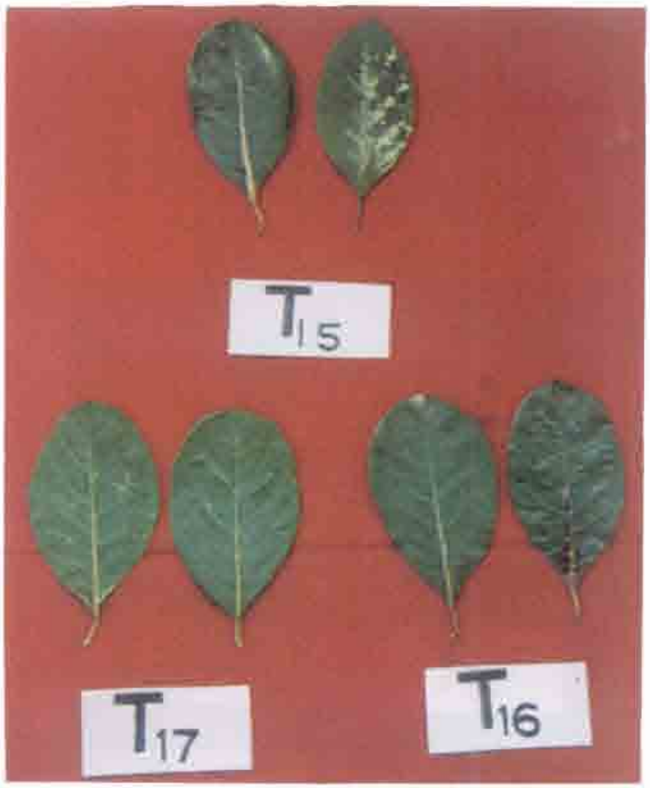
T14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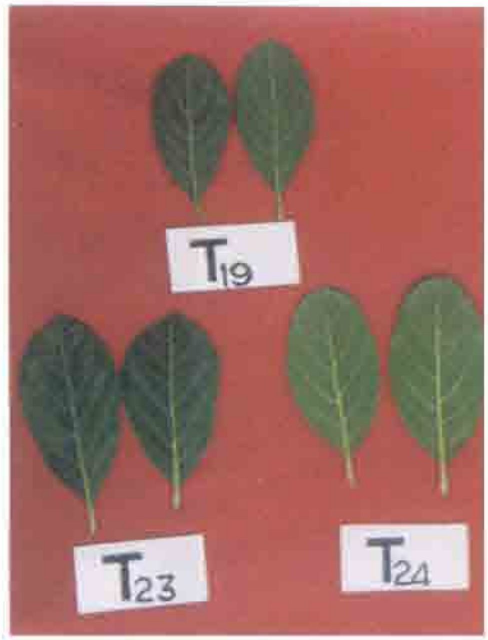
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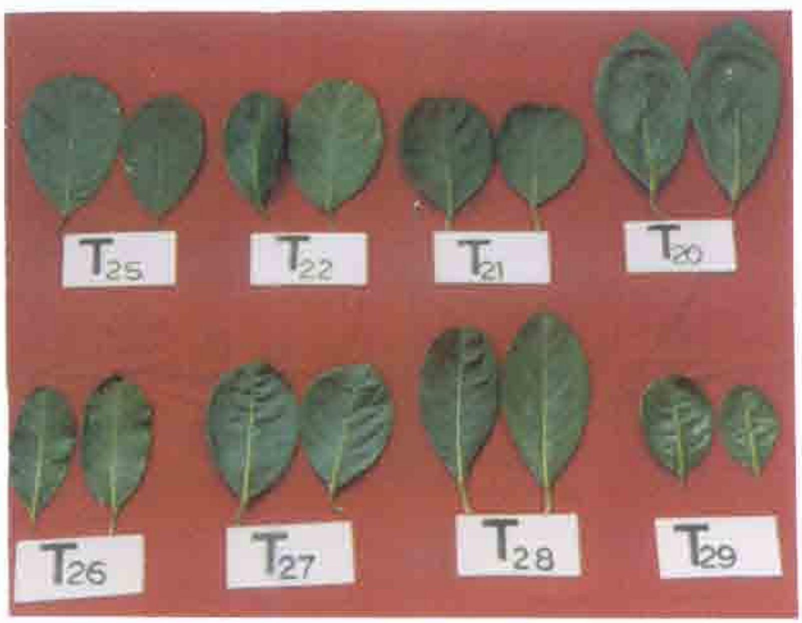
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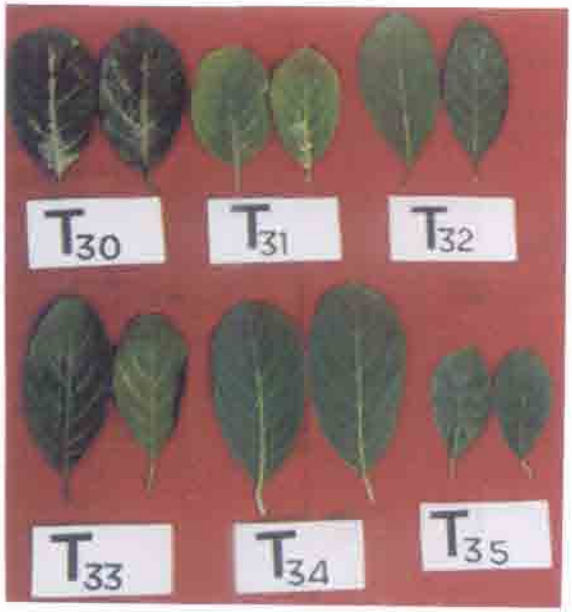
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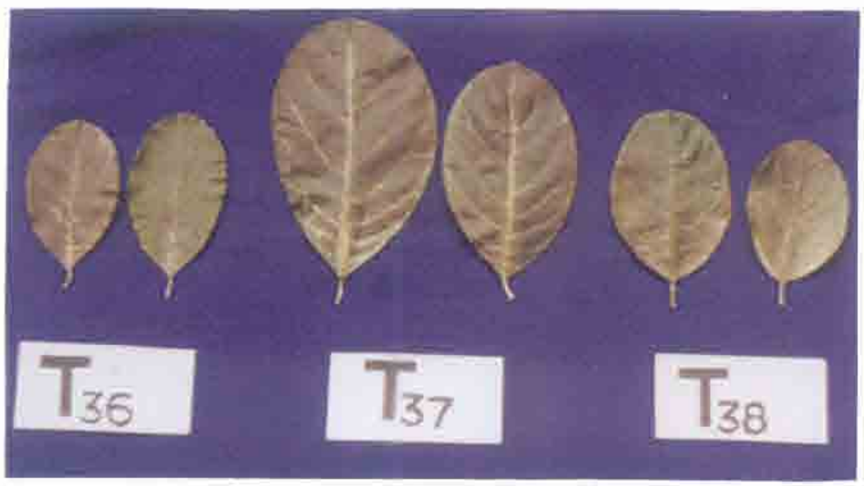
T36
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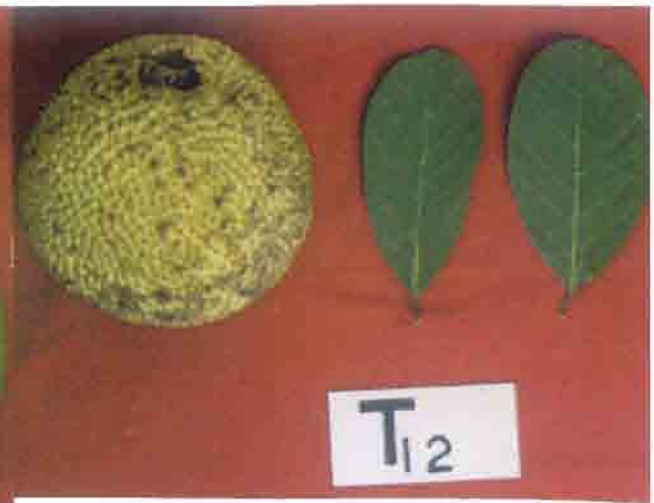
T39
T40
T41

FRUITS OF DIFFERENT SELECTED JACKFRUIT GENOTYPES

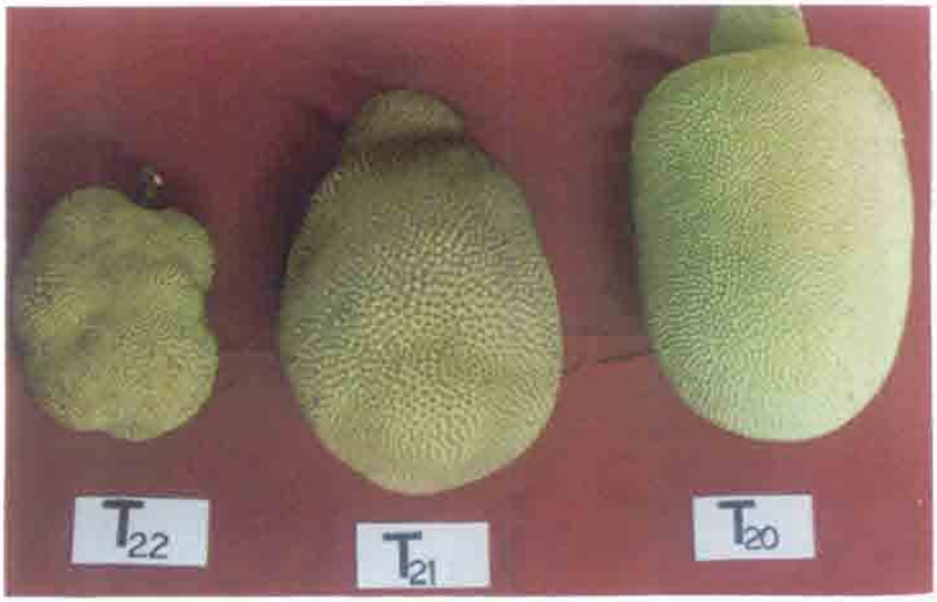

T7
T8

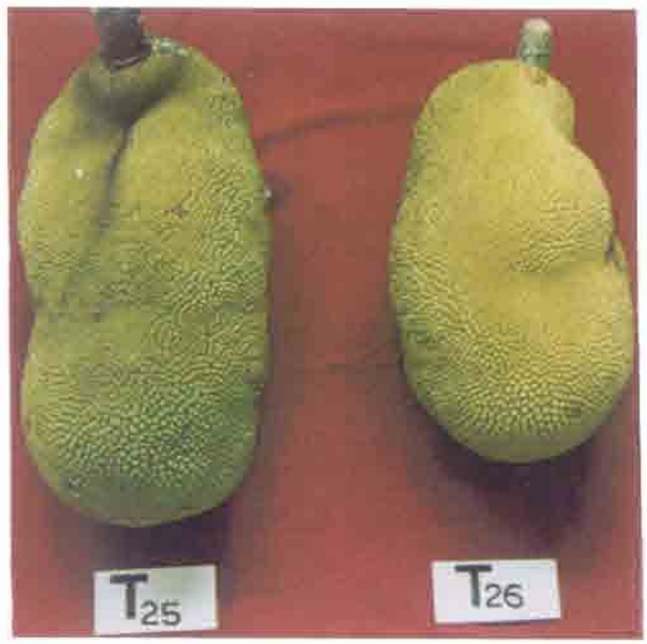

T12


T13


T14


T17
T16
T15


T_{22}
T_{21}
T_{20}


T_{25}
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STONE AND FLAKES OF SELECTED JACKFRUIT GENOTYPES

T28
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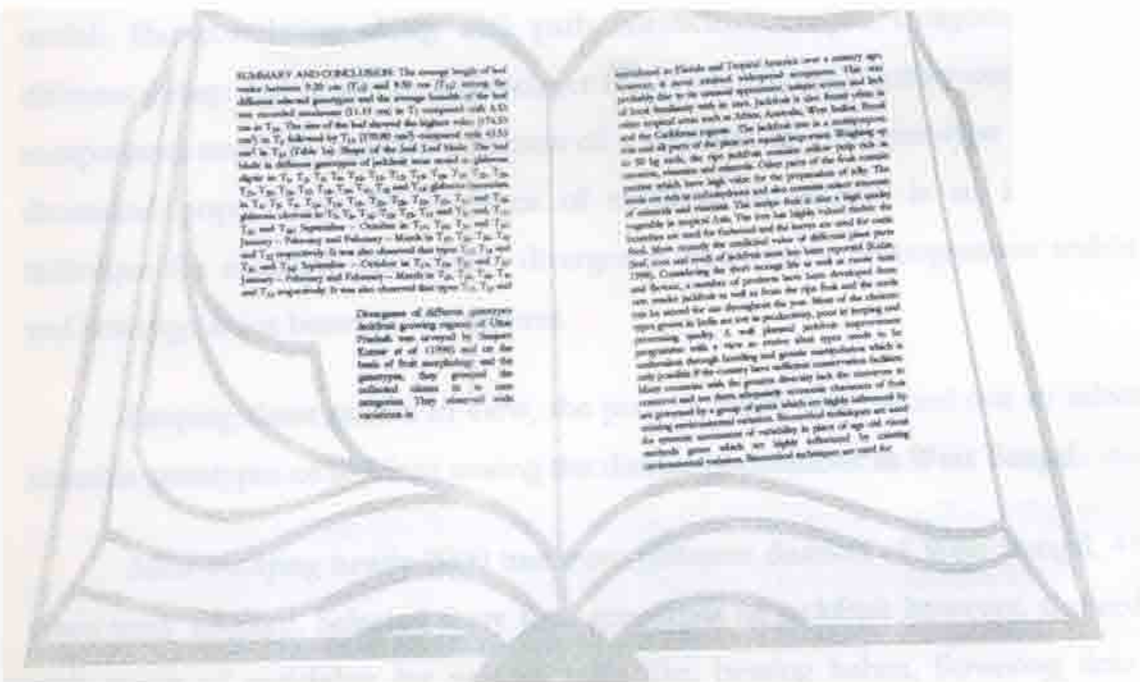
CHAPTER VI



SUMMARY AND CONCLUSION

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Jackfruit (*Artocarpus heterophyllus* Lam.) is one of the most important unusual fruit of the Moraceae family. It is a highly heterozygous, cross pollinated fruit and seedlings of this fruit tree exhibits a wide range of variations in sweetness, acidity, flavour, taste, size, shape, bearing habits, leaf shape and size, tree structure etc. To initiate any crop improvement programme, complete information on general performance of the crop in different diversified climatic conditions, genotypic variation and inter relationship in different qualitative characters are very much useful. The correlation along with path coefficient analysis catagorise into a different group due to direct and indirect effect of yield and quality contributing components towards yield for selection of a superior or elite genotype from the diversified populations. D^2 statistics of multivariate analysis is an important technique for assessing the genetic divergence which were homogeneous within and heterogeneous between the clusters.

Keeping these points in view, the present study was carried out to select superior genotypes of jackfruit among the diverse populations in West Bengal.

After studying nearly 2000 tree from different districts of West Bengal, 44 types were selected. Selected forty four genotypes of jackfruit however, showed wide range of variability for various traits like; bearing habits, flowering time, harvesting time, leaf size and shape, fruit colour, fruit weight, fruit shape, flake numbers, weight of edible parts, rind weight, rachis weight, stone numbers, stone colour, stone size, stone shape, flake colour, flake consistency (texture), spine density, rind/flake ratio and chemical compositions of fruit (TSS, acidity, sugar, vitamin C, TSS/acid ratio). All the characters were recorded for three consecutive yeas (*i.e.* 1997, 1998 and 1999) and each observation of quantitative fruit characters were replicated thrice. The genetical studies were done on the basis of biometrical techniques.

Perusal of the informations collected from the studies on genetic resources of jackfruit in West Bengal revealed that the different aged trees differ widely in characters of bearing (once, twice a year), yield/tree (15 to 1450 fruits per year), average fruit weight (1220 g to 17299.75 g), shape of the fruit (obloid, spheroid, ellipsoid, clavate, oblong and irregular), shape of the leaf blade (obovate elliptic, broadly elliptic, lanceolate, irregular), rind colour (green, greenish, yellow, brownwish), flake colour (yellow, light-yellow, pinkish, ivory and whitish), stone shape (oblong, spheroid, elongate reniform, irregular), stone colour (whitish, ivory, cream, brownwish and white), number of flakes (11 to 425), number of stones (11 to 397), weight of edible part (170 g to 6766 g), flake texture (firm, melting, crisp), average seed weight (21.17 g to 88.0 g per 10 seeds weight). It appears that great variability exists with regard to chemical composition of flake. The range of variation of total soluble solids were 9.1% to 28%, total sugar between (7.6% and 23.6%) acidity between 0.11% and 0.53% and vitamin C between 4.45 mg and 11.11 mg per 100 g juice.

The selected types T_{17}, T_{19}, T_{24}, and T_{36} produced fruit twice in a year in December and May and April and November respectively. The fruit skin colour was noted golden yellow (T_3, T_4), ivory (T_2), green (T_8, T_9), light yellow (T_{15}), pink (T_7) and rusty brown (T_1, T_{16}, T_{17}, T_{19}, T_{23}, T_{28}, T_{39}, T_{43} and T_{44}) at maturity. The flake colour was observed pinkish in T_6 and ivory in T_{20}, however, in types T_8, T_9, T_{12}, T_{13}, T_{34} and T_{35} the colour of flakes were white and in others mostly yellow to light yellow. The consistency (texture) of flake were either melting or smooth, however, crisp in T_5, T_9, T_{11}, T_{13}, T_{23}, T_{24} and T_{42}. The maximum average fruit weight was noted in T_{14} (17.3 kg) compared with 1.2 kg in T_6. The type T_{31} produced only 15 fruits per tree in a year compared with 1450 fruits per tree in T_{23}. The rind : flake ratio was highest in T_{23} (5.20) compared with 0.19 in T_{39}. The flakes of T_{26} and T_{31} and T_{33} showed very high amount of total soluble solids contents (26.0%, 27.1% and 28.0% respectively) while vitamin C content of fruit was recorded 11.11 mg per 100 g in T_{35} and 10.14 mg in T_{43} compared with 4.45 mg in T_{26}.

Among the tree characters, yield/tree had maximum genotype (57670.89) and phenotype (57784.16) variance followed by leaf size and age of the tree. Highest estimate of heritability was noted for leaf length (100.00%) followed by yield/tree (99.80%), leaf size and age of the tree (99.60%). The yield/tree showed highest genetic advance (494.25) followed by leaf size (67.85). It was also found that the yield/tree had maximum genetic advance as percentage of mean (440.31) succeeded by age of the tree (74.41) and leaf size (66.47).

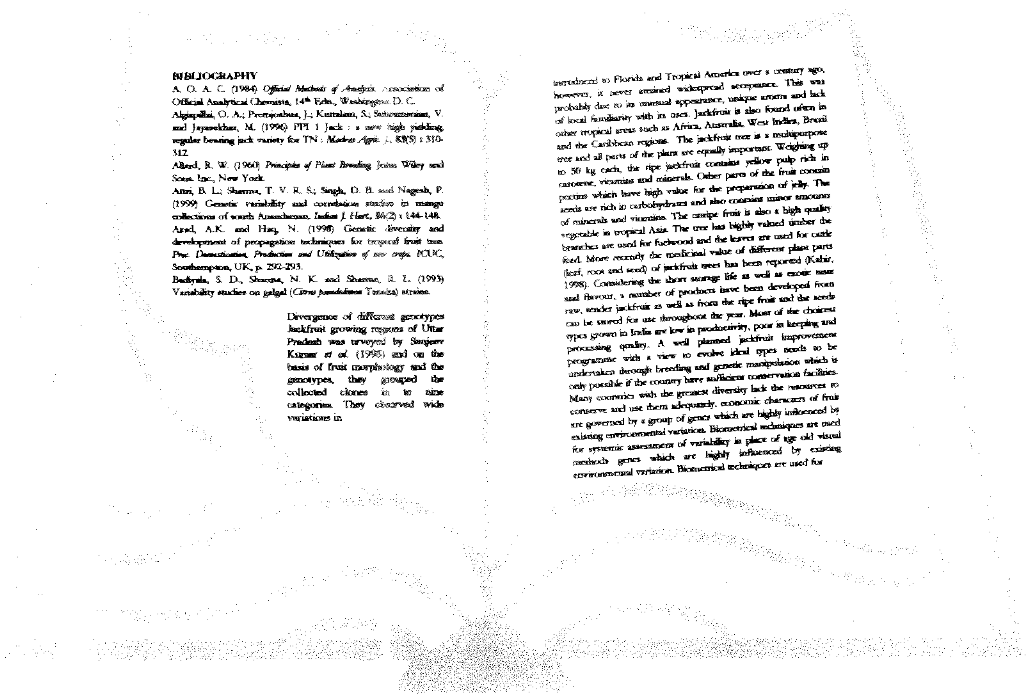
Among the physical characters of fruit, the higher magnitude of genotypic and phenotypic variances were observed (9869906.60 and 9892860.50 respectively) for fruit weight followed by weight of edible part, rind weight, rachis weight, number of flakes and stones. The genotypic and phenotypic co-efficient of variation were low (68.82 and 68.90) for fruit weight than rachis weight (101.40 and 101.49 respectively) but number of flakes and stones showed higher values (88.16, 88.19 and 86.71, 86.75, respectively), although, the estimated heritability were higher (92.60% to 99.90%) for all the physical characters of fruit of the selected genotypes. In fruit weight higher magnitude of genetic advance (6463.87) was observed among the selected genotypes although, the genetic advance as percentage of mean was low (141.59%) but the value of genetic advance as percentage of mean was noted as high as 208.70%. The general mean value of total soluble solids among the selected genotypes was 18.37 ± 0.16 with the range of 9.1% - 28.00%. Although, the genotypic and phenotypic coefficient of variation were low (23.97% and 23.99%, respectively) but the value of heritability was as high as 99.80%. The mean value for total sugar, vitamin C and acidity among the selected genotypes were 15.75 ± 0.89, 7.16 ± 0.11 and 0.26 ± 0.0064 respectively and the variation range were 7.60% - 23.60%, 4.45 – 11.11 mg/100 g of juice and 0.11% - 0.53% respectively. Although, the genotypic and phenotypic variance, GCV and PCV were very low for the same characters among the selected genotypes but heritability were high ranges from 92.90% to 99.40%.

Association between physical and biochemical characters of fruit revealed that, genotypic and phenotypic correlation were positively significant between fruit weight and weight of edible part (0.980 and 0.977), fruit weight and rind weight (0.976 and 0.971), stone numbers and flake numbers (0.999 and 0.999) respectively. Fruit weight, flake numbers, weight of edible part and total soluble solids also showed highly significant, positive genotypic and phenotypic association with stone numbers, rind weight, rachis weight and total sugar content, respectively.

Path coefficient analysis indicated that weight of edible part had positive direct effect on fruit weight both at genotypic (0.459) and phenotypic (0.451) levels. Number of stones and rind weight also had positive direct effect on fruit weight in both the cases but most of the characters, genotypically and phenotypically influenced fruit weight. The magnitude of genetic diversity of forty four genotypes on the basis of eighteen characters revealed that, the genotypes could be grouped into thirteen clusters which were homogeneous within and heterogeneous between the groups. Intra and inter cluster divergence values showed that the intra cluster distance was zero for clusters I, IV and V and XI, XII and XIII. However, maximum values of inter cluster distance were observed between cluster III and IV (14319.137) followed by cluster II and IV (11744.343). Minimum values of inter cluster divergence were recorded between cluster I and II (153.511) followed by between clusters XI and X (218.117).

It can be concluded that the values for fruit characters of the selected genotypes had wide range of variation (both genotypic and phenotypic) and could be exploited through clonal selection for its improvement. From the study of genetic divergence, correlation coefficient, heritability, genetic advance etc., indicated genetic drift and natural selection under different environmental condition could cause considerable diversity than geographical distance. Hence, it would be logical to incorporate genotypes from these clusters in selection programme for new genotypes. Based on the different characters, the following genotypes were finally selected for further crop improvement programme and germplasm conservation for different purposes.

i) Suitable types to use as table fruit	:	T_2, T_3, T_4, T_5, T_9, T_{16}, T_{20}, T_{21}, T_{22}, T_{23}, T_{26}, T_{27}, T_{28}, T_{30}, T_{32}, T_{33}, T_{36}, T_{37}, T_{38}, T_{39}, T_{40} and T_{43}.
ii) Suitable for use as vegetable	:	T_6, T_{12}, T_{15}, T_{17}, T_{18} and T_{24}.
iii) Suitable for processing	:	T_1, T_7, T_{10}, T_{11}, T_{13}, T_{14}, T_{29}, T_{34}, T_{35}, T_{41} and T_{44}.
iv) Drought tolerant	:	T_{31}
v) Suitable for commercial orcharding	:	T_8, T_{19}, T_{25} and T_{41}.



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