GENETIC DIVERSITY AND CANOPY MANAGEMENT IN JACK FRUIT (*Artocarpus heterophyllus* Lam.)

By
P. MUTHULAKSHMI

THESIS

Submitted in partial fulfilment of the requirement for the degree of

Doctor of Philosophy in Horticulture

Faculty of Agriculture
Kerala Agricultural University

Department of Pomology and Floriculture
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2003

DECLARATION

I hereby declare that this thesis entitled **"Genetic diversity and canopy management in jack fruit (*Artocarpus heterophyllus* Lam.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

P. MUTHULAKSHMI

CERTIFICATE

Certified that this thesis, entitled **"Genetic diversity and canopy management in jack fruit** (*Artocarpus heterophyllus* **Lam.)"** is a record of research work done independently by **Ms. P. Muthulakshmi** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellanikkara
4-06-03

Dr. K. Lila Mathew
Chairperson, Advisory Committee
Associate Professor (Horticulture)
Department of Pomology and Floriculture
College of Horticulture
Vellanikkara, Thrissur

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Ms. P. Muthulakshmi,** a candidate for the degree of **Doctor of Philosophy in Horticulture** with major in **Fruit Science,** agree that the thesis entitled **"Genetic diversity and canopy management in jack fruit (*Artocarpus heterophyllus* Lam.)"** may be submitted by Ms. P. Muthulakshmi, in partial fulfilment of the requirements for the degree.

Dr. K. Lila Mathew
Chairperson, Advisory Committee
Associate Professor (Horticulture)
Department of Pomology and Floriculture
College of Horticulture
Vellanikkara, Thrissur

Dr. P.K. Rajeevan
(Member, Advisory Committee)
Associate Professor & Head
Department of Pomology & Floriculture
College of Horticulture
Vellanikkara, Thrissur

Dr. Sarah T. George
(Member, Advisory Committee)
Associate Professor
Department of Pomology & Floriculture
College of Horticulture
Vellanikkara, Thrissur

Dr. Augustin
(Member, Advisory Committee)
AICRP on M&AP
College of Horticulture
Vellanikkara, Thrissur

Dr. P.K. Ashokan
(Member, Advisory Committee)
Department of Tree Physiology & Breeding
College of Forestry
Vellanikkara, Thrisur

EXTERNAL EXAMINER

ACKNOWLEDGEMENT

I have a great pleasure to place on record my profound sense of gratitude and indebtedness to ***Dr.K.Lila Mathew****, Associate Professor, Department of Pomology and Floriculture and Chairperson of my advisory committee. As the chairperson, she has been the main guiding spirit who filled me with zeal and enthusiasm and let me an air of self-assurance. Her personal charm and warmth, wise counselling and unfailing arguments made my task all the more easier. I, from the core of my heart believe that it would have been next to impossible to complete the work had her affection were not showered on me in bountry. I owe her a lot.*

I would like to exploit this opportunity to extend my profound sense of gratitude and heartful thanks to ***Dr.Sarah T. George,*** *Associate Professor, Department of Pomology and Floriculture and member of my advisory committee for her kind concern, expert advise, utmost sense of patience and constant encouragement throughout the course of the study and preparation of thesis. I am really greatly for her untiring support and expert guidance.*

I am respectfully thankful to ***Dr.P.K.Rajeevan****, Associate Professor and Head, Department of Pomology and Floriculture and member of my advisory committee for his timely advice, valuable instructions, evaluation of the manuscript and professional criticism during the course of this research work.*

I am extremely grateful to ***Dr.A.Augustin****, Associate Professor, AICRP on M & AP and member of my advisory committee for his scholarly suggestions, sustained interest, timely help and encouragement during the conduct of the research work.*

I am highly obliged to the member of my advisory committee ***Dr.Ashokan,*** *Associate Professor, Department of Tree Physiology and Breeding, College of Forestry for his valuable suggestions, timely help and co-operation offered me during the study.*

I take this opportunity to express my heartful gratitude to Dr.Kannan, Assistant Professor, Fodder Development Scheme, College of Veterinary and Animal

Sciences, Mannuthy for kind help in conducting the pruning trials in the jack trees available in the research plot of the scheme.

I wish to express my gratitude to Dr.Gheevarghese and Dr.Jayawardhanan, Associate Professors, College of Veterinary and Animal Sciences, Mannuthy for their timely help in carrying out the chemical analysis.

I wish to place on record my deep sense of gratitude to Dr.Radhakrishnan, Associate Professor, Department of Plant Breeding and Genetics, College of Horticulture for helping me in shaping my data into valuable conclusions.

*The thesis would not have materialised but for the help provided by different persons in locating the jack trees. I wish to extend my sincere thanks to **Dr.Lila, K.R., Dr.T.Radha, Dr.Aravindakshan, Smt.Sathiavarma, Smt.Jyothi C. Bindu,** Sri.Sunny and Sri.Murali for their good will and assistance provided in locating the jack trees.*

The members of the panel who have sincerely judged the quality of all the samples of jack flakes need special mention and acknowledgement.

I fully acknowledge the help rendered to me by vehicle drivers Sri.Mohanan, Sri.Sundaran and Sri.Balan. My special thanks to Sri.Salim who has taken atmost pain in harvesting fruits even from the tall trees by climbing.

I am grateful to staffs and labourers of Department of Pomology and Floriculture and Department of Processing Technology, College of Horticulture and Pepper Research Station, for their support given for the smooth conduct of the work.

I am in dearth of words to express my gratitude, appreciation and indebtedness to Sri.K.Chandran, Manager, Canara Bank, Sri.Mahendran, MRF Tyres and Sri.Kumarasamy, Smt. Periyathal and Sri.Premkumar of Poolampatty for their indomitable inspiration, whole hearted encouragement, untiring moral and ethical support during difficult days without which it would have been impossible to complete my study.

The Senior Research Fellowship granted by KAU is gratefully acknowledged.

I extend my thanks to Sri.Jomon, JMJ, Computer Centre, Thottappady for neat and prompt typing and scanning work.

I am thankful to my friends Ajith, Anu G. Krishnan, Dhinesh Babu, Senthilkumar, Karuppaiah, Sunil, Shiji and Reshmi for their valuable help, constant inspiration and moral support.

Finally, I must acknowledge the great and moral backing I received from my parents and brother for their constant prayers, personal sacrifices, affection and tolerance throughout the period of my course.

Above all I bow my head before Almighty whose constant blessings enabled me to complete this endeavour successfully.

Muthulakshmi, P.

CONTENTS

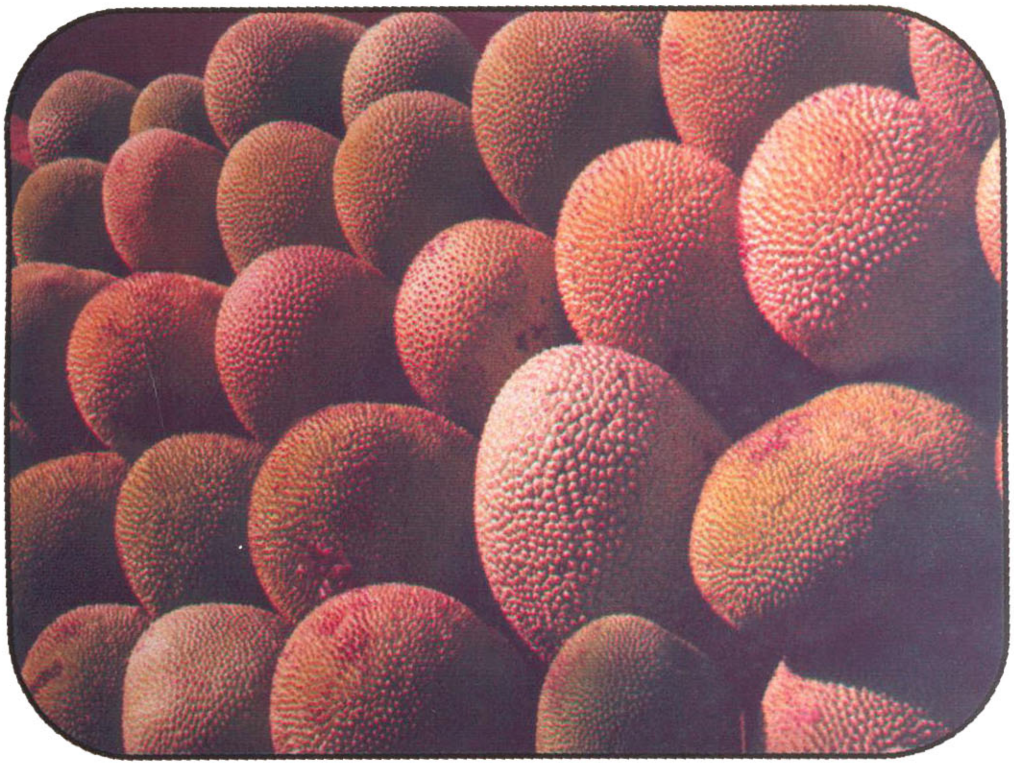
LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

28	A view of the pruning trial plot
29	Twenty five per cent removal of 4° branches a) At pruning b) During flushing
30	Fifty per cent removal of 4° branches a) At pruning b) During flushing
31	Seventy five per cent removal of 4° branches a) At pruning b) During flushing
32	Twenty five per cent removal of 3° branches a) At pruning b) During flushing
33	Seventy five per cent removal of 3° branches a) At pruning b) During flushing
34	Twenty five per cent removal of 2° branches a) At pruning b) During flushing
35	Fifty per cent removal of 2° branches a) At pruning b) During flushing
36	Seventy five per cent removal of 2° branches a) At pruning b) During flushing
37	TLC profile of phenolic leaf extracts of soft and firm fleshed types

Introduction



1. INTRODUCTION

Jack, *Artocarpus heterophyllus* Lam., bearing the largest edible fruit in the world, is a tropical evergreen tree belonging to the family Moraceae. Previously, it was known as *Artocarpus integrifolia*. It is an indigenous fruit crop, probably originated in Western Ghats and is widely cultivated in Southern Asia, East Indies and other warm areas of both the hemispheres. Jack tree is commonly grown in Burma, Malaysia and Brazil. It is hardly recognised as commercial fruit crop in India even though it is widely distributed in Assam, Bihar, South India and the foothills of the Himalayas in North India. It is an invariable component of Kerala's homesteads and also grown as a shade crop in coffee, areca and cardamom. It is also grown as a standard crop in pepper plantations. The crop has got a rare distinction of being used as the staple food of Kerala tribals and also in some African countries like Uganda.

Owing to its numerous culinary uses and its availability in plenty during the heavy monsoon rains, jackfruit has earned the well deserved name "Poor man's food" (Sammadar, 1990). Jack bulbs are rich source of carbohydrates (16 to 20%), total soluble solids (29°brix), carotene (500 to 580 IU) and pectin (1.5 to 6.0%). The bulbs are used both in unripe and ripe stages. Apart from table purpose, the ripe bulbs can also be used for making canned products, nectar , preserves, jam, jelly, squash, fruit bar and candy. Unripe green jack bulbs are used for making chips and papada. In Kerala, tender fruits of about 60 days old are commonly used as vegetable. Seeds are rich source of starch and also forms a popular ingredient in many culinary preparations. It can be relished when boiled and roasted. The tree has got good timber value as it is rarely attacked by white ants (Krishnankutty, 1998).

Recently, it has been reported that jackfruit could be very useful in the treatment of the dreaded disease of human being - AIDS. An extract of jackfruit called 'Jacaline' was seen to have inhibited the growth of HIV infection '*in vitro*'. Jacaline is inactive on lymphocytes which are already infected but has proved its might by protecting the healthy ones. Hot water extracts of leaves improve the glucose tolerance level of diabetic persons. Lectin, an important class of natural protein, plays a significant role in cancer treatment since it has been used in the prediction of transformation of normal to cancer cells. In Ayurveda, it has been used for curing inflammation, constipation, skin disease and wound healing.

Kerala seems to be one of the centres of origin of jackfruit. It is a cross pollinated and heterozygous crop. Innumerable variation in terms of vegetative, flowering, fruiting and biochemical characters are noticed. Further, the crop available in the State are all seedling progenies and their heterogenous makeup offers a tremendous potential for breeding and selection for commercial cultivation.

Due to increasing pressure on land and timber value of the jack tree, there has been an unscrupulous felling of jack trees in which many of the outstanding types are lost. Most of the jack types left within the homesteads are also under the threat of felling or becoming extinct.

No serious attempts have been made so far on the improvement of the crop. As a preliminary step in crop improvement as well as for commercial exploitation, it is desirable to investigate the nature of divergence in terms of vegetative, flowering, fruiting and biochemical characters. Surveys have to be made to identify the elite trees having good agronomic and economic traits with commercial and industrial uses.

Canopy development in perennial crops like jack has a seasonal and life time developmental pattern. The sum of development over individual season results in the final canopy dimension and form.

Where tree growth is unrestricted by climate and cultural practices, trees may reach a height and canopy diameter of 30 m or more, thus occupying more space in the homesteads leading to difficulty in accommodating more number of components in the homestead system and also in harvesting. Keeping the trees compact and dwarf, can solve the problem to some extent.

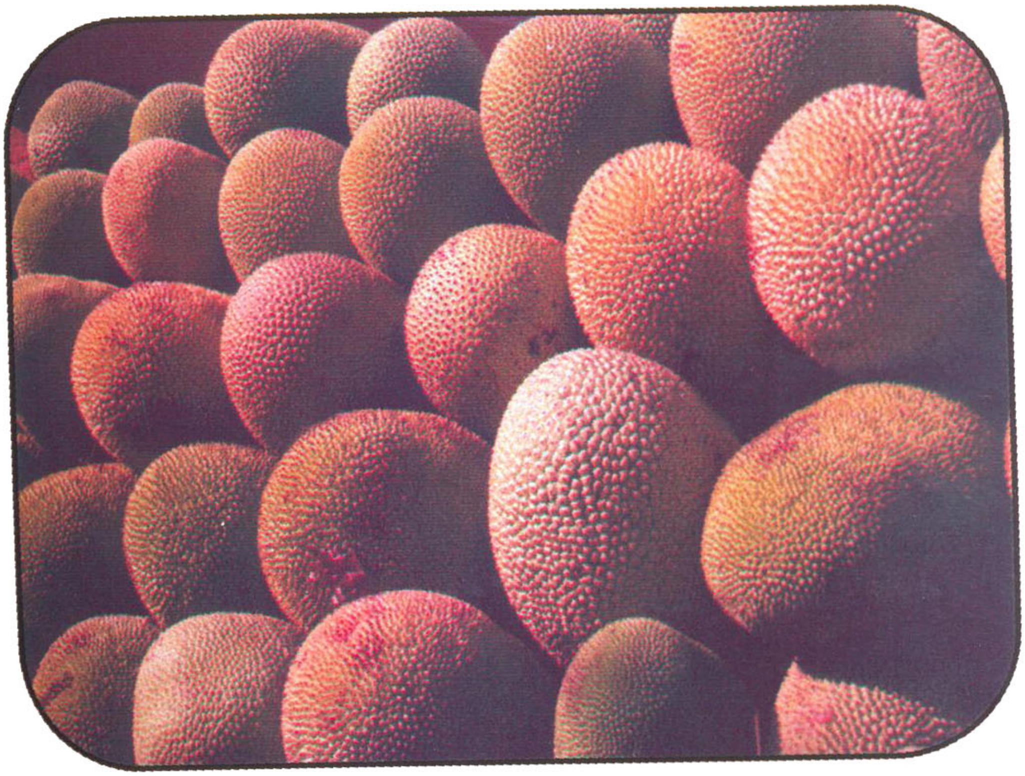
In this context, it is important (i) to study the different phenological phases of jackfruit, (ii) to ascertain the optimum degree and frequency of manipulation of the canopy which results in better distribution of light and subsequent yield and (iii) to assess as to how canopy manipulation and resultant re-distribution of light affects vegetative, flowering, fruiting, yield and biochemical characters.

The firm fleshed types are commercially important in Kerala and other States of India due to the hard crispy texture of flakes. Both firm and soft fleshed types occur in natural population and they appear to be identical in many plant and fruit characters and to a considerable extent in flakes till they ripe. In India, jack is propagated through seeds, and hence there are chances for occurrence of soft fleshed types in populations raised from the selected firm fleshed trees due to cross pollination between the types. It is of academic interest as well as of practical utility if the characteristic features distinguishing the two types are identified. This helps to eliminate the less desirable soft fleshed types at one stage or other of its growth.

In this context the present research programme of "Genetic diversity and canopy management in jack (*Artocarpus heterophyllus* Lam.)" has been carried out with the following objectives:

1. To conduct a comprehensive survey of jackfruit in different topographical regions, namely, plains, hills, coastal and riverside areas of Thrissur district.
2. To study their physico-chemical variation.
3. To select early flowering and ripening types, dwarf and compact types with protracted period of flowering, larger number of fruits with small to medium in size, more number of bulbs with sweet and firm flesh and with minimum latex content.
4. To conserve the selected types.
5. To ascertain the optimum degree and frequency of manipulation of the canopy.
6. To make a comprehensive study to characterise firm and soft fleshed types through morphological, anatomical and biochemical analysis.

Review of Literature



2. REVIEW OF LITERATURE

Artocarpus Forst. is a unique genus which, on account of its peculiar and edible fruits in certain species, has attracted attention from very remote past. It is a tropical genus with about 50 species (Corner, 1952 and Jarrett, 1959) and is a native to South East Asia (Barrau, 1976). The Indian species of this genus are *Artocarpus heterophyllus* Lam, the jack fruit, *A. lakoocha* Roxb., the monkey jack, *A. altilis* (Park) Fosb., the bread fruit, *A. chaplasha* Roxb. and *A. hirsutus* Lam (Sharma, 1962). The genus belongs to the sub family *Artocarpoideae*, tribe *Artocarpae* which is included in Urticaceae (Hooker, 1885 and Corner, 1952) or in Moraceae (Engler and Prantl, 1888; Bailey 1949; Hutchinson, 1959; Rendle, 1971 and Lawrence, 1973). Jarret (1959) subdivided the genus into *Artocarpus* and *Pseudojaca* based on the position of stipules.

The species *A. heterophyllus* Lam. (Syn. *A. integrifolia* L.f. (Syn. *A. intergra* (Thumb.) Merr.) is native of India and found to be growing wild in Western Ghats (Nairne, 1894 and Gamble, 1972). Jack is basically a diploid 2n = 2x = 56 (Habib, 1971 and Barrau, 1976).

Jack is a large, evergreen tree of 10-15 m height, indigenous to evergreen forests of the Western Ghats at an altitude of 450 to 1200 m (CSIR, 1992).

It enjoys a special favour in home gardens on the West coast and also used as the shade tree in coffee, areca, cardamom and pepper plantations.

It is widely cultivated in Southern Asia, the East Indies, Burma, Malaysia, Brazil and other warmer areas of both the hemispheres. Jack trees are distributed in Assam, Bihar, South India and foot hills of the Himalayas in Northern India (CSIR, 1948).

The tree flowers during December to February. Majority of the female and male inflorescences (catkins) appear on the main trunk and primary branches (Tessy, 1982). The fruit is reported to constitute three regions, namely, fruit axis, persistent perianth and true fruit. The perianth is the most important part and constitutes the major bulk of fruit. It has basically three regions, namely, lower free and fleshy edible region, middle fused region and the upper free and thorny non-edible region. The fruit consists of four parts, namely (a) bulb (27-40%), derived from fleshy perianth constituting the edible portion, (b) perigones (18-20%) the unfertilised (or) aborted flowers, (c) rind (20 to 22%) and (d) seeds (20-23%) (Sharma, 1964).

The bulbs are used both in unripe and ripe stages. Apart from the table purpose, the ripe bulbs can also be used for making canned products, nectar, preserves, jam, jelly, squash, fruit bar and candy. Matured unripe green jack bulbs are used for making pickles, chips and papada (Bose and Mitra, 1990).

2.1 VARIABILITY STUDY

2.1.1 Variability in jack fruit

Development of high yielding varieties of crops require information about the nature and magnitude of variability present in the available stock and the selection depends upon a judicious assessment of the available data on phenotypic character that are connected with yield. Therefore, information on interrelationship between various plant characters with yield and quality among themselves and the extent which they are influenced by the environment should be known and it has an important bearing for the formulation of an effective breeding plan (Subramanyam and Iyer, 1981).

The aim of exploration or collection is to capture maximum variability of a crop and its wild relatives to meet the needs for conservation. Maintenance of biological diversity helps in sustaining the agricultural productivity (Kamau, 1992).

Jack fruit has innumerable types (or) forms regarding the fruit characteristics. The types differ widely among themselves in bearing and density of spines on the rind, bearing, size, shape, quality and period of maturity. There is a wide variation in its sweetness, acidity, flavour and taste. These variations among clones offer better scope for its improvement by clonal selection. The types available under various local names have originated in this way (Mitra, 1998).

Jack tree is cultivated in almost all the homesteads of Kerala. Extensive survey has to be under taken to identify the elite clones which are facing the threat of extinction and steps have to be undertaken to preserve the germplasm (Anon, 1996).

2.1.1.1 Varieties/Types

Cultivated jack fruits are broadly classified into two groups, one with firm flesh and the other with soft flesh. The soft pulp group is locally known as pazham ghula, vela, koozha, ghila, tsjakepa or koppa. The mature pericarp of this group is comparatively smaller in size. The juice is either thin or thick, colour varies from pale yellow to dark or golden yellow. Pulp is generally mushy or soft and of varying quality ranging from sweet to insipid. The seeds are comparatively larger. The hard pulp group is locally known as varikka, varcha, kujja, korcha or berka. The pulp is crisp and highly flavoured and therefore relished. The juice is scanty and the seeds are comparatively smaller (Singh *et al.*, 1967).

Srinivasan (1970) described a variety namely "Muttam Varikka" which produced fruits of average weight of 7.0 kg with 46 cm length and 23 cm width.

Bhore *et al.* (1980) identified a highly promising jack type in Ajra village of Kolhapur district of Maharastra which is high yielding and highly pulpy containing more protein, fat, mineral matter and carbohydrate than local jackfruit. The fruits are small and weighing between 1 and 3 kg and uniform in size and shape.

Jack fruit types like 'Varikka', 'Koozha', 'Navarikka', 'Rudraksha chakka' or 'Thamara chakka' and other wild forms have been collected from Wynad Plateau in the Western Ghats of Kerala (NBPGR, 1986). Three types of jack fruits namely 'Rasdar', 'Khajwa' and 'Sugandhi' were identified through survey in the plains of Eastern Uttar Pradesh (NBPGR, 1988).

Several subgroups are recognised depending upon the taste, shape and size of fruits. One of these, is *Rudrakshi*, a small fruited type, with smooth and less spiny rind and are having a less fleshy perianth than the common jack. There are also certain old trees in Assam which show a tendency to produce fruits during off-seasons. These are designated as *baro-mahia* or *baro-mosha*. Ceylon jack or Singapore jack is a recent introduction in South India. It is an early maturing variety and comes to bearing in about 18 months under favourable condition in low elevation but may take more time at higher elevation. It generally matures in off-season during November to February. Fruit is a hard-fleshed varikka. In Assam, soft pulp group is divided into six types, namely, V_1, V_2, V_3, V_4, V_5 and V_6 and hard pulp group into two varieties, namely, V_7 and V_8 (CSIR, 1992).

In Florida, cultivated superior cultivars of jack are Black Gold, Golden Nuggot, J-31, Honey Gold and Lemon Gold (Campbell and Mc Naughton, 1994).

Through selection, Burliar-1, Palur-1 and Pechiparai-1 have been released by Tamilnadu Agricultural University. Burliar-1 is a T Nagar selection developed at Fruit Research Station, Burliar. Palur-1 is a single plant selection isolated in Panikkankuppam village near Panrutti and was developed at Vegetable Research Station, Palur. Pechiparai-1 is a selection from Mulagumoodu local developed at Horticultural Research Station, Pechiparai (Veeraraghavadattam *et al.,* 1996).

Hybrid jack has been developed at Fruit Research Station, Kallar by crossing Singapore jack and Velippala (Veeraraghavadattam *et al.*, 1996).

2.1.1.2 Leaf characters

The leaves varied in length from 5.0 to 25.0 cm and in width from 3.5 to 12 cm. The shape varied from obovate-elliptic to elliptic (CSIR, 1992).

2.1.1.3 Fruit characters

The jack fruits from different trees were compared. Average fruit weight ranged from 3.24 to 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, respectively, in the largest fruit. Skin colour ranged from yellow and pale green to brown (Hussain and Haque, 1977).

The average fruit weight varied from 3.24 to 17.39 kg (Berry and Kalra, 1988).

A comparative study was carried out on yellow-bulb, light yellow-bulb and orange-bulb types. The light-Yellow types 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 types had the maximum seeds per fruit (124.6) and the highest pulp to seed ratio (4.24) (Guruprasad and Thimmaraju, 1989).

From the various genotypes collected in course of surveys of jack fruit growing regions, particularly in Eastern Uttar Pradesh, from November 1989 to August 1990, Kumar and Singh (1996) grouped the genotypes into nine categories based on fruit morphology. They observed wide variation in number, shape, colour, size and rind thickness of fruits. Average fruit weight ranged from 12.0 to 21.2 kg. All genotypes matured during July-August, except one genotype, which matured during March-May. Variability was also noticed in chemical composition of the pulp. The Total Soluble Solids ranged from 14.0 to 20.5 per cent and ascorbic acid content varied from 23.8 to 32.9 mg 100 g^{-1}. The best genotype was considered to be AC.7, with moderate yield, large fruits (more than 15 kg) and bulbs (about 20 g), small cylinders, high pulp/cylinder ratio and average fruit quality.

The fruit number per tree ranged up to 500 annually and fruit weight up to 40 kg (CSIR, 1992).

A survey was conducted during 1995-1996 in the lower Brahmaputra valley zone of Assam to study the fruiting behaviour, yield and physico-chemical characters of local jack fruit germplasm. Significant variation was observed in yield and chemical composition of the different genotypes. Fruit yield (60 fruits/tree) and brix values were highest in KJF 3, while the lowest acid content (6 per cent) was recorded in KJF 12 (Sarma *et al.*, 1997).

Among 672 trees studied during survey, wide variability has been noticed in yield (14 to 325 fruits/plant), fruit weight (2.1 to 10.2 kg), fruit shape (oblong, roundish and conical), skin colour (greenish, light brown, dark brown, yellow and yellow with brown), number of tubercles in skin (5 to 27/cm^2), pulp colour (yellow, whitish, reddish yellow and pinkish yellow), number of segments (34 to 380 per fruit), number of stones (32 to 362 per fruit), texture of pulp (soft, moderately soft and hard), pulp weight (361 to 3648 g), total soluble solids (15.4 to 29.6°Brix), total sugars (12.9 to 26.6%) and acidity (0.10 to 0.31%). The growth, bearing (twice a year in some types) and maturity (June to August) of fruits also showed variation among the genotypes (Mitra, 1998).

2.1.2 Variability in other fruit crops

Jauhari and Singh (1971) surveyed important bael growing areas of Bihar and Uttar Pradesh, and found that Kaghji Etawah, Sewer Large, Mirzapuri and Deoria Large were excellent in taste than other quality traits. Of the five types of bael fruit available in West Bengal, the spherical flattened ones were considered as the best on the basis of fruit weight and chemical composition (Mazumdar, 1975).

Thimmaraju *et al.* (1977) reported that tamarind, being a highly cross pollinated crop and owing to its wide geographical distribution and adaptability to different agroclimatic regions, a large genetic diversity is present in seedling population.

Singh (1978) noticed a lot of variability in annona in Andhra Pradesh, Madhya Pradesh, Gujarat, Maharashtra and Rajasthan.

Pareek and Panwar (1981) reported that in phalsa, a lot of variability exists in Central India, Rajasthan, Bihar and drier parts of South India and suggested that surveys have to be made to collect promising types.

Magdalita *et al.* (1984) obtained significant variation in fruit length, width and volume, flesh thickness and cavity volume among the 100 accessions of papaya surveyed.

Pareek and Sodagar (1986) identified 26 elite date palms from the variability of Kachch in Gujarat which produce large fruits with high pulp content and sweetness in dokka stage.

Due to seed propagation, considerable heterozygosity and variation are observed in the fruit characters of Karonda such as shape, size, pulp quality and yield in North-Western India, particularly in Mount Abu in Rajasthan and Khendala in Maharashtra. It offers a great deal of scope for improvement in Karonda by seedling selections (Bhagwat, 1984 and Joshi *et al.*, 1986).

During the survey conducted in Karonda growing region in Eastern Uttar Pradesh, four types of fruit viz., green, white with pink blush, green with purple blush and maroon were identified. Average fruit weight ranged from 1.6 to 4.7 g and average number of seeds per fruit from 5 to 11. Wide variation was also observed in the biochemical composition of the fruit with total soluble solids ranging from 3.0 to 4.5°Brix, ascorbic acid from 10.26 to 17.94 mg 100 g^{-1}, reducing sugar from 0.93 to 2.4 per cent and non reducing sugars from 0.57 to 1.35 per cent (Kumar and Singh, 1993)

Wide variation was noticed in the tree and fruit characters of sapota. Tree height ranged from 3.92 to 8.54 m, fruits/tree from 730 to 2976, yield per tree from 52.65 to 129.50 kg, ascorbic acid content of the fruit from 1.65 to 3.61 mg/100 g and total sugars from 6.94 to 10.68 per cent (Ponnuswamy and Irulappan, 1989).

In ber, a lot of variability has been identified in several districts of Uttar Pradesh, Rajasthan, Hariyana, Gujarat, Madhya Pradesh, Maharashtra, Andra Pradesh, Karnataka and Tamilnadu and commercial cultivars have developed through selections made by local people in their areas (Pareek and Vashishtha, 1983 and Vashishtha and Pareek, 1989).

In a study of variation in fruit weight, circumference, length, flesh and skin thickness, and flesh and seed weight in six individuals of guava population in the North West of Zulia state, it was observed that 18 G being superior to the rest in fruit weight, length, circumference and skin thickness and 22 G being superior in flesh weight and seed weight (Tong *et al.,* 1991).

Wide variation was observed among the plants in the cashew progeny orchard of Mahatma Phule Agriculture University, particularly for yield (0.3 to 1.45 kg/tree), mature apple weight (8.18 to 47.0 g) and average nut weight (1.73 to 3.7 g) (Shate *et al.*, 1993).

In wild pomegranate, fruit weight ranged from 60 to 145 g with a mean of 82.68 g while rind thickness ranged from 3.6 to 5.72 mm with a mean of 4.25 mm. TSS ranged from 11.9 to 17.5°Brix with a mean 14.8°Brix and total sugars ranged from 5.42 to 9.12 per cent with a mean of 7.45 per cent. Fruits of these wild selections were also more acidic than those of commercial cultivars with the mean of 4.48 per cent of total titrable acid (Awasthi, 1994).

A high degree of variation for fruit characters was observed in the seedling population of the pomegranate cv. Alandi during 1980 to 1981 and 1981 to 1982 seasons. Three soft seeded types were identified, one of which was a highly promising selection (Ramu *et al*., 1996).

Muthulakshmi *et al.* (2001) in a survey of Kodampuli (*Garcinia cambogia*) trees in the homesteads of Kerala, observed a wide variability in terms of vegetative, floral, fruiting and biochemical characters of fruits.

2.2 CANOPY MANAGEMENT

Pruning the trees soon after they are planted restores the balance between the root system and the above ground part. Young trees are usually pruned in order to obtain a frame work that is strong and accessible for other cultural practices. Fully grown fruit trees are pruned to maintain the canopy height, spread and density required for easy spraying, fruit thinning, harvesting, etc. However, the main reason for pruning of mature trees is to foster a high quality and yield of economic parts. Pruning prevents excessive fruiting, increases fruit size and facilitates light penetration into the interior of the tree canopy, which improves fruit colouration (Mika, 1986).

Grubb (1938) outlined the influences of pruning on the following characteristics of a tree: 1) Size as measured by stem size, height and spread. 2) Characters other than size, particularly shape and spur development. 3) Precocity, number of blossoms, number of fruit and percentage of blossoms setting fruit. 4) Fruit quality, size and colour and 5) susceptibility to diseases.

Tubbs (1955) pointed out that response to pruning in mature trees is related to tree vigour and to the balance between vegetative and reproductive process. Response to pruning of varying severity is influenced by the reserves available for regeneration.

Pruning influences photosynthesis indirectly by improving the interception of light and its distribution within the tree canopy. One of the main purposes of pruning is to facilitate light penetration into the bearing area of the tree (Jackson and Palmer, 1980)

Pruning increases photosynthesis but they also increases the demand for photosynthetic products (Mika, 1986).

Tree spacing as well as pruning practices in evergreen orchards are primarily based on maximum light absorption for photosynthesis.

Biological yield = (light available) (percentage intercepted) (photosynsthesis) - (respiration).

Optimising the biological yield is based on maximising the percentage of light intercepted by the orchard canopy which can be altered by pruning (Whiley and Schaffer, 1997).

Pruning of evergreen tree fruit crops is rarely practised compared to deciduous fruits. This is particularly true in crops like jack, mango, etc. whose growth and fruiting habits have been considered as not conducive for pruning every year or every season.

Pruning trials are seldom undertaken in jack. Judicious pruning in jack provides the tree a desirable low head and when the tree becomes old, it invariably requires pruning to induce vigour and productivity (CSIR, 1992).

In ber, the average branch length and girth were greater with the heavier pruning. Average fruit weight and size were enhanced by all pruning treatments (Gupta and Singh, 1977).

In ber, shoot growth, yield, fruit size and quality were the best when shoots pruned to 75 cm (Singh *et al.,* 1978).

In ber cvs. Pewandi and Karaka, fruit set and retention were improved by pruning and were best on moderately pruned trees (Lal and Prasad, 1980).

Effect of pruning on physico-chemical characters of ber reveals that medium pruning resulted in increased fruit weight, volume and pulp : stone ratio. Hard pruning or very light pruning had a negative effect on these characters (Lal and Prasad, 1981).

Due to pruning, ber trees showed delayed flowering, fruit set and fruit maturity with increasing pruning severity. Percentage of fruit set and fruit retention were also increased (Yadav and Godera, 1989).

Medium pruning in ber gave the highest yield and TSS content than light and severe pruning (Hiwala and Raturi, 1993).

Pruning of ber trees resulted in increase in length and diameter of shoots, the number of branches per shoot and number of side shoots per branch. More fruits per tree were noticed in severely pruned trees (2971) than with medium pruned (2848) and unpruned (1980) trees. Yield of trees with severe (59.3 kg) and medium (55.7 kg) pruning were significantly greater with unpruned (36.9) trees. The fruit TSS content followed a similar pattern, being 18.30, 17.70 and 16.50 per cent for severe, medium and unpruned ones respectively (Khan *et al.,* 1992).

Matured Mulgoa mango trees on pruning increased the fruit yield by 10 to 30 fold in next eight years (Rao and Khader, 1980).

Removal of apical buds in mango generally delayed the onset of flowering from mid July to mid to late August. There was marked reduction in the number of fruits retained by the pruned trees, which resulted in reduced yield despite increased fruit size (Oosthuyse, 1993).

Pruning of sensation mango trees resulted in initiation of prolific and synchronous regrowth within thirteen days. Pruning also resulted in greater numbers of new shoots. Slightly delayed and more uniform flowering and increased starch content in the leaves were noticed (Oosthuyse, 1994).

Heavily pruned trees of mango resulted in delayed flowering by 210 days later than those of less severely pruned ones. However, crop load decreased probably because of delayed accumulation of carbohydrate reserves by strong regrowth after heavy pruning resulting in a decrease in flowering shoot rate (Chen *et al.*, 1996).

During the first season after pruning of Sensation mango trees, control trees had a higher yield. In the next season, pruned trees yielded higher than that of control. Fruits of pruned trees had a better external colour than fruits from control trees. No significant differences were found in internal colour, pulp pressure and TSS values between the pruned and unpruned Tommy Atkins (Fivaz *et al.*, 1997).

Pruning of mango trees had a positive effect on carbohydrate production. Delayed flowering and more synchronous flowering was noticed without affecting yield or fruit size (Walt *et al.*, 1996).

Mechanical pruning on mango tree resulted in more and larger new shoots production. Pruning reduced yield in first year. But during second year, significantly higher yield was noticed (Medina-Urrutia *et al.,* 1997).

In the pruned trees of mango, uniform and prolific flushing occurred shortly after pruning. Flowering was delayed. Further, fruit retention and yield was reduced in pruned trees (Oosthuyse, 1997).

For inducing flowering on 40 year old Alphonso mango trees, severe pruning was more effective than mild pruning (Srihari and Rao, 1998).

Pruning in Guava trees resulted in increased shoot length, number of leaves per shoot and leaf area in both flushes and reduced flower and number of fruits produced in the rainy and winter seasons. At the same time, increased fruit size and weight was noticed. Mild pruning, however, favoured the production of more flowers in the July-August flowering season and hence of more fruits in the winter season (Gopikrishna, 1981).

Pruning in guava cultivars resulted in reduced yield. Ten months after pruning, the crown diameter of pruned trees was similar to that of unpruned trees but pruned trees were significantly shorter than unpruned trees (Gonzalez and Sourd, 1982).

In eleven year old trees of Navalur guava cultivars, mild and severe pruning adversely affected flower production and fruit yield per branch. However, individual fruit weight was increased by pruning (Shaikh and Hulmani, 1994).

Experiments during 1988 at Dharwad on five guava cultivars revealed that severe pruning in January produced greater shoot growth and leaf area by April and August than mild or unpruned ones (Shaikh and Hulmani, 1997).

Pruning on custard apple resulted in severe yield reductions due to reduction in number of laterals and floral buds initiated (George and Nissen, 1986).

Tipping and pruning of avocado trees were successful in limiting the length of primary shoot axis and increasing axillary branching without influencing total fruit set (Thorp and Sedgley, 1993).

Pruning of avocado trees resulted in increased sylleptic axillary shoot growth and subsequent fruit set. The increased sylleptic axillary shoot growth may provide the key to improve tree form and productivity in avocado (Thorp and Sedgley, 1993).

Litchi trees on pruning resulted in higher variation in per tree yield than the control trees (Oosthuizen, 1994).

Pruning on litchi trees resulted in increased fruit weight, pulp weight, peel weight, stone pulp ratio, fruit length, TSS, total sugar and reducing sugar content. Acidity of the fruits got reduced (Hassan and Chattopadhyay, 1995).

In summer pruned trees of litchi, flushing was generally one to two months later but heavier. More flowering and yield were noticed (Munzel *et al.*, 1996).

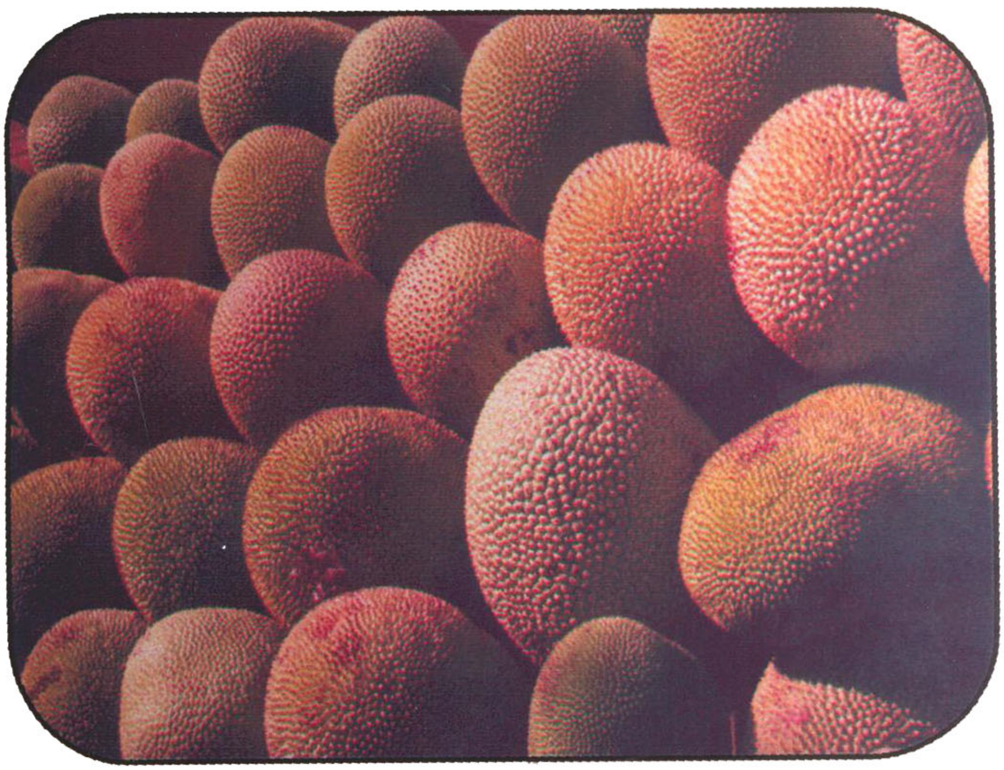
Machine top pruning of 14 year old trees of citrus cv. Orlando before flowering significantly reduced tree height, volume and surface area, but increased fruit weight and yield by four per cent and eight per cent respectively (Avraham and Mordechei, 1993).

Pruning on cashew stimulated the production of flowering laterals and the number of bisexual flowers per panicle. Pruning also gave the highest number of fruits per panicle and yield (Chattopadhyay and Ghosh, 1994).

Pruning the phalsa bushes to 15 cm height gave higher yield and higher percentage of sugars in the fruits than pruning to 30 or 45 cm (Sharma *et al.*, 1975).

Pomegranate trees were pruned to leave a single stem or two, three or four stems from ground level. Fruit yield in terms of number and weight was greatest when four stems were left. This treatment also produced the greatest canopy spread, largest fruits and highest juice and TSS content (Balasubramaniam *et al.*, 1997).

Materials and Methods



3. MATERIALS AND METHODS

The present investigations were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara and Fodder Research Scheme, Mannuthy, during 1998-2002. The project consisted of the following parts:

A. Genetic diversity in jackfruit

B. Canopy management in jackfruit

C. Characterisation of soft and firm fleshed types in jackfruit.

3.1 GENETIC DIVERSITY IN JACKFRUIT

The study was conducted in Thrissur district which was purposefully selected for the following reasons.

1. It is a jack growing area with good diversity.
2. It was convenient to select an area near the vicinity of Kerala Agricultural University to get the benefits of its infrastructure and other resources.

Eighty nine panchayats of Thrissur district were grouped into four major topographical regions, namely, plains, coastal, hilly and riverside regions. In each topographical region, four panchayats were selected randomly. Totally, 16 panchayats were selected as per the following list for the study. The map of Kerala showing the area of study is presented in Fig.1. The map of Thrissur district showing the panchayats selected for the study is presented in Fig.2.

List of panchayats selected in each topography

Sl.No.	Topography	Name of the panchayat
1	Plains	Vilvattam, Arimpur, Madakkathara, Alur
2	Hilly area	Pananchery, Trikkur, Mattathur, Thekkumkara
3	Coastal area	Vatanapally, Valapadu, Nattika, Thalikkulam
4	Riverside area	Manalur, Pudukkadu, Porathussery, Nanmanikkara

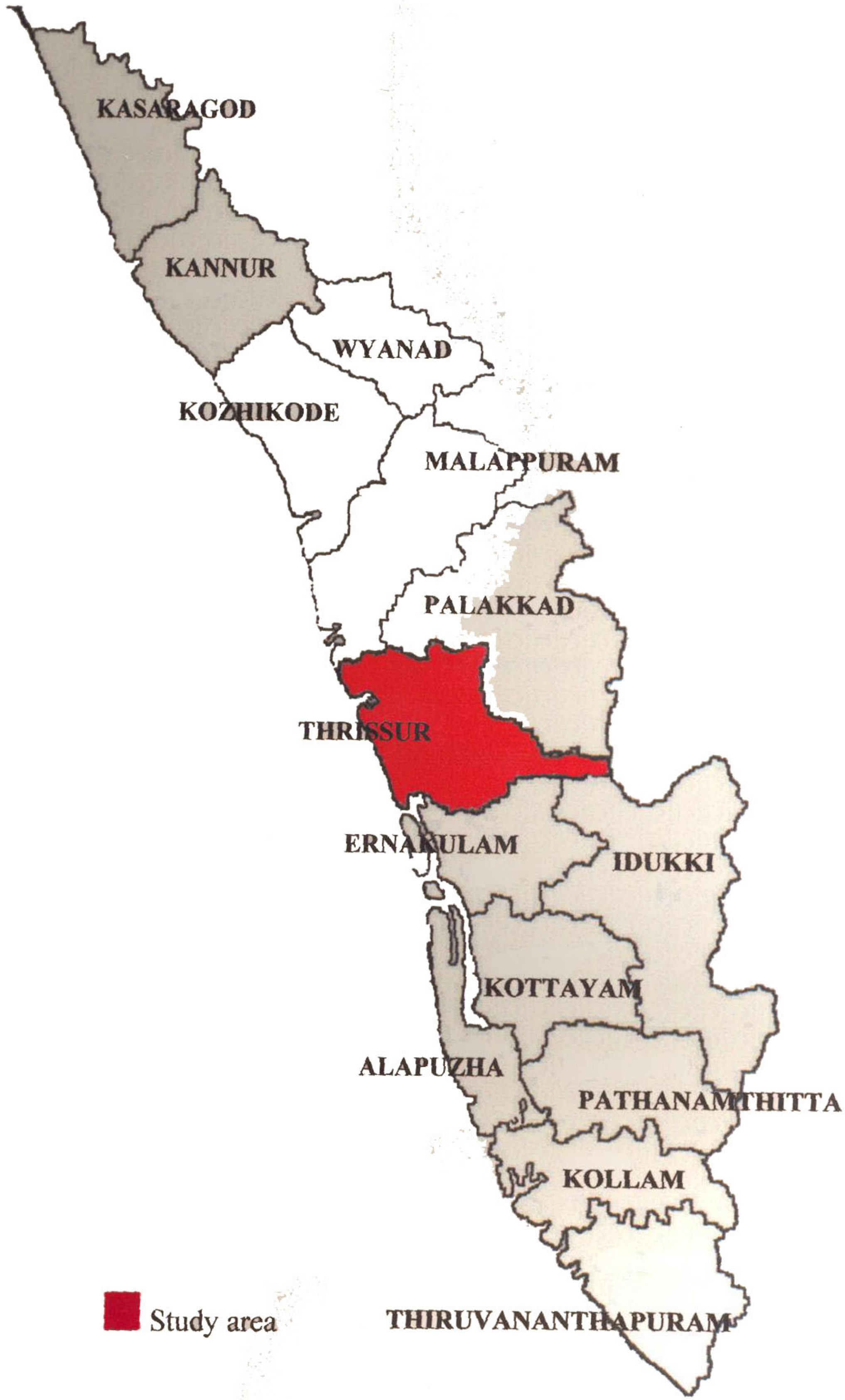
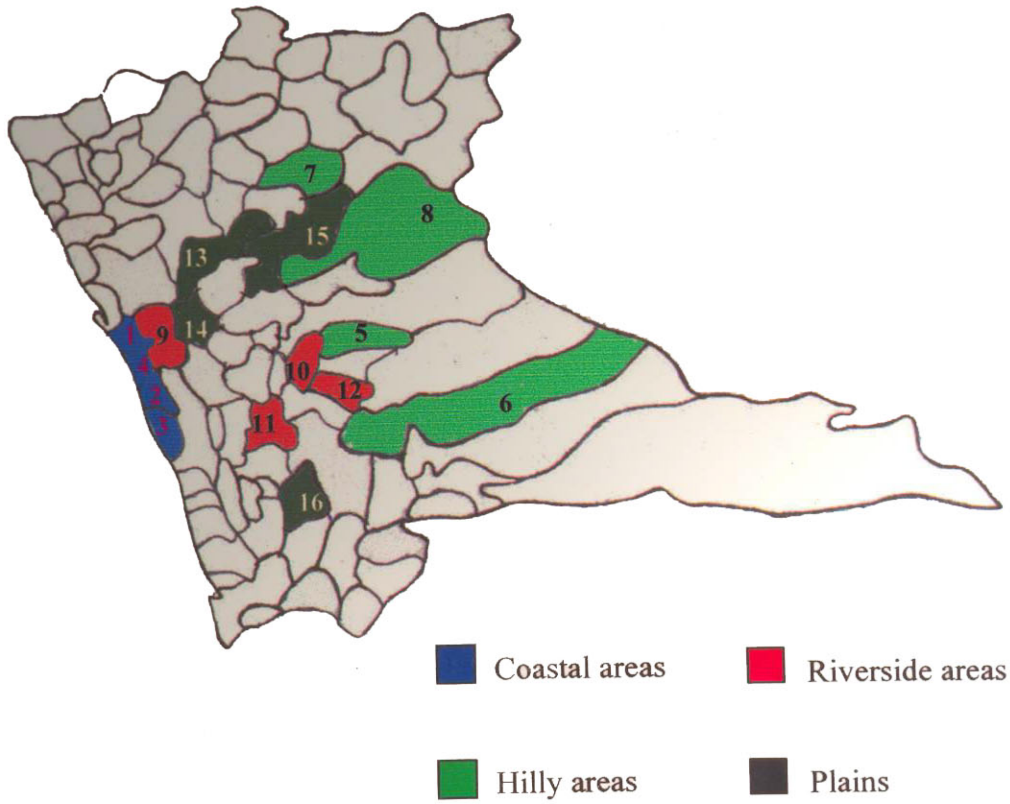


Fig. 1. Map of Kerala showing the area of study



1 - Vatanapally	2 - Nattika
3 - Valapadu	4 - Thalikkulam
5 - Trikkur	6 - Mattathur
7 - Thekkumkara	8 - Pananchery
9 - Manalur	10 - Nanmanikkara
11 - Porathussery	12 - Pudukkadu
13 - Vilvattam	14 - Arimpur
15 - Madakkathara	16 - Alur

Fig. 2. Map of Thrissur district showing the panchayats selected for the study

Trees were located with the help of Department of Agriculture, jackfruit traders and also through personnel contacts. Randomly, twenty households were selected in each panchayat. Thus, 320 households were taken for the study. Apart from these, those farmers who responded for media advertisement were also included.

The following observations on general tree characters, leaves, inflorescence, fruits, seed and soil were recorded from selected trees based on the descriptor given as Appendix-I.

3.1.1 General tree characters

The following observations on general tree characters were made on the collections.

3.1.1.1 Tree age

Approximate age of the tree was noted.

3.1.1.2 Tree height (m)

Approximate height of the tree was recorded and grouped into low (less than 10 m), medium (between 10 and 20 m) and high (more than 20 m).

3.1.1.3 Tree vigour

Vigour of the trees surveyed was noted visually and classified into three groups namely low, medium and high.

3.1.1.4 Canopy shape

Canopy shape of the trees of different accessions was recorded and classified into seven groups namely, pyramidal, broadly pyramidal, obovate, oblong, semi-circular, elliptical and irregular (Fig.3).

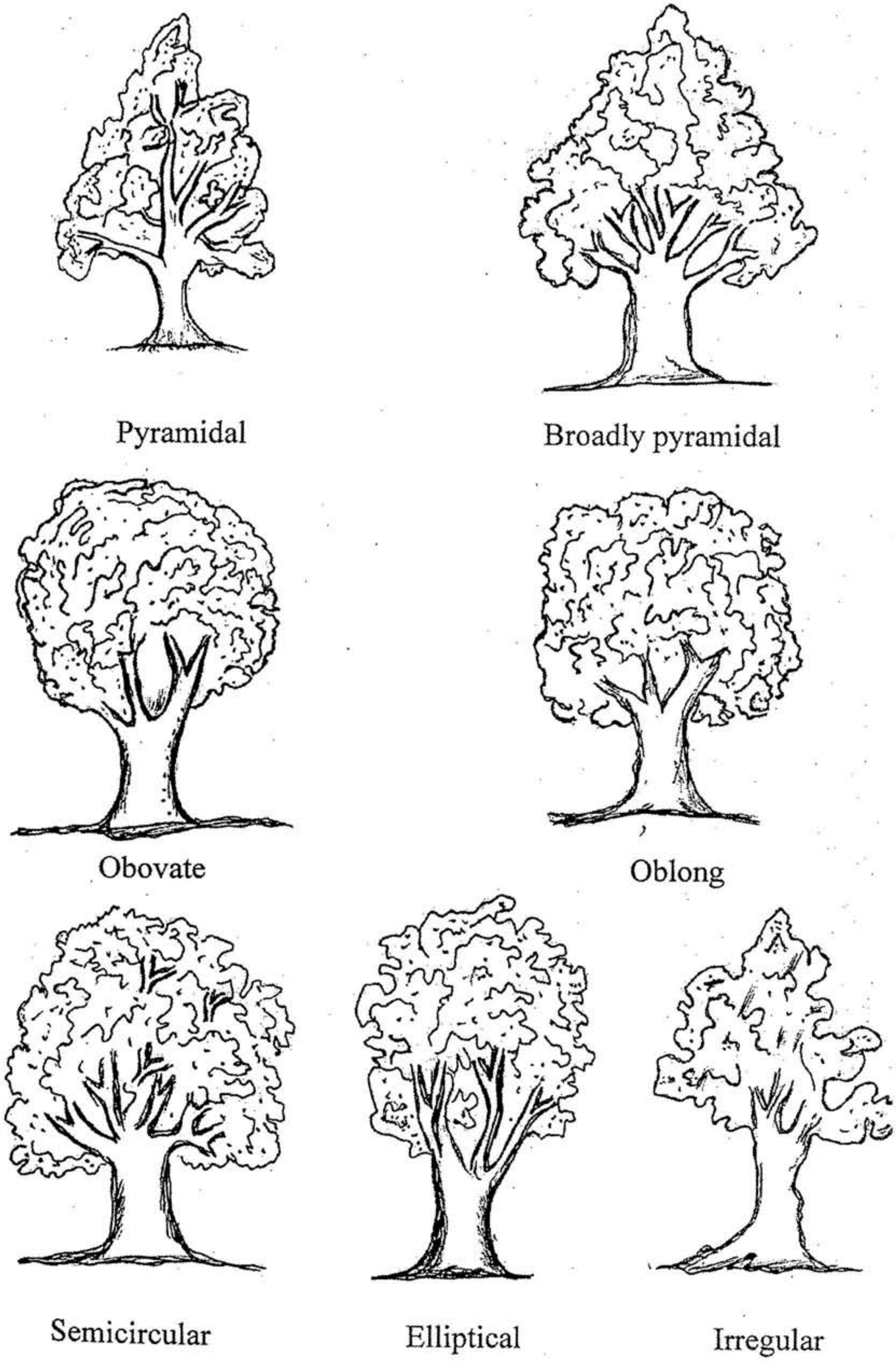


Fig. 3. Jack tree shape

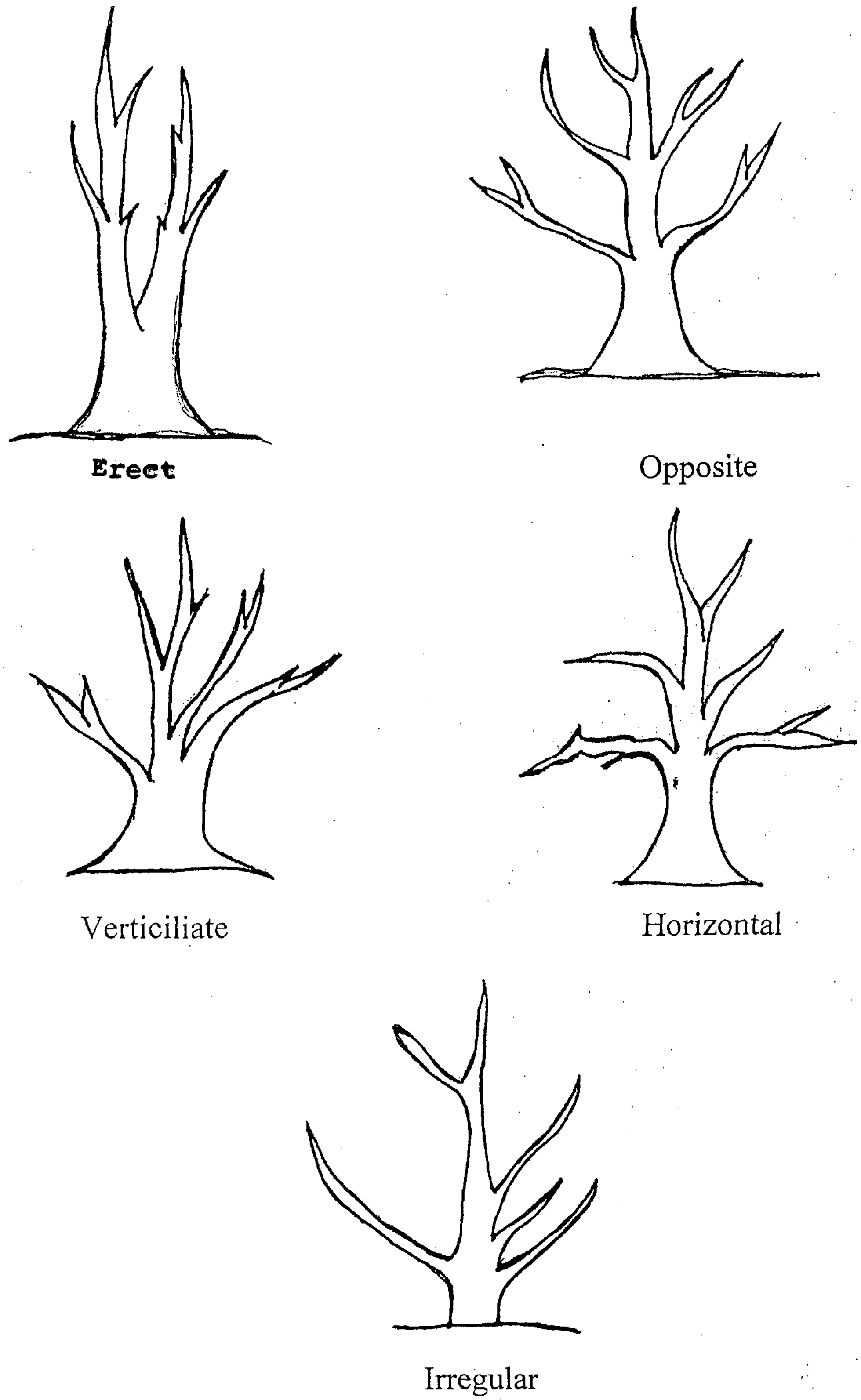


Fig. 4. Jack tree - Branching pattern

3.1.1.5 Tree growth habit

The growth habit of the trees surveyed was observed visually and classified into four groups namely, erect, semi-erect, spreading and drooping.

3.1.1.6 Branching density

Branching density was recorded in each jack collections based on visual observation and classified into three groups namely low, intermediate and high.

3.1.1.7 Branching pattern

Branching pattern of the trees surveyed was recorded and grouped into four classes namely, erect, opposite, verticiliate, horizontal and irregular (Fig.4).

3.1.1.8 Trunk height (m)

Height of the trunk from base to the point of emergence of first branch was measured from surveyed accessions and expressed in centimeters.

3.1.2 Leaf characters

From each accession, ten leaves were collected and the following observations were made.

3.1.2.1 Leaf blade length (cm)

Length of the leaves from base to the tip of the blade was measured in centimeter.

3.1.2.2 Leaf blade width (cm)

Width of the leaves at the widest portion was measured and expressed in centimeter.

3.1.2.3 Leaf blade length/width ratio

The length/width ratio was calculated by taking average length and width of the leaves.

3.1.2.4 Leaf blade shape

The shape of leaves was noted visually and grouped as obovate, elliptic, broadly elliptic, oblong or lanceolate (Fig.5).

3.1.2.5 Leaf apex shape

The shape of leaf apex was noted visually in selected accessions and classified as acute, cuspidate, retuse and obtuse (Fig.6).

3.1.2.6 Leaf base shape

The shape of leaf base was noted visually in selected accessions and categorised as oblique, rounded, cuneate and shortly attenuate (Fig. 7).

3.1.2.7 Petiole length (mm)

Length of the petiole was measured from base of the petiole to the base of the leaf blade in mature leaf and expressed in millimeter.

3.1.3 Flowering characters

3.1.3.1 Season of flowering

Season of flowering in each accession was recorded.

3.1.3.2 Flowering span

Span of flowering, both male and female, in each accession was calculated by recording the period in number of days from first flower formation to the final one.

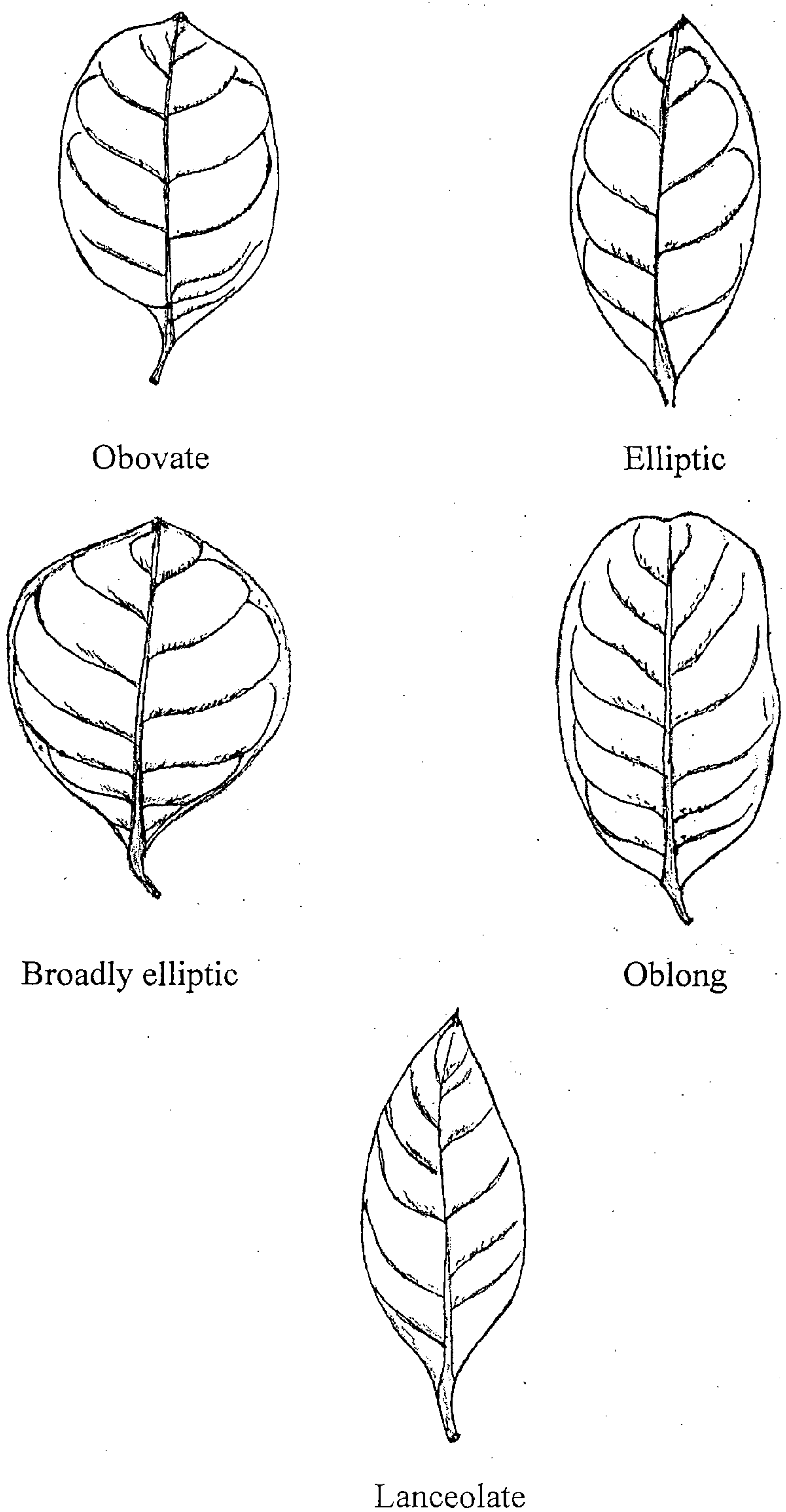
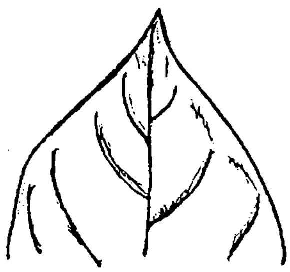
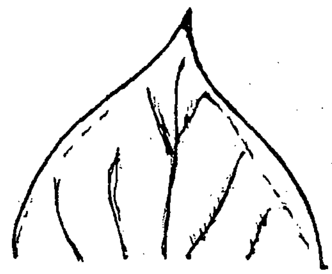


Fig. 5. Leaf blade shape of Jack



Acute

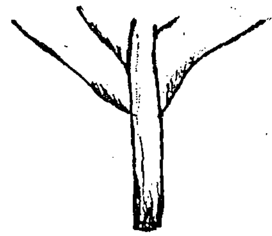


Cuspidate

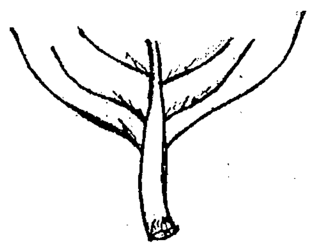
Retuse

Obtuse

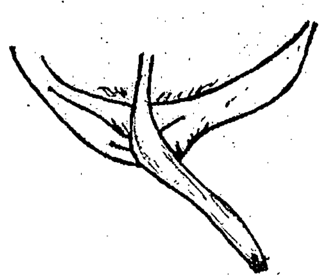
Fig. 6. Leaf apex shape of Jack



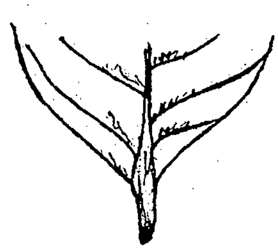
Oblique



Rounded



Cuneate



Shortly attenuate

Fig. 7. Leaf base shape of Jack

3.1.3.3 Inflorescence position

Position of female and male inflorescence in each collections were observed.

3.1.4 Fruit characters

3.1.4.1 General fruit characters

3.1.4.1.1 Season of fruiting

Season of fruiting in each accession was recorded.

3.1.4.1.2 Fruit bearing habit

The bearing habit of the accession was recorded and grouped as regular, alternate and irregular.

3.1.4.1.3 Fruit bearing position

Fruit bearing position in each accession was recorded.

3.1.4.1.4 Fruit clustering habit

Fruit clustering habit in different collections was observed.

3.1.4.1.5 Fruit shape

Shape of the fruits from different trees was recorded and grouped into eight namely, obloid, spheroid, high spheroid, ellipsoid, clavate, oblong, broadly ellipsoid and irregular (Fig.8).

3.1.4.1.6 Junction of stalk attachment to fruit

Junction of stalk attachment to fruit in each accession was recorded visually and classified as depressed, flattened and inflated (Fig.9).

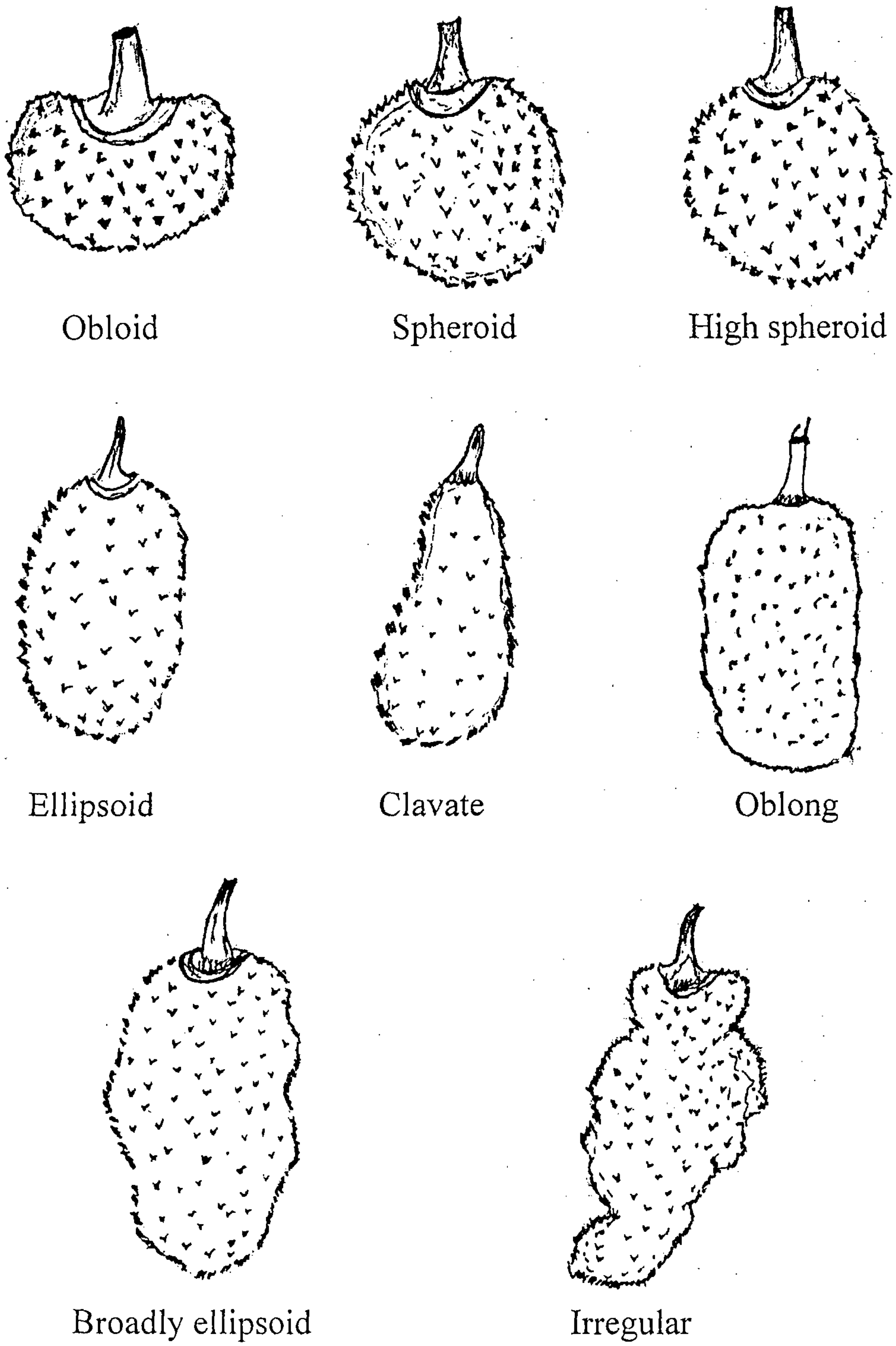
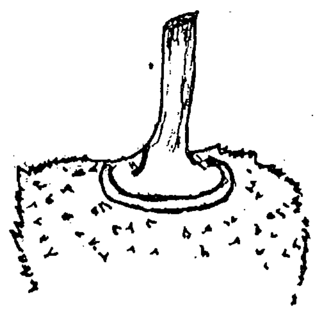
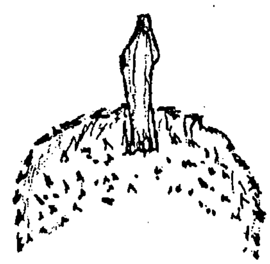


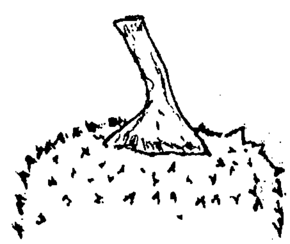
Fig. 8. Jackfruit shape



Depressed



Flattened



Inflated

Fig. 9. Junction of stalk attachment to fruit

3.1.4.1.7 Fruit rind colour (at maturity)

Rind colour of matured fruits was observed and grouped into four groups namely, green, greenish yellow, yellow and greenish brown.

3.1.4.1.8 Fruit surface

Nature of the surface of matured fruits at different collections was observed visually and grouped as smooth or rough.

3.1.4.1.9 Shape of spines

Shape of spines of matured fruits of collected accessions was observed visually and grouped into sharp pointed, intermediate or flat as per the descriptor.

3.1.4.1.10 Spine density

Density of spines of different accessions was observed by counting the number of spines in 5 x 5 cm^2 at the base of matured fruits and grouped into either sparse or dense.

3.1.4.1.11 Latex exudation

Exudation of latex in selected accessions was observed visually and grouped into low, medium and high.

3.1.4.1.12 Flake shape

Shape of the flakes taken from middle region of fruit was visually observed and grouped into eight, namely, spheroid, cordate, twisted, elongated, obovate, rectangular, oblong with curved tip or irregular (Fig.10).

3.1.4.2 Biometric characters

Observations were recorded on two well developed fruits from each genotype.

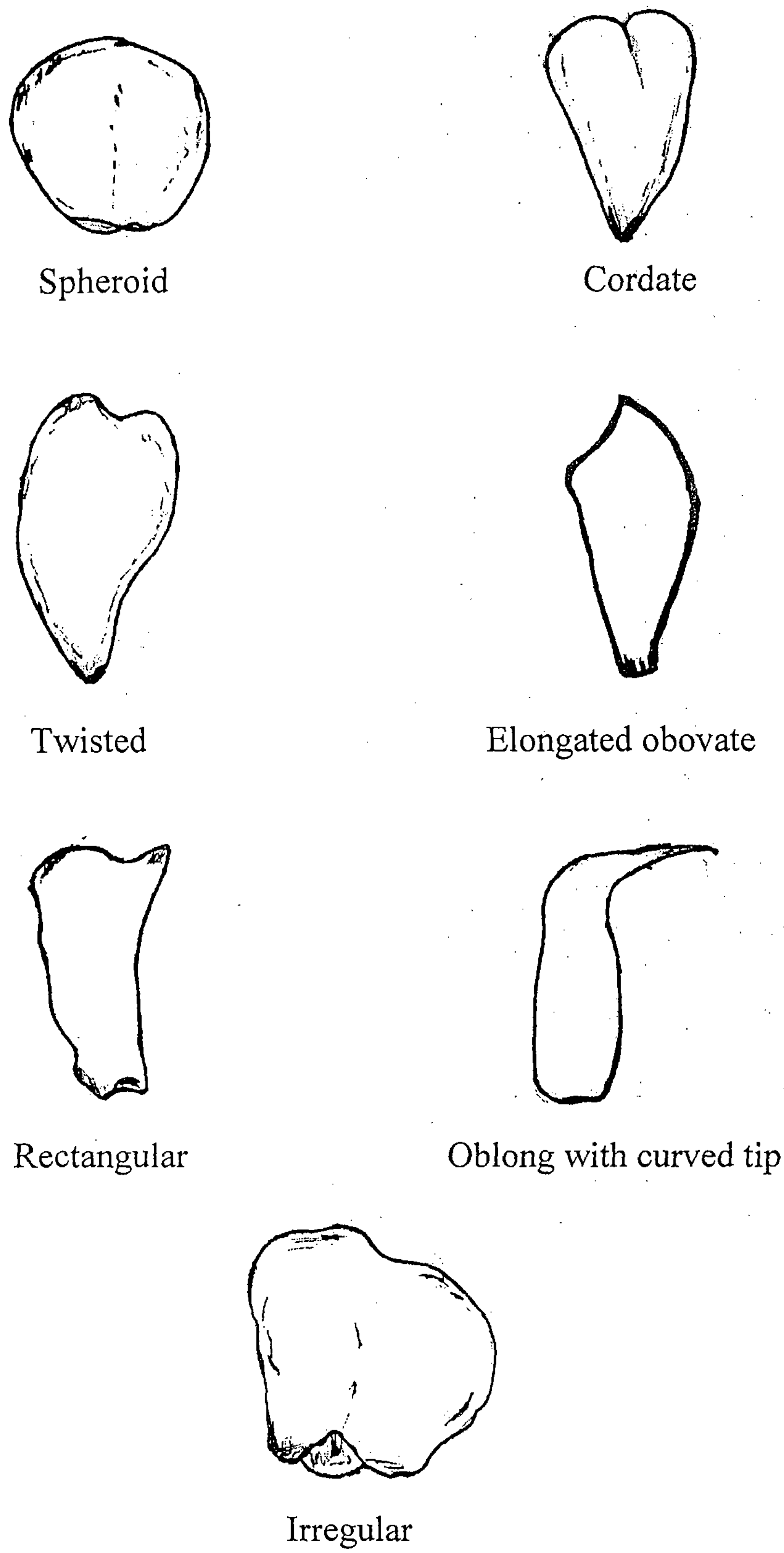


Fig. 10. Jack flake shape

3.1.4.2.1 Stalk length (cm)

Stalk length of matured fruits in each accession was measured from base of the peduncle to the base of the fruit and expressed in centimeter.

3.1.4.2.2 Fruit length (cm)

The length of matured fruits was recorded in centimeter.

3.1.4.2.3 Fruit girth (cm)

Girth at the middle of the fruits was measured and expressed in centimeter.

3.1.4.2.4 Fruit weight (kg)

The weight of fruits from each genotype was recorded and expressed in kilogram.

3.1.4.2.5 Fruit rind weight (kg)

After opening the fruits, bulbs, seeds and perigones were taken out and the rind was separated. The weight of the rind of each fruit was taken and expressed in kilogram.

3.1.4.2.6 Fruit rind thickness

Rind thickness of fruits at the maximum point from each accession was measured and expressed in millimeter. Based on the value, the rind of fruits was classified into thin (less than 1.00 mm), medium (1.00 to 2.00 mm) and thick (more than 2.00 mm).

3.1.4.2.7 Number of flakes per fruit

Number of flakes per fruit was counted.

3.1.4.2.8 Weight of flakes per fruit

Weight of flakes was taken for each accession and expressed in kilogram.

3.1.4.2.9 Weight of a fresh flake with seed (g)

Weight of twenty five fresh flakes along with seed was taken and average was worked out and expressed in gram.

3.1.4.2.10 Weight of a fresh flake without seed (g)

Weight of twenty five fresh flakes after removing seeds was taken and average was worked out and expressed in gram.

3.1.4.2.11 Flakes fruit ratio

Flakes fruit ratio was calculated as the ratio of all the flakes without seed to total weight of fruit.

3.1.4.2.12 Flake length (cm)

Length of 20 flakes of each genotype was noted separately in centimeter and average was worked out.

3.1.4.2.13 Flake width (cm)

Width of 20 flakes at the widest point in each genotype was recorded separately in centimeter and average was worked out.

3.1.4.2.14 Flake thickness

Thickness of 10 flakes at the widest point in each genotype was recorded separately in millimeter and average was worked out. Based on the value, the flakes were classified into thin (less than 0.2 mm), medium (0.2 to 0.3 mm) and thick (more than 0.3 mm).

3.1.4.2.15 Rachis length (cm)

In each genotype, length of the rachis of two riped fruits was recorded separately in centimeter and average was worked out.

3.1.4.2.16 Rachis diameter (cm)

Diameter of the rachis of two riped fruits from each genotype was recorded separately and their average was calculated and expressed in centimeter.

3.1.4.2.17 Perigones weight (kg)

Weight of the perigones i.e., unfertilised flakes was measured and expressed in kilogram.

3.1.4.3 Biochemical characters

3.1.4.3.1 Total, reducing and non-reducing sugars

Total and reducing sugars were determined as per the procedure described by Ranganna (1986). The non-reducing sugars were obtained by substracting the per cent of reducing sugars from the total sugars.

3.1.4.3.2 Total soluble solids (TSS°Brix)

TSS of the ripened flakes was estimated directly using the Erma hand refractometer and expressed in degree brix.

3.1.4.3.3 Acidity

Titrable acidity was estimated as per the procedure described by Ranganna (1986).

3.1.4.4 Sensory evaluation of ripe flakes

Sensory evaluation was carried out with the help of trained panel consisting of 15 members. They were asked to evaluate the samples for its appearance, colour, firmness, flavour, sweetness and overall acceptability on a ten point hedonic scale (Appendix-II). The ratings were as follows.

0.0-2.0 - very poor
2.1-4.0 - poor
4.1-6.0 - satisfactory
6.1-8.0 - good
8.1-10.0 - excellent

3.1.5 Seed characters

3.1.5.1 Descriptive characters

3.1.5.1.1 Seed shape

Shape of the seeds from different accessions was visually noticed and grouped into six categories namely, spheroid, ellipsoid, elongate, oblong, reniform and irregular (Fig.11).

3.1.5.1.2 Seed surface pattern

Seeds from each genotype was visually observed for its surface pattern and classified into three categories such as uniform, with regular striations and with patches.

3.1.5.1.3 Seed coat colour

Colour of the seed coat in each genotype was visually observed and classified into four categories such as off white, creamish, dull brown and brownish.

3.1.5.1.4 Vivipary

Each genotype was observed for presence (or) absence of vivipary.

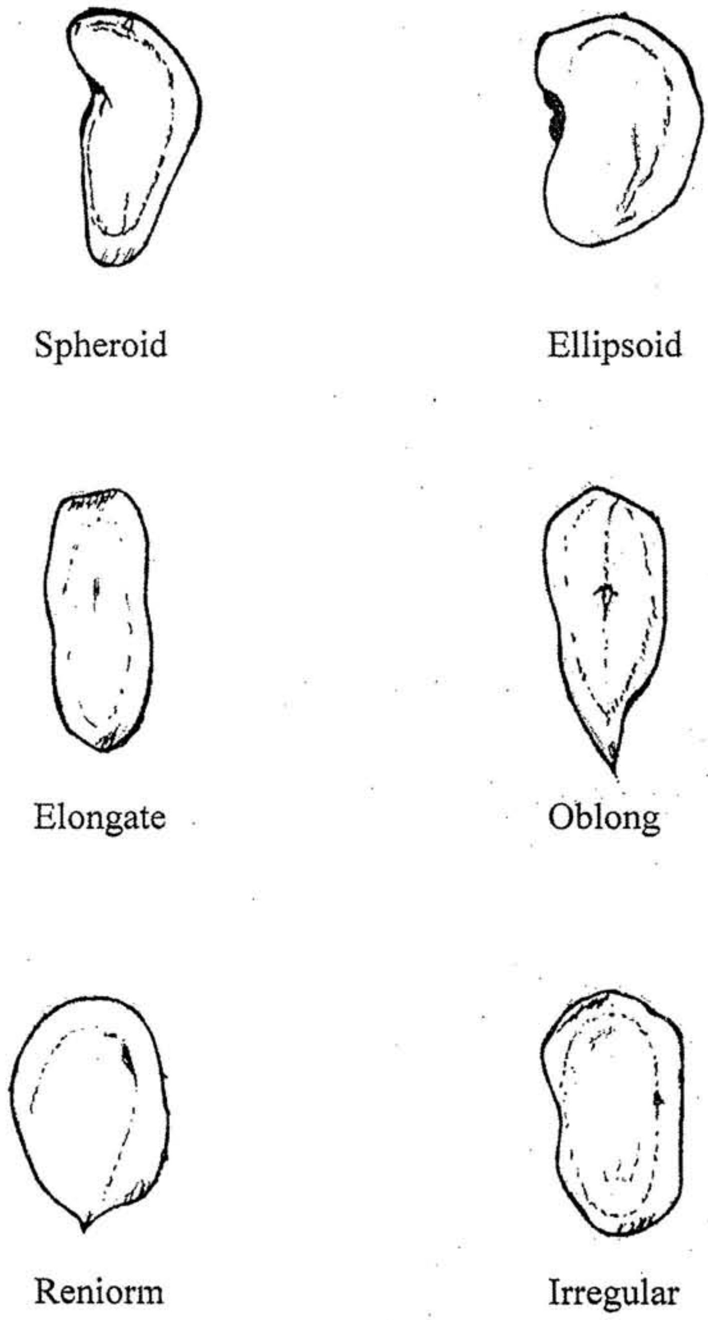


Fig. 11. Jack seed shape

3.1.5.2 Biometric characters

3.1.5.2.1 Seed length (cm)

Length of 20 seeds in each genotype was recorded separately in centimeter and average was worked out.

3.1.5.2.2 Seed girth (cm)

Girth of 20 seeds in each genotype was recorded separately in centimeter and average was worked out.

3.1.5.2.3 Hundred seed weight (g)

Weight of 100 seeds in each genotype was recorded in gram.

3.1.6 Yield characters

3.1.6.1 Yield per tree (kg)

Yield per year of each genotype was estimated for two successive seasons and expressed in kilogram.

3.1.6.2 Number of fruits per tree

Total number of fruits per tree in each accession was recorded.

3.1.7 Soil characters

Soil samples were collected from the base of selected trees from four different spots within the radius of three meters. Then, they were made into a single composit sample and analysed for organic matter, organic carbon, total nitrogen, total phosphorous and potassium content as per the procedure outlined by Jackson (1958).

3.1.8 Statistical analysis

The data on the above mentioned morphological, biochemical and sensory characters of the fruits from different accessions were subjected to analysis of variance as adopted for completely randomised design by Panse and Sukhatme (1975) in order to test the significance of variation. Duncan's multiple range test was also carried out for the comparison of means of different morphological and biochemical characters of fruits from different accessions. Simple correlation between biometric, biochemical and sensory characters of fruit and soil characteristics was worked out. Path analysis was carried out to know the direct and indirect effect between biometric, biochemical and sensory characters of the fruit. The data were consequently subjected to multivariate analysis utilising non-hierarchical euclidean cluster analysis in order to find out the genetic divergence.

3.2 CANOPY MANAGEMENT

The experiment was carried out at the research plot associated with Fodder Development Scheme, College of Veterinary and Animal Sciences, Mannuthy, Kerala Agricultural University, which falls at an altitude of 300 M above mean sea level.

Mannuthy has a highly leached soil (Oxisol and Ultisol) and it receives a total rainfall of about 2500 mm per annum. The mean maximum temperature varied from 27.5 to 36.2°C and the mean minimum temperature varied from 21.5 to 27.8°C. Weather data for the four year period, i.e., 1998 to 2001, when the experiments were carried out, are presented in Appendix-III.

The experimental materials used for the study, were 30 to 35 years old jack trees maintained in the Station. These plants were raised at a spacing of 9 x 9 m and the trees were under uniform management.

3.2.1 Observations before implementation of treatment

The following observations were made on the experimental trees before the implementation of the treatment.

3.2.1.1 Phenological observations

Visual observations were made with respect to the onset and extent of the different phenological changes such as flushing, period of active growth, flowering and harvesting in the experimental trees over a period of one year from October 1998 to September 1999.

3.2.2 Experimental description

The canopies of the experimental trees were opened by removing branches of different orders, thus bringing different regimes of light penetration. The experimental design used was a Simple Randomised Design. Nine treatments were given with six replications each. The treatment details are furnished hereunder.

Treatment I. Removal of 25 per cent of second order branches
Treatment II: Removal of 50 per cent of second order branches
Treatment III: Removal of 75 per cent of second order branches
Treatment IV: Removal of 25 per cent of third order branches
Treatment V: Removal of 50 per cent of third order branches
Treatment VI: Removal of 75 per cent of third order branches
Treatment VII: Removal of 25 per cent of fourth order branches
Treatment VIII: Removal of 50 per cent of fourth order branches
Treatment IX: Removal of 75 per cent of fourth order branches
Treatment X: Control - without any manipulation

The removal of different order of branches was carried out during September 1999. To prevent fungal infection, Bordeaux paste was applied to the cut ends of the branches. The subsequent development of the canopy for the following two years was monitored.

3.2.3 Observations on pruned trees

Observations were taken on the pruned trees on the following aspects.

3.2.3.1 Flushing characters

3.2.3.1.1 Time taken for flushing (days)

Number of days taken for flushing was noted in all the experimental trees and control.

3.2.3.2 *Flowering characters*

3.2.3.2.1 *Time taken for flowering (days)*

Number of days taken for flowering was noted in all the experimental trees and control.

The following observations were taken out on the experimental trees before pruning and first and second year of pruning.

3.2.3.2.2 *Season of flowering*

Flowering season was noted in all the experimental trees for the subsequent two years of pruning.

3.2.3.2.3 *Flowering span (Days)*

The span of flowering in each tree was calculated by recording the period in number of days from the emergence of first spike to the last one.

3.2.3.2.4 *Spike development*

The duration of male and female spike development was calculated from the first visual appearance of the spike in the leaf axil to complete emergence and expressed in days.

3.2.3.3 *Fruiting characters*

The following observations were carried out on the trees before subjecting to different pruning treatments and first and second year after pruning.

3.2.3.3.1 *Fruiting span (Days)*

The span of fruiting in each tree was calculated by recording the period in number of days from first fruit harvesting to final fruit harvesting.

3.2.3.3.2 Per cent of fruit set

Immediately after anthesis 25 flowers were tagged per tree. The number of flowers developed into fruit was counted and per cent of fruit set was worked out.

3.2.3.3.3 Average fruit weight (kg)

The weight of ten fruits from each tree was recorded and average was worked out and expressed in kilogram.

3.2.3.3.4 Number of fruits

Number of fruits in each tree was recorded.

3.2.3.3.5 Yield

Yield of fruits in each tree was calculated and expressed in kilogram.

3.2.3.4 Biochemical characters of flakes

The following biochemical observations were carried out on the fruits of the trees before pruning and first and second year after pruning.

1. Total sugars
2. Reducing sugars
3. Non-reducing sugars
4. Acidity

3.2.4 Statistical analysis

The recorded data were statistically analysed by two factor completely randomised design suggested by Panse and Sukhatme (1975).

3.3 CHARACTERISATION OF SOFT AND FIRM FLESHED TYPES

Twenty five well differentiated soft as well as firm fleshed trees of same age group were selected from different locations in Thrissur district. The following morphological observations of the tree and the anatomical and biochemical analyses of leaves were carried out.

3.3.1 Morphological characterisation

3.3.1.1 Plant characters

The following visual and biometric observations on the jack trees of age about 25 years old were recorded.

1. Tree shape
2. Tree growth habit
3. Apical dominance
4. Trunk surface
5. Branching density
6. Branching pattern
7. Plant height (m)
8. Spread of the plant (m^2)
9. Collar girth (cm)
10. Height at first branching (m)
11. Colour of bark
12. Colour of the tender roots

3.3.1.2 Leaf characters

From the firm and soft fleshed types, 40 leaves of each were collected and the following leaf characters were recorded.

1. Leaf length (cm)
2. Leaf width (cm)
3. Length/width ratio
4. Petiole length (mm)
5. Internodal length (cm)
6. Leaf blade shape
7. Leaf apex shape

8. Leaf base shape
9. Leaf blade margin
10. Leaf colour
11. Petiole shape

3.3.2 Anatomical characterization

3.3.2.1 Stomatal count per unit area

In order to ascertain the number of stomata, peelings of the lower epidermis were taken from the base, middle and tip of leaf lamina and number of stomatal openings were counted per microscopic field and average was calculated from this value. Stomatal index was worked out by using the formula

$$\text{Stomatal index} = \frac{\text{Number of stomata}}{\text{Number of stomata} + \text{Number of other epidermal cells}} \times 100$$

3.3.4 Biochemical characterization

The following biochemical analyses on the mature trees were done.

3.3.4.1 Total phenol

Total phenol content of both young and mature leaves was estimated by Folin-Ciocalteau method (Sadasivam and Manickam, 1992).

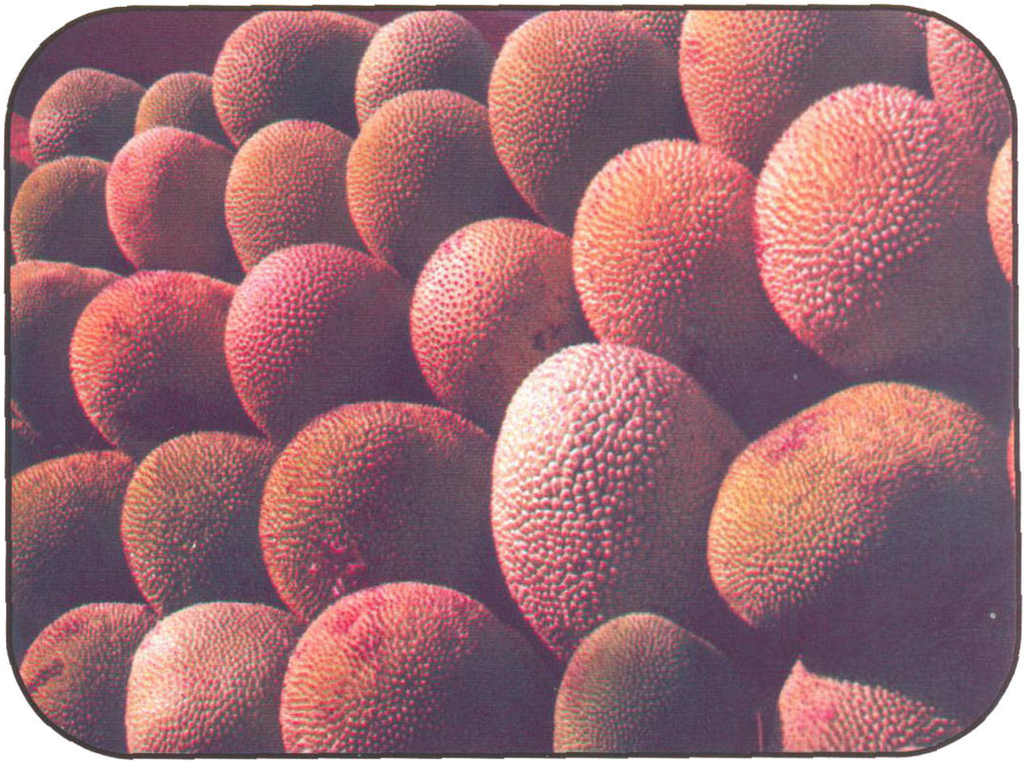
3.3.4.2 Thin layer chromatography (TLC)

TLC was carried out for the separation of phenolic compounds using precoated silica gel plates with the running solvent system 10 per cent glacial acetic acid in chloroform. Folin-Ciocalteau reagent was used as spraying agent.

3.3.5 Statistical analysis

The data collected were statistically analysed and analysis of variance was done as described by Panse and Sukhatme (1975).

Results



4. RESULTS

The results of the present investigations on "Genetic diversity and canopy management in jackfruit (*Artocarpus heterophyllus* Lam.)" are presented under the following major heads.

A. Genetic diversity

B. Canopy management

C. Characterisation of soft and firm fleshed types

4.1 GENETIC DIVERSITY

The study was undertaken in sixteen panchayats equally distributed in four topography namely, plains, hilly, coastal and riverside areas. The results obtained are given below.

4.1.1 General tree characters

Results of the observation recorded on general tree characters are presented in Table 1.

4.1.1.1 Tree age (years)

i) Plains

In plains, about 12.50 per cent of the trees observed was above 50 years old, 27.50 per cent was between 41-50 years, 26.25 per cent between 31-40 years, 22.15 per cent between 21-30 years and about 7.5 per cent of the trees was in the age group of 10-20 years. Only about 3.75 per cent of the trees studied were of age below 10 years (Table 1).

ii) Hills

On comparing with plains, a higher per cent of trees, i.e. 40.00 per cent was above 50 years of age. Among the rest of the trees studied, 25.00 per cent was between 41-50 years, 20.00 per cent between 31-40 years, 8.75 per cent between 21-30 years old and 5.00 per cent was between 10-20 years. Least number of i.e. 1.25 per cent of the trees studied was below 10 years of age, which was still lower than plains (Table 1).

iii) Coastal areas

Similar to hills, a higher per cent of the trees was above 50 years old i.e. 35.00 per cent. About 25.00 per cent of the trees were between 41-50 years, 25.00 per cent was between 31-40 years, 10.00 per cent were between 21-30 years and 3.75 per cent was between 10-20 years of age group. Similar to hills, only 1.25 per cent of the trees was below 10 years of age (Table 1).

(iv) Riverside area

About 16.25 per cent of the trees surveyed in riverside areas were above 50 years. 26.25 per cent was in the age group of 41-50 years, 25.00 per cent in 31-40 years, 22.50 per cent in 21-30 years, 6.25 per cent in 10-20 years of age group. As noticed in plains about 3.75 per cent of the trees surveyed were below 10 years old (Table 1).

Considering all the accessions as a whole irrespective of the topography, about 25.95 per cent of the trees was older i.e. above 50 years of age, 25.93 per cent was between 41-50 years, 24.06 per cent were in the age group of 31-40 years, 15.94 per cent were in the age group of 21-30 years, 5.62 per cent were between 10-20 years age. Only 2.50 per cent were less than 10 years of age (Table 1).

4.1.1.2 Height of trees (m)

(i) Plains

31.25 per cent of trees recorded a height of less than 10 m. Height of 68.75 per cent trees were above 10 m of which 43.75 per cent were between 10-20 m and 25.00 per cent were more than 20 m in height (Table 1).

(ii) Hills

The percentage of trees surveyed in hills having height less than 10 m was 22.50. About 40.00 per cent of trees were between 10-20 m. Comparing with plains, a higher number of trees i.e. 37.50 per cent were above 20 m (Table 1).

(iii) Coastal areas

23.75 per cent of the trees recorded a height of less than 10 m and 31.25 per cent was in the range of 10-20 m. Compared to other topographical levels a higher per cent of trees, i.e., 45.00 per cent were having a height of above 20 m (Table 1).

(iv) Riverside areas

33.75 per cent of the trees surveyed in riverside areas were having a height of less than 10 m. The height of 42.50 per cent of trees was found to range between 10-20 m. About 23.75 per cent of trees were of height above 20 m (Table 1).

Frequency distribution of trees surveyed irrespective of topography showed that about 27.81 per cent were of the height less than 10 m. 39.37 per cent were in the range of 10-20 m, 32.51 per cent of the trees recorded a height of above 20 m (Table 1).

4.1.1.3 Tree vigour

(i) Plains

Only 15.00 per cent of the trees surveyed in plains showed less in vigour. Among the rest of the trees, 60.00 per cent were of medium in vigour and 25.00 per cent were of highly vigorous ones (Table 1).

(ii) Hills

13.75 per cent of the trees were low in vigour and 50.25 per cent were medium in vigour. On comparing with plains, an increased per cent of trees i.e. 30.00 were of highly vigorous (Table 1).

Table 1. Tree characters and distribution of genotypes

Sl. No.	Characters	Description	Plains		Hills		Coastal		Riverside		Overall accessions	
			No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)
1.	Age in years (Approximate)	<10	3	3.75	1	1.25	1	1.25	3	3.75	8	2.50
		10-20	6	7.50	4	5.00	3	3.75	5	6.25	18	5.62
		21-30	18	22.15	7	8.75	8	10.00	18	22.50	51	15.94
		31-40	21	26.25	16	20.00	20	25.00	20	25.00	77	24.06
		41-50	22	27.50	20	25.00	20	25.00	21	26.25	83	25.93
		>50	10	12.50	32	40.00	28	35.00	13	16.25	83	25.95
2.	Height of trees (approximately) (m)	<10	25	31.25	18	22.50	19	23.75	27	33.75	89	27.81
		10-20	35	43.75	32	40.00	25	31.25	34	42.50	126	39.37
		>20	20	25.00	30	37.50	36	45.00	19	23.75	105	32.51
3.	Tree vigour	Low	12	15.00	11	13.75	14	17.50	14	17.50	51	15.93
		Medium	48	60.00	45	50.25	39	48.75	45	56.25	177	55.31
		High	20	25.00	24	30.00	27	33.75	21	26.25	92	28.75
4.	Canopy shape	Pyramidal	14	17.50	19	23.75	23	28.75	16	20.00	72	22.50
		Broadly pyramidal	11	13.75	11	13.75	15	18.75	11	13.75	48	15.00
		Obovate	10	12.50	7	8.75	7	8.75	8	10.00	32	10.00
		Oblong	7	8.75	5	6.25	6	7.50	9	11.25	27	9.00
		Semi-circular	10	12.50	8	10.00	3	3.75	11	13.75	32	10.00
		Elliptical	9	11.25	7	8.75	5	16.00	6	7.50	27	8.43
		Irregular	19	23.75	23	28.75	21	26.25	19	23.75	82	25.65
5.	Tree growth habit	Erect	31	38.75	36	45.00	40	50.00	30	37.50	137	42.81
		Semi-erect	28	35.00	20	25.00	28	35.00	21	26.25	97	30.33
		Spreading	13	16.25	15	18.75	7	8.75	75	31.25	60	18.75
		Drooping	8	10.00	9	11.25	5	6.75	4	5.00	26	8.13

Contd.

Table 1. continued

Sl. No.	Characters	Description	Plains		Hills		Coastal		Riverside		Irrespective of the topography	
			No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)
6.	Branching density	Low	20	25.00	26	32.50	28	35.00	23	28.75	97	30.32
		Intermediate	38	47.50	36	45.00	39	48.75	36	45.00	149	46.56
		High	22	27.50	18	22.50	13	16.25	21	26.25	74	23.12
7.	Branching pattern	Erect	19	23.75	21	26.25	28	35.00	18	22.50	86	26.88
		Opposite	15	18.75	13	16.25	19	23.75	20	25.00	57	17.80
		Verticilliate	13	16.25	15	18.75	13	16.25	16	20.00	57	17.80
		Horizontal	12	15.00	9	11.25	11	13.75	10	12.50	42	13.12
		Irregular	21	26.25	22	27.50	19	23.75	16	20.00	78	24.30
8.	Trunk height (m)	< 2 m	27	33.75	17	21.25	14	17.5	29	36.25	87	27.18
		2-4 m	33	41.25	22	27.50	32	40.0	36	45.00	133	41.73
		> 4 m	20	25.00	31	38.75	34	42.5	15	18.75	100	31.25

(iii) Coastal areas

Only 17.50 per cent of the trees observed in coastal areas were of low vigoured nature. About 48.75 per cent were of medium vigoured. A higher per cent of highly vigorous trees (33.75 per cent) were observed than the other three regions (Table 1).

(iv) Riverside areas

17.50 per cent of trees were of low in vigour. 56.25 per cent were of medium in vigour and 26.25 per cent were of high in vigour trees were observed among the collected accessions (Table 1).

Irrespective of the topography, about 15.93 per cent of trees showed low vigour. Medium vigorous trees were common and it was noted in 55.31 per cent of the surveyed trees. Highly vigorous trees accounted to about 28.75 per cent (Table 1).

4.1.1.4 Canopy shape

(i) Plains

In plains, canopy shapes like pyramidal, broadly pyramidal, obovate, oblong, semi-circular, elliptical and irregular were noticed in about 17.5 per cent, 13.75 per cent, 12.50 per cent, 8.75 per cent, 12.50 per cent, 11.25 per cent and 23.75 per cent of the trees respectively (Table 1).

(ii) Hills

Among the trees surveyed in hilly areas, 23.75 per cent of the trees had pyramidal shape which was higher than that of plains. About 13.75 per cent of the accessions surveyed had broadly pyramidal canopy, 8.75 per cent obovate, 6.25 per cent oblong, 10.00 per cent semi-circular, 8.75 per cent elliptical and 28.75 per cent irregular in tree canopy shape (Table 1).

(iii) Coastal areas

Majority of the accessions, i.e. 28.75 per cent collected from coastal areas had pyramidal tree shape. This was the highest among all other regions. Among the rest, 18.75 per cent were of broadly pyramidal, 8.75 per cent obovate, 7.50 per cent oblong, 3.75 per cent semi-circular, 16.00 per cent elliptical and 26.25 per cent irregular in tree shape (Table 1).

(iv) Riverside areas

Of the 80 trees surveyed, 20.00 per cent were of pyramidal, 13.75 per cent broadly pyramidal, 10.00 per cent obovate, 11.25 per cent oblong, 13.75 per cent semicircular, 7.50 per cent elliptical and 23.75 per cent irregular in canopy shape (Table 1).

A wide variety of tree shapes were noticed among the accessions. Considering the whole accessions as such, pyramidal shape was noticed in 22.50 per cent of the trees. 15.00 per cent had broadly pyramidal trees, 10.00 per cent obovate, 9.00 per cent oblong, 10.00 per cent semi-circular, 8.43 per cent elliptical and 25.65 per cent irregular in canopy shape (Table 1).

4.1.1.5 Tree growth habit

(i) Plains

Of the 80 accessions surveyed in plains, 38.75 per cent had erect growth habit, 35.00 per cent semi-erect, 16.25 per cent spreading and 10.00 per cent drooping in growth habit (Table 1).

(ii) Hills

Erect, semi-erect, spreading and drooping growth habit were noticed in 45.00 per cent, 25.00 per cent, 18.75 per cent and 11.25 per cent of the trees surveyed, respectively (Table 1).

(iii) Coastal areas

Majority of the trees surveyed in coastal areas i.e. 50.00 per cent had erect growth habit which was the highest among all the other regions. 35.00 per cent, 8.75 per cent and 6.75 per cent of the trees surveyed had the growing habits like, semi-erect, spreading and drooping, respectively (Table 1).

(iv) Riverside areas

In riverside areas, 37.50 per cent, 26.25 per cent, 31.25 per cent and 5.00 per cent of the trees studied showed the growth habits such as erect, semi-erect, spreading and drooping, respectively (Table 1).

Based on the tree growth habit, irrespective of the topography, 42.81 per cent of the total accessions collected had the erect growth habit, 30.33 per cent had semi-erect, 18.75 per cent had spreading and 8.13 per cent had drooping growth habit (Table 1).

4.1.1.6 Branching density

(i) Plains

About 25.00 per cent on the trees surveyed had low branching density. 47.50 per cent of the trees had intermediate branching density. Highest branching density was noticed in 27.5 per cent of the accessions which was higher than those of other regions (Table 1).

(ii) Hills

Intermediate branching density was predominantly noticed i.e., in 45.00 per cent of trees. The rest of the trees showed either low (32.50 per cent) or high (22.50 per cent). Compared to plains and riverside the per cent of trees with low branching density was more (Table 1).

(iii) Coastal area

Here also, the maximum number of trees (48.75 per cent) were intermediate in branching density. Low and high branching densities were noticed in 35.00 per cent and 16.25 per cent, respectively. Compared to the plains, hills and riverside areas, the per cent of trees with low branching density was more (Table 1).

(iv) Riverside areas

Branching density was intermediate in 45.00 per cent of trees surveyed. Rest of the trees showed low (28.25 per cent) and high (26.25 per cent) branching density (Table 1).

In general, intermediate branching density was common and was noticed in 46.56 per cent, followed by low branching density (30.32 per cent) and high branching density (23.12 per cent) (Table 1).

4.1.1.7 Branching pattern

(i) Plains

Among the accessions in plains, 23.75 per cent, 18.75 per cent, 16.25 per cent, 15.00 per cent and 26.25 per cent had erect, opposite, verticilliate, horizontal and irregular branching patterns respectively (Table 1).

(ii) Hills

In hilly areas, erect, opposite, verticilliate, horizontal and irregular branching pattern were noticed in 26.25 per cent, 16.25 per cent, 18.75 per cent, 11.25 per cent and 27.50 per cent of surveyed trees, respectively (Table 1).

(iii) Coastal areas

About 35.00 per cent, 23.75 per cent, 16.25 per cent, 13.75 per cent and 23.75 per cent of the accessions studied in the coastal areas showed erect, opposite, verticilliate, horizontal and irregular branching patterns, respectively. Compared with other regions, a higher per cent of trees had erect branching pattern (Table 1).

(iv) Riverside areas

Among the trees surveyed in the riverside areas, 22.50 per cent had erect branching pattern, 25.00 per cent had opposite, 20.00 per cent had verticilliate, 12.50 per cent had horizontal and 20.00 per cent had irregular branching pattern (Table 1).

Branching patterns namely of erect, opposite, verticilliate, horizontal and irregular were observed in 26.88 per cent, 17.80 per cent, 17.80 per cent, 13.12 per cent and 24.30 per cent respectively in all the accessions surveyed irrespective of topography (Table 1).

4.1.1.8 Trunk height (m)

(i) Plains

About 33.75 per cent, 41.25 per cent and 25.00 per cent of the trees surveyed in plains respectively, had their trunk height less than 2 m, 2-4 m and more than 4 m (Table 1).

(ii) Hills

In hilly areas, among the surveyed accessions, 21.25 per cent, 27.50 per cent and 38.75 per cent had their trunk height respectively in the range of less than 2 m, 2-4 m and more than 4 m (Table 1).

(iii) Coastal areas

42.50 per cent of the trees had trunk height more than 4 m and was higher than that of other regions. Among the rest of the trees, 40.00 per cent were in between 2-4 m and 17.50 per cent less than 2 m (Table 1).

(iv) Riverside areas

36.25 per cent, 45.00 per cent and 18.75 per cent of the trees located in riverside areas respectively had their trunk height less than 2 m, 2-4 m and more than 4 m (Table 1).

Irrespective of the topography, about 27.18 per cent of the trees had a trunk height of less than 2 m. 41.73 per cent had the trunk height of 2-4 m range while 31.25 per cent of the trees had more than 4 m of trunk height (Table 1).

4.1.2 Leaf characters

Results of the observations recorded on leaf size are presented in Table 3. Frequency distribution of the accessions under each topography is presented in Table 2.

4.1.2.1 Leaf blade length (cm)

Variation in leaf length is presented in Plate 1.

(i) Plains

The average leaf length was 13.37 cm and the range was 5.60 to 19.70 cm with a coefficient of variation of 35.01 per cent (Table 3). About 67.50 per cent of the trees studied were in the range of 10 to 15 cm (Table 2).

(ii) Hills

The mean leaf blade length was 14.03 cm. It ranged from 8.20 to 22.90 cm with a coefficient of variation of 36.00 per cent (Table 3). 73.50 per cent of the trees recorded leaf length in the range of 10-15 cm (Table 2).

(iii) Coastal areas

The leaf blade length ranged from 8.10 to 19.20 cm with a mean value of 13.78 cm. The coefficient of variation was 37.28 per cent (Table 3). Majority of the accessions (56.25 per cent) were in the range of 10-15 cm. On comparing with other topographical levels, a higher per cent of trees i.e. 40.00 per cent had leaf length more than 15.00 cm (Table 2).

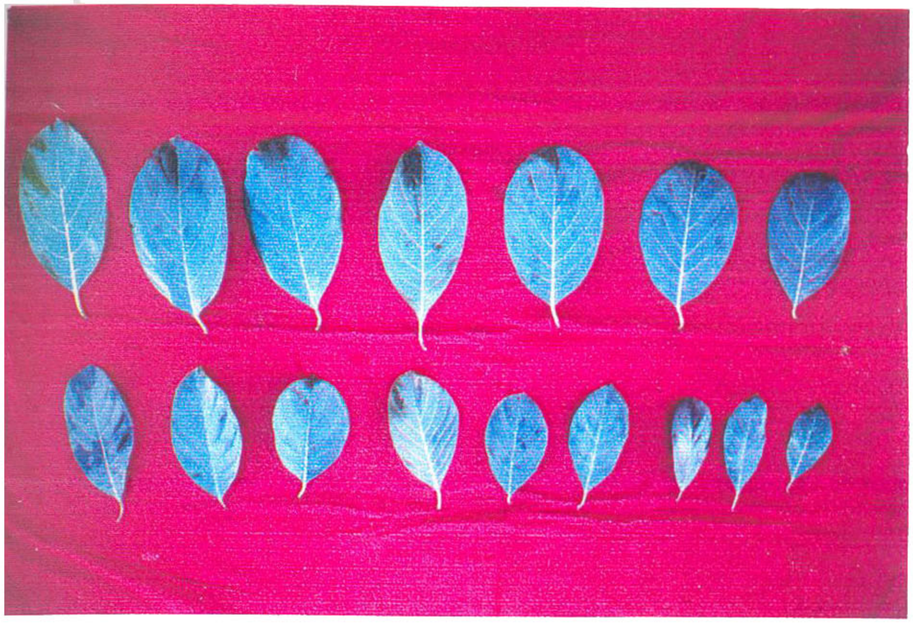


Plate 1. Leaf length variation in jack

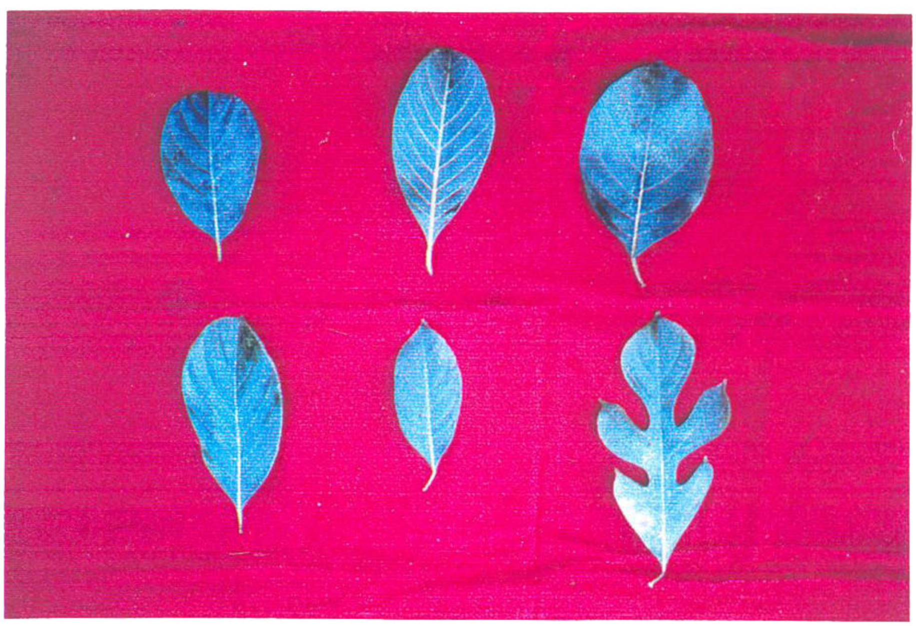


Plate 2. Different shape of leaves in jack

(iv) Riverside areas

The maximum leaf blade length observed was 19.8 cm and the minimum was 8.60 cm. The mean value was 13.53 cm. The coefficient of variation was 34.28 per cent (Table 3). Majority of the accessions (68.75 per cent) had the leaf length in the range of 10-15 cm (Table 2).

The average leaf length was 13.68 cm. It ranged from 5.60 to 22.90 cm with a co-efficient of variation of 36.00 per cent (Table 3). Frequency distribution of the values showed that the majority (66.56 per cent) of the accession were in the range of 10-15 cm (Table 2).

4.1.2.2 Leaf blade width (cm)

(i) Plains

Width of the leaves varied from 4.60 to 13.50 cm with a mean value of 7.58 cm. The coefficient of variation was 26.69 per cent (Table 3). Most of the accessions (66.25 per cent) had the leaf width in the range of 5 to 10 cm (Table 2).

(ii) Hills

Leaf blade width in accessions studied in hills was found to vary from 3.50 to 10.40 with the mean value of 7.74 cm. The coefficient of variation was 23.27 per cent (Table 3). About 63.75 per cent of the accessions were in the range of 5-10 cm (Table 2).

(iii) Coastal areas

Among the accessions surveyed, leaf blade breadth was found to vary from 4.30 to 11.15 cm with a mean value of 8.15 cm. Coefficient of variation was 19.81 per cent (Table 3). About 60.00 per cent of leaves had the breadth of 5-10 cm. Compared to plains and hills, a little higher percentage, i.e., about 30.00 per cent had their leaf blade breadth of more than 10.00 cm (Table 2).

Table 2. Frequency distribution of the accessions under each topography with respect to leaf characters

Sl. No.	Characters	Class interval	Plains		Hills		Coastal		Riverside		Overall accessions	
			No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)
1.	Leaf length (cm)	<10	10	12.50	7	8.75	3	3.75	10	12.50	30	9.38
		10-15	54	67.50	59	73.50	45	56.25	55	68.75	213	66.50
		>15	16	20.00	14	17.50	32	40.00	15	18.75	77	24.06
2.	Leaf width (cm)	<5	13	16.25	10	12.50	8	10.00	20	25.00	51	15.90
		5-10	53	66.25	51	63.75	48	60.00	45	56.25	97	61.56
		>10	14	17.50	19	23.75	24	30.00	15	18.75	72	22.50
3.	Leaf length/ leaf width	<1	0	0	0	0	1	1.25	0	0	1	0.31
		1-2	55	68.75	53	66.25	60	75.00	52	65.00	220	68.75
		>2	25	31.25	27	33.75	19	33.75	28	35.00	99	30.94
4.	Leaf blade shape	Obovate	15	18.75	21	26.25	24	30.00	16	20.00	76	23.75
		Elliptic	29	36.25	21	38.75	30	37.50	19	23.75	99	30.93
		Broadly elliptic	7	8.75	9	11.25	5	6.25	9	11.25	30	9.37
		Oblong	19	23.75	21	26.25	14	17.50	25	31.25	79	24.68
		Lanceolate	10	12.50	8	10.00	7	8.75	11	13.75	36	11.25
		Irregular	0	0	0	0	0	0	0	0	0	0
5.	Leaf apex shape	Acute	28	35.00	31	38.75	29	36.25	27	33.75	115	35.93
		Cuspidate	32	40.00	32	40.00	33	41.25	32	40.00	129	40.31
		Retuse	17	21.25	15	18.75	16	20.00	18	22.50	66	20.62
		Obtuse	3	3.75	2	2.50	2	2.50	3	3.75	10	3.12
6.	Leaf base shape	Oblique	31	38.75	30	37.50	33	41.25	30	37.50	124	38.75
		Rounded	11	13.75	12	15.00	12	15.00	14	17.50	49	15.31
		Attenuate	24	30.00	23	28.75	21	26.25	21	26.25	89	27.81
		Shortly attenuate	14	17.50	15	18.75	14	17.50	15	18.75	58	18.12
7.	Petiole length (mm)	<20	11	13.75	8	10.00	4	50	13	16.25	36	11.25
		20-40	38	47.50	37	46.25	34	42.50	35	43.75	144	45.00
		>40	31	38.75	35	43.75	42	52.50	32	40.00	140	43.75

Table 3. Variation in leaf size characters of the accessions surveyed under different topography

Sl. No.	Characters	Plains			Hills			Coastal			Riverside			Overall accessions		
		Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)
1	Leaf length (cm)	5.60-19.70	13.37	35.01	8.20-22.90	14.03	36.00	8.10-19.20	13.78	37.28	8.60-19.8	13.53	34.28	5.60-22.90	13.68	36.00
2	Leaf width (cm)	4.60-13.50	7.58	26.69	3.50-10.40	7.74	23.27	4.30-11.15	8.15	19.81	4.40-10.10	7.42	22.71	3.05-13.50	7.72	23.00
3	Leaf width/breadth	1.05-3.56	1.89	36.86	1.21-4.60	1.93	32.06	0.98-3.54	1.77	33.05	1.17-2.50	1.87	35.43	0.98-4.60	1.87	36.12
4	Petiole length (mm)	10.00-55.5	39.76	25.62	16.50-49.00	31.24	22.73	16.5-57.5	39.25	23.76	19.50-50.5	37.58	22.50	16.50-57.50	36.96	28.36

(iv) Riverside areas

The breadth appeared to vary from 4.40 to 10.10 cm with a mean value of 7.42 cm. The coefficient of variation was 22.71 per cent (Table 3). About 56.25 per cent of the leaves had the leaf blade breadth in the range of 5 to 10 cm (Table 2).

Considering all the accessions as a whole, leaf blade width ranged from 3.05 to 13.50 cm with a mean value of 7.72 cm. The coefficient of variation was 23.00 per cent indicating the existence of wide variability among accessions (Table 3). Majority of the accessions (61.56 per cent) had a leaf blade width in the range of 5-10 cm (Table 2).

4.1.2.3 Leaf blade length/width ratio (L/W ratio)

(i) Plains

The L/W ratio of leaves varied from 1.05-3.56 with a mean value of 1.89. The coefficient of variation was 36.86 per cent (Table 3). Most of the accessions, i.e., 68.75 per cent, were in the range of 1-2 (Table 2).

(ii) Hills

The L/W ratio of the trees surveyed in hills were coming under the range of 1.21-4.60. The mean of the 80 accession studied was 1.93 and the coefficient of variation was 32.06 per cent (Table 3). Majority of the accessions, i.e., 66.25 per cent were in the range of 1-2 (Table 2).

(iii) Coastal area

The trees surveyed in coastal areas had the L/W ratio in the range of 0.98-3.54 with a mean value of 1.77. The coefficient of variation was 33.05 per cent (Table 3). About 75.00 per cent of the population were having L/W ratio in the range of 1-2 (Table 2).

(iv) Riverside areas

The L/W ratio showed a variation in the range of 1.17-2.50. The mean L/W ratio observed was 1.87. The coefficient of variation calculated accounted to about 35.43 per cent (Table 3). About 65.00 per cent of the studied trees were in the range of 1-2 (Table 2).

Irrespective of the topography the L/W ratio of the accessions studied varied from 0.98-4.60 with a mean value of 1.87. The coefficient of variation was higher (36.12 per cent) (Table 3). Majority of the accessions, (68.75 per cent) were having L/W ratio in the range of 1-2 (Table 2).

4.1.2.4 Leaf blade shape

Different shapes of leaves are presented in Plate 2.

(i) Plains

Accessions collected under plains had obovate, elliptic, broadly elliptic, oblong and lanceolate leaves in 18.75 per cent, 36.25 per cent, 8.75 per cent, 23.75 per cent and 12.50 per cent of the trees respectively (Table 2).

(ii) Hills

Except irregular shaped leaves, all other leaf shapes like obovate, elliptic, broadly elliptic, oblong and lanceolate were noticed. They were present in 26.25 per cent, 38.75 per cent 11.25 per cent, 26.25 per cent and 10.00 per cent of the surveyed trees, respectively (Table 2).

(iii) Coastal areas

Among the trees surveyed in coastal areas, 30.00 per cent, 37.50 per cent, 6.25 per cent, 17.50 per cent and 8.75 per cent had the leaf blade shapes obovate, elliptic, broadly elliptic, oblong and lanceolate respectively. Comparatively a higher per cent of trees had obovate leaf shape in coastal areas than the other three regions (Table 2).

(iv) Riverside areas

20.00 per cent of the trees had obovate leaves, 23.75 per cent had elliptic leaves, 11.25 per cent had broadly elliptic leaves, 31.25 per cent had oblong leaves and 13.75 per cent had lanceolate leaves (Table 2).

Considering all the 320 accessions, obovate leaf was noticed in 23.75 per cent of the trees. 30.93 per cent had elliptic leaves and 9.37 per cent had broadly elliptic leaves. Oblong and lanceolate leaves were noticed in 24.68 per cent and 11.25 per cent of the trees, respectively. None of the trees studied had irregular leaves (Table 2).

4.1.2.5 Leaf apex shape

Leaf apex shapes in jack are presented in Plate 3.

(i) Plains

The leaf apex shape of the accessions collected in plains showed variation like cuspidate (40.00%), acute (35.00%), retuse (21.25%) and obtuse (3.75%) (Table 2).

(ii) Hills

Among the accessions collected in hills, 40.00 per cent showed cuspidate shape, 38.75 per cent showed acute, 18.75 per cent showed retuse and 2.50 per cent showed obtuse leaf apex shape (Table 2).

(iii) Coastal areas

41.25 per cent of the accessions had cuspidate, 36.25 per cent had acute, 20.00 per cent had retuse and 2.50 per cent had obtuse leaf apex shape (Table 2).

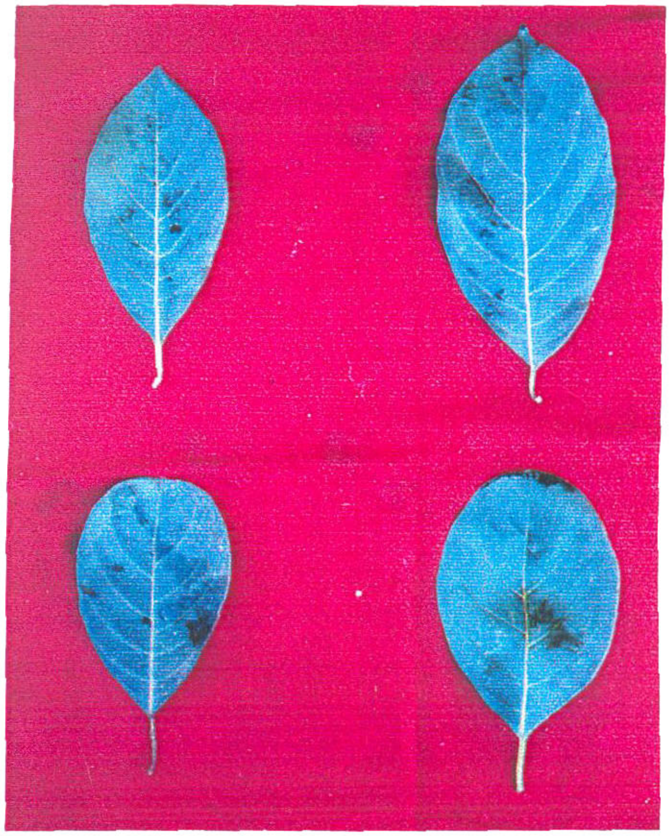


Plate 3. Leaf apex shape in jack

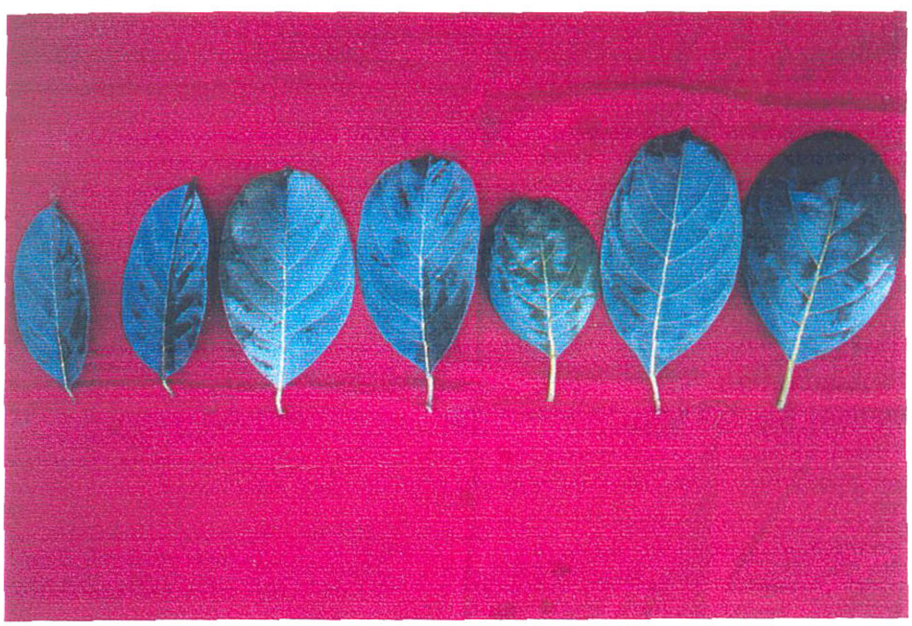


Plate 4. Petiole length variation in jack

(iv) **Riverside areas**

40.00 per cent of the accessions had cuspidate shape, 33.75 per cent had acute shape, 22.50 per cent had retuse shape and 3.75 per cent had obtuse leaf apex shape (Table 2).

Considering all the 320 accessions a wide variation was noticed in leaf apex shape. About 40.31 per cent of the accessions showed cuspidate shape followed by acute (35.93 per cent). Retuse shape was noticed in 20.62 per cent. Obtuse shape was noticed only in 3.12 per cent (Table 2).

4.1.2.6 Leaf base shape

(i) Plains

In plains, 38.75 per cent of the accessions had oblique leaf base shape, 30.00 per cent had attenuate shape, 17.50 per cent had shortly attenuate and 13.75 per cent had rounded leaf base shape (Table 2).

(ii) Hills

Here also, majority of the accessions, i.e., 37.50 per cent showed oblique shape, 28.75 per cent showed attenuate shape, 18.75 per cent had shortly attenuate shape and only 15.00 per cent showed rounded leaf base shape (Table 2).

(iii) Coastal area

About 41.25 per cent of the accessions showed oblique shape, 26.25 per cent exhibited attenuate shape, 17.50 per cent of the accessions had shortly attenuate shape and 15.00 per cent had rounded shape (Table 2).

(iv) Riverside areas

Majority of the accessions collected in the riverside areas, exhibited oblique shape, i.e., 37.50 per cent. Attenuate, shortly attenuate and rounded shapes were noticed in 26.25, 18.75 and 17.50 per cent of the accessions respectively (Table 2).

Irrespective of the topography, a wide variation was noticed among the accessions studied in terms of leaf base shape. Different leaf base shapes like oblique, attenuate, shortly attenuate and rounded has been noticed in 38.75 per cent, 27.81 per cent, 18.12 per cent and 15.31 per cent, respectively (Table 2).

4.1.2.7 Leaf petiole length

(i) Plains

Petiole length among the collections under plains showed a wide variation. It ranged from 10.00-55.50 mm with a mean value of 39.76 mm. The coefficient of variation was 25.62 per cent (Table 3). About 47.50 per cent of the accessions showed a range of 20-40 mm (Table 2).

(ii) Hills

Considerable variation was noticed among the collections under hilly areas in terms of leaf petiole length. The range varied from 16.50-49.00 with a mean value of 31.24 (Table 3). The coefficient of variation was 22.73 per cent. 46.25 per cent of the collections had a value in the range of 20-40 mm (Table 2).

(iii) Coastal areas

The collections had petiole length in the range of 16.5-57.5 mm. The collections had a mean petiole length of 39.25 mm. The coefficient of variation was 23.76 per cent (Table 3). About 42.50 per cent of the accessions had the petiole length in the range of 20-40 mm (Table 2).

(iv) River side areas

Petiole length of the accessions surveyed had a range of 19.50-50.50 mm. The mean petiole length was 37.58 mm. The coefficient of variation was 22.50 per cent (Table 3). About 43.75 per cent of the populations were coming in the range of 20-40 mm (Table 2).

A wide variation in petiole length (16.50 to 57.50 mm) among collections was observed with a mean value of 36.96 mm (Plate 4). The coefficient of variation was 28.36 per cent (Table 3). 45.00 per cent of the population had the petiole length in the range of 20-40 mm (Table 2).

4.1.3 Flowering characters

The observations recorded on flowering characters are presented in Table 4.

4.1.3.1 Season of flowering

(i) Plains

Of the trees located in plains, 18.75 per cent were of early flowering types, 70.00 per cent were of mid season flowering ones and 10.00 per cent were of late flowering types. One of the accessions studied showed sporadic flowering (Table 4).

(ii) Hills

Only 6.25 per cent of trees had early flowering nature. Majority of about 66.25 per cent trees showed mid season flowering. 27.25 per cent were of late flowering ones. None of the trees had sporadic flowering nature (Table 4).

(iii) Coastal areas

Among the 80 accessions studied in coastal areas, about 17.50 per cent had early flowering, 61.25 per cent had mid flowering and 21.25 per cent showed late flowering. No trees observed had sporadic flowering (Table 4).

(iv) Riverside areas

Here, about 17.50 per cent, 73.75 per cent and 8.75 per cent of the trees were found to flower during early, mid and late seasons, respectively. Sporadic flowering trees were not noticed among the collections (Table 4).

A wide variation was noticed among the accessions studied in terms of season of flowering. 15.00 per cent of the accessions commenced flowering earlier by September-October. Majority of the collections (67.82 per cent) were of mid season flowering types (November-January). 16.88 per cent of the collections were late flowering ones, i.e., by February-March. Only one accession showed sporadic flowering (two to three times a year) (Table 4 and Fig.12).

4.1.3.2 Span of flowering

4.1.3.2.1 Male flowering span

(i) Plains

Among the collections made in plains, 13.75 per cent, 60.00 per cent and 26.25 per cent of the trees, respectively had their male flowering span of less than 90 days, 90-120 days and more than 120 days (Table 4).

(ii) Hills

The percentage of accessions having male flowering span of less than 90 days was minimum (11.25 per cent). The percentage of collections having male flowering span in the range of 90-120 days was maximum (63.75 per cent). About 25.00 per cent of the population were producing male flowers for more than 120 days (Table 4).

(iii) Coastal areas

Among the trees surveyed in coastal areas, 16.25 per cent, 57.50 per cent and 26.25 per cent of the populations had the male flowering span of less than 90 days, 90-120 days and more than 120 days, respectively (Table 4).

(iv) Riverside areas

About 10.00 per cent, 67.50 per cent and 22.50 per cent of the surveyed accessions in riverside areas produced male flowers for a period of less than 90 days, 90-120 days and more than 120 days, respectively (Table 4).

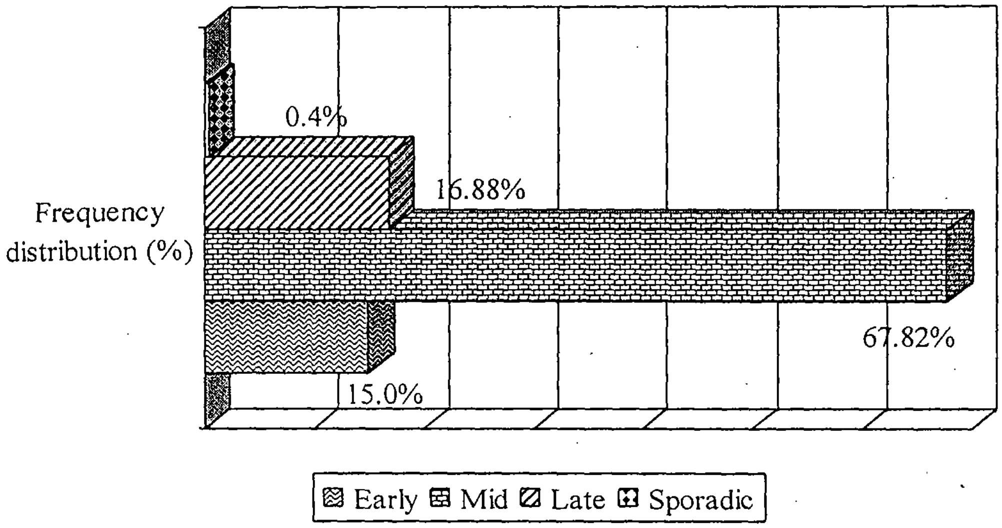


Fig. 12. Distribution of genotypes based on season of flowering

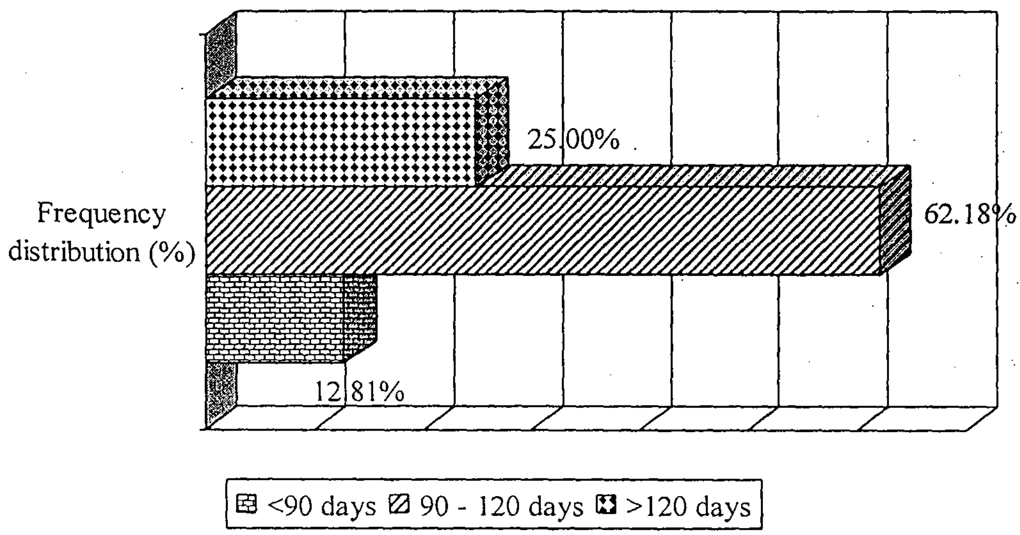


Fig. 13. Distribution of genotypes based on male flowering span

Table 4. Distribution of genotypes based on flowering characters

Sl. No.	Character	Description	Plains		Hills		Coastal		River side		Overall accessions	
			No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)
1	Season of flowering	Early (Sep-Oct)	15	18.75	4	6.25	14	17.50	14	17.50	48	15.00
		Mid (Nov-Jan)	56	70.00	53	66.25	49	61.25	59	73.75	217	67.82
		Late (Feb-Mar.)	8	10.00	22	27.25	17	21.25	7	8.75	54	16.88
		Sporadic	1	1.25	0	0	0	0	0	0	1	0.40
2	Male flowering span	Less than 90 days	11	13.75	9	11.25	13	16.25	8	10.00	41	12.81
		90-120 days	48	60.00	51	63.75	46	57.50	54	67.50	199	62.18
		More than 120 days	21	26.25	20	25.00	21	26.25	18	22.50	80	25.00
3	Female flowering span	Less than 60 days	20	25.00	23	28.75	16	20.00	17	21.25	76	23.75
		60-90 days	40	50.00	39	48.75	47	58.75	43	53.75	169	52.82
		More than 90 days	20	25.00	18	22.25	14	21.25	20	25.00	75	23.43
4	Female inflorescence position	Mainly trunk	0	0	3	3.75	1	1.25	2	2.50	6	1.87
		Mainly on trunk and 1° branchs	49	61.25	39	48.75	42	52.50	40	50.00	170	53.12
		Mainly on trunk, 1° and 2° branches	25	31.25	28	35.00	29	34.25	29	36.25	111	34.68
		On the whole stem including trunk, 1°, 2° and 3° branches	6	7.50	10	12.50	8	10.00	9	11.25	33	10.30

With respect to male flowering span, accessions showed a wide variation. 12.81 per cent of the accessions were producing male flowers for a period of less than 90 days. About 62.18 per cent and 25.00 per cent of the population were producing male flowers for a period of 90-120 days and more than 120 days, respectively (Table 4 and Fig.13).

4.1.3.2.2 Female flowering span

(i) Plains

Of the collections from plains, 25.00 per cent, 50.00 per cent and 25.00 per cent of the trees studied were having female flowering span viz. less than 60 days, 60-90 days and more than 90 days, respectively (Table 4).

(ii) Hills

Among the collections from hills, those having span of female flowering less than 60 days, 60-90 days and more than 90 days accounted to about 28.75 per cent, 48.75 per cent and 22.25 per cent respectively (Table 4).

(iii) Coastal areas

About 20.00 per cent of the collections under coastal areas were having less than 60 days of female flowering span. Accessions having female flowering period in the range of 60-90 days were common i.e. 58.75 per cent. About 21.25 per cent of the accessions had more than 90 days of female flowering (Table 4).

(iv) Riverside areas

About 21.25 per cent, 53.75 per cent and 25.00 per cent of the collections made from riverside areas were having female flowering span of less than 60 days, 60-90 days and more than 90 days, respectively (Table 4).

The accessions studied showed a wide variation in span of female flowering. About 23.75 per cent of the collections had a span of female flowering of

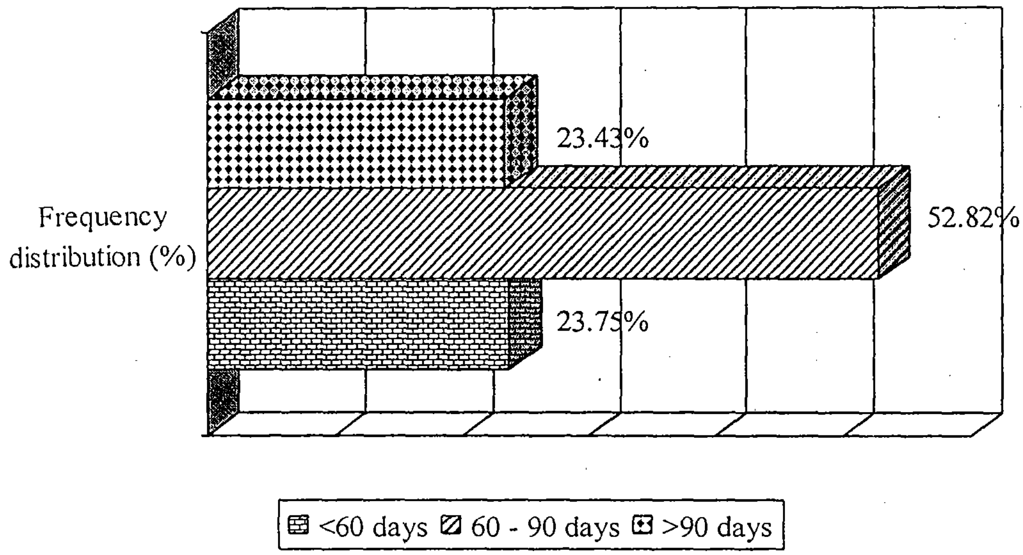


Fig. 14. Distribution of genotypes based on female flowering span

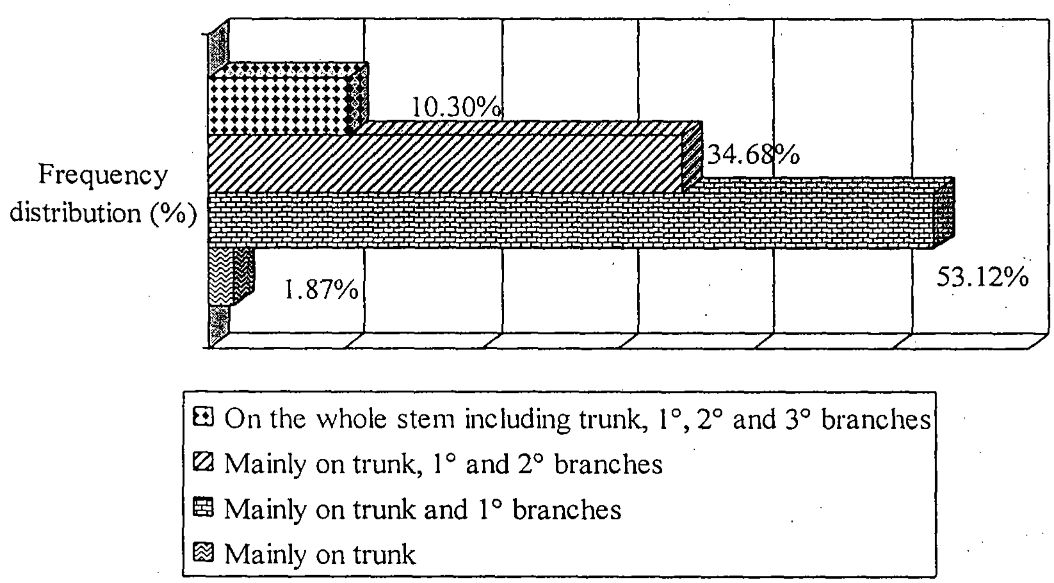


Fig. 15. Distribution of genotypes based on female inflorescence position

less than 60 days. 52.82 per cent were in between 60-90 days. Female flowering span of 23.43 per cent of the collections was more than 90 days (Table 4 and Fig.14).

4.1.3.3 Inflorescence position

4.1.3.3.1 Female inflorescence position

(i) Plains

61.25 per cent, 31.25 per cent and 7.50 per cent of the collections made under plains respectively, had their female flowers on trunk and primary branches only, trunk, primary and secondary branches only and on the whole stem including primary, secondary and tertiary branches. None of the trees observed had their female flowers restricted mainly on trunk (Table 4).

(iii) Hills

Flowering exclusively on the trunk is noticed only in minimum number of trees (3.75 per cent). Female flowering only on trunk and primary branches was common, i.e., in 48.75 per cent followed by female flowering on trunk, primary and secondary branches (35.00 per cent). Only about 12.50 per cent of the trees had female flowering on the whole stem including primary, secondary and tertiary branches (Table 4).

(iii) Coastal areas

Only about 1.25 per cent of the accessions collected under coastal areas had flowering exclusively on trunk. Maximum number of trees (52.50 per cent) had female flowers on trunk and primary branches. About 34.25 per cent of the accessions had female flowers on main trunk, primary and secondary branches. Female flowering on whole stem including primary, secondary and tertiary branches was noticed in 10.00 per cent of the accessions (Table 4).

(iv) Riverside areas

Least number of the accessions (2.50 per cent) had their female flowering exclusively on the trunk. While the female flowering only on trunk and primary branches was seen in 50.00 per cent and only on trunk, primary and secondary branches was noticed in 36.25 per cent of the accessions. About 11.25 per cent of the accessions had female flowering on the whole stem including primary, secondary and tertiary branches (Table 4).

Among the collections, only about 1.87 per cent of trees had flowering exclusively in the trunk. Accessions having female flowers on trunk and primary branches were common (53.12 per cent) followed by the accessions having female flowers on trunk, primary branches and secondary branches (34.68 per cent). About 10.30 per cent of the populations had female flowers on main trunk, primary, secondary and tertiary branches (Table 4 and Fig.15).

4.1.3.3.2 Male inflorescence position

All the accessions surveyed in plains, hills, riverside and coastal areas had their male flowers on trunk and all the orders of branches (i.e.) primary, secondary, tertiary branches, etc.

4.1.4 Fruit characters

4.1.4.1 General fruiting characters

4.1.4.1.1 Season of fruiting

(i) Plain

Among the surveyed accessions in plains, mid season bearing was common i.e. during March-May. It was seen in 70.00 per cent of the trees. About 18.75 per cent of the trees were early bearing nature i.e. during December-February and 10.00 per cent were of late bearing i.e. during June-August. Only one tree spotted in Chalakkudy (AC.126) area had sporadic bearing with bearing more than twice a year with peak season coinciding with March-May (Table 5).

(ii) Hills

Here also mid season bearing trees were common, i.e., about 66.25 per cent. Compared to plains, a higher per cent of 27.25 were bearing late. Compared to

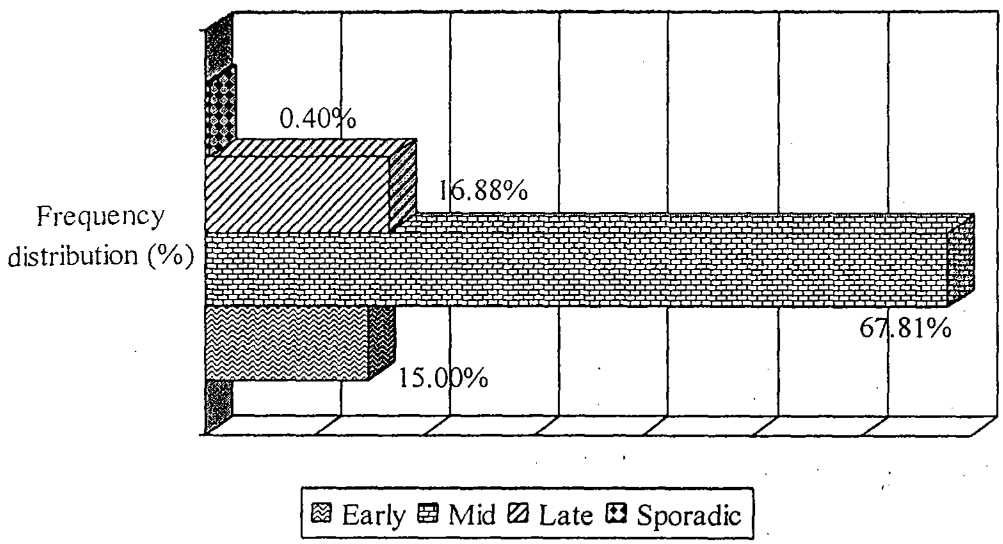


Fig. 16. Distribution of genotypes based on fruiting season

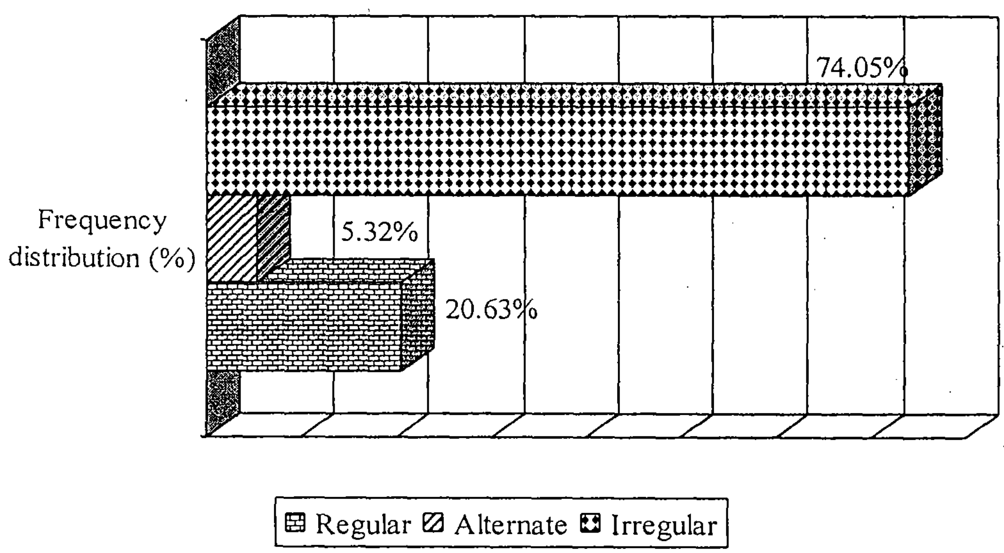


Fig. 17. Distribution of genotypes based on bearing habit

plains, the number of early bearing accessions were lesser, i.e., 6.25 per cent. None of the sporadic bearing trees were spotted during the survey (Table 5).

(iii) Coastal areas

Among the collections, about 61.25 per cent were of mid season bearing. Frequency distribution of accession bearing late was 21.25 per cent. About 17.50 per cent were of early bearing nature. None of the accessions had sporadic bearing nature (Table 5).

(iv) Riverside

About 73.75 per cent of the accession were of mid season bearing, 17.50 per cent were of early bearing and 8.75 per cent were of late bearing nature. None of the studied accessions had the sporadic bearing capacity (Table 5).

Among the accessions surveyed, maximum number of accessions (67.81 per cent) came to bearing during middle of the fruiting season, i.e., during March-May. Late fruiting during June-August was observed in 16.88 per cent of the accessions. Only about 15.00 per cent of the collections were early bearing, i.e., during December to February (Table 5 and Fig.16).

4.1.4.1.2 Fruit bearing habit

(i) Plains

Majority of the accessions studied, i.e., 71.25 per cent showed irregular bearing habit wherein the periodicity of cropping does not follow a systematic pattern unlike alternate bearing but an optimum crop is obtained only once in a number of years. 25.00 per cent of the accessions showed regular bearing habit. Alternate bearing was noticed in about 3.75 per cent of the accessions (Table 5).

(ii) Hills

About 81.25 per cent of the accessions had irregular bearing habit. Regular bearing was noticed in 13.75 per cent of the accessions. Alternate bearing was noticed among 5.00 per cent of the accessions (Table 5).

(iii) Coastal areas

Here also majority of the accessions, i.e., 68.75 per cent of the accessions showed irregular bearing. Alternate bearing was noticed in 5.00 per cent. Regular bearing was observed only in 25.00 per cent (Table 5).

(iv) Riverside

75.00 per cent of the accessions studied had irregular bearing. Regular bearing was noticed in 18.15 per cent of the accessions. Alternate bearing accessions observed were 6.25 per cent (Table 5).

Among the overall accessions studied irrespective of the topography, majority of the accessions, i.e., 74.05 per cent had irregular bearing habit. Regular bearing was noticed upto the extent of 20.63 per cent. Alternate bearing habit was noticed in about 5.32 per cent of the trees (Table 5 and Fig.17).

4.1.4.1.3 Fruit bearing position

(i) Plains

73.75 per cent of the accessions showed bearing on trunk and primary branches, 20.00 per cent of the accessions had bearing on trunk, primary and secondary branches. Bearing on trunk, primary, secondary and tertiary branches was noticed in 5.00 per cent of accessions studied. Trunk bearing was noticed only in 1.25 per cent of accessions (Table 5).

(ii) Hills

48.75 per cent of the accessions had bearing on trunk as well as on primary branches. 36.25 per cent of the accessions showed bearing on trunk, primary and secondary branches. Bearing on trunk, primary, secondary and tertiary branches was noticed only in a few accessions, i.e., 15.00 per cent. None of the accessions studied in hills had their bearing exclusively on trunk (Table 5).

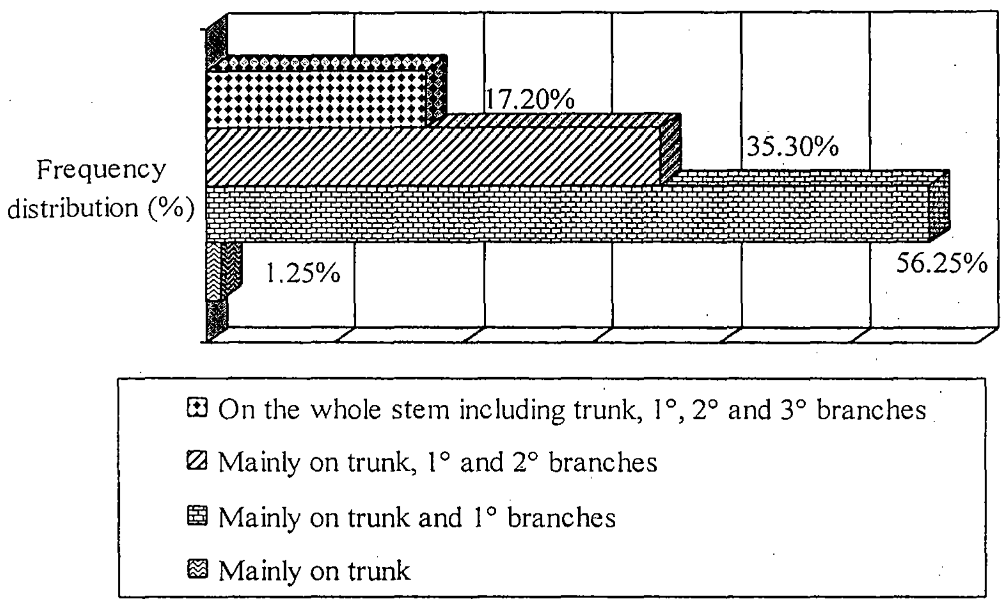


Fig. 18. Distribution of genotypes based on bearing position

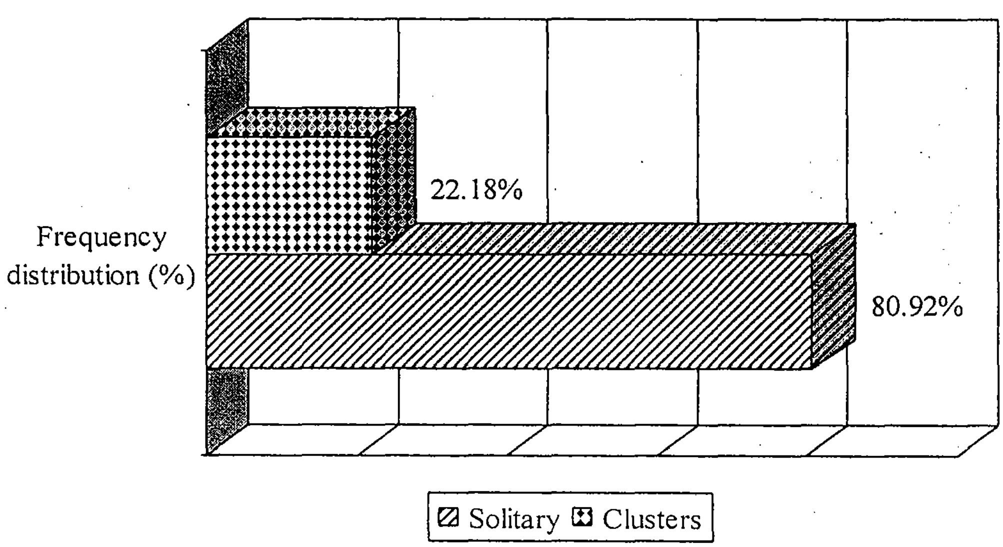


Fig. 19. Distribution of genotypes based on fruit clustering habit

Plate 5. Tree with bearing mainly on trunk

Plate 6. Tree with bearing on trunk and 1° branches

Plate 7. Tree with bearing on trunk, 1° and 2° branches

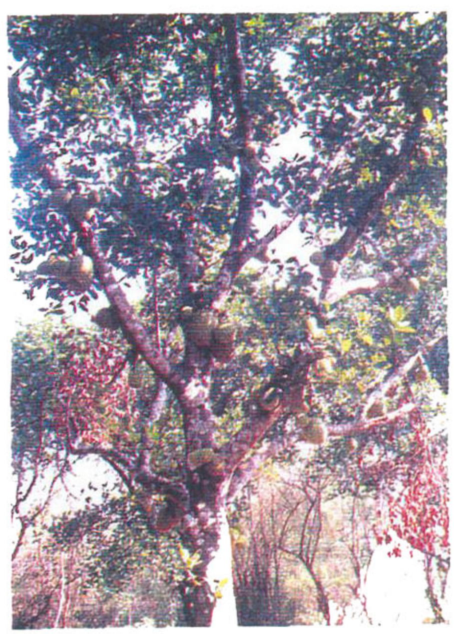


Plate 8. Tree with bearing on trunk, 1°, 2° and 3° branches

(iii) Coastal areas

52.50 per cent of the accessions showed bearing on both the trunk and primary branches. 41.25 per cent of the accessions had their bearing on all over the trunk, primary and secondary branches. About 5.00 per cent of the accessions had their bearing on all over trunk, primary, secondary and tertiary branches and only about 1.25 per cent had their bearing restricted to trunk (Table 5).

(iv) Riverside

50.00 per cent of the accessions under study had their bearing on trunk and primary branches. 43.75 per cent of the accessions had their bearing on trunk, primary and secondary branches. Bearing on all over trunk, primary, secondary and tertiary branches was noticed in only a few accessions, i.e., 3.75 per cent. Least number of accessions restricted their bearing only to trunk i.e. 2.50 per cent (Table 5).

Irrespective of the topography, about 56.25 per cent of the total accessions studied showed their bearing on trunk and primary branches. 35.30 per cent of the accessions showed bearing on trunk, primary and secondary branches. Only about 7.18 per cent had their bearing on trunk, primary, secondary and tertiary branches. Only 1.25 per cent of the accessions showed their bearing mainly on trunk (Table 5 and Fig.18). Plate 5 shows jack tree bearing mainly on trunk. Plate 6 shows jack tree bearing on trunk and primary branches. Plate 7 shows jack tree shows bearing on trunk, primary and secondary branches. Plate 8 shows jack tree bearing on trunk, primary, secondary and tertiary branches.

4.1.4.1.4 Fruit clustering habit

(i) Plains

75.00 per cent of the accessions under plains had solitary bearing habit (Table 5).

(ii) Hills

Here also solitary bearing was common and was noticed in 86.25 per cent (Table 5).

(iii) Coastal areas

52.50 per cent of the accessions showed bearing on both the trunk and primary branches. 41.25 per cent of the accessions had their bearing on all over the trunk, primary and secondary branches. About 5.00 per cent of the accessions had their bearing on all over trunk, primary, secondary and tertiary branches and only about 1.25 per cent had their bearing restricted to trunk (Table 5).

(iv) Riverside

50.00 per cent of the accessions under study had their bearing on trunk and primary branches. 43.75 per cent of the accessions had their bearing on trunk, primary and secondary branches. Bearing on all over trunk, primary, secondary and tertiary branches was noticed in only a few accessions, i.e., 3.75 per cent. Least number of accessions restricted their bearing only to trunk i.e. 2.50 per cent (Table 5).

Irrespective of the topography, about 56.25 per cent of the total accessions studied showed their bearing on trunk and primary branches. 35.30 per cent of the accessions showed bearing on trunk, primary and secondary branches. Only about 7.18 per cent had their bearing on trunk, primary, secondary and tertiary branches. Only 1.25 per cent of the accessions showed their bearing mainly on trunk (Table 5 and Fig.18). Plate 5 shows jack tree bearing mainly on trunk. Plate 6 shows jack tree bearing on trunk and primary branches. Plate 7 shows jack tree shows bearing on trunk, primary and secondary branches. Plate 8 shows jack tree bearing on trunk, primary, secondary and tertiary branches.

4.1.4.1.4 Fruit clustering habit

(i) Plains

75.00 per cent of the accessions under plains had solitary bearing habit (Table 5).

(ii) Hills

Here also solitary bearing was common and was noticed in 86.25 per cent (Table 5).

Table 5. Distribution of genotypes based on fruiting characters

Sl. No.	Character	Description	Plains		Hills		Coastal		River side		Overall accessions	
			No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)
1	Fruiting season	Early (Dec-Feb)	15	18.75	5	6.25	14	17.50	14	17.50	38	15.00
		Mid (Mar-May)	56	70.00	53	66.25	49	61.25	59	73.75	217	67.81
		Late (June-Aug)	8	10.00	22	27.25	17	21.25	7	8.75	54	16.88
		Sporadic	1	1.25	0	0	0	0	0	0	1	0.40
2	Bearing habit	Regular	20	25.00	11	13.75	20	25.00	15	18.75	66	20.63
		Alternate	3	3.75	4	5.00	4	5.00	5	6.25	17	5.32
		Irregular	57	71.25	65	81.25	55	68.75	60	75.00	23	74.05
3	Fruit bearing position	Mainly on trunk	1	1.25	0	0	1	1.25	2	2.50	4	1.25
		Mainly on trunk and 1° branches	59	73.75	39	48.75	42	52.50	40	50.00	186	56.25
		Mainly on trunk, 1° and 2° branch	16	20.00	29	36.25	33	41.25	35	43.75	113	35.30
		Mainly on trunk, 1°, 2° an 3° branches	4	5.00	12	15.00	4	5.00	3	3.75	23	7.18
4	Fruit clustering habit	Solitary	60	75.00	69	86.25	67	83.75	63	78.75	259	80.92
		Clusters	20	25.00	11	13.75	23	28.75	17	21.25	71	22.18
5	Fruit shape	Obloid	3	3.75	2	2.50	4	5.00	4	5.00	13	4.06
		Spheroid	10	12.50	9	11.25	11	13.75	8	10.00	38	11.87
		High spheroid	8	10.00	11	13.75	13	16.25	11	13.75	43	13.43
		Ellipsoid	5	6.25	4	5.00	6	7.50	5	6.25	20	6.25
		Clavate	3	3.75	2	2.50	1	1.25	4	5.00	10	3.12
		Oblong	15	18.75	13	16.25	14	17.50	13	16.25	55	17.80
		Broadly ellipsoid	21	26.25	21	26.25	19	23.75	21	26.25	82	25.62
		Irregular	15	18.75	18	22.50	12	15.00	14	17.50	59	18.43
6	Junction of stalk attachment to fruits	Depressed	56	70.00	53	66.25	55	68.75	50	62.50	214	66.87
		Flattened	16	20.00	22	24.50	21.	26.25	23	28.75	82	25.63
		Inflated	8	10.00	5	6.25	4	5.00	7	8.75	24	7.50
							4.0					
7	Fruit rind colour (at maturity)	Green	11	13.75	8	10.00	13	16.25	12	15.00	44	13.75
		Greenish brown	64	80.00	65	81.25	61	76.25	59	73.75	249	77.81
		Greenish yellow	5	6.25	7	8.75	6	7.50	9	11.25	27	8.43

Table 5. Continued

Sl. No.	Character	Description	Plains		Hills		Coastal		River side		Overall accessions	
			No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)
8	Fruit surface	Smooth	0	0	0	0	0	0	0	0	0	0
		Spiny	80	100	80	100	80	100	80	100	320	100
9	Shape of spine	Sharp pointed	21	26.25	24	30.00	28	35.00	18	22.50	91	28.43
		Intermediate	52	65.00	50	62.50	48	60.00	55	68.75	205	64.06
		Flat	7	8.75	6	7.50	4	5.00	7	8.75	24	7.50
10	Spine density	Sparse	15	18.75	13	16.25	19	23.75	14	17.50	61	19.06
		Dense	65	81.25	67	83.75	61	76.25	66	82.50	259	80.94
11	Latex exudation	Low	4	5.00	3	3.75	5	6.25	6	7.50	18	5.62
		Medium	65	81.25	64	80.00	59	73.75	59	73.75	247	77.18
		High	11	13.75	13	16.25	16	20.00	15	18.75	55	17.18
12	Flake shape	Shperoid	5	6.25	3	3.75	4	5.00	6	7.50	18	5.63
		Twisted	17	21.25	18	22.50	21	26.25	20	20.00	72	22.50
		Cordate	19	23.75	21	26.25	18	22.50	7	25.00	78	24.37
		Elongated obovate	6	7.50	3	3.75	5	6.25	16	8.75	21	6.56
		Rectangular	8	10.00	7	8.75	9	11.25	7	8.75	31	9.68
		Oblong with curved tip	7	8.75	8	10.00	4	5.00	6	7.50	25	7.81
		Irregular	18	22.50	20	25.00	19	23.75	18	22.50	75	23.43

Plate 9. Tree with solitary bearing habit

Plate 10. Tree with cluster bearing habit

Plate 11. Greenish brown jack fruits

Plate 12. Greenish jack fruits

(iii) Coastal areas

A majority of the population (83.75 per cent) had solitary bearing habit (Table 5).

(iv) Riverside

About 78.75 per cent of the population had solitary bearing habit (Table 5).

Among 320 studied accessions, majority of the accessions showed solitary bearing (80.92 per cent). Only about 22.18 per cent had cluster bearing habit (Table 5 and Fig.19). Plate 9 shows tree with solitary bearing habit and Plate 10 shows tree with cluster bearing habit.

4.1.4.1.5 Fruit shape

(i) Plains

Predominant fruit shapes among the surveyed accessions were broadly ellipsoid (26.25 per cent), oblong (18.75 per cent), irregular (18.75 per cent) and spheroid (12.50 per cent) (Table 5).

(ii) Hills

Broadly ellipsoid, irregular, oblong, high spheroid and spheroid shapes were respectively, noticed in 26.25 per cent, 22.50 per cent, 16.25 per cent, 13.75 per cent and 11.25 per cent of the accessions (Table 5).

(iii) Coastal areas

Broadly ellipsoid, oblong, highly spheroid, spheroid and irregular fruit shapes were noticed in 23.75 per cent, 17.50 per cent, 16.25 per cent, 13.75 per cent and 15.00 per cent of the accessions (Table 5).

(iv) Riverside areas

Among the surveyed accessions, about 26.25 per cent of the trees had broadly ellipsoid fruits, 17.50 per cent of them had irregular fruit, 16.25 per cent had oblong and 13.75 per cent of them had high spheroid shape (Table 5).

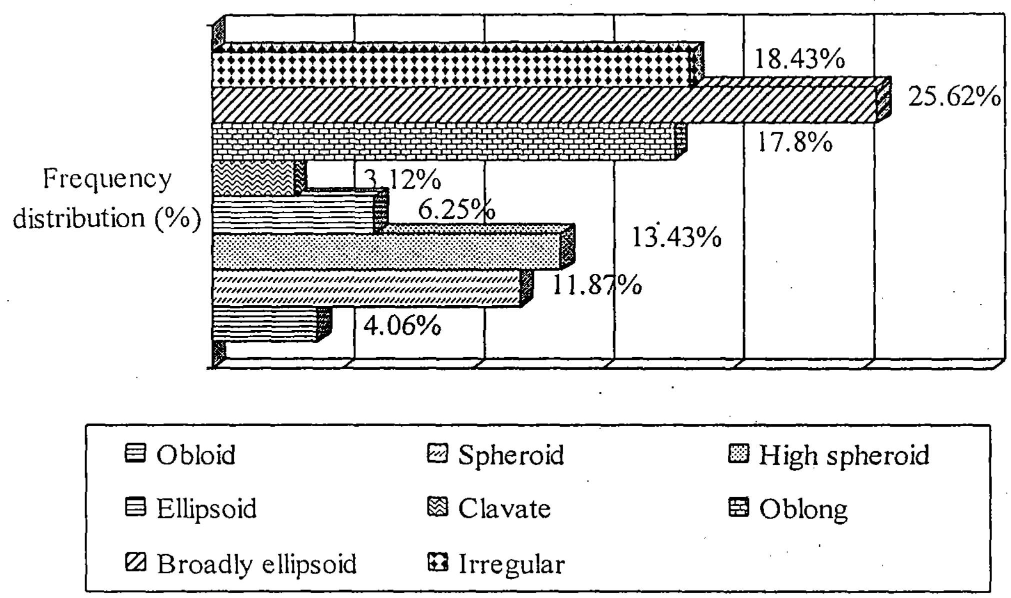


Fig. 20. Distribution of genotypes based on fruit shape

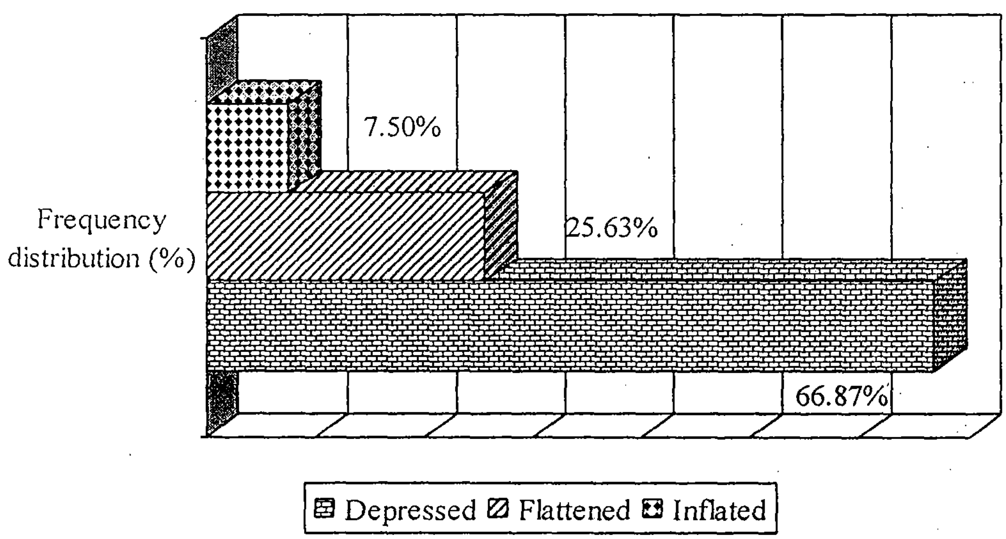


Fig. 21. Distribution of genotypes based on junction of stalk attachment to fruit

Among the accessions surveyed, fruit shapes like broadly ellipsoid, irregular, oblong, high spheroid and spheroid were more frequently noticed among the accessions and were seen respectively in 25.62 per cent, 18.43 per cent, 17.80 per cent, 13.43 per cent and 11.87 per cent of the trees respectively. Other fruit shapes like ellipsoid, obloid and clavate were also observed (Table 5 and Fig.20).

4.1.4.1.6 Junction of stalk attachment to fruit

(i) Plains

70.00 per cent of fruits had the depressed junction of stalk attachment. Flattened and inflated junction of stalk attachments were noticed in 20.00 and 10.00 per cent respectively (Table 5).

(ii) Hills

66.25 per cent of the accessions had depressed junction of stalk attachment. Flattened and inflattened junction of stalk attachment were noticed in 24.50 per cent and 6.25 per cent, respectively (Table 5).

(iii) Coastal area

Majority of the accessions, i.e., 68.75 per cent showed depressed junction of stalk attachment. Only about 26.25 per cent and 5.00 per cent of the accessions had flattened and inflated junction of stalk attachments, respectively (Table 5).

(iv) Riverside areas

Here also, majority of the accessions, i.e., 62.50 per cent had depressed junction of stalk attachment. Flattened junction of stalk attachment was noticed in lesser number of accessions, i.e., 28.75 per cent. Inflatened one was noticed only in 8.75 per cent of the accessions (Table 5).

Irrespective of the topography, majority of the accessions, i.e., 66.87 per cent had depressed junction of stalk attachment. About 25.63 per cent had flattened stalk attachment. Inflated junction of stalk attachment was noticed in a very few accessions, i.e., 7.50 per cent (Table 5 and Fig.21).

4.1.4.1.7 Fruit rind colour (at maturity)

(i) Plains

80.00 per cent of trees were having greenish brown fruit colour at maturity. Green colour was observed in 13.75 per cent and greenish yellow in 6.25 per cent of the accessions (Table 5).

(ii) Hills

Greenish brown at fruit maturity was seen in most of the trees, i.e., 81.25 per cent. The rest had green (10.00 per cent) and greenish yellow (8.75 per cent) fruits (Table 5).

(iii) Coastal areas

Greenish brown colour fruits was noted in 76.25 per cent of the accessions followed by green colour (16.25 per cent) (Table 5).

(iv) Riverside

Greenish brown rind was predominant (73.75 per cent). Green rind was noticed in 15.00 per cent and greenish yellow rind in 11.75 per cent of accessions (Table 5).

Greenish brown colour (Plate 11) at fruit maturity was commonly noticed, i.e., in 77.81 per cent of the trees. 13.75 per cent had green colour (Plate 12) and only about 8.43 per cent of the trees had greenish yellow rind colour at fruit maturity (Table 5 and Fig.22).

4.1.4.1.8 Fruit surface

None of the accessions surveyed had smooth fruit surface. All the trees had fruits with spines on the rind (Table 5).

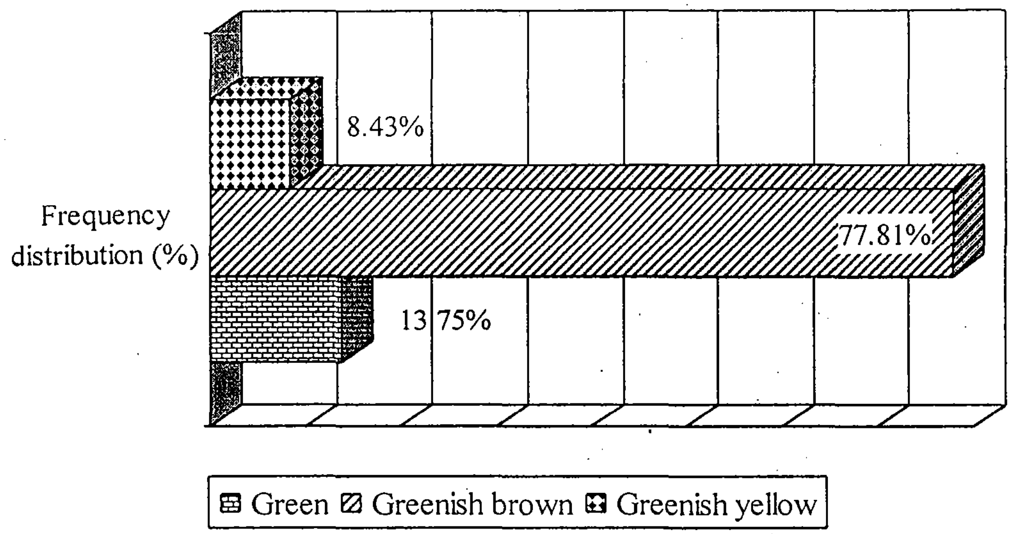


Fig. 22. Distribution of genotypes based on fruit rind colour at maturity

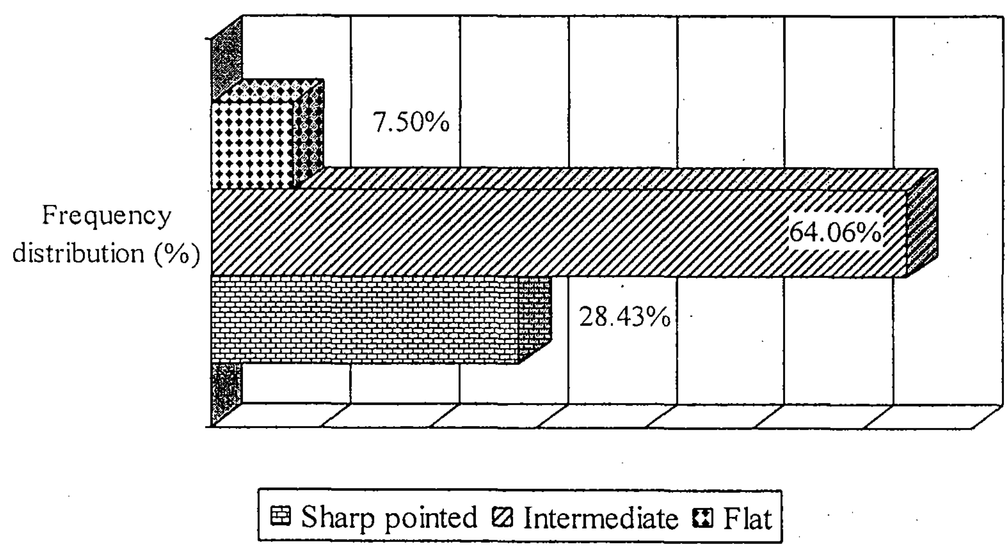


Fig. 23. Distribution of genotypes based on shape of spines at fruit maturity

4.1.4.1.9 Shape of spines

Plate 13 shows jackfruits with sharp pointed spines. Plate 14 shows jackfruits with intermediate spines. Plate 15 shows jackfruit with flat spines.

Shape of the spines on the fruits showed a wide variation among the genotypes. Majority of genotypes (64.06 per cent) had the shape of the spines in between sharp pointed and flat ones. Sharp pointed spines were observed in 28.43 per cent of the trees. Flat spines were seen only in 7.50 per cent of the trees (Table 5 and Fig.23).

4.1.4.1.10 Spine density (at maturity stage)

Most of the accessions had fruits with dense spines i.e. 80.94 per cent. Only 19.06 per cent of the genotypes had sparse spines (Table 5).

4.1.4.1.11 Latex exudation

Latex exudation in fruits was intermediate in 77.18 per cent of the accessions studied. Higher latex exudation was observed in 17.18 per cent of the accessions. Low latex exudation was noticed only in 5.62 per cent of the population (Table 5 and Fig.24).

4.1.4.1.12 Flake shape

(i) Plains

Genotypes having cordate flake shape accounted to about 23.75 per cent. 22.50 per cent were having irregular flake shape, 21.25 per cent were having twisted flakes, 10.00 per cent were having rectangular flakes, 8.75 per cent were having oblong with curved tip and 7.50 per cent of the studied accessions were having elongated obovate flakes (Table 5).

(ii) Hills

Cordate flake shape was noticed in maximum number of accessions (26.25 per cent) followed by irregular flakes (25.00 per cent) and twisted flakes (22.50 per

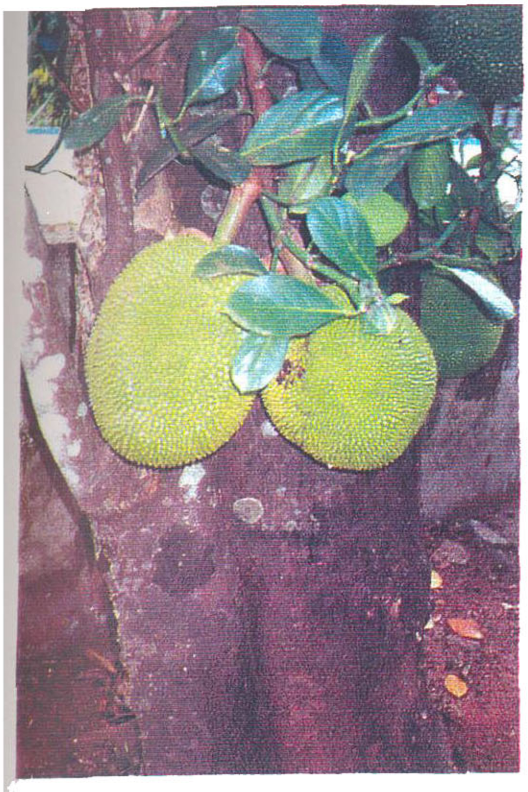


Plate 13. Jack fruits with sharp pointed spines

Plate 14. Jack fruits with intermediate spines

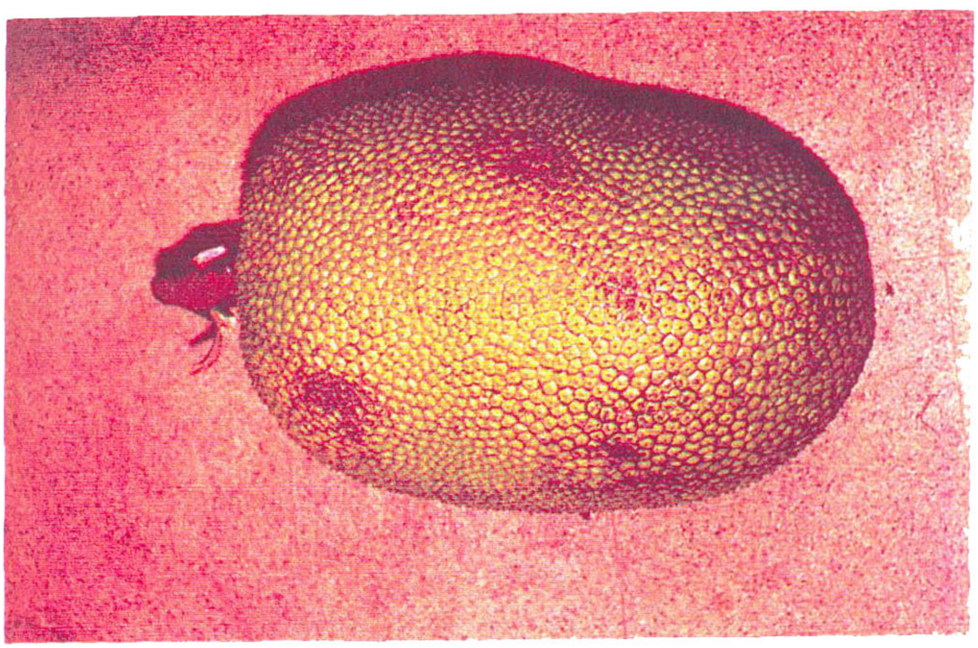


Plate 15. Jack fruit with flat spines

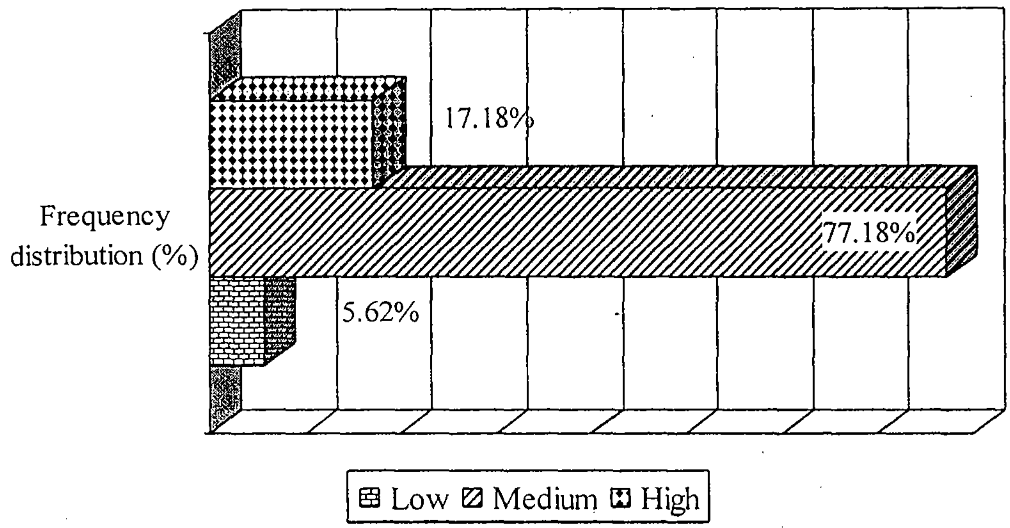


Fig. 24. Distribution of genotypes based on intensity of latex exudation

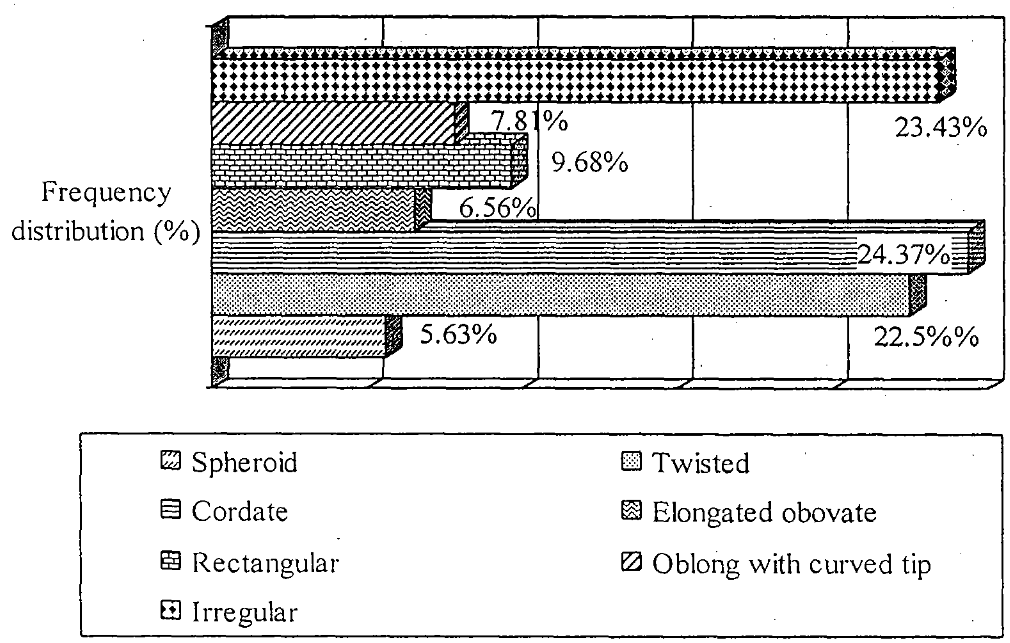


Fig. 25. Distribution of genotypes based on flake shape

cent). Flake shapes like oblong with curved flakes, rectangular, elongated obovate and spheroid were also noticed in 10.00 per cent, 8.75 per cent, 3.75 per cent and 3.75 per cent, respectively (Table 5).

(iii) Coastal areas

Commonly noticed flake shapes were twisted, irregular, and cordate and were noticed in 26.25 per cent, 23.75 per cent and 22.50 per cent of the accessions respectively. Other flake shapes like rectangular, elongated obovate, spheroid and oblong with curved tip were also noticed rarely and seen in 11.25 per cent, 6.25 per cent, 5.00 per cent and 5.00 per cent, respectively (Table 5).

(iv) Riverside

Among the 80 accessions surveyed in riverside areas, flake shapes like cordate, irregular and twisted were more frequently noticed and it was noticed in 25.00 per cent, 22.50 per cent and 20.00 per cent of the accessions. Other flake shapes like rectangular, elongated, obovate, oblong with curved tip and spheroid were noticed less frequently among the accessions (Table 5).

Flake shape differed widely among the accessions collected from different topography, 24.37 per cent had cordate flakes, 23.43 per cent had irregular flakes and 22.50 per cent had twisted flakes. Other flake shapes like rectangular (9.68 per cent), oblong with curved tip (7.81 per cent), elongated obovate (6.56 per cent) and spheroid (5.63 per cent) were also noticed (Table 5 and Fig.25).

4.1.4.2 Biometric fruit characters

The variation in biometric characters of fruits and the distribution of genotypes based on fruit characters are presented in Tables 6 and 7, respectively.

4.1.4.2.1 Stalk length (cm)

(i) Plains

Mean stalk length of the accessions surveyed in plains was 7.98 cm. It varied from 1.00 to 21.50 cm with a coefficient of variation of 37.62 per cent

(Table 6). Regarding the distribution of genotypes under plains, majority of the accessions, had the stalk length of more than 5 cm (Table 7).

(ii) Hills

Mean stalk length was found to be 8.40 cm. The stalk length varied from as low as 2.30 cm to as high as 32.50 cm. The coefficient of variation was 38.30 per cent (Table 6). Majority of the accessions had higher stalk length. About 37.50 per cent of the accessions had stalk length in the range of between 5 to 10 cm and 36.25 per cent of the accessions had stalk length higher than 10 cm (Table 7).

(iii) Coastal areas

The mean stalk length was 7.99 cm and the range was 2.30 to 29.50 cm. The coefficient of variation was 38.91 per cent (Table 6). About 40.00 per cent and 31.25 per cent of the accessions had stalk length in between 5 and 10 cm and more than 10 cm, respectively (Table 7).

(iv) Riverside

The mean stalk length was found to be 8.31 cm. The range noticed was 2.60 to 33.60 cm. Coefficient of variation was 37.89 per cent (Table 6).

Irrespective of topography, the mean stalk length of fruits was 8.01 cm and the range was from 1.00 to 33.60 cm with a coefficient of variation of 36.30 per cent (Table 6). Wide variability was noticed among the accessions studied with respect to stalk length of the fruits.

4.1.4.2.2 Fruit length

(i) Plains

The mean fruit length of the accessions studied under plains was 37.82 cm. The fruit length found to range from 18.50 to 75.60 cm. On analysing statistically, the coefficient of variation was found to be 33.60 per cent (Table 6). Regarding the distribution of genotypes, a majority of the accessions i.e. 66.25 per cent had the fruit length between 30 to 50 cm (Table 7).

(ii) Hills

The fruit length of the accessions studied in hilly regions was found to vary from 20.60 to 80.30 cm with a mean fruit length of 38.30 cm (Table 6). More number of accessions had their fruit length in the range of 30 cm and 50 cm, i.e., 63.50 per cent (Table 7).

(iii) Coastal areas

The accessions studied had the mean fruit length of 39.36 cm. The range varied from 19.30 to 75.60 cm. The coefficient of variation was found to be 27.62 per cent (Table 6). About 63.75 per cent of the accessions had their fruits with length in between 30 cm and 50 cm (Table 7).

(iv) Riverside areas

The fruit length of the accessions was found to vary from 20.50 to 73.40 cm. The mean fruit length was 32.10 cm. Coefficient of variation was found to be 31.20 per cent (Table 6). Majority of the accessions, i.e., about 61.25 per cent had their fruit length coming in the class interval of 30 to 50 cm (Table 7).

The mean fruit length of overall accessions was 38.61 cm with the range varying from 18.50 cm to 80.30 cm (Plate 16). Statistical analysis of fruit length indicated that there exists a higher variability among the genotypes. The coefficient of variation was found to be 28.90 per cent (Table 6).

4.1.4.2.3 Fruit girth

(i) Plains

The mean fruit girth of the accessions surveyed under plains was 65.36 cm. The range varied from 32.40 to 90.60 cm. Coefficient of variation was found to be 21.00 per cent (Table 6). The fruit girth of majority of the accessions, i.e., 56.25 per cent came in the range of 60 to 80 cm (Table 7).

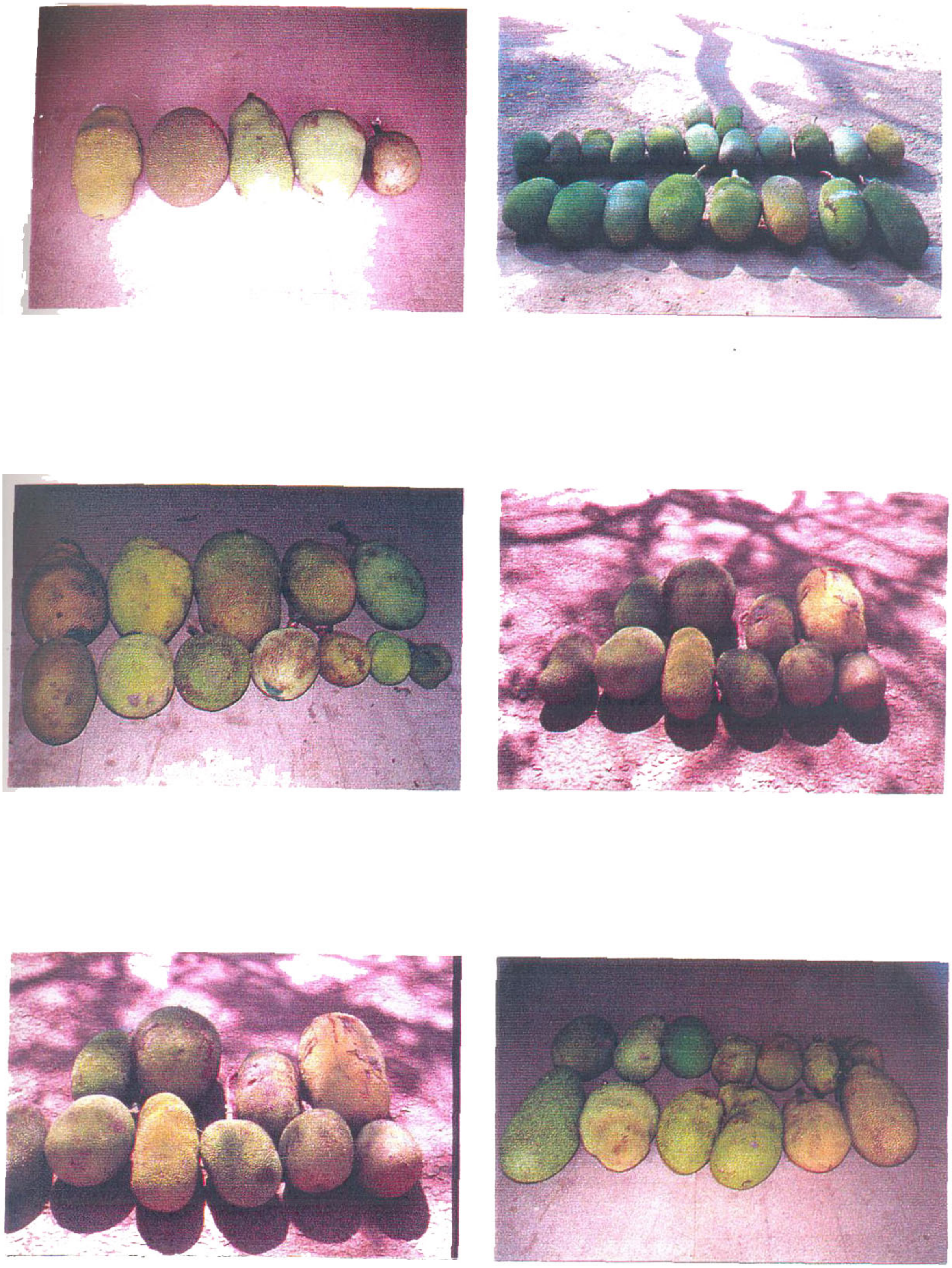


Plate 16. Jack fruits of varying shape and size

(ii) Hills

Fruit girth had a mean value of 64.28 cm. The range was found to vary from 35.40 to 86.30 cm. Coefficient of variation was 21.60 per cent (Table 6). Here also, majority of fruits, i.e., 51.25 per cent had the girth in the range of 60 to 80 cm (Table 7).

(iii) Coastal areas

The fruit girth of the studied accessions varied as low as 30.12 cm to as high as 110.00 cm. The mean value was found to be 66.00 cm. On comparing with plains and hills, coefficient of variation was higher, i.e., 27.30 per cent (Table 6). Regarding the genotype distribution with respect to fruit girth, a higher per cent of fruits, i.e., 27.50 had the value higher than 80 cm. It was higher than the other topographical regions (Table 7).

(iv) Riverside areas

The girth of the fruits ranged from 30.18 to 90.30 cm with a mean value of 60.13 cm. Coefficient of variation calculated was 21.49 per cent (Table 6). About 48.75 per cent of the accessions had the fruit girth values coming in the range of 60 to 80 cm (Table 7).

Pooling all the accessions studied irrespective of topography, the range varied from 30.12 cm to 110.00 cm. The mean value was 64.92 cm. Coefficient of variation was found to be 23.28 per cent indicating a wider variability (Plate 16) among the genotypes with respect to fruit girt (Table 6).

4.1.4.2.4 Fruit weight

(i) Plains

The fruit weight recorded a mean value of 7.38 kg. The range varied from 1.05 to 17.60 kg. Coefficient of variation was found to be higher than the other biometric fruit characters. The coefficient of variation was found to be 43.00 per cent

(Table 6). About 52.50 per cent of accessions had the fruit weight between 5 and 10 kg (Table 7).

(ii) Hills

The mean value of fruit weight was 7.19 kg. The range varied from 2.25 to 20.10 kg. The coefficient of variation was 44.28 per cent indicating a greater variability (Table 6). A majority of fruits 53.75 per cent were having the fruit weight in the range between 5 and 10 kg (Table 7).

(iii) Coastal areas

The fruit weight ranged from 2.71 to 22.30 kg with a mean value of 8.31 kg. The coefficient of variation found to be higher, i.e., 49.70 (Table 6). Compared with plains, a higher per cent of fruits had recorded a fruit weight of above 10.0 kg (Table 7).

(iv) River side areas

The fruit weight ranged from 2.32 to 18.31 kg with a mean value of 7.02 kg. The coefficient of variation was 43.60 per cent (Table 6).

Irrespective of the topography, the fruit weight recorded the mean value of 7.46 kg with a range varying from as low as 1.05 kg to as high as 22.30 kg. The statistical analysis showed that there exist a higher variability among the accessions in terms of fruit weight. The coefficient of variation was found to be 44.68 per cent (Table 6).

4.1.4.2.4 Fruit rind weight

(i) Plains

The fruit rind weight ranged from 0.42 kg 3.76 kg with a mean value of 1.55 kg. The coefficient of variation was 27.36 per cent (Table 6).

(ii) Hills

The fruit rind weight ranged from 0.42 to 3.98 kg. The mean rind weight of the accessions studied was about 1.59 kg. The coefficient of variation was 26.98 per cent (Table 6).

(iii) Coastal areas

The fruit rind weight of the accessions recorded a range from 0.39 to 4.26 kg. The mean value was found to be 1.65 kg. The coefficient of variation was 27.26 per cent (Table 6). On comparing with plains, hills and riverside a higher per cent of accessions had the fruit rind weight of above 2.00 kg (Table 7).

(iv) Riverside areas

The fruit rind weight ranged from 0.49 to 4.13 kg with a mean value of 1.54 kg. The coefficient of variation was found to be 26.82 per cent (Table 6).

On considering all the 320 accessions, the mean fruit rind weight was 1.60 per cent. The range was found to be varying from 0.39 to 4.26 kg. The statistical analysis showed that the coefficient of variation was found to be 27.10 per cent indicating a wider variability among the accessions studied with respect to fruit rind weight (Table 6).

4.1.4.2.6 Fruit rind thickness

(i) Plains

Mean fruit rind thickness of the accessions surveyed in plains was 1.56 cm. It varied from 0.31 to 3.93 cm with a coefficient of variation of 10.41 per cent (Table 6). Regarding the distribution of genotypes, majority of the accessions, i.e., 58.75 per cent had the rind thickness in the interval of 1.00 to 2.00 cm (Table 7).

(ii) Hills

Mean fruit rind thickness was found to be 1.61 cm. The rind thickness ranged from as low as 0.38 cm to as high as 3.79 cm. The coefficient of variation was found to be 10.79 per cent (Table 6). About 61.25 per cent of the accession had the fruit rind thickness in the range of 1.00 to 2.00 cm (Table 7).

(iii) Coastal areas

The mean fruit rind thickness of the accessions studied was found to be 1.64 cm and the range was 0.28 to 3.98 cm. The coefficient of variation was 10.83 cm (Table 6). With respect to distribution of genotypes, a higher per cent of fruits, i.e., 22.50 per cent had the fruit rind thickness more than 2.00 cm (Table 7) than those of plains, hills and riverside.

(iv) Riverside areas

The mean fruit rind thickness was found to be 1.59 cm and it varied from 0.38 to 3.92 cm. The coefficient of variation was found to be 10.29 per cent (Table 6).

Irrespective of topography, the mean rind thickness was 1.61 cm and the range varied from 0.28 to 3.93 cm. The coefficient of variation was found to be 10.47 per cent indicating the existence of wider variability among the genotypes with respect to fruit rind thickness (Table 6).

4.1.4.2.7 Number of flakes per fruit

(i) Plains

The mean number of flakes per fruit of the accessions studied under plains was 93.42. The number of flakes per fruit found to range from 6.00 to 456.00. On analysing statistically, the coefficient of variation was found to be 46.00 per cent. The coefficient of variation was found to be higher than those of the other fruit characters studied earlier (Table 6).

(ii) Hills

The number of flakes per fruit of the accessions studied in hilly regions was found to vary from 0.00 to 420.00 with a mean number of flakes per fruit of

94.69. A higher coefficient of variation of 49.91 per cent was noticed than those of plains (Table 6). A slightly higher percent of the accessions, i.e., 25.00 had the number of flakes per fruit more than 200 (Table 7).

(iii) Coastal areas

The accessions studied had the mean number of flakes per fruit of 107.69, which was higher than those of other regions, plains, hills and riverside. The range varied from 25.00 to 382.00. The coefficient of variation (49.13 per cent) recorded was still higher than that of hills indicating a higher variability among the accessions studied with respect to number of flakes than those of other three topography (Table 6). A slightly higher per cent of the accessions, i.e., 32.50 per cent had the number of flakes per fruit more than 200 (Table 7).

(iv) Riverside areas

The number of flakes per fruit of the accessions was found to vary from 23.00 to 417.00 with the mean value of 94.63. The coefficient variation was found to be 46.30 per cent (Table 6).

The mean number of flakes per fruit of overall accessions was 94.10 with the range varying from 1.00 to 456.00. Higher values of coefficient of variation was recorded, i.e., 48.71 than all the above biometric fruit characters studied indicating a higher variability among the genotypes with respect to number of flakes per fruit (Table 6). Plate 17 shows jachfruit without any flakes. Plate 18 shows jackfruit with a single flake. Plate 19 shows jackfruit with a few flakes.

4.1.4.2.8 Weight of flakes per fruit

(i) Plains

The mean weight of flakes per fruit of the accessions surveyed under plains was 2.63 kg. The range varied from 0.64 to 7.60 kg. Coefficient of variation was found to be 37.00 per cent (Table 6).

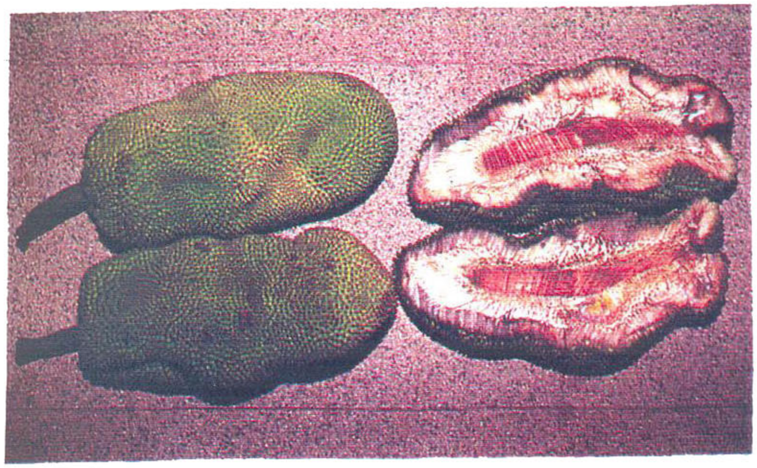


Plate 17. Jack fruit without any flakes

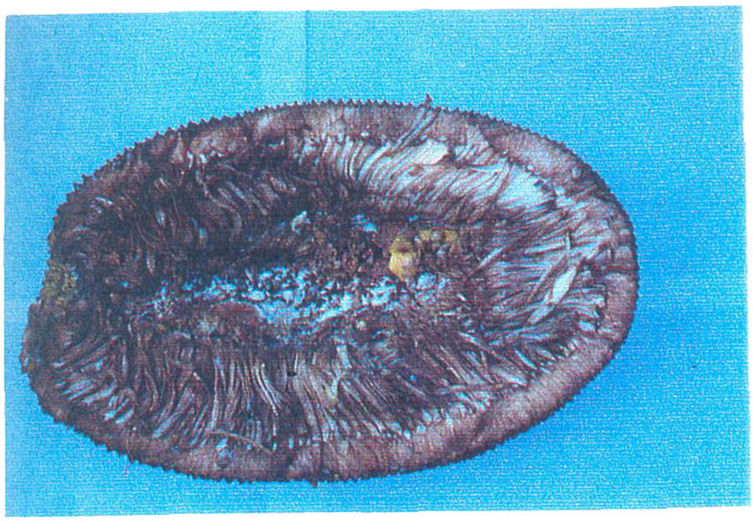


Plate 18. Jack fruit with a single flake

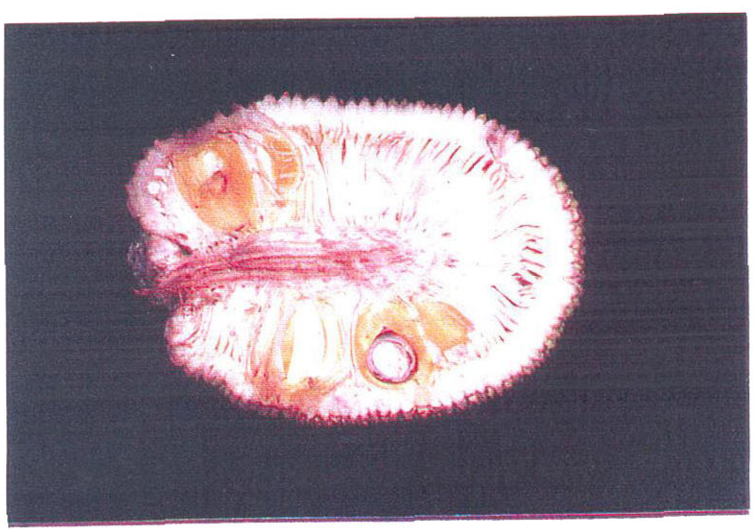


Plate 19. Jack fruit with a few flakes

Table 6. Variation in biometric fruit characters among the genotypes irrespective of the topography

Sl. No.	Characters	Plains			Hills			Coastal			Riverside			Overall accessions		
		Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)
1	Stalk length (cm)	1.0-21.50	7.98	37.62	2.30-32.50	8.40	38.30	2.30-29.5	7.99	38.91	2.60-33.60	8.31	37.89	1.00-33.60	8.01	36.30
2	Fruit length (cm)	18.50-75.60	37.82	33.60	20.60-80.30	38.30	29.64	19.30-75.60	39.36	27.62	20.50-73.40	32.10	31.20	18.50-80.30	38.61	28.90
3	Fruit girth (cm)	32.40-90.60	65.36	21.0	35.40-86.30	64.28	21.60	30.12-110.00	66.00	27.30	30.18-90.30	60.13	21.49	30.12-110.00	64.92	23.28
4	Fruit weight (kg)	1.05-17.60	7.38	43.00	2.25-20.1	7.19	44.28	2.71-22.30	8.31	49.70	2.32-18.31	7.02	43.60	1.05-22.30	7.46	44.68
5	Fruit rind weight (kg)	0.42-3.76	1.55	27.36	0.42-3.98	1.59	26.98	0.39-4.26	1.65	27.26	0.49-4.13	1.54	26.82	0.39-4.26	1.60	27.10
6	Fruit rind thickness (cm)	0.31-3.93	1.56	10.41	0.38-3.79	1.61	10.79	0.28-3.98	1.64	10.83	0.38-3.92	1.59	10.29	0.28-3.93	1.61	10.47
7	No. of flakes per fruit	6.00-456.00	93.42	46.00	0.00-420.00	94.69	49.91	25.00-382.00	107.69	49.13	23.0-417.00	94.63	46.3	1.00-456.00	94.10	48.71
8	Weight of flakes per fruit (kg)	0.64-7.60	2.63	37.00	0.51-6.30	2.56	37.62	0.98-8.21	2.89	38.36	0.79-8.16	2.62	37.62	0.51-8.21	2.76	37.94
9	Weight of a fresh flake with seed (g)	9.35-63.60	30.42	20.21	9.25-55.00	30.64	17.31	12.5-53.80	32.30	17.41	7.15-63.20	30.80	20.16	7.15-63.60	31.28	18.36
10	Weight of a fresh flake without seed (g)	7.01-46.4	23.14	19.19	7.28-39.80	23.18	15.98	9.48-39.84	20.16	15.78	5.36-35.87	22.16	19.03	5.36-46.4	23.48	16.28
11	Flakes fruit ratio	0.79-4.3	2.90	19.9	0.69-3.51	2.91	15.38	0.89-4.21	2.96	15.49	0.76-4.01	2.98	19.28	0.69-4.3	2.97	15.28
12	Flake length (cm)	3.15-12.16	5.12	17.34	3.98-10.61	5.06	17.37	3.76-13.68	5.97	19.68	3.83-11.91	5.14	17.98	3.15-13.68	5.10	17.96
13	Flake girth (cm)	4.25-13.55	8.47	15.62	4.36-13.95	8.67	15.98	4.30-13.40	8.49	15.43	4.69-13.68	8.44	15.08	4.25-13.95	8.42	15.69
14	Flake thickness (mm)	0.1-0.43	0.20	13.56	0.1-0.46	0.20	13.93	0.10-0.47	0.21	13.62	0.10-0.46	0.20	13.36	0.1-0.4	0.20	13.62

Contd.

Table 6. Continued

Sl. No.	Characters	Plains			Hills			Coastal			Riverside			Overall accessions		
		Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)
15	Rachis length (cm)	13.50-60.20	31.88	31.37	14.32 - 63.58	30.28	32.16	14.50 - 60.05	33.01	31.08	14.62-61.28	31.96	30.73	13.5-63.58	32.36	32.16
16	Rachis diameter (cm)	3.55-9.75	6.49	18.62	3.56-12.83	6.43	18.36	4.05-9.85	6.48	18.48	4.00-9.63	6.39	18.73	3.55-12.83	6.40	18.32
17	Perigone weight (kg)	0.43-3.25	1.91	22.65	0.69-4.10	1.91	22.32	0.49-3.76	1.93	22.23	0.43-4.16	1.93	22.32	0.43-4.16	1.68	22.16
18	Peduncle weight (kg)	0.21-2.56	1.33	18.61	0.24-2.81	1.32	18.38	0.27-2.76	1.32	18.96	0.26-2.93	1.38	18.46	0.21-2.93	1.33	18.36

Table 7. Distribution of genotypes based on biometric characters of fruit

Sl. No.	Characters	Class interval	Plains		Hills		Coastal		Riverside		Overall accessions	
			No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)
1	Stalk length (cm)	1) Less than 5 cm	25	31.25	21	26.25	23	28.75	23	28.75	92	28.75
		2) Between 5 and 10 cm	26	32.50	30	37.50	32	40.00	31	38.75	119	37.18
		3) More than 10 cm	29	36.25	29	36.25	25	31.25	26	32.50	109	34.05
2	Fruit length (cm)	1) Less than 30 cm	12	15.00	14	17.50	9	11.25	14	17.50	44	13.75
		2) Between 30 and 50 cm	53	66.25	51	63.50	49	61.25	49	61.25	215	67.18
		3) More than 50 cm	15	18.75	15	18.75	22	27.50	17	21.25	61	19.07
3	Fruit girth (cm)	1) Less than 60 cm	20	25.00	25	31.25	23	28.75	26	32.5	94	29.37
		2) Between 60 and 80 cm	45	56.25	41	51.25	35	43.75	39	48.75	160	50.00
		3) More than 80 cm	15	18.75	14	17.5	22	27.50	15	18.75	66	20.63
4	Fruit weight (kg)	1) Less than 5 kg	20	25.00	21	26.25	26	32.50	21	26.25	88	27.50
		2) Between 5 and 10 kg	42	52.50	43	53.75	31	38.75	40	50.00	156	48.75
		3) More than 10 kg	18	22.50	16	20.00	23	28.75	19	23.75	76	23.75
5	Fruit rind weight (kg)	1) Less than 1 kg	18	22.5	22	27.5	24	30.00	18	22.50	82	25.63
		2) Between 1 and 2 kg	42	52.5	44	55.00	33	41.25	42	52.50	161	50.31
		3) More than 2 kg	20	25.00	14	17.5	23	28.75	20	25.00	77	24.06
6.	Fruit rind thickness (cm)	1) Less than 1 cm	23	28.75	17	21.25	18	22.50	23	28.75	81	25.32
		2) Between 1 and 2 cm	47	58.75	49	61.25	44	55.00	46	57.50	186	58.12
		3) More than 2 cm	10	12.50	14	17.5	18	22.50	11	13.75	53	16.56
7	Number of flakes per fruit	1) Less than 75	17	21.25	18	22.50	14	17.50	16	20.00	65	20.32
		2) Between 75 and 150	47	58.75	42	52.50	40	50.00	47	58.75	176	55.00
		3) More than 150	16	20.00	20	25.00	26	32.50	17	21.25	79	24.68
8	Weight of flakes per fruit (kg)	1) Less than 2 kg	22	27.5	24	30.00	16	20.00	25	31.25	87	27.19
		2) Between 2 to 4 kg	45	56.25	43	53.75	40	50.00	41	51.25	169	52.81
		3) More than 4 kg	13	16.25	13	16.25	24	30.00	14	17.50	64	20.00
9	Weight of a fresh flake with seed	1) Less than 20 g	9	11.25	8	10.00	13	16.25	12	15.00	42	13.13
		2) Between 20 and 40 g	51	63.75	61	76.25	54	67.50	63	78.75	229	71.56
		3) More than 40 g	20	25.00	11	13.75	13	16.25	19	23.75	49	15.31
10	Weight of a fresh flake without seed	1) Less than 15 g	18	22.50	21	26.25	25	31.25	17	21.25	81	25.31
		2) Between 15 and 25 g	41	51.25	45	56.25	42	52.50	43	53.75	171	53.44
		3) More than 25 g	21	26.25	14	17.5	13	16.25	20	25.00	68	21.25

Contd.

Table 7. Continued

Sl. No.	Characters	Class interval	Plains No. of trees	Plains Percentage	Hills No. of trees	Hills Percentage	Coastal No. of trees	Coastal Percentage	Riverside No. of trees	Riverside Percentage	Overall accessions No. of trees	Overall accessions Percentage
11	Flakes fruit ratio	1) Less than 1.5	23	28.75	21	26.25	22	27.50	23	28.75	89	27.81
		2) Between 1.5 and 3	35	43.75	43	53.75	43	53.75	37	46.25	158	49.38
		3) More than 3	22	27.50	16	20.00	15	18.75	20	25.00	73	22.81
12	Flake length (cm)	1) Less than 5 cm	20	25.00	23	28.75	20	25.00	21	26.25	84	26.25
		2) Between 5 and 10 cm	51	63.75	49	61.25	43	53.75	51	63.75	194	60.63
		3) More than 10 cm	9	11.25	8	10.00	17	21.25	8	10.00	42	13.12
13	Flake girth (cm)	1) Less than 7 cm	21	26.25	19	23.75	20	25.00	18	22.50	78	24.37
		2) Between 7 and 10 cm	39	48.75	47	58.75	47	58.75	43	53.75	176	55.00
		3) More than 10 cm	20	25.00	14	17.50	13	16.25	19	23.75	66	20.63
14	Flake thickness (cm)	1) Less than 0.2 cm	20	25.00	27	33.75	27	33.75	26	32.50	100	31.25
		2) Between 0.2 and 0.3 cm	45	56.25	38	47.50	39	48.75	40	50.00	162	50.63
		3) More than 0.3 cm	15	18.75	14	18.75	14	17.50	14	17.50	58	18.12
15	Rachis length (cm)	1) Less than 25 cm	13	16.25	11	13.75	13	16.25	12	15.00	49	15.31
		2) Between 25 and 40 cm	55	68.75	59	73.75	50	62.50	56	70.00	220	68.75
		3) More than 40 cm	12	15.00	10	12.50	17	21.25	12	15.00	51	15.94
16	Rachis diameter (cm)	1) Less than 6 cm	22	27.50	25	31.25	25	31.25	24	30.00	96	30.00
		2) Between 6 and 8 cm	46	57.50	42	52.50	45	56.25	43	53.75	176	55.00
		3) More than 8 cm	12	15.00	13	16.25	10	12.50	13	16.25	48	15.00
17	Perigone weight (kg)	1) Less than 1 kg	22	27.50	24	30.00	22	27.50	23	28.75	91	28.44
		2) Between 1 and 2 kg	44	55.00	41	51.25	43	53.75	43	53.75	171	58.43
		3) More than 2 kg	14	17.50	15	18.75	15	18.75	40	17.50	58	18.13
18	Peduncle weight (kg)	1) Less than 0.75 kg	20	25.00	21	26.25	19	23.75	18	22.50	78	24.39
		2) Between 0.75 and 1.50 kg	42	52.50	39	48.75	39	48.75	43	53.75	163	50.92
		3) More than 1.50 kg cm	18	22.50	20	25.00	22	27.50	19	23.75	79	24.69

(ii) **Hills**

The weight of flakes per fruit had a mean value of 2.56 kg. The range was found to be varying from 0.51 to 6.30 kg which was slightly narrower than other regions. The coefficient of variation was 37.62 per cent (Table 6).

(iii) **Coastal areas**

The weight of flakes per fruit of the accessions studied varied as low as 0.98 to as high as 8.21 kg with a mean value of 2.89 kg. On comparing with plains, hills and riverside the coefficient of variation was slightly higher, i.e., 38.36 per cent (Table 6). Higher per cent of the accessions studied, i.e., 30.00 per cent had the weight of flakes per fruit more than 4.00 kg which was higher than that of the other topographical regions (Table 7).

(iv) **Riverside areas**

The weight of flakes per fruit of the accessions studied ranged from 0.79 to 8.16 kg with a mean value of 2.62 kg. Coefficient of variation recorded was 37.62 per cent (Table 6). About 17.50 per cent had the weight of flakes per fruit more than 4.00 kg (Table 7).

Pooling all the accessions studied foregoing the topography, the range varied from 0.51 to 8.21 kg having a mean value of 2.76 kg. A higher coefficient of variation of 37.94 was recorded indicating the presence of wider variability among the genotypes studied with respect to weight of flakes per fruit (Table 6).

4.1.4.2.9 Weight of a fresh flake with seed

(i) **Plains**

The weight of a fresh flake with seed recorded a mean value of 30.42 g. The range varied from 9.35 to 63.60 g and was found to be higher than those of other topographical regions. Coefficient of variation was recorded as 20.21 per cent was higher than that of other topographical levels like hills and coastal areas (Table 6).

Relatively higher per cent of the accessions, i.e., 25.00 per cent had the flake weight with seed above 20.0 g (Table 7).

(ii) Hills

The mean value of a fresh flake with seed was 30.64 g. The range varied from 9.25 to 55.00 g. The coefficient of variation was 17.31 per cent (Table 6).

(iii) Coastal areas

The mean value of fresh flake with seed was 32.30 g. and the range recorded was 12.50 to 53.80. The coefficient of variation was 17.41 per cent (Table 6).

(iv) Riverside areas

The weight of fresh flake with seed of the accessions ranged from 7.15 to 63.20 g with the mean value of about 30.80 g. Coefficient of variation was observed to be 20.16 per cent (Table 6).

Irrespective of the topography, the weight of fresh flake with seed recorded a mean value of 31.28 g with a range varying from 7.15 to 63.60 g. The statistical analysis showed that there exist significant variability among the genotypes with respect to weight of fresh flake with seed. The coefficient of variation was found to be 18.36 per cent (Table 6).

4.1.4.2.10 Weight of a fresh flake without seed

(i) Plains

The weight of a fresh flake without seed ranged from 7.01 to 46.40 g with a mean value of 23.14 g. The coefficient of variation obtained was higher than those of hills and coastal areas. The coefficient of variation was 19.19 per cent (Table 6). Compared to other regions like hills and coastal, more per cent of fruits had the fresh flake weight excluding seed of above 25.00 g (Table 7).

(ii) **Hills**

The fresh flake weight excluding seed ranged from 7.28 to 39.80 g with a mean value of 23.18 g. The coefficient of variation recorded was 15.98 per cent, which was slightly lower than those of plains (Table 6).

(iii) Coastal areas

The mean value of the fresh flake weight without seed was 20.16 g and the range was 9.48 to 39.84 g. The coefficient of variation was 15.78 per cent which was slightly lower than that of plains and riverside (Table 6).

(iv) Riverside areas

The mean value of the fresh flake weight without seed was 22.16 g having a range varying as low as 5.36 g to as high as 35.87 g. The coefficient of variation was found to be 19.03 per cent, and was slightly higher than that of coastal and hill areas (Table 6).

Considering all the 320 accessions, the mean fresh flake weight excluding seed was 23.48 g. The range was found to be varying from 5.36 to 46.40 g. The coefficient of variation was 16.28 per cent, indicating the existence of variability among the accessions studied with respect to fresh flake weight excluding seed (Table 6).

4.1.4.2.11 Flakes fruit ratio

(i) Plains

Mean flakes fruit ratio of the accessions surveyed in plains was 2.90. It varied from 0.79 to 4.30 with a coefficient of variation of 19.90 per cent. The coefficient of variation was found to be slightly higher than that of other topographical levels (Table 6). Regarding the distribution of genotypes, compared to hills and coastal areas, a higher per cent of the fruits, i.e., 27.50 per cent had the flakes fruit ratio more than three (Table 7).

(ii) Hills

Mean flakes fruit ratio was found to be 2.91. The ratio varied from as low as 0.69 to 3.51. The coefficient of variation was found to be 15.38 per cent, which was slightly lower on comparing with plains (Table 6).

(iii) Coastal areas

The mean flakes fruit ratio of the accessions studied was found to be 2.96 and the range was 0.89 to 4.21. Coefficient of variation was 15.49 per cent which was found to be slightly lower than the plains (Table 6).

(iv) Riverside areas

The mean flakes fruit ratio of the accessions studied was found to be 2.98 and it varied from 0.76 to 4.01. The coefficient of variation was found to be 19.28 per cent which was slightly higher than hills and coastal areas (Table 6).

Irrespective of the topography, the mean flakes fruit ratio was 2.97 and the range varied from 0.69 to 4.3. The coefficient of variation was found to be 15.28 per cent indicating the presence of wider variability among the genotypes studied with respect to flake fruit ratio (Table 6).

4.1.4.2.12 Flake length

(i) Plains

The mean length of the flakes of the accessions studied under plains was 5.12 cm. The flake length found to range from 3.15 to 12.16 cm. On analysing statistically, the coefficient of variation was found to be 17.34 per cent (Table 6).

(ii) Hills

The flake length of fruits studied under hills was found to vary from 3.98 to 10.61 cm with a mean flake length of 5.06 cm. Coefficient of variation noticed was 17.37 per cent (Table 6).

(iii) Coastal areas

The accessions studied had the mean flake length of 5.97 cm. The range varied from 3.76 to 13.68 cm. The coefficient of variation was 19.68 per cent, which was higher than that of other three regions (Table 6). A higher per cent (21.25 per cent) of accessions recorded a flake length value of more than 10.00 cm than that of other topographical levels (Table 7).

(iv) Riverside areas

The flake length of the accessions was found to vary from 3.83 to 11.91 cm with a mean value of 5.14 cm. The coefficient of variation was found to be 17.98 per cent (Table 6).

The mean flake length of overall accessions was 5.10 cm with the range varying from 3.15 to 13.68 cm. Coefficient of variation recorded was 17.96 per cent indicating the existence of wider variability among the genotypes with respect to flake length (Table 6 and Plate 20).

4.1.4.2.13 Flake girth

(i) Plains

The girth of flake recorded a mean value of 8.47 cm. The range varied from 4.25 to 13.55 cm. Coefficient of variation was 15.62 per cent (Table 6). A higher per cent of accessions i.e. 25.00 per cent had flake girth more than 10.00 cm which was higher than coastal and hill areas (Table 7).

(ii) Hills

The mean value of flake girth was 8.67 cm. The range varied from 4.36 to 13.95 cm. Coefficient of variation was 15.98 per cent (Table 6).

(iii) Coastal areas

The mean value of flake girth was 8.49 cm. The range recorded was 4.30 to 13.40 cm. The coefficient of variation was 15.43 per cent (Table 6).

Plate 20. Jack flakes - size and shape variation

Plate 21. Sensory evaluation of jack flakes by the panel members

(iv) Riverside areas

The flake girth of the accessions collected ranged from 4.69 to 13.68 cm with a mean value of about 8.44 cm. Coefficient of variation observed was 15.08 per cent (Table 6).

Irrespective of the topography, the flake girth recorded a mean value of 8.42 cm with a range varying from 4.25 to 13.95 cm. The statistical analysis showed that there exists a significant variability among the genotypes with respect to flake girth (Plate 20). The coefficient of variation was found to be 15.69 per cent (Table 6).

4.1.4.2.14 Flake thickness

(i) Plains

The flake thickness ranged from 0.10 to 0.43 cm with a mean value of 0.20 cm. The coefficient of variation obtained was 13.56 per cent (Table 6).

(ii) Hills

The flake thickness ranged from 0.10 to 0.46 cm having a mean value of 0.20 cm. The coefficient of variation calculated was 13.93 per cent (Table 6).

(iii) Coastal areas

The flake thickness ranged from 0.1 to 0.47 cm with a mean value of 0.21 cm. The coefficient of variation recorded was 13.62 per cent (Table 6).

(iv) Riverside areas

The mean value of the flake thickness was 0.20. The range was 0.10 to 0.46 cm. The coefficient of variation was found to be 13.36 per cent (Table 6).

Considering all the 320 accessions, the mean value of flake thickness was 0.20 cm and the range varied from 0.1 to 0.4 cm. Coefficient of variation noted was 13.62 per cent indicating the existence of variability among the accessions studied with respect to flake thickness (Table 6). About 50.63 per cent of the accessions had the flake thickness in the range of 0.2 to 0.3 cm (Table 7).

4.1.4.2.15 Rachis length

(i) Plains

The mean rachis length of the accessions studied under plains was 31.88 cm. The rachis length found to range from 13.50 to 60.20 cm. On analysing statistically, the coefficient of variation was found to be 31.37 per cent (Table 6).

(ii) Hills

The rachis length of the accessions studied in hilly regions was found to vary from 14.32 to 63.58 cm with the mean rachis length of 30.28 cm. Coefficient of variation was 32.16 per cent (Table 6). More number of accessions had their rachis length in the range of 25.00 to 40.00 cm (Table 7).

(iii) Coastal areas

The accessions studied had the mean rachis length of 33.01 cm. The range varied from 14.50 to 60.05 cm. The coefficient of variation was found to be 31.08 per cent (Table 6). On comparing with other regions, more number of accessions i.e. 21.25 per cent had rachis length more than 40.00 cm (Table 7).

(iv) Riverside areas

The rachis length of the accessions was found to vary from 14.62 to 61.28 cm. The mean fruit length was 31.96 cm. Coefficient of variation was found to be 30.73 per cent (Table 6).

The mean rachis length of overall accessions was 32.36 cm with a range ranging from 13.50 to 63.58. Statistical analysis of rachis length indicated that there exists a higher variability among the genotypes. The coefficient of variation was found to be 32.16 per cent (Table 6).

4.1.4.2.16 Rachis diameter

(i) Plains

The mean rachis diameter of the accessions studied under plains was 6.49 cm. The rachis diameter varied from 3.55 to 9.75 cm. On analysing the data statistically, coefficient of variation was found to be 18.62 per cent (Table 6).

(ii) Hills

The rachis length of fruits studied under hills was found to vary from 3.56 to 12.83 cm with the mean value of 6.43 cm. The coefficient of variation was 18.36 per cent (Table 6).

(iii) Coastal areas

The accessions studied had the mean rachis diameter of 6.48. The range varied from 4.05 to 9.85 cm. The coefficient of variation was found to be 18.48 per cent (Table 6).

(iv) Coastal areas

The rachis diameter of the accessions was found to vary from 4.00 to 9.63 cm with a mean value of 6.39 cm. Coefficient of variation was found to be 18.73 per cent (Table 6).

The mean rachis diameter of the overall accessions studied was 6.40 cm with a range varying from 3.55 to 12.83 cm. Coefficient of variation recorded was 18.32 per cent indicating the existence of wider variability among the genotypes with respect to rachis diameter (Table 6). Majority of the accessions had rachis diameter between 6 and 8 cm (Table 7).

4.1.4.2.17 Perigone weight

(i) Plains

The perigone weight of the fruits recorded a mean value of 1.91 kg. The range varied from 0.43 to 3.25 kg. The coefficient of variation was 22.65 per cent (Table 6).

(ii) **Hills**

The mean value of the perigone weight was 1.91 kg. The range varied from 0.69 to 4.10 kg. The coefficient of variation was 22.32 (Table 6). Higher per cent of accessions, i.e., 51.25 per cent had perigone weight in the range of 1.0 to 2.0 kg (Table 7).

(iii) **Coastal areas**

The mean value of perigone weight of the accessions studied in coastal areas was 1.93 kg. The range recorded was 0.49 to 3.76 kg. Coefficient of variation was 22.23 per cent (Table 6).

(iv) **Riverside areas**

The perigone weight of the collected accessions ranged from 0.43 to 4.16 kg with a mean value of about 1.93 kg. The coefficient of variation observed was 22.32 per cent (Table 6).

Irrespective of topography the perigone weight recorded a mean value of 1.68 kg with a range of 0.43 to 4.16 kg. The statistical analysis showed that there exist a significant variability among the genotypes with respect to perigone weight. The coefficient of variation was 22.16 per cent (Table 6).

4.1.4.2.18 Peduncle weight

(i) **Plains**

The mean peduncle weight of the accessions studied under plains was 1.33 kg. The peduncle weight was found to range from 0.21 to 2.56 kg. Coefficient of variation was 18.61 per cent (Table 6).

(ii) **Hills**

The peduncle weight of the fruits studied under hills was found to vary from 0.24 to 2.81 kg having a mean value of 1.32 kg. The coefficient of variation arrived was 18.38 per cent (Table 6).

(iii) Coastal areas

The peduncle weight of the accessions was found to vary from 0.27 to 2.76 kg with a mean value of 1.32 kg. The coefficient of variation was found to be 18.96 per cent (Table 6).

(iv) Riverside areas

The range varied from 0.26 to 2.93 kg with a mean of 1.38 kg. The coefficient of variation was found to be 18.46 per cent (Table 6).

The mean peduncle weight of overall accessions was 1.33 kg. The range was 0.21 to 2.93 kg. The coefficient of variation recorded was 18.36 per cent indicating the presence of wider variability among the surveyed genotypes with respect to peduncle weight (Table 6).

4.1.4.3 Biochemical characters

4.1.4.3.1 Total sugars

(i) Plains

The mean total sugar content of the accessions studied in plains was 14.56 per cent and was higher than hills and coastal areas. The total sugar content of the accessions was found to vary from 9.10 to 19.30 per cent. The coefficient of variation was 26.46 per cent which was higher on comparing with hills and coastal areas (Table 8).

(ii) Hills

The total sugar content of the accessions studied under hills was found to vary from 8.16 to 17.28 per cent with a mean value of 12.12 per cent. The mean total sugar content of the accessions studied in hills was found to be lower than that of plains and riverside areas. The coefficient of variation was 21.63 per cent (Table 8). Comparing with other regions, a higher per cent of the accessions, i.e., 33.75 per cent had recorded the total sugar content value less than 12.00 per cent (Table 9).

(iii) Coastal areas

The accessions studied had the mean total sugar content of 12.26 per cent. The range varied from 9.17 to 19.26 per cent. The coefficient of variation was 22.78 per cent (Table 8).

(iv) Riverside areas

The total sugar content was found to vary from 9.35 to 19.28 per cent with a mean value of 14.38 per cent which was higher than hills and coastal areas. The coefficient of variation was 25.49 per cent (Table 8). Comparatively a higher per cent of the accessions i.e. 23.75 per cent had total sugar content of above 15.00 per cent (Table 9).

The mean total sugar content of the overall accessions was 13.23 per cent with the range varying from 8.16 to 19.30 per cent. Coefficient of variation recorded was 23.36 per cent indicating the existence of wide variability among the genotypes with respect to total sugar content (Table 8).

4.1.4.3.2 Reducing sugars

(i) Plains

The reducing sugar content of fruits recorded a mean value of 3.53 per cent. The range varied from 1.95 to 5.01 per cent. The coefficient of variation recorded was 27.32 per cent. Similar to that of total sugar content, the coefficient of variation of reducing sugars also found to be higher in plains than the other three topographical regions (Table 8). Comparatively a higher per cent of accessions i.e. 26.25 per cent had reducing sugar more than 4.00 per cent (Table 9).

(ii) Hills

The mean value of reducing sugar content of the accessions studied was 2.91 per cent which was lower than that of plains and riverside. The range varied from 1.63 to 4.23 per cent. The coefficient of variation was found to be 22.38 per cent

(Table 8). Comparing with other regions, a higher per cent of the accessions, i.e., 33.75 per cent had recorded the reducing sugar content value less than 3.00 per cent (Table 9).

(iii) Coastal areas

The mean value of reducing sugar content was 2.98 per cent. The range recorded was 1.89 to 5.23 per cent. The coefficient of variation was 23.12 per cent (Table 8).

(iv) Riverside areas

The reducing sugar content of the accessions collected ranged from 1.86 to 5.16 per cent with a mean value of 3.54 per cent. The coefficient of variation was 26.93 per cent which was higher than hills and coastal areas (Table 8). Comparatively a higher per cent of accessions i.e. 28.75 per cent had reducing sugar content of more than 4.00 per cent (Table 9).

Irrespective of the topography the reducing sugar content recorded a mean value of 3.38 per cent with a range varying from 1.63 to 5.23 per cent. The coefficient of variation was 24.32 per cent indicating the existence of wider variability among the genotypes with respect to reducing sugar content of flakes (Table 8).

4.1.4.3.3 Non-reducing sugars

(i) Plains

The non-reducing sugar content of jack fruit accessions collected in plains ranged from 7.15 to 14.54 per cent with a mean value of 11.01 per cent. The coefficient of variation recorded was 26.83 per cent which was higher on comparing with hills and coastal regions (Table 8).

(ii) Hills

The non-reducing sugar content ranged from 5.96 to 12.83 per cent with a mean value of 9.68 per cent. The mean non-reducing sugar content of the accessions

Table 8. Variation in biochemical fruit characters among the genotypes

Sl. No.	Characters	Plains			Hills			Coastal			Riverside			Overall accessions		
		Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)
1	Total sugars (%)	9.1-19.30	14.56	26.46	8.16-17.28	12.12	21.63	9.17-19.26	12.26	22.78	9.35-19.28	14.38	25.49	8.16-19.30	13.23	23.36
2	Reducing sugars (%)	1.95-5.01	3.53	27.32	1.63-4.23	2.91	22.38	1.89-5.23	2.98	23.12	1.86-5.16	3.54	26.93	1.63-5.23	3.38	24.32
3	Non reducing sugars (%)	7.15-14.54	11.01	26.83	5.96-12.83	9.68	21.98	7.63-14.98	9.74	22.16	7.28-13.96	11.46	26.78	5.96-14.98	10.94	23.86
4	Total soluble solids (° Brix)	15.65-33.00	22.98	18.02	14.63-28.36	20.73	15.28	15.26-32.18	21.66	15.26	15.20-31.98	22.63	17.99	14.63-33.00	21.86	16.02
5	Total acidity (%)	0.62-4.86	2.01	8.68	0.73-5.26	2.66	12.93	0.63-4.91	2.53	12.68	0.64-4.93	2.10	8.49	0.69-5.26	2.23	9.67
6	Sugar acid ratio	2.50-20.81	7.74	17.63	3.06-16.83	6.21	16.53	2.43-19.68	6.08	18.21	2.32-19.49	7.68	17.28	2.32-20.81	7.21	17.43

Table 9. Distribution of genotypes based on biochemical characters of fruit

Sl. No.	Characters	Class interval	Plains		Hills		Coastal		Riverside		Overall accessions	
			No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)
1	Total sugars (%)	1) Less than 12.00	18	22.50	27	33.75	22	27.50	16	20.00	83	25.94
		2) Between 12.00 and 15.00	43	53.75	41	51.25	46	57.50	45	56.25	175	54.68
		3) More than 15.00	19	23.75	12	15.00	12	15.00	19	23.75	62	19.38
2	Reducing sugars (%)	1) Less than 3%	16	20.00	27	33.75	21	26.25	17	21.25	81	25.31
		2) Between 3 and 4%	23	53.75	38	47.50	44	55.00	40	50.00	165	51.56
		3) More than 4%	21	26.25	15	18.75	15	18.75	23	28.75	74	23.13
3	Non reducing sugars (%)	1) Less than 8	17	21.25	23	28.75	25	31.25	15	18.75	80	25.00
		2) Between 8 and 12	43	53.75	42	52.50	40	50.00	44	55.00	169	52.81
		3) More than 12	20	25.00	15	18.75	15	18.75	21	26.25	71	22.19
4	Total soluble solids (° brix)	1) Less than 20° brix	17	21.25	24	30.00	18	22.50	16	20.00	75	23.44
		2) Between 20° and 30° brix	46	57.50	50	62.50	52	65.00	47	58.75	195	60.93
		3) More than 30° brix	17	21.25	6	7.50	10	12.50	17	21.25	50	15.63
5	Acidity (%)	1) Less than 1.5%	19	23.75	15	18.75	17	21.25	20	25.00	71	22.19
		2) Between 1.5 to 3.0%	46	57.50	42	52.50	40	50.00	44	55.00	172	53.75
		3) More than 3.0%	15	18.75	23	28.75	23	28.75	16	20.00	77	24.06
6	Sugar acid ratio	1) Less than 10	22	27.50	27	33.75	22	27.50	19	23.75	90	28.12
		2) Between 10 and 15	37	46.25	43	53.75	46	57.50	41	51.25	167	52.18
		3) More than 15	21	26.25	10	12.50	12	15.00	20	27.50	63	19.70

studied in hills was found to be lower than that of plains and riverside regions. The coefficient of variation was 21.98 per cent (Table 8). Comparing with plains and riverside regions, a higher percent of the accessions, i.e., 28.75 per cent had recorded the non-reducing sugar content value less than 8.00 per cent (Table 9).

(iii) Coastal areas

The non-reducing sugar content ranged from 7.63 to 14.98 per cent with a mean value of 9.74 per cent. The coefficient of variation recorded was 22.16 per cent (Table 8). Comparing with plains and riversides, a higher percentage of the accessions i.e. 31.25 per cent had recorded the non reducing sugar content less than 8.00 per cent (Table 9).

(iv) Riverside areas

The mean value of non-reducing sugar content was 11.46 per cent. The range varied from as low as 7.28 per cent to as high as 13.96 per cent. The coefficient of variation was 26.78 per cent, which was higher than hills and coastal regions. Comparatively a higher per cent of the accessions had non reducing sugar content more than 12.00 per cent (Table 8).

Considering all the 320 accessions the mean value of non-reducing sugar content was 10.94 per cent and the range varied from 5.96 to 14.98 per cent. Coefficient of variation noted was 23.86 per cent indicating the existence of variability among the accessions studied with respect to non-reducing sugar content (Table 8).

4.1.4.3.4 Total soluble solids (TSS)

(i) Plains

The mean value of TSS content of the accessions studied under plains was 22.98°Brix. The TSS varied from 15.65 to 33.00°Brix. On analysing the data statistically, the coefficient of variation was found to be 18.02 per cent, which was found to be higher than hills and coastal areas (Table 8). A higher per cent of accessions, 21.25 per cent had TSS value above 30°Brix (Table 9).

(iii) Hills

The TSS content of the accessions studied in hilly regions was found to vary from 14.63 to 28.36°Brix with the mean value of 20.73°Brix. The mean value of TSS (°Brix) was found to be lower than that of plains and riverside regions. The coefficient of variation recorded was 15.28 per cent which was lower than that of plains and riverside areas (Table 8). Comparing with plains and riverside areas a higher percent of accessions, i.e., 30.00 per cent recorded a TSS value of less than 20°Brix (Table 9).

(iii) Coastal areas

The accessions studied had the mean TSS value of 21.66°Brix. The range varied from 15.26 to 32.18. The coefficient of variation was 15.26 per cent which was found to be lower than that of plains and riverside areas (Table 8).

(iv) Riverside areas

The mean TSS value noted was 22.63°Brix. The range varied from 15.20 to 31.98°Brix. The coefficient of variation observed was 17.99 per cent (Table 8). Comparing with hills and coastal areas, a slightly higher number of accessions, i.e., 21.25 per cent recorded a TSS value more than 30°Brix (Table 9).

The mean value of TSS recorded on overall accessions was 21.86°Brix. The range varied from 14.63-33.00°Brix. Statistical analysis indicated that there exists a wider variability among the genotypes. The coefficient of variation was found to be 16.02 per cent (Table 8).

4.1.4.3.5 Total acidity

(i) Plains

The total acidity of the accessions studied under plains recorded a mean value of 2.01 per cent. The range varied from 0.62 to 4.86 per cent. Coefficient of variation was found to be 8.68 per cent (Table 8).

(ii) **Hills**

The total acid content of the accessions studied under hills found to vary from 0.73 to 5.26 per cent with the mean value of 2.66 per cent. The coefficient of variation was 12.93 per cent which was higher than plains and riverside regions (Table 8). Comparing with the other regions, a higher per cent of accessions had 28.75 per cent the acidity level more than 3.00 per cent (Table 9).

(iii) Coastal areas

The accessions studied had the mean acid content of 2.53 per cent. The mean value recorded was higher than plains and riverside. It ranged from 0.63 to 4.91 per cent. The coefficient of variation was 12.68 per cent which was comparatively higher than plains and riverside areas (Table 8).

(iv) Riverside areas

The total acid content of the accessions was found to vary from 0.64 to 4.93 per cent. The mean value was 2.10 per cent. The coefficient of variation was 8.49 per cent (Table 8).

The total acidity of all the accessions irrespective of the topography had the mean value of 2.23 per cent. The range varied from 0.69 to 5.26 per cent. The coefficient of variation was 9.67 per cent indicating the existence of variability in terms of total acid content (Table 8).

4.1.4.3.6 Sugar acid ratio

(i) Plains

The mean value of sugar acid ratio observed was 7.74. The range varied from 2.50 to 20.81. Coefficient of variation was 17.63 per cent (Table 8).

(ii) Hills

The sugar acid ratio of the accessions studied varied from 3.06 to 16.83 with the mean value of 6.21 (Table 8). When comparing with other regions, a higher percent of accessions, i.e., 33.75 per cent had sugar acid ratio less than 10 (Table 9).

(iii) Coastal areas

The Sugar acid ratio of the accessions was found to vary from 2.43 to 19.68 with the mean value of 6.08. The coefficient of variation observed was 18.21 per cent (Table 8).

(iv) Riverside areas

The mean value of sugar acid ratio of the accessions was 7.68 and the range was 2.32 to 19.49. The coefficient of variation was 17.28 per cent (Table 8). Comparatively a higher per cent of the accessions i.e. 27.50 had sugar acid ratio more than 15.00 (Table 9).

The mean sugar acid ratio of the overall accessions studied was 7.21 and the ratio varied from 2.32 to 20.81. The coefficient of variation of 17.43 per cent indicates the existence of wide variability among the accessions with respect to sugar acid ratio (Table 8).

4.1.4.4 Sensory evaluation of ripened flakes

Sensory qualities of the flakes was based on six characters namely appearance, colour, firmness, flavour, sweetness and overall acceptability. The characters were scored 0-10 with score 0 to 2 attributed for very poor, 2.1-4 for poor, 4.1-6 for satisfactory, 6.1-8 for good and 8.1 to 10 for excellent. Means of the scores of the judges were ranked for each of the six characters. Frequency distribution of the means was presented in the Table 11. Plate 21 shows the sensory evaluation of jack flakes by panel members.

4.1.4.4.1 Appearance of ripened flakes

i) Plains

Appearance of ripened flakes showed a coefficient of variation of 39.00 per cent. The scores recorded ranged from 1.25 to 9.25. The mean score recorded was 5.35 (Table 10). The score of more than 8.0 for excellent appearance was recorded from 22.50 per cent of accessions, which was higher than that of other regions (Table 11).

(ii) Hill areas

The mean score regarding the appearance of flakes for the accessions collected in the hills region was 5.23. The range varied from 1.25 to 8.75. The coefficient variation was 38.00 per cent (Table 10). 13.75 per cent of the accessions had excellent flake appearance by recording the score range above 8.0 (Table 11).

(iii) Coastal areas

The mean score with respect to appearance of flakes was 5.32. The range of score varied from 0.00 to 9.25. The coefficient of variation was 38.84 per cent (Table 10). The highest score of more than 8.00 for excellent appearance was noticed in 16.25 per cent of accessions (Table 11).

(iv) Riverside areas

The flake appearance had recorded the score range varying from 1.50 to 9.00. The mean score recorded was 5.25. The coefficient of variation observed was 37.46 per cent (Table 10). About 22.5 per cent of the accessions recorded score range of above 8.0 and was ranked as the excellent with respect to flake appearance (Table 11).

Irrespective of the topography, the mean score recorded by the 320 accessions for appearance was 5.45. The range was 0.00 to 9.25. The coefficient of variation was 36.82 per cent indicating the presence of wider variability among the accessions with respect to flake appearance (Table 10). About 18.75 per cent of the accessions were having the excellent flake appearance by scoring above 8.0 (Table 11 and Fig.26).

4.1.4.4.2 Colour of the ripened flakes

(i) Plains

The colour of the ripened flakes showed a variation of 43.95 per cent. It was higher than that of other regions. The scores recorded ranged from 1.25 to 8.75. The mean value was 5.01 (Table 10). The highest score of above 8.0 for excellent colour was recorded by 22.50 per cent of the accessions, which was higher than that of hills and coastal areas (Table 11).

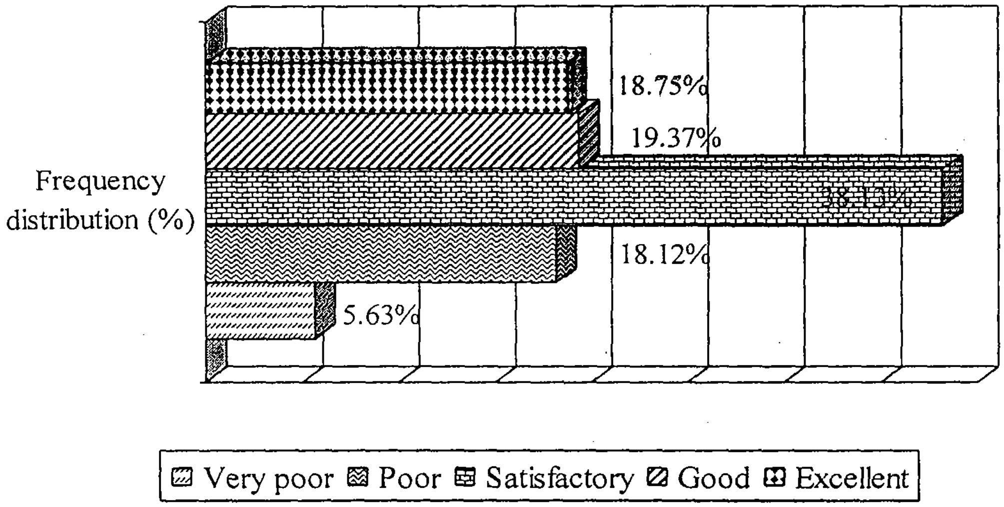


Fig. 26. Distribution of genotypes based on appearance of flakes

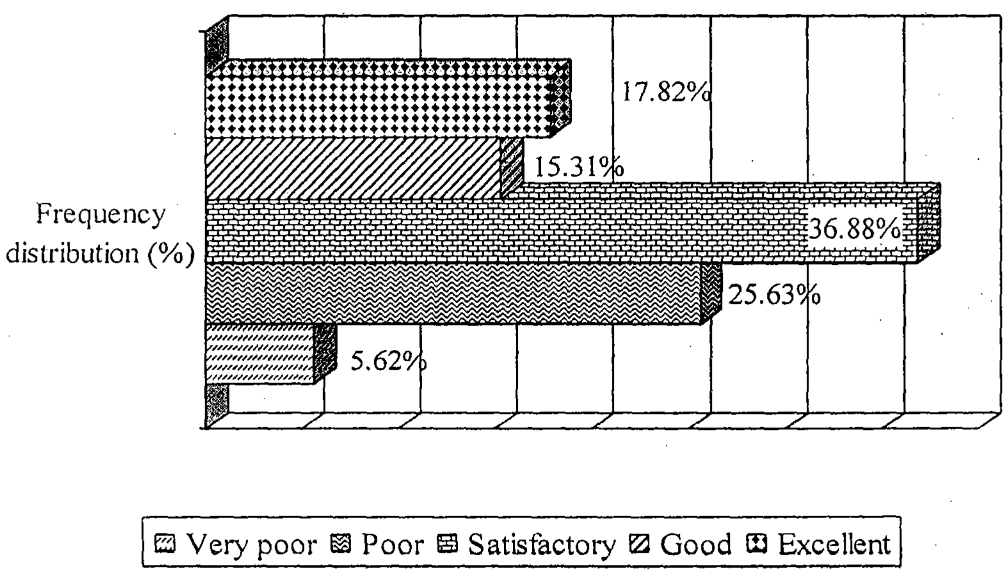


Fig. 27. Distribution of genotypes based on colour of flakes

(ii) Hills

The mean score with respect to colour of flakes was 5.05. The range varied from as low as 1.25 to as high as 9.25. The coefficient of variation recorded was 39.23 per cent (Table 10). The highest score of above 8.0 for excellent appearance was noticed only in 10.00 per cent which was lower than that of plains and riverside areas (Table 11).

(iii) Coastal areas

The mean score regarding the colour of flakes for the accessions collected in coastal areas was 5.03. The range varied from 0.00 to 9.50. The coefficient of variation recorded was 39.78 per cent (Table 10). About 13.75 per cent of the accessions studied had the excellent flake colour by scoring above 8.0 (Table 11).

(iv) Riverside areas

The flake colour had the score range varying from 1.50 to 8.75. The mean score recorded was 5.02. The coefficient of variation was 42.38 per cent (Table 10). About 25.00 per cent of the accessions recorded a score range of above 8.00 and was ranked as the excellent types with respect to flake colour (Table 11).

Irrespective of the topography, the mean score recorded by 320 accessions for colour was 5.11. The range varied from 0.00 to 9.50. The coefficient of variation was 40.63 per cent indicating the presence of wider variability among the accessions with respect to flake colour (Table 10). About 17.82 per cent of accessions had scored above 8.0 for their excellent colour (Table 11 and Fig.27). Plate 22 shows colour variation in jack flakes.

4.1.4.4.3 Firmness of flakes

(i) Plains

Firmness of ripened flakes showed a variation of 42.13 per cent, which was higher than that of hills and coastal regions. The score values ranged from 1.25 to

Plate 22. Colour variation in jack flakes

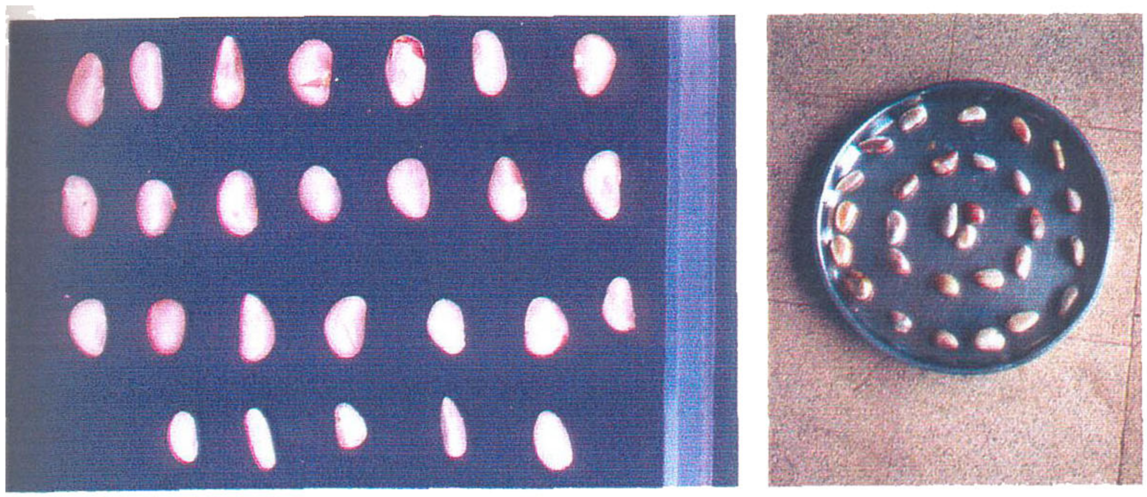


Plate 23. Jack seeds - size and shape variation

9.25. The mean score recorded was 5.95 (Table 10). Compared to hills and coastal areas a higher per cent (20.00%) of the accessions had excellent firmness by scoring above 8.0 (Table 11).

(ii) Hills

The mean score with respect to firmness of flakes was 5.78. The score range varied from 1.25 to 8.75. The coefficient of variation was 36.36 per cent (Table 10). The highest score of more than 8.00 for excellent firmness was noticed in 8.75 per cent of the accessions (Table 11).

(iii) Coastal areas

The mean score regarding the firmness of flakes for the accessions collected in coastal areas was 5.83 per cent. The range varied from 0.00 to 9.25. The coefficient of variation was 36.36 per cent (Table 10). The highest score of more than 8.0 for excellent firmness was recorded in 10.00 per cent of the accessions (Table 11).

(iv) Riverside areas

The flake firmness had recorded the score range varying from 1.75 to 9.00. The mean score was 5.84. The coefficient of variation was 42.00 per cent (Table 10). About 20.00 per cent of the accessions had an excellent firmness by scoring more than 8.0 (Table 11).

On considering all 320 accessions, the mean score recorded for firmness was 5.84. The range was varying from 0.00 to 9.50. The coefficient of variation was 39.13 per cent indicating the presence of wide variability among the genotypes with respect to flake firmness (Table 10). About 15.31 per cent of the accessions were having the excellent flake firmness by scoring above 8.0 (Table 11 and Fig.28).

4.1.4.4.4 Flavour of ripened flakes

(i) Plains

The flavour of the ripened flakes showed a variation of 38.61 per cent. The scores recorded ranged from 1.00 to 8.75. The mean value was 4.89 (Table 10). The

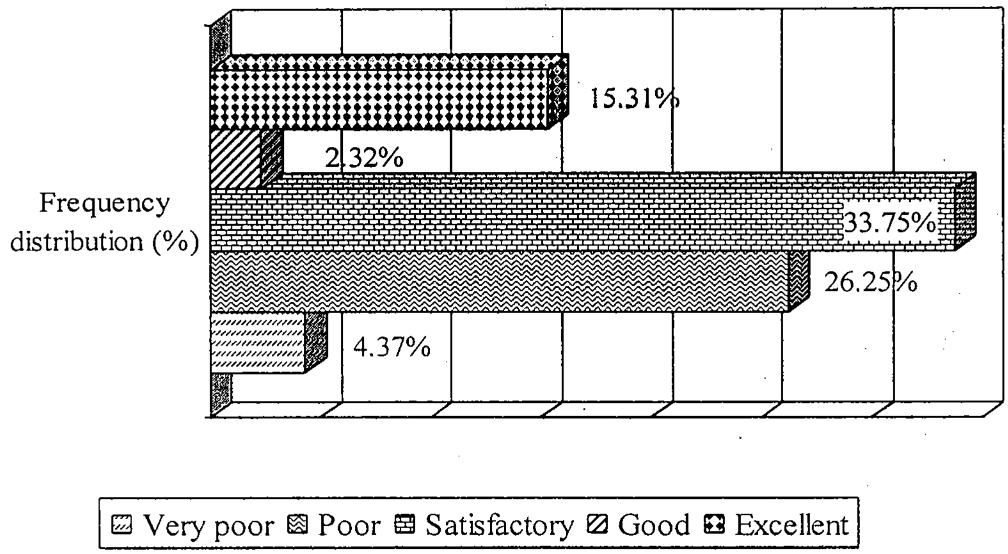


Fig. 28. Distribution of genotypes based on firmness of flakes

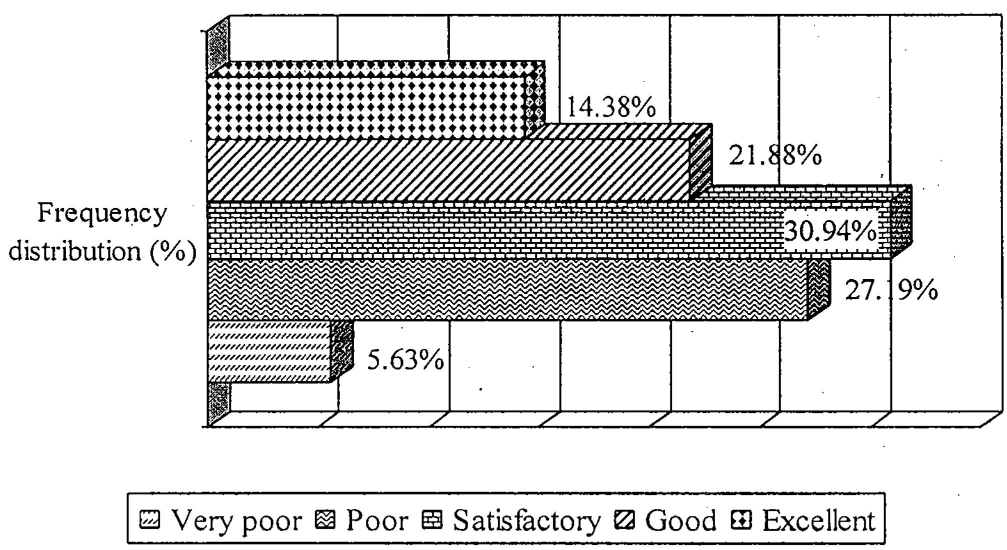


Fig. 29. Distribution of genotypes based on flavour of flakes

Table 10. Variation in sensory qualities of flakes from the surveyed jack fruit accessions

Sl. No.	Characters	Plains			Hills			Coastal			Riverside			Total		
		Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)
1	Appearance	1.25-9.25	5.35	39.00	1.25-8.75	5.23	38.00	0.00-9.25	5.32	38.84	1.50-9.00	5.25	37.46	0.00-9.25	5.45	36.82
2	Colour	1.25-8.75	5.01	43.95	1.25-9.25	5.05	39.23	0.00-9.50	5.03	39.78	1.50-8.75	5.02	42.38	.00-9.50	5.11	40.63
3	Firmness	1.25-9.25	5.95	42.13	1.25-8.75	5.78	36.36	0.00-9.25	5.83	36.36	1.75-9.00	5.84	42.00	0.00-9.50	5.84	39.13
4	Flavour	1.00-8.75	4.89	38.61	0.75-8.75	4.86	43.71	0.00-8.75	4.93	37.74	1.75-8.75	4.88	36.15	0.00-8.75	4.81	37.98
5	Sweetness	1.25-9.25	5.98	39.83	1.50-9.50	5.84	32.96	0.00-9.25	5.94	33.28	1.25-9.25	5.94	38.63	0.00-9.50	5.89	35.93
6	Overall acceptability	0.50-9.00	5.98	39.63	1.00-8.75	5.26	37.63	0.00-9.00	5.23	37.48	2.25-8.75	5.10	39.28	0.00-9.00	5.50	38.36

Table 11. Frequency distribution of genotypes based on sensory qualities of flakes

Sl. No.	Characters	Class interval	Plains		Hills		Coastal		Riverside		Irrespective of topography	
			No. of genotypes	Frequency distribution (%)	No. of genotypes	Frequency distribution (%)	No. of genotypes	Frequency distribution (%)	No. of genotypes	Frequency distribution (%)	No. of genotypes	Frequency distribution (%)
1	Appearance	0-2	5	6.25	5	6.25	4	5.00	4	5.00	18	5.63
		2.1-4	13	16.25	18	22.50	15	18.75	14	17.50	58	18.12
		4.1-6	30	37.50	30	37.50	30	37.50	32	40.00	122	38.13
		6.1-8	14	17.50	16	20.00	18	22.50	14	17.50	62	19.37
		8.1-10	18	22.50	11	13.75	13	16.25	18	12.50	60	18.75
2	Colour	0-2	6	7.50	7	8.75	3	3.75	2	2.50	18	5.62
		2.1-4	18	22.50	22	27.50	25	31.25	17	21.25	82	25.63
		4.1-6	21	26.25	29	36.25	35	43.75	29	36.25	118	36.88
		6.1-8	17	21.25	14	17.50	6	7.50	12	15.00	49	15.31
		8.1-10	18	22.50	8	10.00	11	13.75	20	25.00	57	17.82
3	Firmness	0-2	4	5.00	3	3.75	5	6.25	2	2.50	14	4.37
		2.1-4	22	27.50	25	31.25	17	21.25	20	25.00	84	26.25
		4.1-6	19	23.75	32	40.00	37	46.25	20	25.00	108	33.75
		6.1-8	19	23.75	13	16.25	13	16.25	20	25.00	65	2.32
		8.1-10	16	20.00	7	8.75	8	10.00	16	20.0	40	15.31
4	Flavour	0-1.9	8	10.00	5	6.25	3	3.75	2	2.50	18	5.63
		2-3.9	17	21.50	27	33.75	23	28.75	20	25.00	87	27.19
		4-5.9	19	23.75	25	31.25	33	41.25	22	27.50	99	30.94
		6-7.9	20	25.00	16	20.00	16	20.00	18	22.50	70	21.88
		8-10	16	20.00	7	8.75	5	6.25	18	22.50	46	14.38
5	Sweetness	0-2	1	1.25	4	5.00	3	3.75	3	3.75	11	3.43
		2.1-4	15	18.75	24	30.00	20	25.00	17	21.25	76	23.75
		4.1-6	20	25.00	26	32.50	33	41.25	21	26.25	100	31.25
		6.1-8	25	31.25	20	25.00	16	20.00	20	25.00	81	25.32
		8.1-10	19	23.75	6	7.50	8	10.00	19	23.75	52	16.25
6	Overall acceptability	0-2	5	6.25	7	8.75	3	3.75	0	0	15	4.69
		2.1-4	27	33.75	28	35.00	27	33.75	22	27.50	104	32.50
		4.1-6	17	21.25	28	35.00	34	42.50	28	35.00	107	33.43
		6.1-8	17	26.25	13	16.25	11	13.75	18	22.50	59	18.43
		8.1-10	14	17.50	4	5.00	5	6.25	12	15.00	35	10.95

0-2 - Very poor; 2.1-4 - Poor; 4.1-6 - Satisfactory; 6.1-8 - Good; 8.1-10 - Excellent highest score of more than 8.0 for excellent flavour was recorded from 20.00 per cent of the accessions, which was higher than that of hills and coastal regions (Table 11).

(ii) Hills

The mean score with respect to flavour of flakes was 4.86. The range varied from as low as 0.75 to as high as 8.75. The coefficient of variation recorded was 43.71 per cent (Table 10). The highest score of more than 8.0 for excellent flavour was noticed only in 8.75 per cent of the accessions (Table 11).

(iii) Coastal areas

The mean score regarding the flavour of the flakes for the accessions collected in coastal areas was 4.93 and the range varied from 0.00 to 8.75. The coefficent of variation was 37.74 per cent (Table 10). The highest score of more than 8.0 for excellent flavour was noticed only in 6.25 per cent of the accession (Table 11).

(iv) Riverside area

The flavour had the score range varying from 1.75 to 8.75. The mean score recorded was 4.88. The coefficient of variation was 36.15 per cent (Table 10). Only about 22.50 per cent of the accessions had an excellent flavour by scoring above 8.0 (Table 11).

On considering all 320 accessions, the mean score recorded for flavour was 4.81. The range recorded was from 0.00 to 8.75. The coefficient of variation was 37.98 per cent indicating the presence of wider variability (Table 10). About 14.38 per cent of the accessions recorded a score of above 8.0 and was ranked as excellent for flavour (Table 11 and Fig.29).

4.1.4.4.5 Sweetness of the flakes

(i) Plains

The sweetness of the ripened flakes showed a co-efficient of variation of 39.83 per cent. It was higher than that of hills and coastal regions. The scores recorded ranged from 1.25 to 9.25. The mean value was 5.98 (Table 10). The highest score of more than 8.0 for excellent sweetness was recorded by 23.75 per cent of the accessions, which was higher than that of hills and coastal regions (Table 11).

(ii) Hills

The mean score with respect to sweetness of flakes was 5.84. which was the lower than plains and river side regions. The range varied from as low as 1.50 to as high as 9.50. The coefficient of variation recorded was 32.96 per cent (Table 10). The highest score range of more than 8.0 for excellent sweetness was noticed only in 7.50 per cent which was the lowest of all the other regions (Table 11).

(iii) Coastal areas

The mean score regarding the sweetness of the flakes of the accessions collected in coastal areas was 5.94. The range varied from 0.00 to 9.25. The coefficient of variation recorded was 33.28 per cent (Table 10). About 10.00 per cent of the accessions scored more than 8.0 and was ranking as excellent for sweetness (Table 11).

iv) Riverside areas

The mean score regarding the sweetness of the flakes of accessions collected in riverside areas was 5.94 and the range varied from 1.25 to 9.25. The co-efficient of variation was found to be 38.63 per cent and was found to be higher than that of hills and riverside areas (Table 10). The highest score range of above 8.0 for excellent sweetness was noticed in 23.75 per cent of the accessions and was found to be comparatively higher than that of hills and coastal areas (Table 11).

Irrespective of the topography, the mean score recorded by 320 accessions for sweetness was 5.89. The range varied from 0.00 to 9.5. The coefficient of variation was 35.93 per cent indicating the presence of wider variability among the accessions with respect to sweetness (Table 10). About 16.25 per cent of accessions were having excellent sweetness (Table 11 and Fig.30).

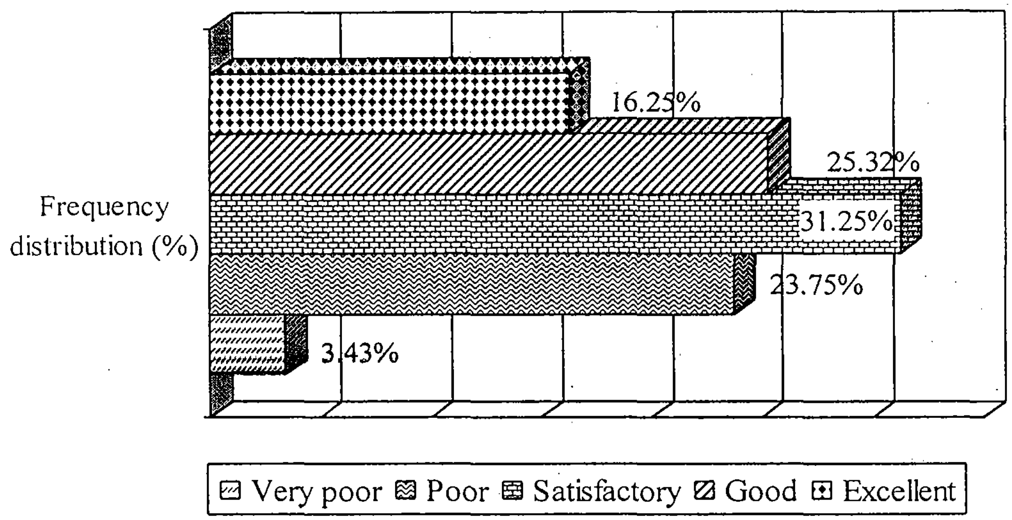


Fig. 30. Distribution of genotypes based on sweetness of flakes

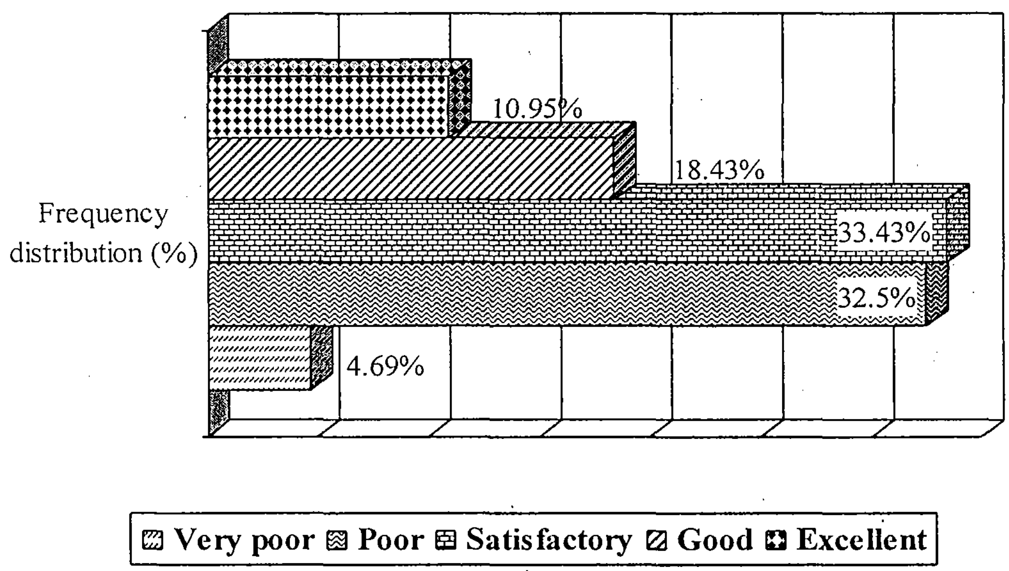


Fig. 31. Distribution of genotypes based on overall acceptability of flakes

4.1.4.4.6 Overall acceptability

(i) Plains

The mean score given by the panel members for sensory evaluation was 5.98, which was found to be higher than hills and coastal regions. The score for overall acceptability found to vary from 0.50 to 9.00. The coefficient of variation was 39.63 per cent which was higher than that of hills and coastal regions (Table 10). Comparing with other regions, more number of accessions recorded excellent in overall acceptability, i.e., 17.50 per cent (Table 11).

(ii) Hills

The mean score of overall acceptability of flakes was 5.26. The range varied from 1.00-8.75. The coefficient of variation was 37.63 per cent (Table 10). Only about 5.00 per cent of the accessions ranked excellent in overall acceptability (Table 11).

(iii) Coastal areas

The overall acceptability of the flakes had recorded the scores ranging from 0.00 to 9.00. The mean score was 5.23. The coefficient of variation was 37.48 per cent (Table 10). Only about 6.25 per cent of the accessions recorded a score range of above 8.0 and was ranked as the excellent ones with respect to overall acceptability (Table 11).

(iv) Riverside areas

The mean score regarding the overall acceptability of flakes for the accession collected in riverside areas was 5.10. The range varied from 2.25 to 8.75. The coefficient of variation was 39.28 per cent (Table 10). About 15.00 per cent of the accessions was found to be excellent in overall acceptability of the flake (Table 11).

Irrespective of the topography, the mean score for overall acceptability recorded by 320 accession was 5.50. The range varied from 0.00 to 9.00. The coefficient of variation was found to be 38.36 per cent. The genotypes showed wider variation with respect to overall acceptability of flakes (Table 10). Only about 10.95 per cent of the accessions were having excellent overall acceptability of the flakes by scoring above 8.0 (Table 11 and Fig.31).

4.1.5 Seed characters

4.1.5.1 Descriptive characters

4.1.5.1.1 Seed shape

(i) Plains

Oblong seed shape was commonly observed (28.75 per cent) followed by irregular seed shape (27.50 per cent). Other shapes like reniform, ellipsoid, elongate and spheroid were noticed respectively in 17.50 per cent, 13.75 per cent, 8.75 per cent and 3.75 per cent of the accessions (Table 12).

(ii) Hills

Here, seed shape was irregular in majority of the accessions, i.e., 35.00 per cent. 31.25 per cent of the accessions had oblong seed shape, 13.75 per cent reniform, 10.00 per cent ellipsoid, 6.25 per cent spheroid and 3.75 per cent of the genotypes studied had spheroid seed shape (Table 12).

(iii) Coastal areas

Oblong seed shape was commonly noticed (27.50 per cent). Seeds were irregular in shape in about 28.75 per cent of the trees observed. Reniform shape was noticed in about 20.00 per cent of the trees. Other seed shapes like spheroid and elongate were also seen in a few of the accessions studied (Table 12).

(iv) Riverside

Here also majority of the accessions (32.50 per cent) had oblong seed shape. In 28.75 per cent of the accessions seed shape was irregular. Reniform and ellipsoid seed shape recorded in 18.75 per cent and 11.25 per cent of the accessions, respectively. Elongate and spheroid shapes were also noticed in a few of the genotypes (Table 12).

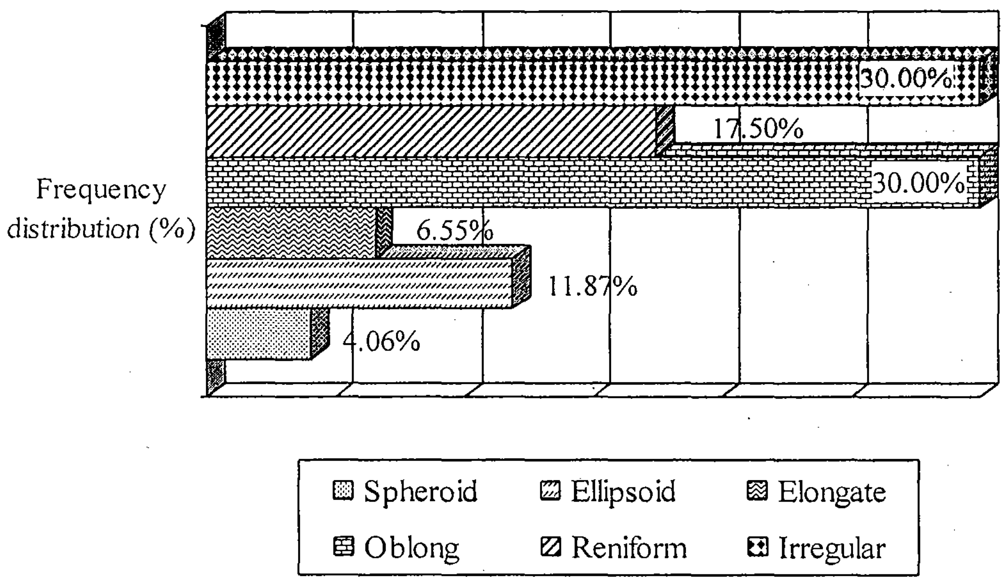


Fig. 32. Distribution of genotypes based on shape of seeds

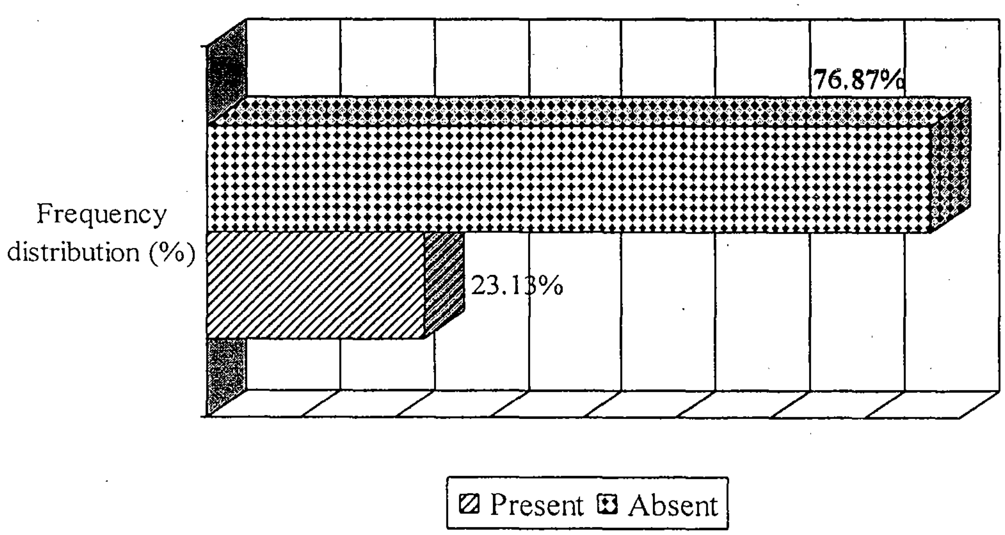


Fig. 33. Distribution of genotypes based on viviparous nature of seeds

A wide variation was noticed in seed shape of the accessions (Plate 23). Majority of the collections (30.00 per cent) had oblong seed shape followed by irregular (30.00 per cent). Reniform seed shape was observed in 17.50 per cent, ellipsoid shape in 11.87 per cent, elongate in 6.55 per cent and spheroid in 4.06 per cent of the trees studied (Table 12 and Fig.32).

4.1.5.1.2 Seed surface pattern

(i) Plains

Regular striations were noticed in the seeds of 76.25 per cent of genotypes, studied in the plains. 13.75 per cent of the accessions were having patches on the seed surface, while 10.00 per cent of the accessions were having uniform seed surface (Table 12).

(ii) Hills

75.00 per cent of the accessions had regular striations on the seed surface. 16.25 per cent were having patches on seed surface and only about 8.75 per cent of the accessions were having uniform seed surface without any striations and patches on the seeds (Table 12).

(iii) Coastal areas

Majority of the collections (78.75 per cent) were having regular striations on the seeds while the seeds with patches on the surface and uniform seed surface were noticed in about 15.00 per cent and 6.25 per cent, respectively (Table 12).

(iv) Riverside areas

Seeds with regular striations on the surface were noticed in 72.50 per cent of the accessions whereas the seeds with patches on seed surface and uniform seeds surface were noticed in 16.25 per cent and 11.25 per cent of the accessions, respectively (Table 12).

Majority of the collections had regular striations on the seeds (75.62 per cent). Among the rest of the accessions, about 15.31 per cent of the seeds had patches on the seeds. Only about 9.06 per cent of the accessions had seed surface without any striations (or) patches (Table 12).

Table 12. Distribution of genotypes based on descriptive characters of seed

Sl. No.	Character	Description	Plains		Hills		Coastal		River side		Overall accessions	
			No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)
1	Seed shape	Spheroid	3	3.75	5	6.25	2	2.50	3	3.75	13	4.06
		Ellipsoid	11	13.75	8	10.00	10	12.50	9	11.25	38	11.87
		Elongate	7	8.75	3	3.75	7	8.75	4	5.00	21	6.55
		Oblong	23	28.75	25	31.25	22	27.50	26	32.50	96	30.00
		Reniform	14	17.50	11	13.75	16	20.00	15	18.75	56	17.50
		Irregular	22	27.50	28	35.00	23	28.75	23	28.75	96	30.00
2	Seed surface pattern	Uniform	8	10.00	7	8.75	5	6.25	9	11.25	29	9.06
		Regular striations	61	76.25	62	75.00	63	78.75	58	72.50	242	75.62
		Patches	11	13.75	13	16.25	12	15.00	13	16.25	49	15.31
3	Seed coat colour	Off white	6	8.75	4	5.00	4	5.00	5	6.25	19	5.93
		Creamish	8	10.00	9	11.25	8	10.00	9	11.25	34	10.62
		Dull brown	40	50.00	39	48.75	44	55.00	42	52.50	165	51.56
		Brownish	26	32.50	28	35.00	24	30.00	24	30.00	102	31.87
4	Vivipary	Present	15	18.75	24	30.00	21	24.00	14	17.50	74	23.13
		Absent	65	81.25	56	70.00	56	56.00	66	82.50	246	76.87

4.1.5.1.3 Seed coat colour

(i) Plains

The collections under plains had dull brown as the most frequently noticed seed coat colour. It was observed in 50.00 per cent of the trees studied. Brownish seeds were noticed in 32.50 per cent of the accessions. Creamish and off white seed coat colour was noticed in a few of the collections (Table 12).

(ii) Hills

Here also the predominant seed coat colour is dull brown (48.75 per cent) and brownish (35.00 per cent). Creamish and off-white seed colour was observed less frequently (Table 12).

(iii) Coastal areas

Most frequently noticed seed coat colour was dull brown (55.00 per cent) and also brownish (30.00 per cent). Creamish and off white colour was also noticed in a few of the accessions (Table 12).

(iv) Riverside

Dull brown seed coat colour was widely prevalent among the genotypes (52.50 per cent) followed by brownish (30.00 per cent). Green and off-white seed coat colour was also observed (Table 12).

Among the studied accessions, seed coat colour had a wide variation. Majority of the accessions had dull brown seed coat colour (51.56 per cent) followed by brownish seeds in 31.87 per cent of the trees. Creamish and off-white seed coat colour was noticed 10.62 per cent and 5.93 per cent, respectively (Table 12).

4.1.5.1.4 Vivipary

(i) Plains

Viviparous seed germination was noticed only in 18.75 per cent of the accessions studied (Table 12).

Plate 24. Viviparous jack seeds

Plate 25. Double seeded jack flake

(ii) Hills

Compared to plains, a higher percentage (30.00 per cent) of viviparous seed germination was noticed (Table 12).

(ii) Coastal areas

Compared to plains, slightly higher percentage of viviparous seeds were noticed (24.00 per cent) among the collection (Table 12).

(iv) River side

About 17.50 per cent of viviparous seeds were noticed among the collections made in riverside areas (Table 12).

Observation pertaining to the presence (or) absence of vivipary reveals that a majority of the accessions collected (76.87 per cent) does not have vivipary. Vivipary was noticed upto the extent of 23.13 per cent of the accessions studied (Table 12 and Fig.33). Plate 24 shows viviparous jack seeds.

4.1.5.2 Biometric seed characters

4.1.5.2.1 Length of seeds

(i) Plains

The length of seeds of the accessions surveyed in plains found to vary from 2.02 to 4.83 cm with a mean value of 3.28 cm. The coefficient of variation was 16.82 per cent (Table 13).

(ii) Hills

The mean value of seed length was 3.43 cm. The range varied from as low as 1.98 cm to as high as 4.98 cm. The coefficient of variation was 17.92 per cent (Table 13).

(iii) Coastal area

The mean value of seed length observed was 3.62 cm which was slightly higher than all other regions. The range was 2.13 to 5.83 cm. The coefficient of

Table 13. Variation in biometric seed characters of the surveyed genotypes

Sl. No.	Characters	Plains			Hills			Coastal			Riverside			Overall accessions		
		Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)
1	Seed length (cm)	2.02-4.83	3.28	16.82	1.98-4.98	3.43	17.92	2.13-5.83	3.62	16.93	2.07-4.73	3.26	17.63	1.98-5.83	3.39	17.83
2	Seed girth (cm)	3.61-8.30	4.28	15.01	3.23-7.98	4.21	15.26	3.68-8.12	4.16	15.49	3.59-7.94	4.26	15.23	3.23-8.30	4.23	15.31
3	100 seed weight (g)	5.72-2400	1006	14.01	549-2100	998	14.63	560-2080	1004	14.26	480-2070	1003	14.89	480-2400	1002	14.63

Table 14. Distribution of genotypes based on biometric characters of seed

Sl. No.	Characters	Class interval	Plains		Hills		Coastal		Riverside		Overall accessions	
			No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)	No. of trees	Frequency distribut-ion (%)
1	Seed length (cm)	1) Less than 3 cm	10	12.50	12	15.0	10	12.5	13	16.25	45	14.06
		2) Between 3 and 4 cm	55	68.75	58	72.5	47	58.75	53	66.25	213	66.56
		3) More than 4 cm	15	18.75	10	12.5	23	28.75	14	17.50	62	19.38
2	Seed girth (cm)	1) Less than 5 cm	6	7.50	9	11.25	9	11.25	6	7.50	30	9.38
		2) Between 5 and 7 cm	63	78.75	64	80.0	64	80.00	68	85.00	259	80.94
		3) More than 7cm	11	13.75	7	8.75	7	8.75	6	7.50	31	9.69
3	100 seed weight (kg)	1) Less than 750	15	18.75	21	26.25	17	21.25	16	20.00	60	21.56
		2) Between 750 and 1500	44	55.00	39	48.75	41	51.25	43	53.75	167	52.19
		3) More than 1500	21	26.25	20	25.00	22	27.50	21	26.25	84	26.25

variation was 16.93 per cent (Table 13). Comparing with all other three regions, a higher per cent of accessions had seed length more than 4.0 cm i.e 28.75 per cent (Table 14).

(iv) Riverside areas

The range of length of seeds of surveyed accessions varied from 2.07 to 4.73 cm with the mean of 3.26 cm. The coefficient of variation was 17.63 per cent (Table 13).

Irrespective of the topography, considering the overall accessions, the length of seeds varied from 1.98 to 5.83 cm with the mean value of 3.39 cm. The coefficient of variation was 17.83 per cent (Table 13). There exist wide variability with respect to length of seeds among the accessions (Plate 23).

4.1.5.2.2 Girth of seeds

(i) Plains

The girth of seeds had the mean value of 4.28 cm. The range observed was 3.61 to 8.30 cm. The coefficient of variation recorded was 15.01 per cent (Table 13).

(ii) Hills

The girth of seeds had the range of 3.23 to 7.98 cm with the mean value of 4.21 cm. The coefficient of variation was 15.26 per cent (Table 13).

(iii) Coastal areas

The range observed with respect to girth of seeds was 3.68 to 8.12 cm having the mean value of 4.16 cm. The coefficient of variation was 15.49 per cent (Table 13).

(iv) Riverside areas

The mean value of girth of seeds was 4.26 cm. The range varied from 3.59 to 7.94 cm. The coefficient of variation was 15.23 per cent (Table 13).

Analysing all the 320 accessions, the mean value was 4.23 cm. The range varied from 3.23 to 8.30 cm. The coefficient of variation was 15.31 per cent. With respect to seed length, wide variability exist among the accessions collected (Table 13 and Plate 23).

4.1.5.2.3 Hundred seed weight

(i) Plains

The range for hundred seed weight recorded was 572.00 to 2400 g with the mean value of 1006 g. The coefficient of variation observed was 14.01 per cent (Table 13).

(ii) Hills

The hundred seed weight of the accessions studied in hills varied from 549.00 to 2100.00 g. The mean value was 998.00 g. The coefficient of variation recorded was 14.63 per cent (Table 13).

(iii) Coastal areas

The range and the mean value of hundred seed weight was 560.00 to 2080.00 g and 1004 g respectively. The coefficient of variation was 14.26 per cent (Table 13).

(iv) Riverside areas

The range and the mean value of hundred seed weight was 480.00 to 2070.00 g and 1003.00 g respectively. The hundred seed weight of the accessions surveyed in riverside areas recorded a coefficient of variation of 14.89 per cent (Table 13).

Irrespective of the topography, the accessions had a mean hundred seed weight of 1002 g. The range was found to be varying from 480.00 g to 2400.00 g. The coefficient of variation was 14.63 per cent (Table 13).

4.1.6 Yield character

4.1.6.1 Yield per tree per year

(i) Plains

Fruit yield per tree ranged from 21.23 to 1698.00 kg per year. The mean value was 536.53 kg (Table 15). The co-efficient of variation was found to be 42.36 per cent (Table 15). About 41.25 per cent of the trees had yield more than 500 kg which was higher than hills and coastal areas (Table 16).

(ii) Hills

The range recorded for yield per tree per year was 31.63 to 1412.30 kg. The mean value of 302.72 kg was recorded which was also lesser than that of plains and riverside regions. The coefficient of variation was 42.00 per cent (Table 15).

(iii) Coastal areas

The range and the mean value of yield per tree per year was 42.16 to 1383.00 kg and 312.16 respectively. The coefficient of variation was 42.38 per cent (Table 15).

(iv) Riverside areas

The mean and the range of yield per tree per year was 523.61 kg and 37.49 to 1710.00 kg respectively. The coefficient of variation recorded was 43.28 per cent (Table 15). About 37.50 per cent of the trees had yield more than 500 kg which was higher than hills and coastal areas (Table 16).

Irrespective of topography, the mean yield per the per year was 419.12 kg. It ranged from 21.23 to 1710.00 kg. The coefficient of variation was 41.28 per cent. There exists a wider variability among the collected accessions with respect the yield per year.

4.1.6.2 Number of fruits per tree per year

(i) Plains

The number of fruits per tree per year was found to vary from 3.66 to 230.60. The mean value was 63.13. The coefficient of variation was 43.28 per cent,

Table 15. Variation in yield characters of the genotypes

Sl. No.	Characters	Plains			Hills			Coastal			Riverside			Overall accessions		
		Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)	Range	Mean	CV (%)
1	Yield per tree (kg)	21.23-1698.00	536.53	42.36	31.63-1412.32	302.72	42.00	42.16-1383.00	312.16	42.38	37.49-1710.00	523.61	41.68	21.23-1710.00	419.12	41.28
2	Number of fruits per tree	3.66-230.60	63.13	43.28	6.28-190.12	37.64	44.38	10.39-184.36	38.33	42.18	7.93-222.48	62.86	43.28	3.60-230.60	47.94	42.94

Table 16. Distribution of genotypes based on yield characters

Sl. No.	Characters	Class interval	Plains		Hills		Coastal		Riverside		Overall accessions	
			No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)	No. of trees	Frequency distribution (%)
1	Yield per tree (kg)	1) Less than 250	22	27.50	27	33.75	27	33.75	23	28.75	99	30.94
		2) Between 250 and 500	25	31.25	41	51.25	42	52.50	27	33.75	135	42.19
		3) More than 500	33	41.25	12	15.00	11	13.75	30	37.50	86	26.87
2	Number of fruits per tree	1) Less than 40	22	27.50	25	31.25	20	25.00	20	25.00	87	27.19
		2) Between 40 and 80	30	37.50	37	46.25	43	53.75	32	40.00	142	44.38
		3) More than 80	28	35.00	18	22.50	17	21.25	28	35.00	91	28.43

Plate 26. Some of the profuse bearing genotypes

Plate 27. Fruits of Thamarachakka

which was higher than all other regions (Table 15). Comparitively a higher per cent of accessions, i.e., 35.00 per cent had recorded the number of fruits more than 80 fruits per year and this was higher than coastal and hill areas (Table 16).

(ii) Hills

The mean value of number of fruits per tree per year was 37.64 and the range was 6.28 to 190.13. The coefficient of variation was 44.38 per cent (Table 15).

(iii) Coastal areas

The mean and range of number of fruits per tree per year was 38.33 and 10.39 to 184.36 respectively. The coefficient of variation was 42.18 per cent (Table 15).

(iv) Riverside areas

The mean and range of number of fruits per tree per year was 63.13 and 7.93 to 222.48. The coefficient of variation was 43.28 per cent (Table 15).

On analysing all the 320 accessions surveyed in four topographical levels, the mean value was 47.94 and the range was 3.6 to 230.60. The coefficient of variation noticed was 42.94 per cent indicating the existence of wider variability among the accessions with respect to number of fruits per tree per year (Table 15). Plate 26 shows some of the profuse bearing genotypes.

4.1.7 Soil characters

Correlation was worked out between the soil characters like organic matter content, organic carbon content, total nitrogen, available phosphorus and potassium content and biometric fruit characters like fruit length, fruit girth, fruit weight, number of flakes per fruit, weight of flakes per fruit, fruit number and yield. No significant correlation was obtained.

Correlation was also worked out between the analysed soil characters and biochemical characters of the flake like reducing sugar, non reducing sugar, total sugar, acidity and TSS. No significant correlation was obtained.

Correlation was worked between the analysed soil characters and sensory qualities of flakes like appearance, colour, flavour, firmness, sweetness and overall acceptability. No significant correlation was obtained.

4.1.8 Character association

Character association was worked out between tree, leaf, fruit and seed characters.

4.1.8.1 Tree characters

4.1.8.1.1 Tree shape and tree growth habit

Association of tree shape and tree growth habit was significant. Pyramidal tree shape and erect growth habit was common followed by broadly pyramidal tree shape and erect growth habit. Obovate tree shape was commonly associated with spreading tree growth habit. Similarly, the oblong trees were frequently associated with semi-erect growth habit. Spreading trees were more commonly having semicircular growth habit. Elliptical trees were more frequently noticed with semi-erect tree growth habit (Table 17).

4.1.8.1.2 Tree shape and branching density

Association of tree shape and branching density was significant. Pyramidal trees with low branching density were common. Semicircular and broadly pyramidal trees were more frequently having intermediate branching density. Obovate and oblong trees were commonly associated with higher branching density. Elliptical trees were commonly noticed with lower branching density (Table 18).

4.1.8.1.3 Tree growth habit and apical dominance

There was significant association between tree growth habit and apical dominance. Association of strong apical dominance with erect trees were more common followed by semi-erect trees. Spreading trees frequently had intermediate apical dominance while drooping trees had weak apical dominance (Table 19).

Table 17. Distribution of trees according to tree shape and tree growth habit

Sl. No.	Tree shape	Tree growth habit			
		Erect	Semi-erect	Spreading	Drooping
1.	Pyramidal	67	9	1	0
2.	Broadly pyramidal	27	17	4	1
3.	Obovate	3	6	16	7
4.	Oblong	3	11	7	6
5.	Semicircular	6	9	14	3
6.	Elliptical	8	10	6	3
7.	Irregular	26	25	12	6
	Chisquare	2551.887**			

**Significant at 0.01 level

Table 18. Distribution of trees according to tree shape and branching density

Sl. No.	Tree shape	Branching density		
		Low	Intermediate	High
1.	Pyramidal	36	35	6
2.	Broadly pyramidal	7	23	13
3.	Obovate	6	10	16
4.	Oblong	7	6	14
5.	Semicircular	10	18	4
6.	Elliptical	11	9	7
7.	Irregular	15	33	74
	Chi square	2412.455**		

**Significant at 0.01 level

Table 19. Distribution of trees according to tree growth habit and apical dominance

Sl. No.	Tree growth habit	Apical dominance		
		Weak	Intermediate	Strong
1.	Erect	10	54	73
2.	Semi-erect	13	40	44
3.	Spreading	23	32	5
4.	Drooping	16	8	2
	Chi square	1767.563**		

**Significant at 0.01 level

4.1.8.1.4 Branching density and branching pattern

Association of branching density and branching pattern was significant. Trees with erect branching pattern and low branching density were common. Trees with verticilliate, horizontal and opposite branching pattern were frequently found to have intermediate branching density (Table 20).

4.1.8.2 Fruit characters

4.1.8.2.1 Fruit shape and junction of stalk attachment

There was no significant association between fruit shape and junction of stalk attachment (Table 21).

4.1.8.2.2 Fruit shape and flake shape

No significant association was recorded between fruit shape and flake shape (Table 22).

4.1.8.2.3 Shape of the spines on the fruit and latex exudation

There was no significant association between shape of the spines on the fruit and latex exudation (Table 23).

4.1.8.2.4 Spine density and latex exudation

There was no significant association between spine density of fruits and latex exudation (Table 24).

4.1.8.2.5 Fruit clustering habit and fruit shape

Significant association was noticed between fruit clustering habit and fruit shape. Oblong fruits and solitary habit were commonly noticed followed by spheroid fruits with clustering habit (Table 25).

4.1.8.4 Seed characters

4.1.8.4.1 Fruit shape and seed shape

No significant association was noticed between fruit shape and seed shape (Table 26).

Table 20. Distribution of trees according to branching pattern and branching density

Sl. No.	Branching pattern	Branching density		
		Low	Intermediate	High
1.	Erect	43	29	19
2.	Opposite	18	30	14
3.	Verticilliate	16	27	14
4.	Horizontal	12	20	10
5.	Irregular	23	38	17
	Chi square	688.79**		

**Significant at 0.01 level

Table 21. Distribution of trees according to fruit shape and junction of stalk attachment

Sl. No.	Fruit shape	Junction of stalk		
		Depressed	Flattened	Inflated
1.	Obloid	10	3	0
2.	Spheroid	23	10	5
3.	High spheroid	21	18	4
4.	Ellipsoid	10	5	5
5.	Clavate	4	3	3
6.	Oblong	68	13	1
7.	Broadly ellipsoid	37	15	3
8.	Irregular	41	15	3
	Chisquare	19.03 NS		

NS - Non significant

Table 22. Distribution of trees according to fruit shape and flake shape

Sl. No.	Fruit shape	Flake shape						
		Spheroid	**Cordate**	**Twisted**	**Elongated** obovate	**Rectangular**	**Oblong**	**Irregular**
1.	Obloid	1	3	3	1	1	1	3
2.	Spheroid	1	9	8	3	5	3	9
3.	High spheroid	5	9	9	3	5	3	9
4.	Ellipsoid	1	5	4	1	2	2	5
5.	Clavate	1	2	2	1	1	1	2
6.	Oblong	4	20	20	5	7	6	20
7.	Broadly ellipsoid	3	14	13	3	4	4	14
8.	Irregular	2	16	13	4	6	5	13
	Chisquare	14.64 NS						

NS - Non significant

Table 23. Distribution of trees according to shape of spines and latex exudation

Sl. No.	Shape of spine	Latex exudation		
		Low	Medium	High
1.	Sharp pointed	6	70	15
2.	Intermediate	10	160	35
3.	Flat	2	17	5
	Chisquare	1.02NS		

NS - Non significant

Table 24. Distribution of trees according to spine density and latex exudation

Sl. No.	Latex exudation	Spine density	
		Sparse	Dense
1.	Low	3	15
2.	Medium	48	199
3.	High	10	45
	Chisquare	0.116NS	

NS - Non significant

Table 25. Distribution of trees according to fruit clustering habit and fruit shape

Sl. No.	Fruit shape	Fruit clustering habit	
		Solitary	Cluster
1.	Obloid	8	5
2.	Spheroid	27	37
3.	High spheroid	36	8
4.	Ellipsoid	12	8
5.	Clavate	6	4
6.	Oblong	70	12
7.	Broadly ellipsoid	48	8
8.	Irregular	42	17
	Chisquare	436.70**	

** Significant at 0.01 level

Table 26. Distribution of trees according to seed shape and fruit shape

Sl. No.	Fruit shape	Seed shape					
		Spheroid	Ellipsoid	Elongate	Oblong	Reniform	Irregular
1.	Obloid	1	2	1	4	2	3
2.	Spheroid	2	5	2	12	6	11
3.	High spheroid	1	5	2	14	8	12
4.	Ellipsoid	1	2	1	6	4	6
5.	Clavate	1	1	1	2	2	3
6.	Oblong	3	9	3	27	15	24
7.	Broadly ellipsoid	2	6	3	18	9	16
8.	Irregular	2	8	2	19	10	18
	Chisquare	33.06NS					

NS - Non significant

Table 27. Distribution of trees according to flake shape and seed shape

Sl. No.	Flake shape	Seed shape					
		Spheroid	Ellipsoid	Elongate	Oblong	Reniform	Irregular
1.	Spheroid	1	2	1	6	3	5
2.	Cordate	2	9	3	25	14	25
3.	Twisted	2	8	3	23	14	22
4.	Elongated	2	3	2	6	3	5
5.	Rectangular	1	4	1	10	5	10
6.	Oblong with curred tip	3	4	3	7	3	5
7.	Irregular	2	8	2	25	14	24
	Chisquare	14.64NS					

NS - Non significant

4.1.8.4.2 Seed shape and flake shape

No significant association was noticed between seed shape and flake shape (Table 27).

4.1.9 Influence of descriptive characters on biometric characters

Analysis of variance was conducted to find out the relationship between descriptive and biometric characters of jack tree.

4.1.9.1 Leaf characters

4.1.9.1.1 Leaf shape on leaf length

There was significant difference in the length of leaves between different shapes of leaves. Broadly elliptic leaves had maximum the length and lanceolate leaves had the minimum (Table 28).

4.1.9.1.2 Leaf shape on leaf breadth

There was significant difference in the breadth of leaves between different shapes of leaves. Broadly elliptic leaves had maximum breadth followed by obovate and oblong leaves. The lanceolate leaves had the minimum (Table 29).

4.1.9.1.3 Leaf shape on length/breadth ratio of leaves

There was significant difference in the length/breadth ratio between the leaves of different shapes. Lanceolate leaves had the maximum length and breadth of leaves followed by elliptic leaves. Broadly elliptic leaves had the minimum (Table 30).

4.1.9.1.4 Leaf shape on petiole length of leaves

There was no significant difference in length of petiole between different shapes of leaves (Table 31).

4.1.9.2 Fruit characters

4.1.9.2.1 Fruit shape on fruit length

There was significant difference in fruit length between fruits of different shapes. Oblong fruits had maximum length (47.59 cm) followed by broadly ellipsoid

Table 28. Effect of leaf shape on leaf length

Sl. No.	Leaf shape	Leaf length (cm)
1.	Obovate	13.91
2.	Elliptic	14.38
3.	Broadly elliptic	15.36
4.	Oblong	12.96
5.	Lanceolate	11.98
	CD (0.05)	0.934

Table 29. Effect of leaf shape on leaf breadth

Sl. No.	Leaf shape	Leaf breadth (cm)
1.	Obovate	8.34
2.	Elliptic	6.99
3.	Broadly elliptic	10.38
4.	Oblong	8.02
5.	Lanceolate	6.02
	CD (0.05)	0.286

Table 30. Effect of leaf shape on length/breadth ratio of leaves

Sl. No.	Leaf shape	Llength/breadth ratio
1.	Obovate	1.49
2.	Elliptic	1.58
3.	Broadly elliptic	1.11
4.	Oblong	1.21
5.	Lanceolate	1.82
	CD (0.05)	0.10

Table 31. Effect of leaf shape on petiole length of leaves

Sl. No.	Leaf shape	Petiole length
1.	Obovate	31.28
2.	Elliptic	29.31
3.	Broadly elliptic	30.63
4.	Oblong	31.23
5.	Lanceolate	30.49
	ANOVA	NS

Table 32. Effect of fruit shape on fruit length

Sl. No.	Fruit shape	Fruit length (cm)
1.	Obloid	32.63
2.	Spheroid	33.62
3.	High spheroid	32.89
4.	Ellipsoid	36.23
5.	Clavate	39.48
6.	Oblong	47.59
7.	Broadly ellipsoid	46.73
8.	Irregular	43.28
	CD (0.05)	1.02

Table 33. Effect of fruit shape on fruit girth

Sl. No.	Leaf shape	Fruit girth (cm)
1.	Obloid	66.28
2.	Spheroid	65.36
3.	High spheroid	66.39
4.	Ellipsoid	67.26
5.	Clavate	66.93
6.	Oblong	65.26
7.	Broadly ellipsoid	65.91
8.	Irregular	65.23
	ANOVA	NS

Table 34. Effect of fruit shape on fruit weight

Sl. No.	Fruit shape	Fruit weight (kg)
1.	Obloid	7.29
2.	Spheroid	6.91
3.	High spheroid	7.63
4.	Ellipsoid	8.28
5.	Clavate	9.98
6.	Oblong	10.36
7.	Broadly ellipsoid	9.28
8.	Irregular	6.98
	CD (0.05)	0.312

(46.73 cm). Obloid fruits had the minimum fruit length (32.63) followed by high spheroid (32.89 cm) (Table 32).

4.1.9.2.2 Fruit shape on fruit girth

No significant difference was noticed in fruit girth between the fruit of different shapes (Table 33).

4.1.9.2.3 Fruit shape on fruit weight

There was significant difference in fruit weight between fruits of different shapes. Oblong fruits had the maximum (10.36 kg) followed by clavate (9.98 kg). Spheroid fruits had the minimum (6.91) (Table 34).

4.1.9.2.4 Fruit shape on flake length

No significant difference in flake length between fruits of different shapes was noticed (Table 35).

4.1.9.2.5 Fruit shape on seed length

There was no significant difference in seed length between different shapes of fruit (Table 36).

4.1.9.2.6 Fruit clustering habit on fruit length

Significant difference in fruit length between solitary and clustering fruits. Solitary fruits had maximum fruit length (42.16 cm) followed by clustering fruits (35.28 cm) (Table 37).

4.1.9.2.7 Fruit clustering habit on fruit girth

Significant difference in fruit girth between solitary and clustering fruits was noticed. Solitary fruits had more fruit girth (66.58 cm) on comparing with cluster fruits (58.36 cm) (Table 38).

Table 35. Effect of fruit shape on flake length

Sl. No.	Fruit shape	Fruit weight (kg)
1.	Obloid	7.83
2.	Spheroid	7.91
3.	High spheroid	6.91
4.	Ellipsoid	7.63
5.	Clavate	7.48
6.	Oblong	7.49
7.	Broadly ellipsoid	7.38
8.	Irregular	7.61
	ANOVA	NS

Table 36. Effect of fruit shape on seed length

Sl. No.	Fruit shape	Seed length
1.	Obloid	3.62
2.	Spheroid	3.52
3.	High spheroid	3.49
4.	Ellipsoid	3.68
5.	Clavate	3.48
6.	Oblong	3.72
7.	Broadly ellipsoid	3.61
8.	Irregular	3.59
	ANOVA	NS

Table 37. Effect of fruit clustering habit on fruit length

Sl. No.	Fruit clustering habit	Fruit length
1.	Solitary	42.16
2.	Cluster	35.28
	CD (0.05)	3.283

Table 38. Effect of fruit clustering habit on fruit girth

Sl. No.	Fruit clustering habit	Fruit girth (cm)
1.	Solitary	66.58
2.	Cluster	58.36
	CD (0.05)	4.231

Table 39. Effect of fruit clustering habit on fruit weight

Sl. No.	Fruit clustering habit	Fruit weight (kg)
1.	Solitary	9.29
2.	Cluster	7.63
	CD (0.05)	0.983

Table 40. Effect of junction of stalk attachment to fruits on fruit length

Sl. No.	Junction of stalk attachment to fruit	Fruit length (cm)
1.	Depressed	39.86
2.	Flattered	40.13
3.	Inflated	30.12
	ANOVA	NS

Table 41. Effect of junction of stalk attachment to fruit on fruit girth

Sl. No.	Junction of stalk attachment to fruits	Fruit girth (cm)
1.	Depressed	63.89
2.	Flattered	65.28
3.	Inflated	64.36
	ANOVA	NS

Table 42. Effect of junction of stalk attachment to fruit on fruit weight

Sl. No.	Junction of stalk attachment to fruits	Fruit weight (kg)
1.	Depressed	8.76
2.	Flattered	8.63
3.	Inflated	8.49
	ANOVA	NS

Table 43. Effect of shape of the spines on flake weight

Sl. No.	Shape of spines	Flake weight (kg)
1.	Sharp pointed	2.83
2.	Intermediate	2.91
3.	Flat	2.64
	ANOVA	NS

4.1.9.2.8 Fruit clustering habit on fruit weight

Significant difference in fruit weight between solitary and clustering fruits was recorded. Solitary fruits had more fruit weight (9.29 kg) on comparing with those of cluster fruits (7.63 kg) (Table 39).

4.1.9.2.9 Junction of stalk attachment to fruits on fruit length

No significant difference in fruit length was noticed between different types of junction of stalk attachment to fruits (Table 40).

4.1.9.2.10 Junction of stalk attachment to fruits on fruit girth

No significant difference in fruit girth was noticed between different types of junction of stalk attachment of fruits (Table 41).

4.1.9.2.11 Junction of stalk attachment to fruits on fruit weight

No significant difference in fruit weight was noticed between different types of junction of stalk attachment of fruits (Table 42).

4.1.9.2.12 Shape of the spines on flake weight

No significant difference in flake weight between the different shapes of the spines was noticed (Table 43).

4.1.9.2.13 Shape of spines on fruit weight

No significant difference in fruit weight between the different shapes of the spines was recorded (Table 44).

4.1.9.2.14 Flake shape on flake length

Significant difference in flake length between different flake shapes was observed. Oblong flakes with curved tip recorded maximum flake length (7.33 cm) followed by twisted (6.48 cm). Spheroid flakes had the minimum (5.26 cm) (Table 45).

Table 44. Effect of shape of the spines on fruit weight

Sl. No.	Shape of spines	Fruit weight (kg)
1.	Sharp pointed	8.69
2.	Intermediate	8.91
3.	Flat	8.28
	ANOVA	NS

Table 45. Effect of flake shape on flake length

Sl. No.	Flake shape	Flake length (cm)
1.	Spheroid	5.26
2.	Cordate	6.13
3.	Twisted	6.48
4.	Elongated obovate	5.87
5.	Rectangular	6.38
6.	Oblong with curved tip	7.33
7.	Irregular	5.93
	CD (0.05)	0.028

Table 46. Effect of flake shape on seed length

Sl. No.	Flake shape	Seed length (cm)
1.	Spheroid	3.23
2.	Cordate	4.16
3.	Twisted	4.21
4.	Elongated obovate	3.38
5.	Rectangular	4.19
6.	Oblong with curved tip	4.91
7.	Irregular	3.52
	ANOVA	NS

Table 47. Effect of density of the spines on flake weight

Sl. No.	Density of spines	Flake weight (kg)
1.	Sparse	2.21
2.	Intermediate	2.83
3.	Dense	3.01
	ANOVA	NS

Table 48. Effect of density of spines on fruit weight

Sl. No.	Density of spines	Flake weight (kg)
1.	Sparse	8.36
2.	Intermediate	8.79
3.	Dense	9.23
	ANOVA	NS

Table 49. Effect of seed shape on seed length

Sl. No.	Seed shape	Seed length (cm)
1.	Spheroid	3.28
2.	Ellipsoid	3.52
3.	Elongated	4.19
4.	Oblong	4.93
5.	Reniform	3.68
6.	Irregular	3.36
	CD (0.05)	0.142

4.1.9.2.15 Flake shape on seed length

There was no significant difference in seed length between different flake shapes (Table 46).

4.1.9.2.16 Density of spines on flake weight

There was no significant difference in flake weight between varying density of spines (Table 47).

4.1.9.2.17 Effect of density of spines on fruit weight

There was no significant difference in fruit weight between varying density of spines (Table 48).

4.1.9.3 Seed characters

4.1.9.3.1 Seed shape on seed length

There was significant difference in seed length between different seed shapes. Oblong seeds had maximum seed length followed by elongated seeds. Spheroid seeds recorded the minimum (Table 49).

4.1.10 Correlation

Correlation was worked out between leaf characters, fruit characters, biochemical characters and sensory qualities of flakes. Correlation was also worked out between biometric and biochemical fruit characters, between biochemical and sensory qualities of flake and between biometric and sensory qualities of flakes.

4.1.10.1 Leaf characters

Correlation coefficient between leaf characters are presented in Table 50. Leaf length had highly significant positive correlation with leaf area and petiole length. It is also significantly correlated positively with leaf width.

Leaf width had highly significant positive correlation with leaf area. Petiole length had highly significant negative correlation with leaf width (Table 50).

Table 50. Correlation coefficients between leaf characters of jack accessions

	Leaf length	Leaf width	Length/width	Leaf area	Petiole length
Leaf length	1.00				
Leaf width	0.205*	1.00			
Length/width	0.072	-0.106	1.00		
Leaf area	0.733**	0.802**	-0.032	1.00	
Petiole length	0.540**	-0.660**	0.138	-0.143	1.00

* - Signficant at 0.05 level

** - Significant at 0.01 level

4.1.10.2 Fruit characters

4.1.10.2.1 Biometric fruit characters

The correlation matrix for biometric characters of the fruits are presented in the Table 51.

Yield of the fruit had highly significant positive correlation with fruit length, fruit diameter, fruit weight, weight of flakes and fruit number. Yield had significant positive correlation with number of flakes, rachis length, perigone weight, seed weight and peduncle weight (Table 51).

Correlation between stalk length and fruit number was found to be significant (Table 51).

Correlation between fruit length and other fruit characters like fruit diameter, fruit weight, rind weight, number of flakes, weight of flakes, rachis length, rachis diameter, perigone weight, seed weight, peduncle weight and fruit number were found to be highly significant. Among these, fruit number was negatively correlated with fruit length. Significant correlation was also observed between fruit length and other fruit characters like flake length, seed length and seed girth (Table 51).

Highly significant correlation was observed between fruit diameter and other fruit characters like fruit weight, rind weight, number of flakes, weight of flakes, flake length, rachis length, rachis diameter, perigone weight, seed weight, seed length and fruit number. Among these, the correlation between fruit diameter and fruit number was highly negative (Table 51).

Fruit weight had highly significant positive correlation with fruit rind weight, number of flakes, weight of flakes, flake length, rachis length, rachis diameter, perigone weight, seed weight, peduncle weight, seed length and fruit number. Among these, the correlation between fruit weight and fruit number was highly negative (Table 51).

Highly significant positive correlation was noticed between fruit rind weight and other fruit characters like number of flakes, weight of flakes, flake length, rachis length, rachis diameter, perigone weight, seed weight, peduncle weight, seed length and seed girth. The correlation between fruit rind weight and fruit number was found to be highly negative (Table 51).

Number of flakes had highly significant positive correlation with weight of flakes, rachis length, rachis diameter, peduncle weight and seed weight. The number of flakes had highly significant negative correlation with perigone weight, fruit number and flake weight without seed (Table 51).

Highly significant correlation was observed between weight of flakes and other fruit characters like weight of flakes fruit ratio, flake length, rachis length, rachis diameter, seed weight and peduncle weight. Highly significant negative correlation was also observed between weight of flakes and perigone weight and fruit number. Significant positive correlation was noticed between weight of flakes and seed length (Table 51).

Flake weight with seed had significant positive correlation with other fruit characters like flake weight without seed, flake length and flake girth (Table 51).

Flake weight without seed and other fruit characters like flake fruit ratio, flake girth, were significantly correlated (Table 51).

Flake length had highly significant positive correlation with other fruit characters like flake girth, seed weight and seed length. Significant positive correlation was noticed between flake length and seed girth (Table 51).

Flake girth had significant positive correlation with seed girth.

Rachis length had highly significant positive correlation with rachis diameter, perigone weight, seed weight, peduncle weight, and fruit number. Among these the correlation between rachis length and fruit number is highly negative. Significant positive correlation was observed between rachis length, seed length and girth (Table 51).

Table 51. Correlation matrix between biometric fruit characters

	Yield	Stalk length	Fruit length	Fruit diameter	Fruit weight	Fruit rind weight	Fruit rind thickness	No. of flakes	Weight of flakes	Flake+ seed	Flake-seed	Flake fruit ratio	Flake length	Flake girth	Flake thick-ness	Rachis length
Yield	1.000															
Stalk length	-0.029	1.000														
Fruit length	0.411**	-0.116	1.000													
Fruit diameter	0.283	-0.117	0.635**	1.000												
Fruit weight	0.258**	-0.088	0.741**	0.824**	1.000											
Fruit rind weight	0194	-0.055	0.599**	0.705**	0.783**	1.000										
Fruit rind thickness	-0.059	0.045	0.005	0.015	0.034	0.192	1.000									
No. of flakes	0.232*	-0.079	0.538**	0.675**	0.799**	0.544**	-0.002	1.000								
Weight of flakes	0.265	-0.027	0.677**	0.740**	0.899**	0.635**	-0.023	0.799**	1.000							
Flake+ seed	0.001	-0.015	0.174	-0.008	0.095	0.117	0.036	-0.411	0.072	1.000						
Flake-seed	0.024	0.068	0.133	-0.051	0.055	0.034	0.001	-0.365**	0.165	0.907**	1.000					
Flake fruit ratio	0.037	0.037	0.029	0.010	-0.019	-0.028	-0.182	0.121	0.312**	-0.007	0.233*	1.000				
Flake length	0.114	-0.098	0.219*	0.297**	0.259**	0.247**	-0.021	0.116	0.194**	0.225*	0.190	-0.046	1.000			
Flake girth	0.040	0.062	0.158	0.181	0.101	0.131	-0.010	-0.105	0.103	0.316**	0.332**	0.065	0.356**	1.000		
Flake thickness	0.011	-0.026	0.026	0.073	-0.001	-0.086	-0.019	0.030	0.082	0.069	0.106	0.119	0.172	0.119	1.000	
Rachis length	0.194*	-0.098	0.964**	0.618**	0.727**	0.599**	0.017	0.535**	0.667**	0.157	0.109	0.036	0.152	0.153	-0.046	1.000
Rachis diameter	0.030	-0.029	0.337**	0.380**	0.344**	0.328**	0.014	0.307**	0.275**	-0.022	-0.047	0.021	0.115	-0.128	0.117	0.296**
Peng weight	0.204*	-0.029	0.586**	0.609**	0.746**	0.535**	-0.047	0.616**	-0.627**	0.030	-0.015	-0.064	0.171	0.092	0.058	0.576**
Seed weight	0.211*	-0.145	0.662**	0.701**	0.846**	0.633**	-0.029	0.609**	0.666**	0.144	-0.011	-0.127	0.284**	0.143	-0.005	0.650**
Peduncle weight	0.194*	-0.089	0.629**	0.583**	0.720**	0.558**	-0.072	0.575**	0.594**	0.035	-0.008	0.012	0.162	0.061	-0.052	0.634**
Seed length	0.068	-0.150	0.231**	0.264**	0.320**	0.281**	0.093	0.168	0.227*	0.177	0.051	-0.172	0.314**	0.013	0.019	0.238**
Seed girth	0.034	0.025	0.194*	0.185	0.188	0.326**	0.137	0.051	0.099	0.092	0.018	-0.029	0.213*	0.233*	0.050	0.193*
Fruit number	0.511**	0.197*	-0.400**	-0.436**	-0.467**	-0.413**	-.0.041	-0.335**	-0.401**	-0.107	-0.065	0.018	-0.106	-0.002	0.044	-0.395**

	Rachis diameter	Perigone weight	Seed weight	Peduncle weight	Seed length	Seed girth	Fruit No.
Rachis diameter	1.000						
Perigone weight	0.313**	1.000					
Seed weight	0.310**	0.787**	1.000				
Peduncle weight	0.327**	0.682**	0.732**	1.000			
Seed length	0.143	0.285**	0.428**	0.120	1.000		
Seed girth	0.096	0.171**	0.281**	0.129	0.317**	1.000	
Fruit number	-0.204**	-0.360**	-0.424**	-0.374**	-0.195**	-0.081	1.000

Highly significant positive correlation was observed between rachis diameter and other characters like perigone weight, seed weight and peduncle weight. Highly significant negative correlation was observed between rachis diameter and fruit number (Table 51).

Correlation of perigone weight with other fruit characters like seed weight, peduncle weight, seed length and fruit number was highly significant. Among these, the number of fruits and perigone weight had highly significant negative correlation (Table 51).

Seed weight had highly significant positive correlation with other characters like peduncle weight, seed length and seed girth. Highly significant negative correlation was observed between seed weight and fruit number (Table 51).

Peduncle weight had highly significant negative correlation with fruit number.

Seed length had highly significant positive correlation with seed girth and significant negative correlation with fruit number (Table 51).

4.1.10.2.2 Biochemical characters of flakes

The correlation matrix for biochemical characters of flakes has been presented in Table 52.

Non reducing sugar had highly significant positive correlation with other biochemical characters like reducing sugars, total surgars, sugar acid ratio and TSS (°Brix) content. Reducing sugars had highly significant positive correlation with total sugars and TSS (°Brix). Total sugars had highly significant positive correlation with sugar acid ratio and TSS (°Brix). Acidity had highly significant negative correlation with sugar acid ratio. Sugar acid ratio had significant positive correlation with TSS (°Brix) (Table 52).

Table 52. Correlation matrix between biochemical and sensory qualities of flakes

	Non reducing sugar	Reducing sugar	Total sugar	Acidity	Sugar acid ratio	TSS	Appear-ance	Colour	Firmness	Flavour	Sweetness	Overall acceptab-ility
Non-reducing sugars	1.00											
Reducing sugars	0.681**	1.00										
Total sugars	0.980**	0.813**	1.00									
Acidity	0.065	0.130	0.087	1.00								
Sugar acid ratio	0.279**	0.127	0.256**	-0.702**	1.00							
TSS	0.866**	0.722**	0.884**	0.122	0.198*	1.00						
Appearance	0.074	0.053	0.073	0.071	0.046	0.098	1.00					
Colour	0.064	0.052	0.065	0.035	0.021	0.082	0.803**	1.00				
Firmness	0.038	0.044	0.042	0.044	0.031	0.064	0.664**	0.664**	1.00			
Flavour	0.136	0.091	0.133	0.014	-0.024	0.131	0.685**	0.669**	0.705**	1.00		
Sweetness	0.622**	0.628**	0.625**	0.025	0.630**	0.708**	0.052	0.565**	0.558**	0.534**	1.00	
Overall acceptability	0.652**	0.655**	0.657**	-0.043	0.615**	0.655**	0.775**	0.766**	0.756**	0.803**	0.759**	1.00

** - Significant at 0.01 level
* - Significant at 0.05 level

4.1.10.2.3 Sensory qualities of flakes

The correlation matrix between the sensory qualities of flakes is presented in Table 52.

Flake appearance had highly significant positive correlation with colour, firmness, flavour, sweetness and overall acceptability.

Flake colour had highly significant positive correlation with flavour, firmness, sweetness and overall acceptability.

Flavour, sweetness and overall acceptability of flakes had highly significant positive correlation with flake firmness.

Flavour of flakes had highly significant positive correlation with sweetness and overall acceptability. Sweetness of flakes had highly significant positive correlation with overall acceptability of the flakes (Table 52).

4.1.10.3 Correlation between biometric and biochemical fruit characters

Correlation was worked out between biometric fruit characters like length, diameter, weight, rind weight, rind thickness, number of flakes, weight of flakes, weight of seed and peduncle weight and biochemical fruit characters like reducing sugars, total sugars, sugar acid ratio and TSS. No significant results were obtained (Table 52).

4.1.10.4 Correlation between biochemical and sensory qualities of flakes

The correlation between biochemical and sensory qualities of flakes are presented in Table 52. The biochemical characters of flakes like non reducing sugars, reducing sugars, total sugars, sugar acid ratio, TSS, had highly positive significant correlation with sensory qualities like sweetness and overall acceptability.

Table 53. Matrix of direct and indirect effects of fruit characters on yield

	Fruit length	Fruit weight	Number of flakes	Weight of flakes/ fruit	Rachis length	Perigone weight	Seed weight	Peduncle weight	Seed length	Seed girth	Fruit number
	1	2	3	4	5	6	7	8	9	10	11
1	**0.2861**	0.2620	-0.0042	0.0839	-0.1700	0.0079	010197	0.0461	-0.0018	0.0001	-0.3192
2	0.2120	**0.3536**	-0.0063	0.1114	-0.1282	0.0101	0.0251	0.0527	0.0005	-0.0010	-0.3723
3	0.5400	0.2825	**-0.0079**	0.0991	-0.0943	0.0084	0.0181	0.0421	-0.0019	-0.0002	-0.2674
4	0.1936	0.3178	-0.0063	**0.1240**	-0.1777	0.0085	0.0198	0.0435	0.0060	-0.0044	-0.3198
5	0.2759	0.2571	-0.0042	0.0828	**-0.1763**	0.0078	0.0193	0.0464	0.0021	-0.0016	-0.3154
6	0.1676	0.2639	-0.0048	0.0778	-0.1016	**0.0136**	0.0234	0.0499	0.0049	-0.0043	-0.3382
7	0.1893	0.2991	-0.0048	0.0826	-0.1147	0.0107	**0.0297**	0.0536	0.0077	-0.0043	-0.2987
8	0.1801	0.2547	-0.0045	0.0736	-0.1119	0.0092	0.0218	**0.0732**	-0.0051	0.0015	-0.2987
9	-0.0028	0.0009	0.0001	0.0039	-0.0020	0.0003	0.0012	-0.0019	**0.1447**	-0.0983	0.1185
10	-0.004	0.0034	0.0000	0.0055	-0.0028	0.0004	0.0013	-0.0011	0.1878	**-0.1003**	0.1125
11	-0.1145	-0.1650	0.0026	-0.0497	0.0697	-0.0049	-0.0126	-0.0274	0.0285	-0.0141	**0.7979**

Residual: 0.1946

4.1.10.5 Correlation between biometric characters of fruit and sensory qualities of flakes

No significant correlation was obtained between biometric characters of fruit like length, diameter, fruit weight, rind weight and rind thickness, number of flakes, weight of flakes, weight of seed and peduncle weight. Sensory qualities of flakes like appearance, colour, firmness, flavour, sweetness and overall acceptability.

4.1.11 Path analysis

Path analysis was conducted to workout the direct and indirect effects of selected factors on yield and overall acceptability of flakes.

4.1.11.1 Direct and indirect effects of biometric characters of fruit on yield

The direct and indirect effects of selected biometric characters of fruit on yield are presented in Table 53. Fruit length, fruit weight, seed length and fruit number had direct effect on yield. Number of flakes, rachis length and fruit weight had indirect effect on yield via. fruit length. Number of flakes, weight of flakes, rachis length, perigone weight, seed weight and peduncle weight had indirect positive effect on yield via. fruit weight.

Fruit length, fruit weight, number of flakes, weight of flakes per fruit, rachis length, perigone weight and seed weight had indirect negative effect on yield via. fruit number.

4.1.11.2 Direct and indirect effects of biochemical and sensory qualities of flakes on overall acceptability of flakes

The direct and indirect effects of biochemical and sensory qualities of flakes are overall acceptability of flakes is presented in Table 54. Non reducing sugars, reducing sugars, total sugars, firmness, colour, flavour and sweetness had direct positive effect on overall acceptability of flakes.

Reducing sugars, total sugars, sugar acid ratio, TSS and sweetness had indirect effect on overall acceptability of flakes via. Non reducing sugars. Total

Table 54. Direct and indirect effects of biochemical and sensory qualities of flake on overall acceptability of flakes

	Non reducing sugars	Reducing sugars	Total sugars	Sugar/ acid ratio	TSS	Appearance	Colour	Firmness	Flavour	Sweetness
	1	2	3	4	5	6	7	8	9	10
1	**1.7697**	0.3789	2.1968	0.0076	-0.0568	0.0900	0.0912	0.1027	0.1458	0.2826
2	1.2062	**0.5561**	1.8233	0.0035	-0.0474	0.0768	0.0716	0.0779	0.1138	0.2319
3	1.7345	0.4523	**2.2416**	0.0070	-0.0580	0.0924	0.0919	0.1082	0.1468	0.2877
4	0.4940	0.6707	0.5747	**0.2274**	-0.0130	0.0201	0.0170	0.0232	0.0369	0.0672
5	1.5321	0.4013	1.9819	0.0054	**-0.0656**	0.0930	0.0939	0.0984	0.1484	0.2920
6	0.0383	0.0516	1.2202	0.0032	-0.0360	**0.1697**	0.1357	0.1319	0.1607	0.1795
7	0.0563	0.0359	1.2211	0.0028	-0.0365	0.1395	**0.2687**	0.1319	0.1576	0.1777
8	0.0173	0.0184	1.1627	0.0032	-0.0326	0.1129	0.1123	**0.1982**	0.1656	0.6960
9	0.0996	0.0696	1.4023	0.0043	-0.0415	0.1162	0.1133	0.1399	**0.2347**	0.2032
10	1.5778	0.4067	2.0339	0.0058	-0.0604	0.0961	0.0946	0.1060	0.1504	**0.3171**

Residual : 0.1946

sugars, non reducing sugars, sugar/acid ratio, TSS and sweetness had indirect effect on overall acceptability of the flakes. Non reducing sugars, total sugars, reducing sugars, TSS, firmness and flavour had indirect effect on overall acceptability via. sweetness (Table 54).

4.1.12 Genetic diversity

As already seen, the analysis of variance indicated the existence of variability for all the above mentioned characters studied among the 80 accessions collected in each of four topographical regions and also among 320 accessions on considering irrespective of topographical levels. These data were consequently subjected to multivariate analysis utilising non-hierarchial euclidean cluster analysis.

i) Plains

The average inter and intra-culster D values are presented in Table 55. The clusterwise composition of accessions are presented in Table 56. The computed D values varied from 95.84 to 795.71. Cluster I had the maximum number of 17 accessions and VI had the minimum number of two accessions. The maximum intercluster distance (795.71) was noticed between IX and I and the minimum (208.49) was observed between VII and II.

The maximum cluster means for fruit length (56.20 cm), fruit weight (15.69 kg), rachis length (49.62 cm), perigone weight (2.63 kg), seed weight (3.32 kg), weight of peduncle (1.85 kg), sugar acid ratio (11.89) and yield (773.90 kg) was recorded by cluster III. Cluster I record the maximum cluster mean for fruit number (182.38). Cluster II had the maximum cluster means for appearance (8.07), colour (7.85), firmness (7.76), flavour (7.83) and overall acceptability (7.47). Cluster VI recorded the maximum cluster mean for acidity (3.46). Cluster IX had the maximum cluster means for total sugars (17.07 per cent), TSS (28.76°Brix) and sweetness (7.83) cluster X had the maximum cluster means for number of flakes (288.62) and weight of flakes (5.09 kg) (Table 57).

Table 55. Average inter and intra cluster D values of jack accessions collected from plains

	I	II	III	IV	V	VI	VII	VIII	IV	X
I	95.84									
II	750.01	95.93								
III	429.86	402.13	111.54							
IV	464.91	360.52	516.02	184.75						
V	247.34	466.61	289.57	302.2	121.59					
VI	384.20	434.99	410.68	640.39	492.19	112.93				
VII	300.67	208.49	344.34	240.44	780.48	530.68	147.41			
VIII	751.52	732.75	476.18	388.46	490.25	440.20	225.144	104.60		
IX	795.71	257.57	230.26	528.94	342.02	265.53	384.45	262.14	182.65	
X	562.01	464.95	604.20	278.27	356.33	711.79	351.76	483.43	642.07	208.00

Table 56. Composition of clusters based on D statistic in jack accessions collected from plains

Cluster number	Number of entries in cluster	Accessions in the cluster
I	17	2, 13, 18, 24, 28, 30, 31, 36, 42, 45, 56, 57, 61, 67, 69, 76, 80
II	15	4, 5, 6, 16, 21, 29, 33, 34, 41, 54, 62, 65, 72, 74, 77
III	8	7, 9, 10, 17, 20, 44, 50, 70
IV	4	1, 8, 27, 51
V	6	37, 38, 39, 59, 64, 79
VI	2	11, 47
VII	6	23, 32, 53, 60, 73, 75
VIII	16	12, 14, 15, 19, 26, 35, 40, 43, 48, 49, 52, 55, 58, 63, 66, 68
IX	3	3, 71, 78
X	3	22, 25, 46

Table 57. Cluster means of fruit characters of the accessions collected in **plains**

Sl. No.	Characters	Cluster number									
		I	II	III	IV	V	VI	VII	VIII	IX	X
1	Fruit length (cm)	26.81	35.17	56.20	35.38	36.72	36.94	51.05	27.39	35.49	53.38
2	Fruit weight (kg)	4.22	7.34	15.69	7.34	8.96	7.34	14.58	4.30	7.44	15.42
3	No. of flakes	84.71	127.32	277.69	127.68	160.27	139.26	269.98	86.50	128.20	288.62
4	Weight of flakes (kg)	1.38	2.48	5.08	2.25	2.81	2.36	4.80	1.41	2.54	5.09
5	Rachis length (cm)	21.65	29.52	49.62	29.44	30.37	30.53	44.94	22.07	29.74	47.02
6	Perigone weight (kg)	0.81	1.20	2.63	1.26	1.74	1.23	2.51	0.81	1.18	2.55
7	Seed weight (kg)	0.76	1.47	3.32	1.52	1.84	1.42	2.70	0.78	1.48	2.93
8	Weight of peduncle (kg)	0.44	0.78	1.85	0.86	1.07	0.85	1.80	0.46	0.80	1.81
9	Total sugars (%)	12.83	10.98	16.48	11.26	14.60	12.48	11.99	13.25	17.07	13.51
10	Acidity (%)	2.18	2.61	1.91	1.63	2.30	3.46	2.35	2.13	2.62	2.17
11	Sugar/acid ratio	6.79	7.83	11.89	7.94	7.12	3.75	6.44	7.18	7.77	8.51
12	TSS (° Brix)	22.18	28.73	27.28	19.85	25.04	22.31	20.75	22.88	28.76	22.92
13	Fruit number	182.38	74.12	49.36	52.80	55.65	56.07	40.64	175.17	77.92	44.47
14	Yield (kg)	692.96	546.13	773.90	381.35	471.49	395.24	577.74	678.46	544.29	671.93
15	Appearance	4.67	8.07	6.90	4.30	5.66	3.84	4.49	4.57	7.47	5.10
16	Colour	5.08	7.85	6.33	3.94	5.16	3.57	4.04	4.99	7.80	4.68
17	Firmness	4.74	7.76	7.11	4.07	4.67	3.97	4.46	4.70	7.67	5.18
18	Flavour	4.21	7.83	6.51	3.85	5.15	4.05	3.63	4.07	7.75	4.51
19	Sweetness	4.58	7.79	7.41	3.63	6.09	4.63	4.15	4.90	7.83	5.25
20	Overall acceptability	3.95	7.47	1.62	1.14	4.89	3.39	3.60	4.09	7.43	4.46

ii) Hills

The average inter and intra-cluster D values are presented in Table 58. The cluster wise composition of accessions are presented in Table 59. The computed D values varied from 104.26 to 968.99. Cluster I had the maximum number of accessions (20) and III had the minimum accessions (2). The maximum intercluster distance (968.99) was observed between VI and VIII and the minimum (209.22) between VI and X.

The cluster means for the fruit length (53.38 cm), fruit weight (15.47 kg), number of flakes (288.62), weight of flakes (5.09 kg), rachis length (47.02 cm), perigone weight (2.55 kg), seed weight (2.93 kg) and sugar acid ratio (8.51) were noticed in cluster III. Cluster VIII recorded the maximum cluster mean values for appearance (8.05), colour (7.86), firmness (7.75), flavour (7.84), sweetness (7.98) and overall acceptability (7.48). Cluster IX recorded the maximum cluster mean for weight of peduncle (1.83 kg), cluster VI for acidity (3.36 per cent), cluster V for total sugar (13.74 per cent) and cluster II for TSS (28.76°Brix). Cluster I recorded the maximum cluster mean values for fruit number (175.17) and yield (678.48 kg) (Table 60).

iii) Coastal areas

The average inter and intra-cluster D values are aligned in Table 61. The cluster-wise composition of accessions are presented in Table 62. The computed D values varied from 133.74 to 1208.56. On the basis of relative magnitude of D values, all the 80 entries were grouped into ten clusters so that the accessions within a cluster had smaller D values among themselves than those belonging to different clusters. Group I had the maximum number of genotypes, i.e., 16. The minimum number was in group II and X. The maximum intercluster distance was noticed between cluster I and IV, i.e., 1208.56 indicating the maximum genetic distance between cluster I and IV. The minimum intercluster distance noticed between the clusters IV and VI, i.e., 234.23 indicating the least genetic difference between the clusters.

The maximum cluster means for fruit length (57.12 cm), fruit weight (15.75 kg), number of flakes (279.29), weight of flakes (5.06 kg), seed weight

Table 58. Average inter and intra cluster D values of jack accessions collected in hill areas

	I	II	III	IV	V	VI	VII	VIII	IV	X
I	125.69									
II	236.83	125.4								
III	813.30	705.02	104.26							
IV	286.30	229.87	701.06	202.88						
V	527.83	444.42	813.32	330.35	166.39					
VI	372.82	263.3	916.82	385.60	640.68	116.30				
VII	275.28	382.45	577.12	252.16	385.68	640.68	113.56			
VIII	455.24	390.01	462.31	317.08	309.22	968.99	258.34	197.05		
IX	824.33	917.91	383.59	495.12	414.89	737.77	397.91	288.57	208.01	
X	223.15	270.22	856.96	388.43	821.41	209.22	359.87	937.00	695.46	176.82

Table 59. Composition of clusters based on D statistic in jack accessions collected from hill areas

Cluster number	Number of entries in cluster	Accessions in the cluster
I	20	6, 7, 22, 25, 26, 36, 38, 42, 44, 48, 52, 54, 56, 57, 58, 60, 66, 67, 68, 62
II	16	14, 20, 23, 31, 39, 40, 41, 47, 50, 51, 61, 63, 65, 69, 74, 78
III	2	15, 30
IV	6	5, 10, 19, 34, 79, 5
V	4	8, 9, 11, 37
VI	12	2, 3, 16, 33, 35, 46, 53, 55, 62, 64, 71, 73
VII	9	12, 15, 16, 27, 27, 29, 32, 49, 76
VIII	4	1, 21, 24, 70
IX	3	4, 43, 80
X	4	18, 45, 59, 75

Table 60. Cluster means of fruit characters of the accessions collected in hill areas

Sl. No.	Characters	I	II	III	IV	V	VI	VII	VIII	IX	X
1	Fruit length (cm)	27.39	35.49	53.38	34.97	39.49	36.27	27.83	35.72	51.95	35.15
2	Fruit weight (kg)	4.30	7.44	15.47	7.39	9.96	6.94	4.44	7.46	14.92	7.47
3	No. of flakes	86.50	128.20	288.62	125.94	175.29	132.29	89.38	129.72	272.87	131.07
4	Weight of flakes (kg)	1.41	2.54	5.09	2.24	3.08	2.25	1.40	2.53	4.80	2.38
5	Rachis length (cm)	22.07	29.79	47.02	29.16	33.15	29.81	22.71	30.04	45.73	28.94
6	Perigone weight (kg)	6.81	1.18	2.55	1.30	2.00	1.16	0.82	1.20	2.61	1.31
7	Seed weight (kg)	0.78	1.48	2.93	1.52	2.09	1.36	0.83	1.49	2.90	1.53
8	Weight of peduncle (kg)	0.46	0.80	1.81	0.86	1.26	0.81	0.47	0.80	1.83	0.86
9	Total sugars (%)	13.25	17.07	13.51	11.22	13.74	12.88	13.32	17.02	13.41	10.96
10	Acidity (%)	2.13	2.62	2.71	1.69	2.37	3.36	2.46	2.62	2.21	2.06
11	Sugar/acid ratio	7.18	7.77	8.51	7.70	6.75	4.10	6.37	7.77	8.20	6.71
12	TSS (° Brix)	22.88	28.76	22.92	19.72	23.84	22.45	23.23	28.73	22.78	19.59
13	Fruit number	175.17	77.92	44.47	54.60	16.54	58.71	150.56	78.12	44.02	52.87
14	Yield (kg)	678.48	544.29	671.93	397.01	444.30	397.62	608.17	546.51	638.28	389.85
15	Appearance	4.57	7.97	5.10	4.33	5.55	4.14	4.37	8.05	5.19	3.94
16	Colour	4.99	7.80	4.68	3.96	5.04	3.68	4.39	7.86	4.69	3.57
17	Firmness	4.70	7.67	5.18	4.06	4.91	3.87	4.55	7.75	5.16	3.84
18	Flavour	4.07	7.75	4.51	3.75	5.19	4.12	3.88	7.84	4.47	3.46
19	Sweetness	4.90	7.83	5.25	3.57	5.53	4.95	5.03	7.98	5.18	3.50
20	Overall acceptability	4.09	7.43	4.46	3.43	4.67	3.55	3.91	7.48	4.43	3.15

Table 61. Average inter and intra cluster D values of jack accessions collected from coastal areas

	I	II	III	IV	V	VI	VII	VIII	IV	X
I	152.40									
II	588.86	184.91								
III	639.65	1003.29	159.28							
IV	1208.56	1140.99	701.29	133.74						
V	705.02	251.17	1087.20	554.64	200.26					
VI	372.51	287.33	931.31	234.23	388.06	143.08				
VII	576.69	299.05	995.91	454.14	422.80	330.78	218.66			
VIII	435.07	287.40	860.40	298.17	341.51	799.88	403.99	198.26		
IX	302.45	430.21	789.45	238.06	570.30	482.93	402.34	362.17	234.00	
X	622.91	457.70	960.09	504.26	393.74	420.43	628.40	332.51	598.14	232.76

Table 62. Composition of clusters based on D statistic in jack accessions collected from coastal areas

Cluster number	Number of entries in cluster	Accessions in the cluster
I	16	1, 3, 6, 16, 17, 24, 29, 42, 53, 59, 65, 67, 70, 71, 72, 78
II	8	5, 13, 14, 19, 23, 24, 44, 47
III	2	25, 43
IV	12	2, 7, 11, 20, 22, 26, 27, 32, 37, 40, 45, 48
V	4	4, 28, 49, 57
VI	10	9, 10, 12, 35, 36, 38, 39, 46, 52, 69
VII	5	15, 54, 58, 63, 75
VIII	5	18, 33, 41, 50, 55
IX	5	8, 30, 31, 34, 77
X	2	73, 76

Table 63. Cluster means of fruit characters of the accessions collected in coastal areas

Sl. No.	Characters	Cluster number									
		I	II	III	IV	V	VI	VII	VIII	IX	X
1	Fruit length (cm)	25.23	34.76	38.44	32.60	39.23	37.31	52.44	57.12	30.54	39.45
2	Fruit weight (kg)	3.80	6.57	11.88	6.48	9.10	7.53	15.17	15.75	5.25	9.28
3	No. of flakes	79.30	110.11	232.92	11.71	158.67	143.69	278.91	279.29	93.69	159.03
4	Weight of flakes (kg)	1.20	2.08	3.49	2.02	2.90	2.46	5.03	5.06	1.73	3.16
5	Rachis length (cm)	20.31	28.66	33.04	27.01	32.88	30.70	46.01	50.45	25.32	33.33
6	Perigone weight (kg)	0.75	1.24	2.90	1.11	1.59	1.28	2.37	2.56	0.91	1.46
7	Seed weight (kg)	0.70	1.29	2.71	1.28	1.84	1.48	2.71	3.34	1.03	1.86
8	Weight of peduncle (kg)	0.39	0.74	1.73	0.77	1.03	0.83	1.84	1.88	0.55	0.99
9	Total sugars (%)	12.58	14.90	15.30	10.63	12.47	12.34	11.69	16.33	16.44	17.48
10	Acidity (%)	2.33	2.00	2.79	1.74	2.00	3.63	2.24	1.91	2.95	2.30
11	Sugar/acid ratio	6.49	8.84	6.05	6.84	7.01	3.51	6.79	12.02	6.25	9.22
12	TSS (° Brix)	21.51	26.10	25.26	18.99	21.66	22.10	20.18	27.55	28.08	29.19
13	Fruit number	207.40	73.28	44.14	51.24	51.60	57.77	42.20	48.53	85.28	72.33
14	Yield (kg)	716.56	471.15	497.90	325.71	452.37	413.86	620.12	764.70	433.69	641.71
15	Appearance	5.00	5.05	5.06	3.80	5.28	3.88	4.38	6.99	7.99	8.07
16	Colour	5.02	5.05	3.96	3.35	4.93	3.64	3.96	6.60	7.77	7.92
17	Firmness	4.90	4.34	4.38	3.66	5.00	3.78	4.36	7.15	7.56	7.88
18	Flavour	4.38	4.58	4.67	3.12	5.08	4.04	3.38	6.63	7.70	7.94
19	Sweetness	4.23	6.50	6.68	3.36	4.41	4.51	3.83	7.37	7.50	7.95
20	Overall acceptability	3.82	4.91	4.47	3.07	4.24	3.29	3.45	6.53	7.28	7.61

(3.34 kg), peduncle weight (1.88 kg) yield (764.70 kg) and sugar acid ratio (12.02) was observed in cluster VIII. The maximum cluster mean for maximum acidity (3.63 per cent) was recorded in cluster VI and perigone weight (2.90 kg) in cluster III. The maximum cluster mean for total sugars (17.48 per cent), TSS (29.19°Brix), appearance (8.07), colour (7.92), firmness (7.88), flavour (7.94), sweetness (7.95) and overall acceptability (7.61) was recorded in cluster X (Table 63).

iv) Riverside areas

The average inter and intra-cluster D values are aligned in Table 64. The clusterwise variation of accessions are presented in Table 65. The computed D values varied from 89.36 to 1048.83. The maximum intercluster distance (1048.83) was noticed between IX and III and the minimum distance (262.07) between III and I.

The maximum cluster means for fruit length (53.21 cm), fruit weight (16.50 kg), number of flakes (365.79), weight of flakes (5.59 kg), rachis length (45.50 cm), seed weight (2.88 kg), weight of peduncle (1.97 kg) and yield (1201.60 kg) was observed in VI. Maximum cluster mean for TSS (29.35°Brix), appearance (8.22), colour (8.04), firmness (7.95), flavour (7.97), sweetness (7.98) and overall acceptability (7.68) was recorded in cluster IX (Table 66).

Maximum cluster means for total sugar (17.46 per cent) was observed in cluster IX, Sugar acid ratio (9.55) in cluster VII, perigone weight (2.59 kg) in cluster III and fruit number (126.98) in cluster I (Table 66).

Based on the above study, the following selection criteria were formulated for selecting ideal genotype:

i) Broadly pyramidal shaped trees, (ii) horizontal branching pattern, (iii) dwarf and compact high yielding trees, (iv) early flowering types (v) large number of fruits with small to medium in size, (vi) more number of bulbs with sweet and firm flesh, (vii) minimum latex content, (viii) minimum number of perigones, (ix) medium to biggger sized flakes, (x) minimum rachis (core) thickness and (xii) deep yellow/orange bulbs. Applying the selection criteria, nine firm fleshed accessions were selected. Of which, AC-7, 254, 306 and 307 were from the plains, AC-254 and 285 from the riverside, AC-102 and 293 from the coastal region and AC-203 from the hilly tract. Fruit quality of the selected accessions were depicted in Table 66a.

Table 64. Average inter and intra cluster D values of jack accessions collected in riverside areas

	I	II	III	IV	V	VI	VII	VIII	IV	X
I	193.55									
II	770.55	121.46								
III	262.07	604.41	138.14							
IV	630.29	422.81	439.43	202.10						
V	495.39	493.02	315.54	281.57	183.52					
VI	1029.69	622.64	838.60	503.09	590.92	106.70				
VII	383.19	504.32	348.21	798.32	496.48	473.28	93.80			
VIII	723.31	948.42	396.36	498.72	678.69	402.36	693.89	102.48		
IX	436.63	942.72	1048.83	479.56	948.93	743.98	638.36	562.36	97.38	
X	743.41	863.38	539.28	963.62	326.21	298.61	363.49	498.36	328.93	89.36

Table 65. Composition of clusters based on D statistic in jack accessions collected from riverside areas

Cluster number	Number of entries in cluster	Accessions in the cluster
I	10	14, 22, 27, 51, 52, 55, 57, 63, 67, 68
II	3	71, 73, 75
III	22	2, 9, 10, 11, 12, 13, 15, 16, 19, 30, 36, 40, 45, 48, 61, 64, 66, 69, 70, 78, 7, 9
IV	7	3, 6, 18, 20, 39, 59, 77
V	7	21, 23, 29, 31, 33, 35, 76
VI	2	43, 80
VII	16	4, 17, 24, 25, 26, 28, 32, 37, 41, 44, 46, 47, 49, 56, 62, 65
VIII	7	1, 8, 38, 42, 50, 54, 72
IX	6	5, 7, 34, 53, 58, 60
X	1	74

Table 66. Cluster means of fruit characters of the accessions collected in riverside areas

Sl. No.	Characters	Cluster number									
		I	II	III	IV	V	VI	VII	VIII	IV	X
1	Fruit length (cm)	28.48	35.76	51.12	37.58	34.65	53.21	46.36	30.54	39.79	32.82
2	Fruit weight (kg)	4.85	7.54	14.65	8.22	7.84	16.50	11.22	5.25	9.30	6.63
3	No. of flakes	93.66	133.54	266.72	146.87	140.73	365.79	72.81	93.68	162.00	119.41
4	Weight of flakes (kg)	1.51	2.56	4.75	2.58	2.66	5.59	1.33	1.73	3.14	2.11
5	Rachis length (cm)	23.54	29.93	44.97	31.06	30.33	45.50	11.09	25.32	33.71	27.12
6	Perigone weight (kg)	0.88	1.23	2.59	1.45	1.26	2.49	0.78	0.91	1.48	1.14
7	Seed weight (kg)	0.93	1.53	2.87	1.65	1.55	2.88	0.71	1.03	1.86	1.29
8	Weight of peduncle (kg)	0.54	0.83	1.81	0.95	0.86	1.97	0.73	0.55	1.00	0.76
9	Total sugars (%)	13.26	16.87	13.63	11.92	16.76	13.83	3.55	16.44	17.46	10.62
10	Acidity (%)	2.19	2.58	2.25	2.38	2.63	2.33	0.24	2.95	2.38	1.89
11	Sugar/acid ratio	7.66	7.68	8.14	5.91	7.50	7.63	9.55	6.24	8.62	6.53
12	TSS (° Brix)	23.13	28.52	22.99	21.14	28.32	23.58	23.02	28.08	29.35	18.80
13	Fruit number	126.98	74.45	44.31	49.51	75.31	96.07	17.86	85.28	73.50	48.84
14	Yield (kg)	555.52	533.91	629.82	399.38	554.88	1201.6	176.70	1141.01	653.19	312.75
15	Appearance	4.48	7.74	5.18	4.47	7.84	3.71	1.70	7.99	8.22	3.61
16	Colour	4.33	7.35	4.68	4.24	7.56	4.07	2.15	7.77	8.04	3.21
17	Firmness	4.49	7.20	5.17	4.16	7.43	5.89	1.61	7.56	7.95	3.51
18	Flavour	3.94	7.49	4.53	4.24	7.46	4.21	1.18	7.70	7.97	2.99
19	Sweetness	5.04	7.71	5.31	4.18	7.64	5.21	1.69	7.55	7.98	3.28
20	Overall acceptability	3.82	7.16	4.44	3.71	7.19	4.21	1.68	7.28	7.68	2.97

Table 66a. Details of selected accessions

Sl. No.	Ac. No.	Topography	Fruit number	Fruit weight (Kg)	Total sugars (%)	TSS (°Brix)	Sensory Quality Ratings
1	306	Plains	102	10.13	14.13	29.3	Excellent
2	307	Plains	98	12.18	13.36	27.4	Excellent
3	293	Coastal	70	8.16	14.48	29.8	Excellent
4	285	Riverside	120	9.34	12.83	28.3	Excellent
5	102	Coastal	65	9.68	14.36	27.4	Excellent
6	203	Hills	82	10.38	13.83	28.3	Excellent
7	224	Plains	87	10.18	13.49	27.4	Excellent
8	7	Plains	80	10.13	14.68	27.3	Excellent
9	254	Riverside	79	12.16	15.38	28.3	Excellent

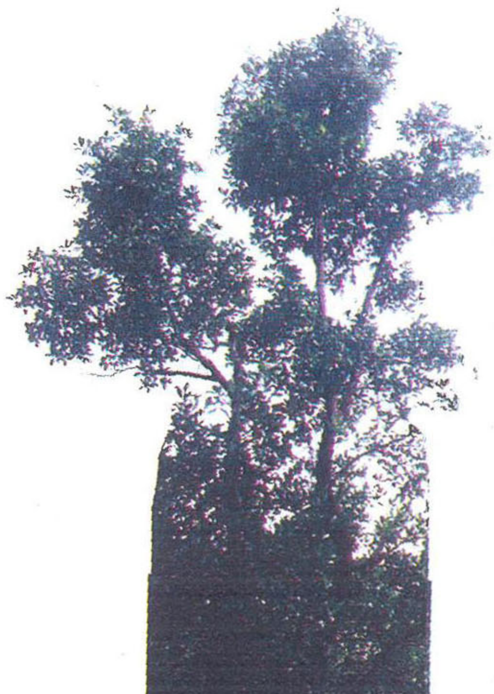
Plate 28. A view of the pruning trial plot

At pruning

During flushing

Plate 29. Twenty five per cent removal of 4° branches

At pruning



During flushing

Plate 30. Fifty per cent removal of 4° branches

At pruning

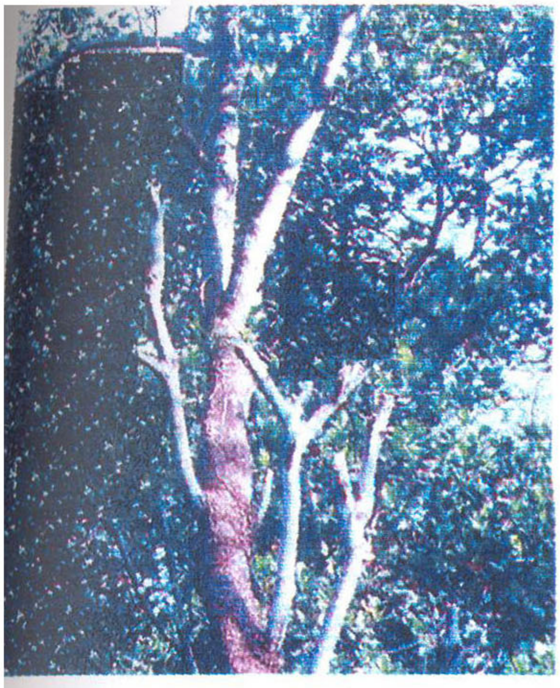
During flushing

Plate 31. Seventy five per cent removal of 4° branches

At pruning

During flushing

Plate 32. Twenty five per cent removal of 3° branches



At pruning

During flushing

Plate 33. Seventy five per cent removal of 3° branches

At pruning

During flushing

Plate 34. Twenty five per cent removal of 2° branches

At pruning

During flushing

Plate 35. Fifty per cent removal of 2° branches

At pruning

During flushing

Plate 36. Seventy five per cent removal of 2° branches

4.2 CANOPY MANAGEMENT

Pruning one of the canopy management techniques was conducted to standardise its level without affecting yield parameters and also favouring the trees to remain compact in the longer run making harvest easier and providing feed for goats. Plate 28 shows a view of the experimental plot.

Before subjecting to pruning treatments, visual observations were made with respect to the onset and extent of the different phenological changes. The canopy of the experimental trees were opened by removing branches of different orders, namely,

1) removal of 25 per cent of second order branches
2) removal of 50 per cent of second order branches
3) removal of 75 per cent of second order branches
4) removal of 25 per cent of third order branches
5) removal of 50 per cent of third order branches
6) removal of 75 per cent of third order branches
7) removal of 25 per cent of fourth order branches
8) removal of 50 per cent of fourth order branches
9) removal of 75 per cent of fourth order branches

Plates 29 to 36 shows jack trees of different pruning treatments at the time of pruning and during flushing stages.

4.2.1 Phenological observations

It is clear from the data that the onset and extent of flushing was more or less uniform in all the trees. The extent of major phenological phases in jack trees are presented as follows (Fig.35).

Phenological phases	Period	Duration (days)
1. Flushing	i) January-February	60
	ii) June-November	150
2. Flowering	November-February	150
3. Harvesting	March-August	180

4.2.2 Flushing characters

4.2.2.1 Days taken for flushing

Observation on days taken for flushing after pruning is presented in Table 67. Light pruning treatments like removal of 25 and 50 per cent of n_4 order, 25 per cent of n_3 order started flushing early (i.e.) 47, 49 and 52 days, respectively. Medium

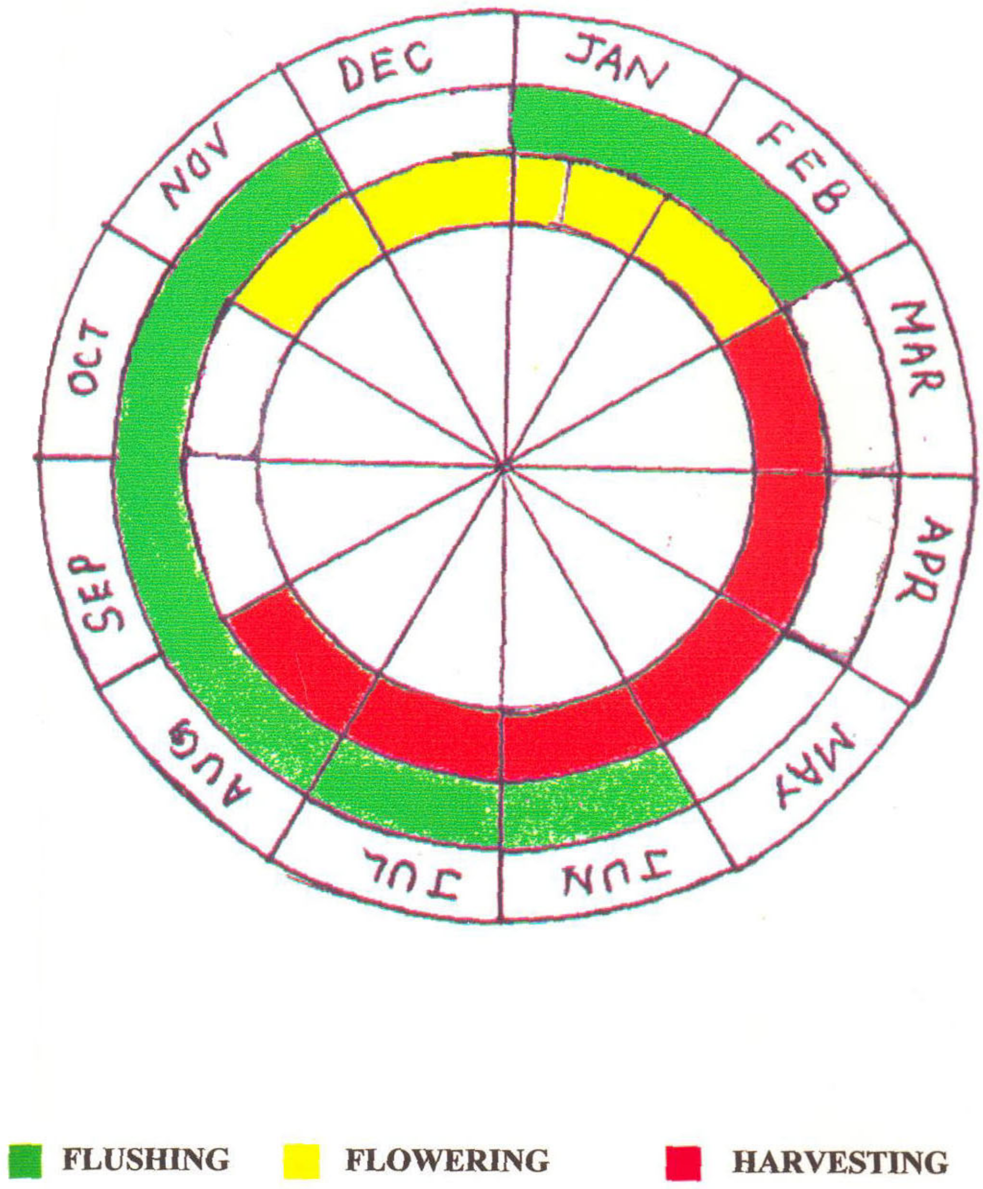


Fig. 3 Phenological phases in jack

Table 67. Days taken for flushing after pruning as influenced by various pruning treatments.

Sl. No.	Treatments	Number of days for flushing
1.	Removal of 25% of the n_4 order	47
2.	Removal of 50% of the n_4 order	49
3.	Removal of 75% of the n_4 order	53
4.	Removal of 25% of the n_3 order	52
5.	Removal of 50% of the n_3 order	55
6.	Removal of 75% of the n_3 order	57
7.	Removal of 25% of the n_2 order	56
8.	Removal of 50% of the n_2 order	60
9.	Removal of 75% of the n_2 order	64
10.	Control	50
CD (0.05)		1.98

Table 68. Days taken for flowering after pruning as influenced by various pruning levels.

Sl. No.	Treatments	Number of days for flowering
1.	Removal of 25% of the n_4 order	43
2.	Removal of 50% of the n_4 order	45
3.	Removal of 75% of the n_4 order	50
4.	Removal of 25% of the n_3 order	46
5.	Removal of 50% of the n_3 order	51
6.	Removal of 75% of the n_3 order	57
7.	Removal of 25% of the n_2 order	52
8.	Removal of 50% of the n_2 order	60
9.	Removal of 75% of the n_2 order	64
10.	Control	50
CD (0.05)		1.98

Table 69. Influence of different levels of pruning on flowering span.

Sl. No.	Treatments	Flowering span (days)		
		Before pruning	First year of pruning	Second year of pruning
1.	Removal of 25% of the n_4 order	120.5	117.5	119.5
2.	Removal of 50% of the n_4 order	88.5	85.50	87.50
3.	Removal of 75% of the n_4 order	105.5	100.20	101.31
4.	Removal of 25% of the n_3 order	90.5	88.00	89.50
5.	Removal of 50% of the n_3 order	99.5	94.38	97.14
6.	Removal of 75% of the n_3 order	109.5	101.84	104.86
7.	Removal of 25% of the n_2 order	98.5	93.81	96.48
8.	Removal of 50% of the n_2 order	81.5	74.50	82.50
9.	Removal of 75% of the n_2 order	109.5	96.64	104.38
10.	Control	108.5	106.50	107.50

CD (0.05) 2.76

Table 70. Effect of different levels of pruning on male spike development.

Sl. No.	Treatments	Male spike development (days)		
		Before pruning	First year of pruning	Second year of pruning
1.	Removal of 25% of the n_4 order	31.50	32.50	32.50
2.	Removal of 50% of the n_4 order	37.50	36.50	37.50
3.	Removal of 75% of the n_4 order	36.50	37.50	35.50
4.	Removal of 25% of the n_3 order	34.67	35.50	34.50
5.	Removal of 50% of the n_3 order	34.67	33.50	32.50
6.	Removal of 75% of the n_3 order	35.50	36.50	34.00
7.	Removal of 25% of the n_2 order	34.50	33.50	34.50
8.	Removal of 50% of the n_2 order	32.50	34.50	31.67
9.	Removal of 75% of the n_2 order	33.50	30.50	33.33
10.	Control	37.50	36.50	37.50

Non significant

pruning treatments like removal of 75 per cent of n_4 order, 50 per cent of n_3 order and 25 per cent of n_2 order took comparatively longer time for flushing than the lightly pruned ones (i.e.) 53, 55 and 56 days, respectively. Severely pruned treatments like removal of 75 per cent of n_3 order and 50 and 75 per cent of n_2 order took longer time for flushing (i.e.) 57, 60 and 64 days respectively. Control trees took 50 days for flushing.

4.2.3 Flowering character

4.2.3.1 Days taken for flowering

Observations on days taken for flowering after pruning is given in Table 68. The treatments differ significantly. Number of days taken for flowering reduced with decreasing order of severity of pruning. Light pruning treatments like removal of 25 and 50 per cent of n_4 order, 25 per cent of n_3 order started flowering early (i.e.) 43, 45 and 46 days, respectively. Medium pruning treatments like removal of 75 per cent n_4 order, 50 per cent of n_3 order and 25 per cent of n_2 order took comparatively longer time for flowering than the lightly pruned ones (i.e.) 50, 51 and 52 days respectively. Severely pruned treatments like removal of 75 per cent of n_3 order and 50 and 75 per cent of n_2 order took longer time for flowering (i.e.) 57, 60 and 64 days respectively.

4.2.3.2 Season of flowering

Flowering season in trees of all the treatments was November to February which was the main flowering season for jack.

4.2.3.3 Flowering span

The flowering span in days before pruning and first and second year of pruning are presented in Table 69.

There was no significant difference in flowering span in different pruning treatments. All the pruning treatments showed reduction in the span of flowering. Trees which received severe pruning treatments recorded the shortest flowering span. 75.00 per cent of n_2 order removed had recorded a shortest flowering open of 91.64

Table 71. Effect of different levels of pruning on female spike development.

Sl. No.	Treatments	Female spike development		
		Before pruning	First year of pruning	Second year of pruning
1.	Removal of 25% of the n_4 order	59.50	50.60	59.50
2.	Removal of 50% of the n_4 order	56.50	57.50	58.50
3.	Removal of 75% of the n_4 order	62.50	59.50	57.50
4.	Removal of 25% of the n_3 order	57.33	59.50	60.50
5.	Removal of 50% of the n_3 order	64.50	62.50	62.50
6.	Removal of 75% of the n_3 order	58.50	57.50	58.50
7.	Removal of 25% of the n_2 order	55.50	57.50	56.50
8.	Removal of 50% of the n_2 order	65.50	67.50	64.50
9.	Removal of 75% of the n_2 order	62.50	61.50	58.50
10.	Control	60.50	59.50	60.50

Non significant

Table 72. Influence of different levels of pruning on fruiting span.

Sl. No.	Treatments	Fruiting span (days)		
		Before pruning	First year of pruning	Second year of pruning
1.	Removal of 25% of the n_4 order	122.50	120.50	123.60
2.	Removal of 50% of the n_4 order	95.50	85.50	92.23
3.	Removal of 75% of the n_4 order	109.50	100.38	104.50
4.	Removal of 25% of the n_3 order	95.36	94.38	94.42
5.	Removal of 50% of the n_3 order	113.80	103.28	105.36
6.	Removal of 75% of the n_3 order	114.50	102.36	108.32
7.	Removal of 25% of the n_2 order	95.50	89.31	91.63
8.	Removal of 50% of the n_2 order	94.50	80.50	86.50
9.	Removal of 75% of the n_2 order	108.50	91.30	96.80
10.	Control	111.50	109.50	110.50
CD (0.05)			2.52	

and 98.36 days during first and second year of pruning on comparing with those of 109.50 days before pruning. Similar trend was noticed in the treatments of 50.00 per cent removal of n_2 order and 75.00 per cent removal of n_3 order. However, the medium pruned trees like removal of 75.00 per cent n_4 order, 50.00 per cent n_3 order and 25.00 per cent n_2 order showed shorter flowering span than light pruned trees.

4.2.3.4 Spike development

Influence of different levels of pruning on the duration male and female spike development is presented in Table 70 and 71.

On analysing the data it was observed that different levels of pruning had no effect on the duration of male and female spike development.

4.2.4 Fruiting characters

4.2.4.1 Fruiting span

The fruiting span in days before pruning and first and second year of pruning are presented in Table 72.

There was no significant difference in fruiting span in different pruning treatments. All the pruning treatments showed reduction in fruiting span. However the trees which received severe pruning treatments recorded shorter fruiting span. 75.00 per cent of n_2 order removed had recorded the shortest fruiting span of 91.30 and 96.80 days during first and second on comparing with those of 108.5 days before pruning. Similar trend was noticed in treatments of 50.00 per cent removal of n_2 order and 75.00 per cent removal of n_3 order. However the medium pruned trees like 75.00 per cent removal of n_4 order, 50.00 per cent of n_3 order and 25.00 per cent of n_2 order showed, comparatively shorter fruiting span than the light pruned trees.

4.2.4.2 Fruit set

The data on fruit set as influenced by different levels of pruning are presented in Table 73.

Table 73. Percent of fruitset as influenced by different levels of pruning.

Sl. No.	Treatments	Fruiting set (%)		
		Before pruning	First year of pruning	Second year of pruning
1.	Removal of 25% of the n_4 order	76.50	79.12	78.36
2.	Removal of 50% of the n_4 order	71.33	74.60	72.68
3.	Removal of 75% of the n_4 order	74.83	83.10	82.46
4.	Removal of 25% of the n_3 order	73.50	79.86	78.47
5.	Removal of 50% of the n_3 order	74.50	80.14	79.36
6.	Removal of 75% of the n_3 order	75.50	78.68	74.16
7.	Removal of 25% of the n_2 order	74.50	80.38	79.16
8.	Removal of 50% of the n_2 order	68.50	70.60	70.50
9.	Removal of 75% of the n_2 order	82.50	84.36	81.62
10.	Control	75.80	77.79	75.49
CD (0.05)			1.98	

Table 74. Effect of different levels of pruning treatments on average fruit weight.

Sl. No.	Treatments	Fruiting weight (g)			
		Before pruning	First year of pruning	Second year of pruning	Third year of pruning
1.	Removal of 25% of the n_4 order	9.79	10.32	10.01	9.89
2.	Removal of 50% of the n_4 order	10.09	10.86	10.62	10.28
3.	Removal of 75% of the n_4 order	10.08	12.64	11.69	10.57
4.	Removal of 25% of the n_3 order	8.81	9.63	9.28	8.87
5.	Removal of 50% of the n_3 order	8.50	10.83	9.99	8.76
6.	Removal of 75% of the n_3 order	9.41	9.62	9.50	9.37
7.	Removal of 25% of the n_2 order	9.90	12.76	12.36	10.89
8.	Removal of 50% of the n_2 order	10.20	11.05	11.01	10.86
9.	Removal of 75% of the n_2 order	9.90	10.12	10.03	10.12
10.	Control	10.01	10.13	10.26	10.14
CD (0.05)			0.52		

On analysing the data statistically, significant difference in per cent of fruit set was noticed with varying level of pruning treatments. All the pruning treatments improved the fruit set significantly. Medium pruning treatments proved the most effective. This was observed during first and second year after the pruning treatments like removal of 75.00 per cent of n_4 order, 50.00 per cent of n_3 order and 25.00 per cent of n_2 order. Removal of 75.00 per cent of n_4 order had the highest fruit set of 83.10 per cent and 82.46 per cent during first year and second year of pruning, respectively, when compared with 74.83 per cent prior to the implementation of pruning. Similarly, removal of 50.00 per cent of n_3 order had 80.14 per cent and 79.36 per cent of fruit set during first and second year of pruning when compared to 74.50 per cent before giving pruning treatment. Removal of 25.00 per cent of n_2 order had 80.38 per cent and 79.16 per cent of fruit set during first and second year of pruning when compared to 74.50 per cent of before pruning.

Removal of 75 per cent of n_2 branches had recorded only a slight increase in the per cent fruit set, 84.36 per cent and 81.62 per cent, respectively, during first and second year of pruning and the trees recorded 82.50 per cent of fruit set before pruning.

4.2.4.3 Average fruit weight

Fruit weight before pruning and first and second year of pruning are presented in Table 74.

On analysing the data statistically, significant difference in average fruit weight was noticed with varying level of pruning treatments. All the pruning treatments resulted in an increase in fruit weight. Medium level of pruning, i.e., removal of 75.00 per cent of n_4 order 50.00 per cent of n_3 order, 25.00 per cent of n_2 order had maximum effect on average fruit weight.

Removal of 75.00 per cent of n_4 order had the fruit weight of 12.64, 11.69 and 10.57 kg during first, second and third year of pruning, respectively. The same trees had recorded 10.08 kg before giving pruning treatments. The trees which received 50.00 per cent removal of n_3 order had recorded an average fruit weight of 10.83, 9.99 and 8.76 kg during first, second and third year of pruning, respectively. The trees had recorded an average fruit weight of 8.50 kg before pruning.

25 per cent removal of n_2 order branches had resulted in an average fruit weight of 12.76, 12.36 and 10.89 kg, respectively, during first, second and third year of pruning when compared with 9.90 kg of fruit weight before pruning.

Removal of 75 per cent of n_2 branches had recorded the least increase in average fruit weight 10.12, 10.03 and 10.12 kg, respectively, during first, second and third year of pruning when compared with 9.90 kg before pruning.

4.2.4.4 Number of fruits

Effect of different levels of pruning on number of fruits is presented in Table 75.

Statistical analysis of the data showed significant variation among the treatments. All the pruning treatments resulted in the reduction in number of fruits during first year. The reduction in number of fruits was increased with increasing severity of pruning. Maximum reduction in number of fruits (14.78 fruits) had been noticed in the treatment of removal of 75 per cent of n_2 order branches during first year of pruning. The minimum reduction was noted in removal of 25 per cent of n_4 order (53.31 fruits). During second year, an increase in number of fruits was noted.

In light pruning treatments like 25 and 50 per cent removal of n_4 order and 25 per cent removal of n_3 order branches, the number of fruits produced (55.50, 52.42 and 52.68, respectively) was more or less similar to that of before implementation of pruning treatments (56.23, 50.86 and 53.10, respetively).

During third year also an increase in fruit number was noticed from the medium and severe pruned treatments. Maximum increase in number of fruits was noticed in severely pruned treatments followed by medium pruned treatments (i.e.) severe pruning treatments like 75.00 and 50.00 per cent removal of n_2 order and 75 per cent removal of n_3 order produced 53.64, 55.62 and 66.36 fruits, respectively, during

Table 75. Influence of different levels of pruning on number of fruits.

Sl. No.	Treatments	Number of fruits			
		Before pruning	First year of pruning	Second year of pruning	Third year of pruning
1.	Removal of 25% of the n_4 order	56.23	53.31	55.50	56.38
2.	Removal of 50% of the n_4 order	50.86	40.52	52.42	51.63
3.	Removal of 75% of the n_4 order	59.75	43.75	66.42	66.28
4.	Removal of 25% of the n_3 order	53.10	45.10	52.68	53.24
5.	Removal of 50% of the n_3 order	57.37	35.08	65.36	62.36
6.	Removal of 75% of the n_3 order	53.97	28.96	48.46	66.36
7.	Removal of 25% of the n_2 order	49.74	26.41	56.62	55.36
8.	Removal of 50% of the n_2 order	48.63	19.63	38.14	55.62
9.	Removal of 75% of the n_2 order	48.78	14.78	38.48	53.64
10.	Control	52.50	51.50	52.78	53.61

CD (0.05) 1.63

Table 76. Fruit yield as influenced by various pruning treatments.

Sl. No.	Treatments	Fruit yield (kg)			
		Before pruning	First year of pruning	Second year of pruning	Third year of pruning
1.	Removal of 25% of the n_4 order	550.49	550.15	555.55	557.59
2.	Removal of 50% of the n_4 order	513.17	439.23	555.21	530.75
3.	Removal of 75% of the n_4 order	602.28	553.00	776.44	700.57
4.	Removal of 25% of the n_3 order	467.81	434.31	488.87	472.23
5.	Removal of 50% of the n_3 order	487.64	379.91	652.90	546.27
6.	Removal of 75% of the n_3 order	507.86	278.60	460.37	621.79
7.	Removal of 25% of the n_2 order	492.42	336.99	699.82	602.87
8.	Removal of 50% of the n_2 order	496.02	216.91	419.92	604.03
9.	Removal of 75% of the n_2 order	482.92	149.57	385.95	542.83
10.	Control	525.52	521.69	541.52	543.60

CD (0.05) 4.34

third year. Medium pruning treatments like removal of 75 per cent n_4 order, 50.00 per cent of n_3 order and 25 per cent of n_2 order produced 66.28, 62.36 and 55.36 fruits, respectively.

4.2.4.5 Fruit yield

The fruit yield before pruning and first, second and third year of pruning are presented in Table 76.

Statistical analysis of the data showed significant variation among the treatments. All the treatments showed reduction in yield and this increased with increasing severity of pruning. Maximum reduction in yield (149.57 kg) was noticed in the treatment of removal of 75 per cent n_2 order branches during first year of pruning. The minimum reduction was noted in removal of 25 per cent of n_4 order (550.15 kg). During second year an increase in yield was noted. Trees which received medium pruning treatments like the removal of 75 per cent of n_4 order, 50 per cent of n_3 order and 25 per cent of n_2 order showed maximum increase in yield. The yield recorded from the trees receiving medium pruning treatments was higher than those recorded before implementation of pruning. In light pruning treatments like 25 and 50 per cent removal of n_4 order and 25 per cent removal of n_3 order branches, the yield recorded (555.55, 555.21 and 488.87 kg, respectively) was more or less similar to that of before implementation of pruning (550.49, 513.17 and 467.81 kg respectively).

During third year also an increase in yield was noticed from the medium and severe pruned treatment. Maximum increase in yield was noticed in severely pruned treatments followed by medium pruned treatments (i.e.) severe pruning treatments like 75 and 50 per cent of removal of n_2 order and 75 per cent of n_3 order produced 542.83, 604.03 and 621.79 kg, respectively. Medium pruning treatments like removal of 75 per cent n_4 order, 50 per cent of n_3 order and 25 per cent of n_2 order produced 700.57, 546.27 and 602.87 kg, respectively (Table 76).

4.2.4.6 Biochemical characters of flakes

4.2.4.6.1 Reducing sugars

The reducing sugar content of flakes before pruning and first and second year of pruning are presented in Table 77.

Table 77. Reducing sugar content (%) of flakes as influenced by various pruning treatments.

Sl. No.	Treatments	Reducing sugar content (%)		
		Before pruning	First year of pruning	Second year of pruning
1.	Removal of 25% of the n_4 order	3.73	3.55	3.66
2.	Removal of 50% of the n_4 order	4.15	4.25	4.26
3.	Removal of 75% of the n_4 order	3.56	3.63	3.71
4.	Removal of 25% of the n_3 order	3.29	3.36	3.23
5.	Removal of 50% of the n_3 order	3.77	3.76	3.57
6.	Removal of 75% of the n_3 order	3.66	4.29	3.95
7.	Removal of 25% of the n_2 order	3.72	3.74	3.79
8.	Removal of 50% of the n_2 order	3.50	3.86	3.66
9.	Removal of 75% of the n_2 order	4.18	4.73	4.42
10.	Control	4.13	4.21	4.19

Non significant

Table 78. Total sugar content (%) of flakes as influenced by various pruning treatments.

Sl. No.	Treatments	Total sugar content (%)		
		Before pruning	First year of pruning	Second year of pruning
1.	Removal of 25% of the n_4 order	15.04	14.91	15.05
2.	Removal of 50% of the n_4 order	14.63	14.92	12.15
3.	Removal of 75% of the n_4 order	16.60	16.89	16.62
4.	Removal of 25% of the n_3 order	16.92	17.07	16.84
5.	Removal of 50% of the n_3 order	16.44	16.94	16.54
6.	Removal of 75% of the n_3 order	14.23	14.79	14.76
7.	Removal of 25% of the n_2 order	15.41	15.23	15.47
8.	Removal of 50% of the n_2 order	14.67	15.01	14.97
9.	Removal of 75% of the n_2 order	15.18	15.98	15.64
10.	Control	13.70	13.69	13.69

Non significant

There was no significant difference in reducing sugar content of flakes in different pruning treatments. The trees where 75.00 per cent of n_2 order removal had recorded an increased reducing sugar content of flakes in first (4.73 per cent) and second year (4.42 per cent) of pruning than the fruits of the trees before implementing pruning treatments (4.18 per cent). Similar trend was noticed in the severely pruned trees like removal of 50 per cent of n_2 order and 75 per cent of n_3 order.

4.2.4.6.2 Total sugar content

The total sugar content of flakes before pruning and first and second year of pruning are presented in Table 78.

There was no significant difference in total sugar content of flakes in different pruning treatments. The trees where 75.00 per cent of n_2 order removed had recorded an increased total sugar content of flakes in first (15.98%) and second year (15.64%) of pruning than the fruits of the trees before implementing pruning treatment (15.18%). Similar trend was noticed in the treatments like removal of 50 per cent of n_2 order and 75 per cent of n_3 order branches.

4.2.4.6.3 Non-reducing sugars

The non-reducing sugar content of flakes before pruning and first and second year of pruning are presented in Table 79.

On analysing the data statistically, no significant difference in non-reducing sugar content of flakes was noticed in different level of pruning treatments.

However, a slight increase in non-reducing sugar content of flake was noticed in the treatment where 75 per cent of n_2 order removed in first year (11.08 per cent) and second year (10.84 per cent) of pruning than that of the trees before implementing pruning treatment (10.06 per cent). The other treatments like removal of 50 per cent of n_2 order and 75 per cent of n_3 order branches (Table 79).

4.2.4.6.4 Acidity

The acid content of flakes before pruning and first and second year of pruning are presented in Table 80.

Table 79. Non-reducing sugar content (%) of flakes as influenced by various pruning treatments.

Sl. No.	Treatments	Non-reducing sugar content (%)		
		Before pruning	First year of pruning	Second year of pruning
1.	Removal of 25% of the n_4 order	11.36	11.30	11.34
2.	Removal of 50% of the n_4 order	12.89	10.60	10.22
3.	Removal of 75% of the n_4 order	12.37	12.90	12.86
4.	Removal of 25% of the n_3 order	12.18	12.52	12.58
5.	Removal of 50% of the n_3 order	12.43	12.91	12.93
6.	Removal of 75% of the n_3 order	9.74	10.60	10.17
7.	Removal of 25% of the n_2 order	11.63	12.07	11.58
8.	Removal of 50% of the n_2 order	11.28	11.78	11.45
9.	Removal of 75% of the n_2 order	10.06	11.08	10.84
10.	Control	9.37	9.36	9.38

Non significant

Table 80. Acidity (%) of flakes as influenced by various pruning treatments.

Sl. No.	Treatments	Acidity (%)		
		Before pruning	First year of pruning	Second year of pruning
1.	Removal of 25% of the n_4 order	2.34	2.00	2.00
2.	Removal of 50% of the n_4 order	1.96	1.92	1.93
3.	Removal of 75% of the n_4 order	2.52	2.21	2.30
4.	Removal of 25% of the n_3 order	1.98	1.91	1.93
5.	Removal of 50% of the n_3 order	2.17	2.06	2.10
6.	Removal of 75% of the n_3 order	1.73	1.63	1.72
7.	Removal of 25% of the n_2 order	1.78	1.71	1.73
8.	Removal of 50% of the n_2 order	1.98	1.88	1.93
9.	Removal of 75% of the n_2 order	1.83	1.50	1.76
10.	Control	1.73	1.76	1.73

Non significant

Statistical analysis of the data revealed no significant difference in acid content of flakes in different level of pruning treatments. However a slight reduction in acid content of flakes of the trees wherein 75 per cent of n_2 order branches were removed during the first (1.50 per cent) and second (1.76 per cent), year of pruning than that of the trees before implementing pruning treatments (1.83 per cent). The similar trend was also noticed in the treatment of removal of 50 per cent of n_2 order branches and 25 per cent of n_2 order branches.

4.3 CHARACTERIZATION OF SOFT AND FIRM FLESHED TYPES

4.3.1 Morphological characterization

4.3.1.1 Plant characters

4.3.1.1.1 Tree shape

Observation recorded with respect to shape of tree is presented in Table 81. A variety of tree shapes like pyramidal, broadly pyramidal, obovate, oblong, semicircular, elliptical and irregular were noticed in both soft and firm fleshed trees. Both the types of trees did not show any difference between each other with respect of tree shape.

4.3.1.1.2 Tree growth habit

Observation regarding growth habit of the tree in firm and soft types is presented in Table 81. Different growth habits like erect, semi-erect, spreading and drooping were noticed in both the types.

4.3.1.1.3 Apical dominance

Apical dominance observed in soft and firm fleshed types are presented in the Table 81. Both the types of trees showed varying degrees of apical dominance like weak, intermediate and strong. Both the types did not show any difference between each other with respect to apical dominance.

4.3.1.1.4 Trunk surface

Observation regarding the surface of the trunk of the trees is presented in Table 81. Smooth, rough and very rough nature of trunk surface were observed in both the trees.

Table 81. Tree shape, tree growth habit, apical dominance, trunk surface, branching density and branching pattern in soft and firm fleshed types

Sl. No.	Tree shape		Tree growth habit		Apical dominance		Trunk surface		Branching density		Branching pattern	
	Soft	Firm	Soft	Firm	Soft	Firm	Soft	Firm	Soft	Firm	Soft	Firm
1	Pyramidal	Obovate	Erect	Drooping	Strong	Weak	Smooth	Smooth	High	Low	Erect	Verticilliate
2	Irregular	Oblong	Erect	Semi-erect	Strong	Inter-mediate	Smooth	Rough	Low	High	Irregular	Irregular
3	Semi-circular	Oblong	Drooping	Erect	Weak	Strong	Smooth	Smooth	high	High	Opposite	Erect
4	Pyramidal	Irregular	Erect	Erect	Strong	Strong	Rough	Smooth	high	Medium	Horizontal	Erect
5	Broadly pyramidal	Obovate	Semi-erect	Spreading	Inter-mediate	Strong	Very rough	Smooth	Medium	High	Erect	Erect
6	Pyramidal	Pyramidal	Erect	Erect	Strong	Strong	Smooth	Smooth	Low	High	Erect	Horizontal
7	Obovate	Pyramidal	Drooping	Erect	Strong	Strong	Rough	Very rough	Low	Low	Irregular	Irregular
8	Oblong	Broadly pyramidal	Semi-erect	Semi-erect	Inter-mediate	Inter-mediate	Smooth	Rough	Medium	Low	Opposite	Erect
9	Oblong	Semi-circular	Spreading	Drooping	Strong	Weak	Smooth	Smooth	Low	Low	Horizontal	Verticilliate
10	Irregular	Obovate	Erect	Erect	Strong	Strong	Smooth	Smooth	High	Medium	Verticilliate	Irregular
11	Pyramidal	Pyramidal	Semi-erect	Erect	Inter-mediate	Strong	Smooth	Smooth	High	Medium	Verticillate	Irregular
12	Semi-circular	Irregular	Erect	Spreading	Strong	Inter-mediate	Smooth	Smooth	Low	Low	Opposite	Opposite
13	Semi-circular	Broadly pyramidal	Spreading	Semi-erect	Strong	Inter-mediate	Rough	Smooth	Medium	High	Irregular	Opposite
14	Broadly pyramidal	Pyramidal	Spreading	Spreading	Weak	Weak	Smooth	Smooth	High	Low	Erect	Erect
15	Pyramidal	Broadly pyramidal	Drooping	Erect	Weak	Strong	Smooth	Rough	Low	High	Erect	Irregular
16	Oblong	Semi-circular	Semi-erect	Semi-erect	Inter-mediate	Inter-mediate	Rough	Smooth	Low	High	Opposite	Erect
17	Irregular	Pyramidal	Erect	Erect	Strong	Strong	Smooth	Rough	Medium	Low	Verticilliate	Opposite
18	Broadly pyramidal	Irregular	Erect	Spreading	Strong	Strong	Smooth	Smooth	High	Medium	Horizontal	Irregular
19	Obovate	Oblong	Erect	Erect	Strong	Strong	Smooth	Rough	Medium	Medium	Verticilliate	Horizontal
20	Obovate	Irregular	Semi-erect	Erect	Inter-mediate	Strong	Rough	Smooth	High	Low	Opposite	Erect

Contd.

Table 81. Continued

Sl. No.	Tree shape		Tree growth habit		Apical dominance		Trunk surface		Branching density		Branching pattern	
	Soft	Firm	Soft	Firm	Soft	Firm	Soft	Firm	Soft	Firm	Soft	Firm
21	Semi circular	Broadly pyramidal	Spreading	Drooping	Weak	Weak	Smooth	Rough	Low	High	Erect	Erect
22	Pyramidal	Obovate	Drooping	Spreading	Weak	Strong	Rough	Smooth	Medium	Low	Opposite	Irregular
23	Irregular	Pyramidal	Erect	Erect	Strong	Strong	Smooth	Smooth	Low	Medium	Irregular	Erect
24	Irregular	Irregular	Spreading	Semi-erect	Weak	Inter-mediate	Smooth	Rough	High	High	Verticilliate	Verticilliate
25	Pyramidal	Semi-circular	Erect	Erect	Strong	Strong	Smooth	Smooth	High	Low	Irregular	Irregular

Table 82. Plant characters of soft and firm fleshed types

	Height of plant (m)		Spread of tree (m^2)		Collar girth (cm)		Height at first branching (cm)	
	Soft fleshed	Firm fleshed	Soft fleshed	Firm fleshed	Soft fleshed	Firm fleshed	Soft fleshed	Firm fleshed
Mean (Standard error)	14.58 (0.611)	14.40 (0.599)	96.60 (3.454)	95.63 (3.600)	129.80 (5.358)	126.40 (5.331)	149.00 (17.011)	151.00 (17.163)
Range	7.50-20.10	7.00-20.20	69.0-131.6	65.70-125.80	83.0-190.0	72.0-185.0	35.0-450.0	40.0-385.0

4.3.1.1.5 Branching density

With respect to branching density, soft and firm fleshed types did not show any difference (Table 81). Branching densities of low, medium and high were noticed in both the types of trees.

4.3.1.1.6 Branching pattern

Soft and firm fleshed types did not show any difference in branching pattern (Table 81). Different branching patterns like erect, opposite, verticilliate, horizontal and irregular were observed in both the types.

4.3.1.1.7 Height of the tree (m)

The height of the soft fleshed types was found to be ranged from 7.50 to 20.10 m whereas in firm fleshed types it varied from 7.00 to 20.20 m. The average height of soft and firm fleshed types were 14.58 m and 14.40 m, respectively. The analysis of variance indicated no significant difference in this character between soft and firm fleshed types and the values were found to be broadly overlapping (Table 82).

4.3.1.1.8 Spread of the tree (m^2)

The mean spread of soft fleshed types was observed to 96.60 m^2 and that of firm fleshed types was 95.63 m^2. The spread of soft fleshed types varied from 69.00 to 131.60 m^2 whereas in firm fleshed types it ranged from 65.70 to 125.80 m^2. The difference in this character was not significant enough to discriminate between soft and firm fleshed types (Table 82).

4.3.1.1.9 Collar girth (cm)

Collar girth of soft fleshed types was observed to range from 83.0 cm to 190.0 cm and that of firm fleshed types from 72.0 to 185.0 cm. The mean collar girth of soft fleshed types was 129.8 cm and that of firm fleshed types was 126.4 cm. However analysis of variance did not reveal any pronounced difference between soft and firm fleshed types (Table 82).

Table 83. Colour of the shoot bark and feeder roots in soft and firm fleshed types

Sl. No.	Colour of the shoot bark				Colour of the feeder root	
	Soft fleshed		Firm fleshed			
	Internal	External	Internal	External	Soft fleshed	Firm fleshed
1	Cream	Brown	Green	Brown	Pale brown	Reddish brown
2	,,	Dark brown	,,	Brown	Dark brown	Brown
3	,,	Brown	,,	Dark brown	Dark brown	Brownish red
4	,,	Dark brown	,,	Brown	Reddish brown	Dark brown
5	,,	Dark brown	,,	Brown	Dark brown	Brown
6	,,	Brown	,,	Dark brown	Brownish red	Brown
7	,,	Brown	,,	Brown	Brown	Light brown
8	,,	Dark brown	,,	Brown	Pale brown	Reddish brown
9	,,	Brown	,,	Dark brown	Reddish brown	Brown
10	,,	Dark brown	,,	Brown	Reddish brown	Reddish brown
11	,,	Brown	,,	Dark brown	Dark brown	Reddish brown
12	,,	Brown	,,	Brown	Reddish brown	Pale red
13	,,	Brown	,,	Dark brown	Pale red	Reddish brown
14	,,	Dark brown	,,	Brown	Dark brown	Brown
15	,,	Brown	,,	Brown	Pale brown	Reddish brown
16	,,	Dark brown	,,	Brown	Brown	Brown
17	,,	Brown	,,	Dark brown	Dark brown	Dark brown
18	,,	Brown	,,	Brown	Brown	Brown
19	,,	Dark brown	,,	Brown	Dark brown	Pale brown
20	,,	Brown	,,	Brown	Pale brown	Dark brown
21	,,	Brown	,,	Dark brown	Reddish brown	Pale red
22	,,	Dark brown	,,	Brown	Dark brown	Dark brown
23	,,	Brown	,,	Brown	Reddish brown	Reddish brown
24	,,	Dark brown	,,	Dark brown	Brown	Dark brown
25	,,	Brown	,,	Brown	Brown	Pale brown

4.3.1.1.10 Height at first branching (cm)

Even though wide variation was noticed in the branching heights of the soft and firm fleshed trees, no distinguishable difference existed between soft and firm fleshed types in this character. The branching height varied from 35.00 cm to 450.00 cm in soft fleshed types and 40.00 cm to 385.00 cm in firm fleshed types. The mean branching height of soft and firm fleshed types were 149.00 cm and 151.00 cm, respectively.

4.3.1.1.11 Colour of the shoot bark

Soft and firm fleshed plants did not show any marked difference with respect to colour of the bark (Table 83). Different shades of brown was noticed externally on the bark in both the types. Internally, colour of the bark was cream in both soft and firm types.

4.3.1.1.12 Colour of the feeder roots

Feeder roots showed different shades of red, brown and pale brown in both the types. No marked differences were noticed (Table 83).

4.3.1.2 Leaf characters

4.3.1.2.1 Leaf length (cm)

The average length of leaves in soft and firm fleshed trees was 12.19 cm and 11.18 cm, respectively. The length of leaves in soft fleshed plants ranged from 7.30 cm to 18.10 cm whereas in firm fleshed types it was varying from 6.80 cm to 19.10 cm. This indicated no significant variation between both the types in terms of length of the leaves (Table 84).

4.3.1.2.2 Leaf width (cm)

The average width of the leaves in soft fleshed types was 7.78 cm and that of firm fleshed types was 7.83 cm. The width ranged from 5.80 cm to 10.10 cm in soft fleshed types. The corresponding range in firm fleshed types was 5.70 cm to 10.98 cm. Statistically, there was no significant variation between soft and firm fleshed types in terms of width of the leaf (Table 84).

Table 84. Leaf length, leaf width and length/width ratio of soft and firm fleshed types

	Leaf length (cm)		Leaf width (cm)		Length/width ratio	
	Soft	Firm	Soft	Firm	Soft	Firm
Mean (standard error)	12.19 (0.59)	11.18 (0.62)	7.78 (0.25)	7.83 (0.26)	1.58 (0.075)	1.56 (0.076)
Range	7.30-18.10	6.8-19.10	5.80-10.10	5.70-10.98	0.85-2.57	0.91-2.29

Table 86. Petiole length, internodal length and stomatal count per unit area of firm and soft fleshed types

	Petiole length (mm)		Internodal length (cm)		Stomatal index	
	Soft	Firm	Soft	Firm	Soft	Firm
Mean (standard error)	36.17 (2.21)	38.4 (1.95)	5.08 (0.29)	4.93 (0.28)	2017 (49.1)	1983 (49.3)
Range	11.0-55.0	18.0-63.0	2.2-8.3	2.4-8.4	1621-2456	1456-2406

Table 87. Total phenol content in leaves of soft and firm fleshed types

	Total phenol (mg/100 g)			
	Matured leaves		Young leaves	
	Soft	Firm	Soft	Firm
Mean	293.16	290.14	33.49	32.29
Range	203.63-396.38	199.48-381.63	20.49-48.36	21.63-50.13

Table 85. Leaf blade shape, apex shape, base shape and margin of firm and soft fleshed types

Sl. No.	Leaf blade shape		Leaf apex shape		Leaf base shape		Leaf blade margin	
	Soft	Firm	Soft	Firm	Soft	Firm	Soft	Firm
1	Obovate	Elliptic	Acute	Acute	Oblique	Oblique	Undulate	undulate
2	Lanceolate	Obovate	Acute	Abtuse	oblique	Oblique	Undulate	Entire
3	Oblong	Broadly elliptic	Cuspidate	Acute	Rounded	Cuneate	Undulate	undulate
4	Elliptic	Oblong	Acute	Acute	Oblique	Rounded	Undulate	Undulate
5	Obovate	Obovate	Retuse	Acute	Shortly attenuate	Oblique	Entire	Undulate
6	Broadly elliptic	Elliptic	Acute	Cuspidate	Oblique	Oblique	Undulate	Entire
7	Oblong	oblong	Acute	Acute	Rounded	Oblique	Entire	Undulate
8	Obovate	Obovate	Cuspidate	Acute	Rounded	Shortly attenuate	Entire	Entire
9	Elliptic	Oblong	Retuse	Retuse	Oblique	Oblique	Undulate	Entire
10	Elliptic	Elliptic	Acute	Acute	Rounded	Rounded	Undulate	Undulate
11	Obovate	Broadly elliptic	Acute	Acute	Oblique	Oblique	Undulate	Undulate
12	Oblong	Obovate	Retuse	Acute	Cuneate	Oblique	Entire	Undulate
13	Lanceolate	Oblong	Acute	Acute	Rounded	Cuneate	Undulate	Undulate
14	Obovate	Elliptic	Acute	Retuse	Oblique	Cuneate	Undulate	Entire
15	Lanceolate	Oblong	Cuspidate	Acute	Rounded	Oblique	Entire	Undulate
16	Oblong	Lanceolate	Acute	Acute	Shortly attenuate	Oblique	Undulate	Undulate
17	Broadly elliptic	Oblong	Acute	Acute	Oblique	Shortly attenuate	Undulate	Entire
18	Lanceolate	Broadly elliptic	Acute	Cuspidate	Oblique	Rounded	Undulate	Undulate
19	Elliptic	Lanceolate	Acute	Acute	Rounded	Cuneate	Entire	Undulate
20	Lanceolate	Obovate	Retuse	Acute	Cuneate	oblique	Undulate	Entire
21	Lanceolate	Elliptic	Acute	Retuse	Shortly attenuate	Cuneate	Entire	Entire
22	Elliptic	Elliptic	Acute	Acute	Oblique	Oblique	Undulate	Undulate
23	Oblong	Broadly elliptic	Cuspidate	Acute	Rounded	Cuneate	Undulate	Undulate
24	Obovate	Oblong	Acute	Retuse	Oblique	Oblique	Entire	Undulate
25	Obovate	Elliptic	Acute	Cuspidate	Oblique	Oblique	Undulate	Entire

4.3.1.2.3 Length/width (L/W) ratio

Length by width ratio was found to range from 0.85 to 2.57 for soft fleshed types and 0.91 to 2.29 for firm fleshed ones. The average L/W ratio of soft and firm fleshed plants were 1.58 and 1.56 respectively. The analysis of variance indicated no significant differences in this characters between soft and firm fleshed types (Table 84).

4.3.1.2.4 Petiole length (mm)

No pronounced difference in the petiole length was observed between soft and firm fleshed trees. The average value for soft fleshed types was 36.17 cm and for firm fleshed types was 38.40 cm. The range was 11.0 to 55.0 cm and 18 to 63 cm for soft and firm fleshed types respectively (Table 86).

4.3.1.2.5 Internodal length (cm)

No marked difference in the internodal length was observed between soft (5.08 cm) and firm (4.93 cm) fleshed types (Table 86).

4.3.1.2.6 Leaf blade shape

The observation recorded with respect of leaf blade shape is furnished in Table 85. A variety of leaf shapes like obovate, elliptic, broadly elliptic, oblong, lanceolate and irregular were observed in both the types.

4.3.1.2.7 Leaf apex shape

Various shapes of leaf apex namely, acute, cuspidate, retuse and obtuse were noticed in both soft and firm fleshed types (Table 85). Both the types of tree did not show any difference between each other with respect to leaf apex shape.

4.3.1.2.8 Leaf base shape

Different shapes of leaf base namely oblique, rounded, cuneate and shortly attenuate were noticed in both soft and firm fleshed types (Table 85). Both the types of trees did not show any difference between each other with respect to leaf base shape.

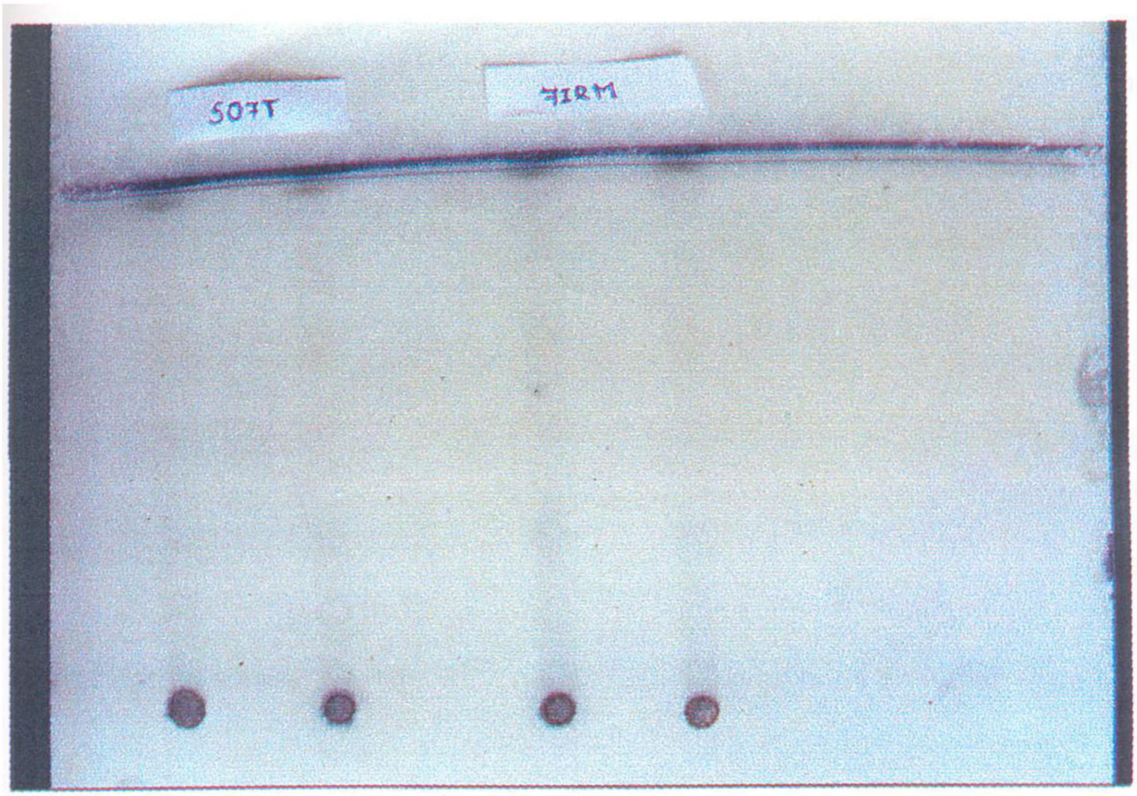


Plate 37. TLC profile of phenolic leaf extracts of soft and firm fleshed types

4.3.1.2.9 Leaf blade margin

Trees of both soft and firm fleshed types showed entire and undulate margin (Table 85).

4.3.2 Anatomical characters

4.3.2.1 Stomatal count per unit area

Stomatal count was also not found to vary significantly between firm and soft fleshed types. Average of stomatal count per mm² was 2017 in soft fleshed and 1983 in firm fleshed types (Table 85) with a range of 1621 to 2456 in soft types and 1456 to 2406 in firm types.

4.3.3 Biochemical characters

4.3.3.1 Total phenol

a) Mature leaves

The total phenol content of mature leaves in soft fleshed trees ranged from 203.63 to 396.38 mg/100 g with an average of 293.16 mg/100 g. In firm fleshed types, the total phenol content varied from 199.48 to 381.63 mg/100 g with a mean value of 290.14 mg/100 g. On analysing statistically, no significant difference has been recorded between soft and firm fleshed types with respect to total phenol content of mature leaves (Table 87).

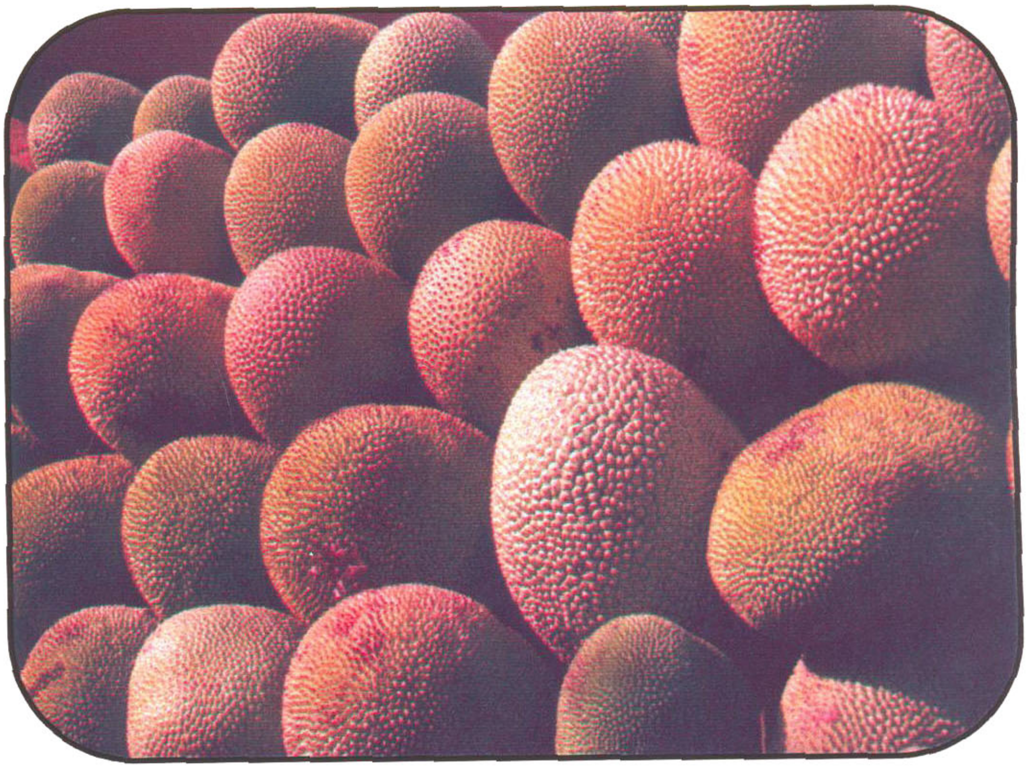
b) Young leaves

The total phenol content of young leaves ranged from 21.63 to 50.13 mg/100 g in firm fleshed types. The mean value recorded was 32.29 mg/100 g. The total phenol content of soft fleshed types ranged from 20.49 to 48.36 mg/100 g with a mean value of 33.49 mg/100 g (Table 87). On analysing statistically, no significant difference was recorded between soft and firm fleshed types with respect to total phenol content of young leaves (Table 87).

4.3.2.2 Phenolics composition of jack leaves

The TLC profile of phenolic extract after acid hydrolysis showed four phenolic spots with Rf value 0.831, 0.294, 0.134 and 0.176. Both the soft and firm fleshed plants displayed the same pattern (Plate 37).

Discussion



5. DISCUSSION

The results of the present investigations on genetic diversity, canopy management and characterization of soft and firm fleshed types in jack are discussed in this chapter.

5.1 GENETIC DIVERSITY

The world's largest fruit, jack fruit, occupies a unique position in the widely prevailing multi-tier cropping system of Kerala's homesteads. Jack is an indigenous fruit crop of cross pollinated and heterozygous nature with its origin in the Western Ghats. Further, the trees prevailing in the households are of seedling origin. All these factors contribute to the tremendous variability observed in vegetative, flowering, fruiting and quality parameters of jack.

Srinivasan (1970) reported that jack, being cross pollinated and seed propagated crop, there were innumerable types which differ widely with respect to density of spines on rind, bearing capacity, size, shape and quality.

Kerala, the most densily populated State wherein the households are mushrooming up at an unimaginable rate leading to increased pressure on land. Houses are built by destroying perennial trees like jack leading to genetic erosion of excellent types. The potentiality of these good types are lost without serving any purpose. Hence, it is high time to make efforts for identifying and conserving the good types which are likely to be lost due to unscrupulous felling. In a survey conducted by Kerala Agricultural University during 1978-82, 38 good accessions were identified based on the fruit characters and these are maintained at the Agricultural Research Station, Mannuthy as seedling progenies (KAU, 1982). Survey in other States like Uttar Pradesh and Assam resulted in the identification of three good types (NBPGR, 1988). Survey in Brahmaputhra valley of Assam revealed the existence of an unusual type of jack fruit i.e., the flakeless jack (Sarma and Mohan, 1999). Hence an attempt was made to study the genetic diversity of jack fruit in Thrissur district wherein a rich level of diversity has been noticed.

In the present study, survey was conducted in four panchayats, each, in four major topography, namely, plain, hills, coastal and riverside regions. Twenty households were selected randomly in each panchayat accounting to a total of 320 households. From these households, trees were selected for detailed observation based on the proforma given in Appendix I.

5.1.1 General tree characters

Most of the seedling trees surveyed were of the age group 21 to 50 years where in the yield was stabilized. Only about 2.50 per cent of the trees observed were less than ten years old and were of grafted nature. Frequency distribution of trees of above 50 years was higher in coastal and hilly areas than plains and riverside regions. The proliferation of new residential buildings at an alarming rate in plains and riversides might have led to the destruction of aged trees in those areas. In hills and coastal areas such destruction is minimal and hence the aged trees are at higher level.

Majority of the trees surveyed had the height in the range of 10 to 20 m. With respect to topography of the land, slight difference was noticed in terms of tree height. Tall trees were more frequently noticed in coastal areas followed by hills when compared with plains and riverside areas. About 37.50 per cent and 45.00 per cent of the trees, respectively, from hills and coastal areas had a height of more than 20 m as compared to a share of 25.00 per cent and 23.75 per cent, respectively, from plains and riverside areas. It may be due to the presence of more number of age old trees in those areas and also may be due to climatic factors prevailing in hills and coastal areas.

Most of the accessions located in homesteads had higher tree height than the trees located outside. The reason for the tall stature of the trees in homesteads may be attributed due to the competition between the component trees of the homesteads for light. In mango also, trees growing in homesteads were noted to have greater height compared to the ones growing in open condition (Jyothi, 2000).

Among the trees surveyed, majority of the accessions (55.31%) were of medium vigorous nature. Highly vigorous trees were more commonly noticed in hills (30.00%) and coastal areas (33.75%) than in plains (25.00%) and riverside areas (26.25%). This may be due to higher frequency distribution of tall trees in hills and coastal areas. Ram (1993) reported in mango that vigorous and very vigorous cultivars were tall in stature.

Different canopy shapes like pyramidal, broadly pyramidal, obovate, oblong, semi-circular, elliptical and irregular were noticed among the accessions. Of these, irregular, pyramidal, broadly pyramidal, semicircular and obovate tree shapes were more common. A higher number of pyramidal trees was observed in coastal (23.75%) and hilly areas (28.75%) compared to the other two regions (20.00% in riverside areas and 17.50% in plains). A close association between the tall and pyramidal shape of the trees was noticed during the study. The existence of higher number of pyramidal trees in coastal and hilly areas may be due to the existence of taller trees in those areas.

About 42.81 per cent and 30.33 per cent of the trees surveyed had erect and semi-erect growth habit. Such trees were more common in coastal (50.00%) and hilly areas (45.00%).

About 46.56 per cent of the accessions showed intermediate branching density irrespective of the topography. Higher branching density was noticed in 27.50 per cent of the trees in plains, 22.50 per cent in hills, 16.25 per cent in coastal areas and 26.25 per cent in riverside. Frequent disturbances done to trees in plains and riverside areas might have resulted in control of apical dominance and increased branching density.

5.1.2 Leaf characters

Wide variation was noticed among the accessions collected in all of the four topographical levels with respect to leaf characters like leaf length, leaf width, length/width ratio, etc. More frequently, the trees of coastal areas had broader (above 10.00 cm) and longer (above 15.00 cm) leaves. Jack leaves varied in length from 5.00 to 25.00 cm and width from 3.50 to 12.00 cm (CSIR, 1992).

The surveyed trees had varied leaf shapes like obovate (23.75%), elliptic (30.93%), broadly elliptic (9.37%), oblong (24.68%) and lanceolate (11.25%) leaves. In coastal area, a higher number of trees (30.00%) had obovate leaf shape than the other three regions. Leaves with greater length was significantly associated with obovate leaf shape. In coastal area, a higher per cent of the accessions had more leaf length and hence more per cent of obovate leaf shape. It is reported that jack leaf shape varied from obovate - elliptic to elliptic (CSIR, 1992).

Correlation was studied between biometric characters of leaves. Leaf length had significant correlation with leaf width and leaf area. Leaf width had significant correlation with leaf area. Similar results were also observed in mango (Jyothi, 2000).

5.1.3 Flowering characters

According to the season of flowering, the accessions studied could be grouped into three, namely i) early flowering (September-October), ii) mid season flowering (November-January) and iii) late season flowering (February-March) types.

Majority of the accessions were of mid-season flowering (67.82%). Early flowering types were more commonly noticed in plains (18.75%) and riverside (17.50%). In the coastal areas, both early (17.50%) and late flowering (21.25%) types were more or less equally distributed. Late bearing types were more common in hills

(27.25%). A single sporadic flowering genotype was identified from plains which showed three flowering seasons with its main season coinciding with normal flowering season. Such sporadic flowering was also noticed in mango (Jyothi, 2000).

In jack, early flowering ones are mostly preferred, as they attain maturity earlier fetching a higher price in the market. Fruits of such types reach harvesting before the commencement of rainy season. Hence quality loss as well as quantity loss can be prevented.

Mid season flowering types come to harvesting during April-May when there is a glut in the market. This results in low market price and reduction in profit to the growers. Late season flowering types come to harvesting during the peak monsoon period resulting in deterioration of fruit quality. The sweetness of the fruits is affected and keeping quality also reduced. Fruit rotting is common during rainy season and hence marketability of such fruits is reduced. Therefore, late flowering types are not much preferred.

The accessions studied had male phase varying from 75 to 135 days. Majority of the accessions (62.18%) had male phase in the range of 90 to 120 days. Wide variation was noticed in the span of female flowering, varying from 55 to 106 days. But, majority of the accessions (52.82%) had female flowering span in the range of 60-90 days.

During the survey, we observed that generally the young trees were having prolonged male flowering phase. In medium aged trees, the male flowering span was comparatively shorter. In age old trees also, the male phase is longer but not so longer as that of younger ones. In general when the male flowering span was more, the female flowering span got reduced and the stored energy can be utilized for the development of fruits.

Trees with a lengthy female flowering span is mostly preferred since such trees present in homesteads can supply fruits continuously catering the culinary and table needs of the households without wastage. The occurrence of two flowering seasons per year was mentioned by Sambamurthy (1954) in Coimbatore and Aman (1980) in Malaysia. It did not occur under the prevailing climatic conditions of Thrissur district of Kerala (Appendix-III). Taking into consideration of the rainfall distribution in this area, it is evident that a single distinct rainfall peak might have resulted in only one flowering season as against two distinct rainfall peaks concomitant with two flowering seasons available elsewhere.

Regarding the position of female flowers, majority of the accessions (53.12%) had female flowers on the trunk and primary branches. 34.68 per cent of the accessions had female flowers on the main trunk, primary and secondary branches. Only 10.30 per cent had flowers all over the tree.

During the survey, it was observed that young trees had female inflorescence position even up to 4° branches. As age advances, bearing on increased order decreases. This may be due to the fact that as age advances, the tree may set a strong sink in the trunk and lower order branches wherein all the nutrients and hormones get diverted.

In general, female flower drop was higher on higher order branches. If all the female flowers on higher order branches set fruits, the strength of such branches may not be sufficient enough to hold the fruits up to full maturity. Therefore, the flower drop noticed on higher order branches may be a nature's adaptation.

In all the accessions studied, irrespective of topography, male flowers were observed on the trunk and all over the branches.

5.1.4 Fruit characters

5.1.4.1 General fruiting characters

Regarding bearing season, accessions studied were grouped into three namely i) early bearing (December-February), ii) Mid season bearing (March-May) and iii) late bearing (June-August). Majority of the accessions (67.81%) were of mid-season bearing. Early bearing types were more commonly noticed in plains (18.75%)

and riverside (17.50%). In the coastal areas, both early (17.50%) and late bearing (21.25%) types were more or less equally distributed. Late bearing types were more common in hills (27.25%). A single sporadic bearing genotype was identified from plains which showed three fruiting seasons, the main season coinciding with normal bearing. In a survey conducted in Eastern Uttar Pradesh (Kumar and Singh, 1996) in jack fruit, it was observed that all the genotypes matured in July to August except one type which matured in March to May. Mitra (1998) reported that some of the jack fruit types had bearing twice a year. Sporadic bearing was also noticed in mango (Jyothi, 2000).

Early bearing ones are mostly preferred. There is a very good demand for the fruits as it has the advantage of early market. Besides, fruits come to harvestable stage, well before the commencement of rainy season. Hence quality of the fruit is better. Mid bearing types reach harvestable stage when the market is glutted with jack fruits fetching cheaper price. The harvest of late season bearing types coincide with peak monsoon season, leading to quality loss and fruit damage.

Three types of bearing habits namely regular, alternate and irregular were noticed during the survey. Majority of the accessions (74.05%) had irregular bearing habit wherein the periodicity of cropping did not follow a systematic pattern unlike alternate bearing and an optimum crop is obtained only once in two or more years. About 20.63 per cent of the surveyed trees had regular bearing habit wherein optimum fruits are produced every year. About 5.32 per cent of the trees had alternate bearing wherein heavy load of fruits in one year had reduced flowering and fruiting in the next year and the cycle got repeated.

Singh (1990) reported in mango that the potentiality of the shoots to form flower bud will depend on the floriferous condition of the tree which in turn will be determined by the amount of crop load. Chacko and Ananthanarayanan (1982) suggested that the irregular bearing in mango might be due to the inability of plants to form flower buds under natural condition because of lack of sufficient reserves and their possible hormone directed redistribution and mobilisation.

About 56.25 per cent of the accessions studied had their bearing on trunk and primary branches followed by bearing on trunk, primary and secondary branches in 35.30 per cent. About 7.18 per cent had their bearing on trunk, primary, secondary and tertiary branches. Only 1.25 per cent of the accessions showed their bearing exclusively on trunk.

It was generally observed that fruit drop was more on higher order branches. It may be due to the action of strong sink at trunk/primary branches. Further this may be a natural adaptation of the tree wherein the higher order branches cannot hold all the developing fruits to maturity. The limbs may break due to increasing weight of the developing fruit. Bearing in higher order branches are not preferred since it results in difficulty in harvesting of the fruits.

Majority of the accessions studied had solitary bearing tendency (80.92%). Only about 22.18 per cent had cluster bearing habit. It was also observed that single flowering shoot produces many flowers. At times more number of flowers may develop into fruits leading to clustering of fruits. Sometimes all the flowers except one in a single flowering shoot drop leading to solitary nature. Generally, fruits in a cluster showed delayed maturity than the solitary ones. All the fruits in a cluster did not reach maturity simultaneously. The size of the clustering fruits was lesser than that of solitary ones. This may be due to competition for food reserves among the developing fruits in the cluster.

Predominant fruit shapes observed were broadly ellipsoid (25.62%), irregular (18.43%), oblong (17.80%), high spheroid (13.43%) and spheroid (11.87%). Other fruit shapes like ellipsoid, obloid and clavate were less commonly noticed among the accessions. During the survey, fruit abnormalities were observed, the most common being distorted fruits. This may be due to inadequate pollination. This view was also supported by Krishnamoorthy and Rao (1963). During the survey it was also noticed that the frequency of occurrence of irregular shaped fruits was more in older trees and also in higher order branches. Mitra (1998) reported the existence of variability in fruit shape namely conical, oblong and roundish. Variation in fruit shape was also reported by Kumar and Singh (1996).

Majority of the accessions had depressed junction of stalk attachment (66.87%) followed by flattened ones (25.63%). Inflated junction of stalk attachment was noticed only in a very few accessions i.e., 7.50 per cent. During the survey, it was understood that the fruits with depressed junction of stalk attachment are not preferred. The depressed junction used to accumulate rainwater making its easy entry into the fruits leading to loss in quality of flakes. Inflatted junction of stalk attachment in late bearing types prevented entry of rain water and hence the quality loss was also prevented.

Greenish brown colour at fruit maturity was commonly noticed i.e., in 77.81 per cent of the trees. 13.75 per cent had green colour and only about 8.43 per cent of the trees had greenish yellow rind colour at maturity. Mitra (1998) recorded variation in skin colour like green, light brown, dark brown and yellowish brown.

It was observed that frequency of occurrence of green colour rind was more in young trees and greenish yellow and greenish brown colour rind was more in older trees. Rarely, black spined fruits were also spotted during the survey.

Majority of the genotypes studied had spine shape intermediate between sharp pointed and flat (64.06%). Sharp pointed spines were noticed in 28.43 per cent and flat spines were seen only in 7.50 per cent. No significant difference was noticed in distribution of genotypes in four regions with respect to shape of spines. Fruits with sharp pointed spines are less desirable since in such fruits rain water gets stagnated paving the way for entry inside the fruits leading to quality loss and fruit damage. Fruits with sharp pointed ones also create difficulty in handling. The most desirable spine shape is flat spines. In these fruits rain water does not stagnate over it and hence there may not be loss of quality. Such fruits won't create difficulty in handling. Mitra (1998) observed variation in spine density ranging from 5 to 27 /cm^2.

Majority of the accessions i.e., 77.18 per cent had intermediate latex exudation. Higher latex exudation was noticed in 17.18 per cent of the accessions. Low latex exudation was noticed only in 5.62 per cent. The consumers prefer fruits with lesser latex exudation as it offers easy handling, cutting and removal of flakes from the fruit. Latex consist of protein, mineral substances and wax, and are found to possess bacteriolytic activity (Berry and Kalra, 1988).

There was a wide variation among the accessions surveyed in terms of flake shape. Flake shapes like cordate, twisted and irregular were commonly noticed. Other flake shapes like spheroid, elongated obovate, rectangular and oblong with curved tip were less commonly noticed. No significant difference was noticed in distribution of genotypes in four regions with respect to shape of flakes.

5.1.4.2 Biometric characters of fruit

Wide variability was noticed among the accessions studied with respect to stalk length of fruits. It varied from 1.00 to 33.60 cm. No significant difference was noticed in distribution of genotypes in four regions with respect to stalk length of fruits. During the survey, it was generally noticed that stalk length of fruits in a cluster was more when compared to solitary fruits. Longer stalk length in cluster fruits may be a natural adaptation. Presence of more stalk length for the cluster fruits enable the developing fruits to grow avoiding competition for space among the developing fruits. If the stalk length is very short, the developing fruits in a single flowering shoot touch each other making hurdle for further development. In the same cluster itself, the stalk length of the fruits found to vary. The fruits located at the base of the flowering shoots had more stalk length as compared with the fruits located at the tip of flowering shoots. During the study, it was observed that the preference is towards the fruits with longer stalk, as it will be convenient for handling of the fruits after harvest.

Sturdiness of the stalk increases with decreasing length of stalk. The shorter stalk length makes attachment of the fruit stronger with stem. Solitary fruits, being bigger in size needs a stronger attachment with stem to prevent from dropping. Clustered fruits generally were smaller in size and with longer stalk. The longer stalk being slender in size makes the fruit attachment with stem comparatively weaker since the clustered fruits are generally smaller in size, despite its slender size the longer stalk can carry the developing fruits up to maturity without dropping. Premature drop was noticed in clustered slender stalked fruits.

Significant variability was noticed among the accessions with respect to length of the fruits. Length of the fruits more than 50 cm was more frequently noticed in coastal areas (27.50%) than in other regions. It was also observed that majority of the heavier fruits had longer length.

Significant variability was noticed among the accessions studied with respect to fruit girth. The co-efficient of variation was more for fruit girth in coastal areas (27.30%) indicating a higher variability than the other three topographical levels. More number of trees in coastal areas had greater fruit girth (27.50%) than all other regions. Generally, it was observed that fruit with higher girth values had longer flakes. The space between outer region of peduncle and inner region of rind was found to be wider in fruits with higher girth and hence flakes of such fruits find more space for flake elongation resulting in longer flakes. In exceptional cases, where there exists thicker peduncle at the centre of fruit inspite of the larger girth of fruit, flake size remains smaller due to minimum availability of space for flake elongation.

Highly significant variation was noticed in fruit weight among the accessions studied. Compared with other characters of jack trees, fruit weight had recorded the highest variation among the accessions studied. Higher number of surveyed trees in coastal areas (28.75%) had heavier fruits (even weighing up to 22.50 kg) than the other three regions. The co-efficient of variation for fruit weight (49.70%) was comparatively higher than the other three regions. Extremely large sized fruits are not generally preferred in homesteads. Jack fruits once cut opened, canot be kept for longer time since the shelf life is much shorter. Households cannot utilise such fruits in a single day. Hence, medium sized fruits weighing between 5 and 8 kg are generally preferred. But for the commercial purposes like chips making, etc. bigger sized fruits are preferred since the cutting and removing of flakes may be made easier and quicker.

Accessions studied had showed a greater variation with respect to rind weight. The frequency distribution of types with higher rind weight was more in coastal areas (28.75%) than in other regions. Not only size of the fruit but rind thickness influences the total rind weight.

We observed that thin rinded bigger sized fruits showed frequent fruit cracking. During the survey, it was also noticed that in thin rinded fruits when the maturity and harvesting coincide with rainy season, the quality of the fruits get deteriorated. This may be due to easy and quick penetration of rain water in thin rinded fruits than in thick rinded fruits.

The variability recorded in jack fruits with respect to flake number per fruit was higher than all other characters. The number varied from 1 to 456 per fruit. A slightly higher per cent of the accessions in coastal areas had more than 200 flakes per fruit than the accessions from plains (20.00%), hills (25.00%) and riverside (21.25%).

More number of flakes was recorded in bigger sized fruits with smaller flake size. The perigones, i.e., the unfertilised flowers also influences the number of flakes. More the perigone numbers, lesser the number of flakes. Assymmetrical fruits had lesser flake number when compared with symmetrical fruits of same size. The number of flakes was lesser in assymetrical side of such fruits. In coastal areas, the distribution of trees with bigger sized fruits was more when compared with other regions. Hence, the trees with more number of flakes was also high. Variation in flake number from 32 to 380 was noticed by Mitra, 1998.

Higher variability was recorded among the accessions studied in terms of weight of all the flakes per fruit. The range was from 0.51 to 8.21 kg. In coastal areas a higher per cent of accessions (30.00%) with more weight of flakes per fruit was noticed than plains (16.25%), hills (16.25%) and riverside (17.50%). Generally, bigger sized fruits with lesser perigones had more weight of flakes. Assymmetrical fruits had lesser flake weight.

Variability was also noticed in weight of single flake with seed and without seed among the accessions studied.

The length of flakes had showed wider variation among the genotypes. The length varied from 3.15 to 13.68 cm. A higher per cent of accessions in coastal areas (21.25%) had a flake length values more than 10.00 cm than that of plains (11.25%), hills (10.00%) and riverside (10.00%).

Even in a single fruit, the flake length varied. The length of the flakes at basal region was found to be shorter than middle and apex region of the fruit. The space available for flake growth is shorter in basal region than the other regions.

Flake girth varied from 4.25 to 13.95 cm among the accessions studied. In plains (25.00%) and riverside areas (23.75%), a higher per cent of the accessions recorded flake girth above 10 cm than the hills (17.50%) and coastal areas (16.25%).

A wide variability was noticed among the accessions studied in terms of flake thickness. Thin to medium rinded flakes are highly suitable for chips making. Thick rinded ones are highly fibrous and are comparatively less suitable for chips making. For table purpose, medium to thicker flakes are highly preferred.

The rachis length and diameter also had higher variability among the accessions. With respect to weight of perigones, the accessions studied had showed high variability. Asymmetrical fruits recorded higher perigone number and weight. The late season flowering types also had more number of perigones. Late season flowering coincides with hot and dry period which may pose hindrance for stigma receptivity and thereby resulting in improper pollination.

5.1.4.3 Biochemical characters of fruit

The total sugar content of the overall accessions varied from 8.16 to 19.30 per cent. About 54.68 per cent of the accessions had total sugar in the range of 12.00 to 15.00 per cent. Slightly a higher per cent of the accessions in plains (23.75%) and riverside areas (23.75%) had recorded total sugar content above 15.00 per cent on comparing with the accessions collected in hills (15.00%) and coastal areas (15.00 %).

The reducing sugar content of the accessions varied from 1.63 to 5.23 per cent. About 51.56 per cent of trees had the reducing sugar content in the range of 3.00 to 4.00 per cent. The per cent of accessions with reducing sugar content value of above 4.00 per cent was noticed more in riverside areas (28.25%) and plains (26.25%) followed by hills (18.75%) and coastal areas (18.75%).

The non-reducing sugar content of the accessions had the range varying from as low as 5.96 to 14.98 per cent. 52.81 per cent of the accessions had the non-reducing sugar content in the range of 8.00 to 12.00 per cent. A higher number of accessions with non-reducing content above 12.00 per cent was noticed in plains

(25.00%) and riverside (26.25%) compared to hills (18.75%) and coastal areas (18.75%).

The TSS content of the overall accessions varied from 14.63 to 33.00 °Brix. About 60.93 per cent of the accessions had TSS in the range of 20.00 to 30.00 °Brix. Slightly a higher per cent of the accession in plains (21.25%) and riverside areas (21.25%) had recorded total sugar content above 30.00°Brix when compared to those of hills (7.50%) and coastal areas (12.50%).

The total acid content of the accessions studied had the range varying from 0.69 to 5.26 per cent. About 53.75 per cent of the accessions had the total acidity in the range of 1.5 to 3.0 per cent. A higher number of accessions with higher total acid content of above 3.0 per cent were noticed in hills (28.75%) and coastal areas (28.75) compared to plains (18.75%) and riverside areas (20.00%).

Correlation was worked out between biochemical characters of flakes. Non-reducing sugars had highly significant positive correlation with reducing and total sugar, sugar acid ratio and TSS. Reducing sugars had highly significant positive correlation with total sugars and TSS. Total sugars had highly significant positive correlation with sugar acid ratio and TSS. Sugar acid ratio had significant negative correlation with acidity and significant positive correlation with TSS.

Total, non-reducing and reducing sugars had direct positive effect on overall acceptability of flakes.

5.1.4.4 Sensory qualities of flakes

Appearance of the flakes was found to have higher variability among the accessions studied. Appearance was dependent on shape, colour and size of flakes. Any shape except irregular shape, deep yellow to orange coloured flakes, and medium to bigger sized flakes were having more eye appealing nature. Such a combination of characters were more frequently recorded in the decreasing order in plains, riverside, hills and coastal areas.

Various shades of white, yellow, orange and pink flake colours were commonly noticed. Pure white, pinkish red, deep orange, etc. were rarely noticed. Unusually, there were fruits wherein white dots were noticed on yellow flakes. Double colour flakes were also noticed wherein base of flakes was yellow and the top was white. Firmness of the flakes was found to have significant variation among the accessions studied. Firmness depends upon thickness and texture of flakes. Firm textured and medium - high thickness flakes are highly preferred. Flakes with good firmness was more frequently noticed in plains and riverside areas than the other two regions. It may be due to the selection pressure imposed on the firm fleshed types in those areas. Mitra (1998) grouped the flakes into soft, moderately soft and hard.

With respect to flavour also, jack accessions recorded a wide variability. The ripe jack fruit emits a characteristic aroma, which is not preferred by many because it persists for longer period. Volatile constituents like esters and aliphatic alcohols were responsible for such aroma (Berry and Kalra, 1988). Jackfruit volatiles contain 45 components. Esters represents a high proportion (31.90%) of jackfruit volatiles and are important contributors to the flavour (Wong *et al.*, 1992). During the survey, flakes with cardamom flavour were also located (Pananchery).

Regarding sweetness, wide variability was noticed among the accessions. Flakes with highest sweetness are preferred for processed products like jam, jelly, etc. High sweetness flakes were preferred for table purpose. Sweetness types were more frequently noticed in plains (23.75%) and riverside areas (23.75%). The sweetness of the flakes is due to glucose, fructose and sucrose (Berry and Kalra, 1988).

5.1.4.5 Seed characters

Wide variation was also noticed among the genotypes with respect to seed characters like seed shape, seed surface pattern and seed coat colour.

Vivipary was noticed in 23.13 per cent of the accessions studied. Higher percent of viviparous seeds was noticed in hills (30.00%) and coastal areas (24.00%) than plains (18.75%) and riverside areas (17.50%). Vivipary was more frequently noticed in late maturing types. The late maturing types were more frequently distributed in hills and coastal areas and hence more number of viviparous trees in those areas. In late maturing types, the fruit maturity coincides with the rainy season and hence seeds started to germinate even inside the fruit. The taste of the flakes in which the seed has germinated differs from the normal and is mostly not preferred.

5.1.4.6 Yield characters

Yield per tree varied from 21.23 to 1710.00 kg with mean value of 419.12 kg. Distribution of higher yielding trees of above 500 kg were more common in plains (41.25%) and riverside areas (37.50%). Such trees were less frequently noticed is coastal areas (13.75%) and hills (15.00%). The mean yield recorded was more in plains (536.53 kg) and riverside (523.61 kg) than in hills (302.72 kg) and coastal areas (312.16 kg).

Irrespective of the topography, the number of fruits varied from 3.6 to 230.60 with the mean value of 47.94. The mean number of fruits per tree was higher in plains (63.13) and in riverside (62.86). This was lower in hills (37.64) and coastal areas (38.33). Higher yielding trees of above 80 fruits per year were more frequently distributed in plains (35.00%) and riverside areas (35.00%) than hills (22.50%) and coastal areas (21.25%).

Nine firm fleshed accessions namely Ac-7, 224, 306 and 307 from plains, AC-254 and 285 from the river side, Ac-102 and 293 from the coastal regions and AC-203 from the hilly tract were selected.

5.1.4.7 Genetic diversity

Clustering was done separately for each topography by subjecting the data to multivariate analysis utilising non-hierarchial euclidean cluster analysis. A wide genetic diversity was noticed among the accessions collected in four topographical regions.

5.2 CANOPY MANAGEMENT

Canopy development in jack has a seasonal and life time developmental pattern. The sum of development over individual seasons results in the final canopy dimension and form. When the tree growth is unrestricted by climate and cultural practices, trees may reach greater height and canopy diameter and occupy more space in the homesteads leading to difficulty in accommodating more number of components in the homestead system and also in harvesting. Jack leaves form the most preferred feed for goats. Hence lopping of branches is a common practice among goat keepers especially during summer. Hence, pruning, one of the canopy management techniques was conducted to standardize its level without affecting yield parameters and also favouring the trees to remain compact in the longer run making harvest easier and providing feed for goats.

The extent of phenological phases in jack fruit consist of 1) Two main season of flushing, (i) January-February extending up to 60 days and (ii) June-November for 150 days. 2) Main season of flowering was November-February lasting for about 150 days and 3) harvesting from March-July i.e., for about 150 days. Sinha and Singh (1971) observed two main periods of vegetative bud emergence i.e., January-February and June-October; out of which second period was the main.

The results of the present pruning study are discussed hereunder.

5.2.1 Flushing characters

The number of days for flushing were reduced with decreasing order of severity of pruning. Light pruning treatments like removal of 25 (47 days) and 50 per cent of n_4 branches (49 days) and 25 per cent n_3 branches (52 days) took the minimum days for flushing followed by medium pruning treatments like removal of 75 per cent of n_4 order (53 days), 50 per cent of n_3 order (55 days) and 25 per cent of n_2 order branches (56 days). The trees which received severe pruning treatments like 75 per cent of removal of n_3 order (64 days) and 50 (60 days) and 75 per cent (57 days) of n_2 order had taken maximum time for flushing. Severe pruning in litchi trees resulted in delayed flushing for about 30 days (Munzel *et al.*, 1996).

In the present investigation, it could be observed that pruning induced the production of more number of shoots with increased vigour and this increased with increasing severity of pruning. This is well confirming with the observation of Koopman (1896). He observed that in orange, more severe pruning always induces the development of longer and often, more numerous shoots; in most cases, the average length of new shoots is greater than that of shoots on unpruned trees. Further the growth of shoots under severe pruning was faster and lasted longer in the growing season. Maggs (1959) concluded the general responses of pruning 1) the individual shoots arising from a pruned branch were larger than those from unpruned branch. 2) Despite the faster growth of their individual shoots, pruned trees do not equal unpruned trees in size, at least until fruiting has checked the laters growth and (3) for a given degree of pruning, the size of the shoot growing from a pruned stem is positively correlated with the length of the stem before pruning.

Jonkers (1962) and Norton (1980) reported that the growth responses to pruning restore the disturbed balance between the above and underground part of a **tree by increasing shoot growth and reducing root growth.**

An investigation of pruning effects suggest that they results from a well functioning communication system within the tree. If the plant parts are removed by pruning, the remaining part of the tree is informed that the lost organ must be rebuilt in order to restore the balance between the parts. Growth promoting hormones probably play the main role in the functioning of the communication systems by switching certain genes on and off. When the shoot apex is removed, the hormonal status between the meristem is changed. As a result of these changes in hormone levels, lateral buds are stimulated to grow, branching induced, photosynthesis of basal leaves is increased and dry matter partitioning is changed in such a way that the tree is able to rebuild the lost parts quickly. At the same time, other "more distant" processes seem to be subordinated to the process of new shoot growth. Thus, the growth increment of trunk and new roots decreased as assimilates and mineral nutrients are directed towards the rebuilding of shoots. In addition, a transport system to new growing meristem is developed and fruit bud formation is hampered as reproduction is subordinated to the vegetative state (Mika, 1986).

Pruning can be expected to profoundly change the hormonal pattern of fruit trees because it reduces the number of meristems which are both the sink and source of hormones. Also the balance between the hormones supplied by the root system and above ground part of a tree is disturbed by pruning. Pruning increased cytokinin like activity to about 90 per cent; auxin like activity to about 60 per cent and gibberrellin like activity to about 19 per cent. This increase in the growth hormones synthesis promote the development of the vascular system and activates the nutrient transport and thus intensifying the already initiated growth (Mika, 1986).

5.2.2 Flowering characters

Pruning treatments differ significantly among themselves in terms of number of days taken for flowering. Light pruned trees like removal of 25 and 50 per cent of n_4 branches and 25 per cent n_3 branches came to flowering earlier i.e. in 43, 45 and 46 days, respectively, than the medium pruned trees like removal of 75 per cent n_4 order, 50 per cent n_3 order and 25 per cent n_2 order which had taken 50, 51 and 52 days, respectively. The trees which had received severe pruning treatments like removal of 75 per cent n_3 order and 50 and 75 per cent of n_2 order had taken maximum time for flowering i.e., 57, 60 and 64 days, respectively. This is in conformation with pruning results of ber and mango.

Yadav and Godera (1989) reported a delayed flowering in ber with increasing pruning severity. Pruning in mango generally delayed the onset of flowering from mid July to mid to late August (Oosthuyse, 1993). Pruning of Sensation variety of mango trees resulted in greater number of new shoots, slightly delayed and more uniform flowering (Oosthuyse, 1994). Heavily pruned mango trees resulted in delayed flowering by 210 days later than those of less severely pruned ones (Chen *et al.*, 1996). Pruning of mango trees had a delayed flowering and increased synchrony of flowering (Walt *et al.*, 1996).

Roy (1999) reported that excessive top pruning stimulated vegetative growth and suppressed flowering. Continual heavy pruning of fruit trees each year can delay the onset of flowering. This particularly happens in tropical evergreen fruit trees which store their food material mainly on the leaves, twigs and branches rather than the deciduous trees which stores food materials in trunks and roots. In evergreen trees, heavy pruning always delay the flower bud formation.

Oosthuyse (1997) observed a delayed flowering in mango as a result of pruning. Severe pruning in Dashehari mango trees induced more vegetative growth and delayed flowering (Lal *et al.*, 2000).

In the present study different levels of pruning had no effect on the duration of male and female spike development.

All the pruning treatments showed reduction in span of flowering and fruiting. However, no significant difference in flowering and fruiting span was noticed among various pruning treatments. Trees which received severe pruning treatments showed maximum reduction in fruiting span (10 to 20 days) followed by medium pruning (5 to 10 days) and light pruning (3 to 5 days) treatments.

Pruning in mango resulted in short span of flowering of within a few weeks instead of extending up to months (Srihari and Rao, 1998).

In jack there are both advantages and disadvantages in flowering and fruiting within a short span and also upto an extended period. If there is synchronization in flowering, harvesting can also be synchronized. We can obtain the jack fruits well before rainy period so that the quality can be assured. In Kerala, most of the jack fruits are in homesteads catering the culinary and table needs of the households. If harvesting done in a very short span, the consumptive use of the fruits are low since the fruits cannot be stored for longer periods. If the harvesting of fruits is done on an extended period, then the consumptive use of fruits for culinary and table purpose can also be enhanced.

5.2.3 Fruiting characters

All the pruning treatments showed enhanced percent of fruit set during first and second year of pruning. Medium pruned trees showed maximum increase in fruit set (3-6%) than the severe (1-2%) and light pruned trees (1-2%).

Chandler (1919) suggested that better fruit set in pruned trees might have resulted from the increased water and nitrogen supply to the remaining wood but not from increased photosynthate resources. Better fruit set might also be due to increased respiration or activation of enzymes or growth promoting substances.

There is a well established consensus that fruit retention or abscission is influenced by the level of endogenous hormones (auxins, gibberellins, cytokinins and ethylene) both directly and indirectly by shifting translocation of assimilates to competing areas of growing shoots (Groschowska and Keraszewska, 1978). Hormonal levels are modified by pruning (Groschowska, 1981). It may be possible that pruning increased fruit set as a direct result of growth hormone action.

Lal and Prasad (1981) and Yadav and Godera (1989) observed an increased fruit set and retention in ber by pruning.

Significant difference in fruit weight was observed with varying level of pruning treatments. All the pruning treatments resulted in an increased fruit weight. Medium pruning treatments had maximum increase in fruit weight (1-2 kg) than severe (0.1-0.23 kg) and light (0.3-0.8 kg) pruned trees. In ber the fruit weight was increased by pruning treatments (Gupta and Singh, 1977, Singh *et al.*, 1978 and Lal and Prasad, 1981). In guava, mild pruning resulted in increased fruit weight (Gopikrishna, 1981). Pruning in litchi trees resulted in an increase in fruit weight (Hassan and Chatopadhyay, 1995).

During first year of pruning all the treatments showed reduction in fruit number and yield and the reduction increased with severity of pruning. In the second year of pruning an increase in fruit number and yield was noticed. Trees which received medium pruning treatments showed a maximum increase in fruit number (20-30 fruits) and yield (150-200 kg) in the second year. In the medium pruned trees, the reduction in fruit number and yield observed during first year was tending towards the normal rate during second year. Severely pruned trees also showed an increase in fruit number and yield during second year but not yet regained the original bearing capacity. During third year of pruning, the severely pruned trees showed maximum increase in yield and fruit number followed by medium pruned trees. It was interesting to note that, during third year the severely pruned trees produced more number of fruits and yield than that recorded before pruning.

Drastic pruning destroys the structural framework and photosynthetic surfaces. During the first and second year, there is an increased infiltration percentage, which tends to become like that of control during third year. This gives as a clue to how much time the pruning effect lasts. Once the per cent infiltration of light comes on par with that of control it can be understood that canopy gets closed and original canopy surface formed.

Apparently the quiescent fruit bearing buds ought to have been activated by the treatment of pruning as was shown in mango, owing to redistribution of endogenous hormonal substance to favour flowering and fruiting (Rao and Shanmugavelu, 1975).

The yield suppressing effect of a pruning operation depends on how much it stimulates the shoot growth (Mika, 1986). Stimulation of shoot growth is the highest in severely pruned trees, higher in medium pruned trees and the lowest in lightly pruned trees. The yield suppressing factor was higher in medium and the highest in severely pruned trees which may get decreased gradually later on. That is why medium pruned trees tend to bear normal fruit number and yield during second year of pruning, severely pruned trees during third year of pruning. Similar observations were also observed in other fruit crops like ber and mango.

Awasthi and Misra (1969) reported that the total yield was more in the unpruned trees of ber when compared to the pruned trees during first year of pruning. Sharma *et al.* (1979) reported that the light pruning in ber proved better than medium and severe pruning with respect to yield. Rao (1971) reported an increase in productivity of old mango orchard in South India by pruning and he substantiated the increase in yield of pruned trees over unpruned trees may be due to increase in photosynthetic surface and increased availability of light to newly developed canopy and fruits.

Rao and Khader (1980) reported that matured mulgoa mango trees on pruning increased the fruit yield by 10 to 30 fold in the next eight years. Oosthuyse (1993) reported that pruning in mango resulted in reduction in the yield and number of fruits during first year of pruning.

Chen *et al.* (1996) observed a reduced crop yield in mango due to delayed accumulation of carbohydrate reserves by strong regrowth after heavy pruning. Fivaz *et al.* (1997) observed during the first season after pruning of Sensation mango trees, control trees had a higher yield. In the next season, pruned trees yielded higher than that of control. Durand (1997) reportd that in mango, pruning facilitated the light penetration in the canopy leading to increased yield. Medina-Urrutia *et al.* (1997) reported that the mechanical pruning of mango trees resulted in reduced yield during first year and significantly higher yield during second year. In Dashehari mango trees, Lal *et al.* (2000) reported that the increase in the yield of fourth and fifth order treatments over first, second and third order treatments during early years was due to availability of more canopy area for fruiting due to less severe pruning. Shaikh and Hulmani (1997) reported that eleven year old trees of Navalur guava cultivars on mild and severe pruning had an adverse effect on flower production and fruit yield per bunch. However, individual fruit weight was increased.

5.2.3 Quality characters

Regarding the effect of pruning on the fruit quality, no significant difference was noticed in total sugars, reducing sugars and non-reducing sugars of flakes of the pruned trees during first and second year of pruning. However, in severely pruned trees, there was a slight increase in the total (0.5-0.8%), reducing (0.2-0.3%) and non-reducing sugars (0.3-0.5%) of the flakes. This is in confirmity with the findings of Awasthi and Misra (1969), Singh *et al.* (1978) and Khan *et al.* (1992) in which a higher total sugar value was recorded in ber fruits from pruned trees.

Low yield is generally associated with a high concentration of carbohydrates and minerals in the fruits because the nutrients absorbed and carbohydrates synthesised are readily available to the few fruits produced (Olszewski and Slowik, 1982). Pruning facilitated light penetration into the interior parts of the tree canopy and increased the rate of photosynthesis. This might increased the content of soluble solids in fruits. Further, a higher photosynthesis of existing leaves associated with chlorophyll content and mesophyll cell enlargement might also be responsible for the increased quality of the fruits (Taylor and Feree, 1981).

In mango also Fivaz *et al.* (1997) observed an increase in sweetness in fruits from the pruned Sensation mango trees. Similar results were noticed in pomogranate fruits (Balasubramaniam *et al.*, 1997).

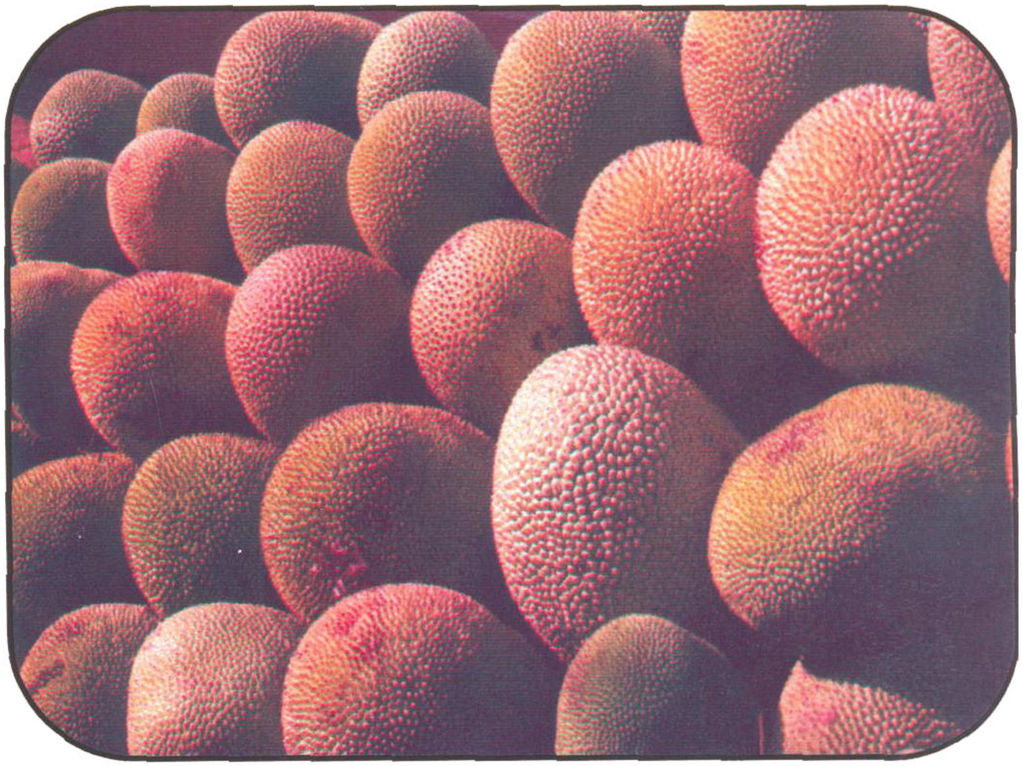
The above discussion points out that pruning of 50 per cent n_3 order at an interval of three years can be advised in jack. It can favour the trees to remain compact in the longer run without affecting the yield parameters drastically. With increasing severity of pruning, the new shoot growth increased while the trunk cross sectional increment decreases. In long run, a small reduction in trunk growth in each year may lead to significant dwarfing of the whole tree after several years (Preston, 1969).

5.3 CHARACTERISATION OF SOFT AND FIRM FLESHED TYPES

Development of an identification mode for soft and firm fleshed types in jack at the seedling stage itself will be much appreciated by the farmers. With this intension, morphological, anatomical and biochemical ways of characterisation was done in the present study. Conclusive results to distinguish the soft and firm fleshed types were not obtained.

Molecular characterization of the genetic variability between the genotypes, effect of pruning on endogenous hormones like auxin, cytokin and gibberellin and characterisation of soft and firm fleshed types by studying the biochemical traits at different phases of fruit development are suggested for future line of work.

Summary



6. SUMMARY

The present investigations on genetic diversity and canopy management in jack (*Artocarpus heterophyllus* Lam.) were undertaken in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara and Fodder Research Scheme, Mannuthy during 1998-2002. The study consisted of three parts, namely, genetic diverity, canopy management and characterisation of soft and firm fleshed types in jack fruit.

The objectives of the study were

1. To conduct a comprehensive survey of jack tree in four different topographical regions of Thrissur district, namely plains, hills, coastal and riverside areas.
2. To select high yielding and quality jack fruit types, dwarf and compact types and with minimum latex content.
3. To ascertain the optimum degree and frequency of canopy manipulation which results in better distribution of light and subsequent yield and to assess as how canopy manipulation and resultant re-distribution of light affects yield and quality of fruits.
4. To characterise firm and soft fleshed types through morphological observations, anatomical and biochemical analysis.

6.1 GENETIC DIVERSITY

For studying the genetic diversity in jack fruit, 89 panchayats of Thrissur district were grouped into four major topographical regions, namely, plains, coastal, hilly and riverside regions. In each topographical region, four panchayats were selected randomly. In each panchayats, twenty households were selected on random basis accounting to about 320 households. From these, trees were selected for detailed observation.

The following conclusions were made based on the present investigation.

Variation was noticed with respect to tree vigour viz. low, medium and high. Different canopy shapes like pyramidal, broadly pyramidal, obovate, oblong, semi-circular, elliptical and irregular were noticed among the accessions studied. Trees showed variation in growth habit like erect, horizontal and drooping.

Different branching densities like low, intermediate and high and branching patterns, namely, erect, opposite, verticiliate, horizontal and irregular were noticed among the trees studied.

Association was worked out between the general tree characters. Significant association was noticed between the following

1) Pyramidal tree shape and erect growth habit
2) Obovate tree shape and spreading growth habit
3) Oblong tree shape and semi-erect growth habit
4) Elliptical tree shape and semi-erect growth habit
5) Pyramidal tree shape and low branching density
6) Broadly pyramidal tree shape and intermediate branching density
7) Obovate tree shape and high branching density
8) Oblong tree shape and high branching density
9) Erect tree and strong apical dominance
10) Spreading tree and intermediate apical dominance
11) Drooping tree and weak apical dominance
12) Erect branching pattern and low branching density

Regarding leaf characters, a wide variation was noticed in all topographical levels with respect to leaf length, leaf width and length/width ratio. The surveyed trees showed different leaf shapes like obovate, elliptic, broadly elliptic, oblong and lanceolate leaves. Different leaf apex shapes like acute, cuspidate, retuse and obtuse and leaf base shapes like oblique, rounded, cuneate and shortly attenuate were noticed among the accessions.

Regarding the influence of descriptive characters on biometric characters of leaves 1) oblong leaves had more length, 2) lanceolate leaves had lesser length and breadth and 3) broadly elliptic leaves had more breadth. Significant correlation was obtained between leaf characters like length, breadth and area.

Surveyed accessions were grouped into three based on the flowering and bearing seasons, namely, 1) Early flowering (September-October) and bearing (December-February) types 2) mid season flowering (November-January) and bearing (March-May) types and 3) late flowering (February-March) and bearing (June-August) types. A sporadic flowering and bearing type was also spotted during the survey.

Regarding the bearing habit, accessions irrespective of the topography exhibited regular, alternate and irregular bearing habits.

Fruit shapes like broadly ellipsoid, oblong, high spheroid, spheroid, ellipsoid, obloid, clavate and irregular were noticed. Accessions showed different junction of stalk attachments like depressed, inflatened and flatened. Different fruit colours at maturity like greenish, greenish brown and greenish yellow were noticed.

Different shapes of spines on the fruit like sharp pointed, intermediate and flat were noticed. Accessions differ with respect to the intensity of latex exudation like low, medium and high. Flake shapes like cordate, twisted, spheroid, elongated obovate, rectangular, oblong with curved tip and irregular were noticed among the accessions in all the topographical levels.

Wide variation was noticed in terms of biometric characters of fruit. The length of the fruits varied from 18.50-80.30 cm; girth 30.12-110.00 cm; fruit weight 1.05-22.30 kg; fruit rind weight 0.39-4.26 kg; fruit rind thickness 0.28-3.93 cm; number of flakes 1.00-456.00, weight of flakes per fruit 0.51-8.21 kg; weight of fresh flake with seed 7.15-63.60 g; weight of fresh flake without seed 5.36-46.4 g; flake fruit ratio 0.69-4.3; flake length 3.15-13.68 cm; flake girth 4.25-13.95 cm; flake thickness 0.1-0.4 cm; rachis length 13.5-63.58 cm; rachis diameter 3.55-12.83 cm; perigone weight 0.43-4.16 kg and peduncle weight 0.21-2.93 kg.

Significant variation was noticed with respect to biochemical characters of fruit like total sugar (8.16-19.30), reducing sugar (1.63-5.23%), non reducing sugar (5.96-14.98%), total soluble solids (14.63-33.00°Brix) total acidity (0.69-5.26%) and sugar acid ratio (2.32-20.81%).

The jack collections had widely varied sensory attributes of flakes like appearance, colour, firmness, flavour, sweetness and overall acceptability.

Different seed shapes like spheroid, ellipsoid, elongate, oblong, reniform and irregular, seed surface patterns like uniform, regular striations and patches, and different seed coat colours like off white, creamish, dull brown and brownish were noted in the accessions irrespective of the topography. Vivipary was noticed in about 76.87 per cent of accessions.

Seed length varied from 1.98 to 5.83 cm seed girth from 3.23 to 8.30 cm and hundred seed weight from 480 to 2400 g.

Surveyed accessions showed wide variation in yield per tree (21.23 to 1710.00 kg) and number of fruits (3.60 to 230.60).

Character association was worked out between different fruit characters. Significant association was noticed between fruit clustering habit and fruit shape. Oblong fruits were mostly solitary. Spheroid fruits were more frequently noticed with clustering habit.

Influence of descriptive characters on biometric parameters was worked out between different fruit characters. The following significant influences were observed.

1. Obloid fruits with lesser fruit length, girth and fruit weight
2. Solitary fruits with more fruit length, girth and fruit weight
3. Oblong flakes with more flake length
4. Spheroid flakes with lesser flake length

Significant correlation was noticed between the biometric characters like yield, fruit length and diameter, fruit weight, rind weight, number of flakes, weight of flakes, rachis length, rachis diameter, perigone weight, seed weight, peduncle weight, fruit number, flake length, seed length and girth and number of fruits.

Path analysis revealed that fruit length, fruit weight, seed length and fruit number had direct effect on yield. Number of flakes, rachis length and fruit weight had indirect effect on yield via. fruit length. Number of flakes, weight of flakes, rachis length, perigone weight, seed weight and peduncle weight had indirect positive effect on yield via. fruit length.

Fruit length, fruit weight, number of flakes, weight of flakes per fruit, rachis length, perigone weight and seed weight had indirect negative effect on yield via fruit number.

Nine firm fleshed accessions namely Ac-7, 224, 306 and 307 from plains, AC-254 and 285 from the river side, Ac-102 and 293 from the coastal regions and AC-203 from the hilly tract were selected.

6.2 CANOPY MANAGEMENT

Pruning trials in jack trees resulted in reduction in number of days taken for flushing and flowering with decreasing order of severity, i.e., light pruning treatments resulted in early flushing and flowering followed by medium and severe pruning treatments.

On pruned trees more number of shoots with increased vigour was emerging with increasing severity of pruning. No significant difference in duration of male and female spike development, flowering and fruiting span was noticed among various pruning treatments. However, all the pruning treatments showed reduction in span of flowering and fruiting. Trees which received severe pruning treatments showed reduction in fruiting span by 10-20 days followed by medium (5-10 days) and light pruning treatments (3-5 days).

All the pruning treatments showed enhanced percent of fruit set during first and second year of pruning. Medium pruned trees showed maximum increase in fruit set (3-6%) than severe (1-2%) and light pruned trees (2-3%).

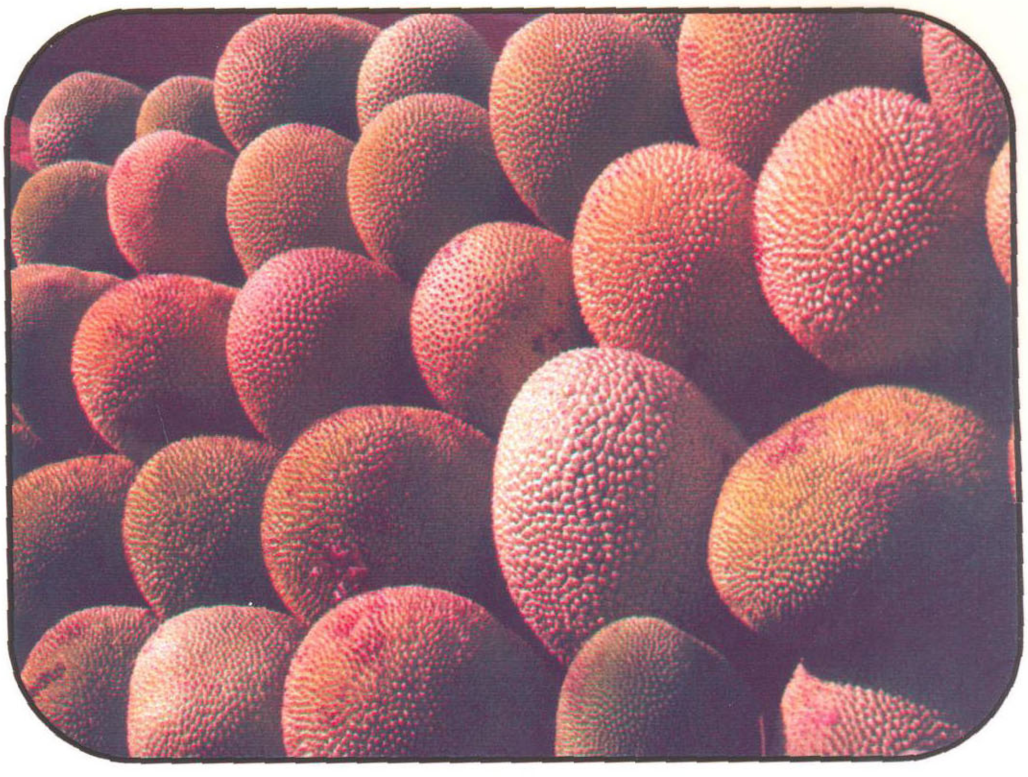
During first year of pruning all the pruning treatments showed reduction in fruit number and yield and the reduction was increasing with increasing severity of pruning. In the second and third year of pruning, an increase in fruit number and yield was observed.

No significant difference was noticed in total sugar, reducing sugars and non-reducing sugars of flakes. However, in severely pruned trees, a slight increase in the sugar content was noticed.

6.3 CHARACTERISATION OF SOFT AND FIRM FLESHED TYPES

There were no significant differences between soft and firm fleshed types in terms of morphological, anatomical and biochemical characters studied.

References



REFERENCES

Aman, R. 1980. *A Guide to Jack Fruit Cultivation*. Department of Agriculture, Malaysia, p.60

Anonymous 1996. ICAR Adhoc scheme on technology development for handling and utilisation of common types of jack fruit. *Final Report*. Kerala Agricultural University, Vellanikkara, pp.45-46

Avraham, S. and Mordechei, Y. 1993. Machine top pruning increases fruit weight and yield of orlando tangelo. *Alon-Hanotea* 47: 504-506

Awasthi, R.N. 1994. Variation in some selections of wild pomegranate, *Punica granatum*. *Hort. J.* 7: 67-70

Awasthi, A.N. and Misra, R.S. 1969. Effect of pruning and the subsequent vegetative growth, fruit set, fruit drop and quality of ber (*Zizyphus mauritiana* Lamk.). *Punjab Hort. J.* IX: 54-60

Bailey, I.H. 1949. *Manual of Cultivated Plants*. Macmillan Ltd., New York, p.280

Balasubramaniam, S., Anbu, S., Bangarusamy, U. and Chokalingam, P. 1997. Effect of pruning and training on growth, yield and quality of pomegranate in black soil under rainfed conditions. *S. Indian Hort.* 45: 271-273

Barrau, J. 1976. Bread fruit and relatives. *Evolution of Crop Plants* (ed. Simmonds, N.W.). Longman, pp.202-210

Berry, S.K. and Kalra, C.L. 1988. Chemistry and technology of jack fruit (*Artocarpus heterophyllus*) - A review. *Indian Food Packer* 8: 63-75

Bhagwat, N.R. 1984. Studies on flowering and fruiting in Karonda (*Carissa carondas* L.). M.Sc.(Ag.) thesis, Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India, p.118

Bhore, D.P., Ghunke, S.H. and Shelke, V.G. 1980. A promising type of jack-fruit. *J. Maharashtra Agric. Univ.* 5: 81-82

Bose, J.K. and Mitra, S.K. 1990. *Fruits Tropical and Subtropical*. Naya Prakash, Calcutta, pp.484-487

*Campbell, R.J. and Mc Naughton, R. 1994. New Jack fruit cultivars under trial in South Florida. *Proc. Interamerican Soc. trop. Hort.* 38: 201-205

*Chacko, E.K. and Ananthanarayanan, T.V. 1982. Accumulation of reserve substances in *Mangifera indica* L. during flower initiation. *Z. Planzenphysiol.* 106: 281-85

Chandler, W.H. 1919. Results of some experiments in pruning fruit trees. *Proc. Am. Soc. Hort. Sci.* 16: 88-101

Chattopadhyay, N. and Ghosh, S.N. 1994. Studies on the effect of time and extent of pruning in increasing the yield of cashew. *J. Plantation Crops* 22: 111-114

Chen, H., Zheng, H., Chen, H.B. and Zheng, H.L. 1996. A preliminary study of pruning to delay flowering in mango trees. *J. S. China Agric. Univ.* 17: 63-67

Corner, E.J.H. 1952. *Wayside Trees of Malaya.* Singapore Government Printer, Singapore, pp.193-199

CSIR, 1948. *The Wealth of India (Raw Materials) Vol.I.* Publications and Information Directorate, CSIR, New Delhi, pp.125-126

CSIR. 1992. *The Wealth of India (Raw Materials) Vol.IA.* Publications and Information Directorate, CSIR, New Delhi, p.447

Durand, G. 1997. Effects of light availability on the architecture of canopy in mango (*Mangifera indica* L.) cv. Manzana trees. *Acta Hort.* 455: 217-27

*Engler, A. and Prantl, K. 1888. *Die Nutritrlichen Pflanzenfamilien.* Leipzig, p.80-93

Fivaz, J., Stassen, P.J.C. and Grove, H.G. 1997. Pruning and training strategies for Tommy Atkins and Sensation mango trees in higher density hedgerow systems. Yearbook South African Mango Growers Assoc. 17: 8

Gamble, J.S. 1972. *A Manual of Indian Timbers.* Bishon Singh and Mahendra Singh, Dehra Dun, pp.652-654

George, A.P. and Nissen, R.J. 1986. Effect of pruning and defoliation on precocity of bearing of custard apple var. African Pride. *Acta Hort.* 175: 237-241

*Gonzalez, G. and Sourd, D. 1982. Pruning trial with five guava (*Psidium gujava*) cultivars. *Ciencia-y-Tecnica-en-la-Agricultura-Citricos-y-Otros-Frutales* 5: 39-51

Gopikrishna, N.S. 1981. Studies on the effects of pruning on vegetative growth, flowering and fruiting in 'Sardar' guava (*Psidium gujava* L.). M.Sc.(Hort.) thesis, University of Agricultural Sciences, Dharward, Karnataka, India, p.210

Groschowska, M.J. 1981. Physiological aspects of pruning and other treatments promoting flower formation and fruit retention in the apple trees. *Annual Report 1980-1981.* Research Institute of Pomology, Skierniewice, Poland. pp.79-133

Groschowska, M.J. and Keraszewska, A. 1978. A possible role of hormones in growth and development of apple trees and a suggestion on how to modify their action. *Acta Hort.* 80: 457-464

Grubb, N.H. 1938. Winter pruning of apple trees - some advice based on the East Malling experiments. *Annual Report E. Malling Res. Stn.* pp.237-241

Gupta, M.K. and Singh, S. 1977. Effect of pruning on the growth, yield and fruit quality in Ber. *Punjab Hort. J.* 17: 54-57

Guruprasad, J.R. and Thimmaraju, K.R. 1989. Seed and spine characters in three jack fruit *Artocarpus heterophyllus* Lam. types. *Environ. Ecol.* 7: 511-512

Habib, A.F. 1971. Cytology of jack. *Mysore J. Agric. Sci.* 6: 200-202

Hassan, M.A. and Chattopadhyay, P.K. 1995. Effect of pruning on the physico-chemical composition of different litchi cultivars. *Environ. Ecol.* 13: 110-116

Hiwala, S.S. and Raturi, G.B. 1993. Influence of severity of pruning on growth, yield and quality of ber. *Prog. Hort.* 25: 161-163

Hooker, J.D. 1885. *The Flora of British India Vol.V.* L.Reeve Co., London, p.493

Hussain, M. and Haque, A. 1977. Studies on the physical characteristics of jack fruit. *Bangladesh Hort.* 5: 9-14

Hutchinson, J. 1959. *The Families of Flowering Plants Vol.I - Dicotyledons.* Oxford University Press, London, p.88

Jackson, M.L. 1958. *Soil Chemical Analysis.* Prentice Hall Inc., USA, p.245

Jackson, J.E. and Palmer, J.W. 1980. A computer model study of light interception by orchards in relation to mechanised harvesting and management. *Sci. Hort.* 13: 1-7

Jarrett, F.M. 1959. Studies in Artocarpus and allied genera. *J. Arnold Arbor.* 40: 1-37

Jauhari, O.S. and Singh, R.B. 1971. Bael - a valuable fruit. *Indian Hort.* 6:9-10

Jonkers, H. 1962. Pruning young apple trees and bending of branches. *Proc. Sixteenth Int. Hort. Congr.* pp.441-443

Joshi, G.D., Pradhudesai, V.G. and Salri, M.J. 1986. Physico-chemical characteristics of Karonda (*Carissa carondas* L.). *Maharastra J. Hort.* 3: 39-44

Jyothi, M.L. 2000. Variability and character association analysis of pickling type mango. Ph.D. thesis, Kerala Agricultural University, Thrissur, India. p.240

Kamau, H.N. 1992. Germplasm exploration and collection. *Dinteria* 23: 50-54

KAU. 1982. Annual Research Report 1981-82. Kerala Agricultural University, Thrissur, India. p.314

Khan, M.S.I., Hossain, A.K.M.A., Amzad Hossan, A.K.M. and Subhadrabandha, S. 1992. Effect of pruning on growth, yield and quality of ber. *Acta Hort.* 321: 684-690

*Koopman, K. 1896. *Grundlehren des obstbaumschniltes.* Paul Parey, Berlin. p.48

Krishnamoorthy, S. and Rao, V.N.M. 1963. Certain proteins in pollination of fruit crops. *S. Indian Hort.* 2:10

Krishnankutty, C.N. 1998. Timber price trends in Kerala. *KFRI Research Report* 160: 51

Kumar, S. and Singh, I.S. 1993. Variation in quality traits of karonda (*Carissa carondas* L.) germplasm. *S. Indian Hort.* 41: 108-109

Kumar, S. and Singh, J.S. 1996. Improvement of jack fruit (*Artocarpus heterophyllus* Lam.) through selection. *Recent Hort.* 3: 55-59

Lal, B., Rajput, M.S., Rajan, S. and Rathore, D.S. 2000. Effect of pruning on rejuvenation of old mango trees. *Indian J. Hort.* 57(3): 240-242

Lal, H. and Prasad, A. 1980. Pruning in ber and its effect on flowering, fruit set and fruit retention. *Punjab Hort. J.* 20: 52-55

Lal, H. and Prasad, A. 1981. Effect of pruning on physico-chemical characters in ber (*Zizyphus mauritiana* Lamk.). *Sci. Culture* 47: 142-143

Lawrence, G.H.M 1973. *Taxonomy of Vascular Plants.* Oxford IBH, New Delhi, p.464

Magdalita, P.M., Pimental, R.B., Solto, R.C., Rivera, F.N. and Espino, R.R.C. 1984. Phenotypic variability in some characters of papaya. *Philippine Agric.* 67: 289-294

Maggs, D.H. 1959. The pruning responses of one-year apple trees. *Ann. Bot.* 23: 319-320

Mathura, R. and Dwivedi, R. 1992. Bael diversity in India - an under utilised fruit of medicinal value. *IBPGR Newslett.* 10: 13-14

Mazumdar, B.C. 1975. Physico-chemical analysis of some types of bael (*Aegle marmelos* Correa.) fruit growing in West Bengal. *Indian Agric.* 19: 295-298

Medina-Urrutia, V.M., Nunez-Elisea, R., Lavi,V. and Degani, C. 1997. Mechanical pruning to control tree size, flowering and yield of mature 'Tommy Atkins' mango trees. *Acta Hort.* 455: 305-314

Mika, A. 1986. Physiological Responses of fruit trees to pruning. *Horticultural Review Vol.8* (eds. Jules and Janick). Avl Publishing Company, INC Connecticut, pp.168-200

Mitra, S.K. 1998. Genetic diversity in jack fruit (*Artocarpus heterophyllus* Lam.) *Indian Hort.* 43: 2

Munzel, C.M., Simpson, S.R. and Doogan, V.J. 1996. Preliminary observations on growth, flowering and yield of pruned lychee trees. *J. S. African Soc. Hort. Sci.* 6: 16-19

Muthulakshmi, P., Sarah, T.G. and Mathew, K.L. 2001. Genetic diversity - *Garcinia cambogia. Indian Hort.* 46: 1-17

Nairne, A.K. 1894. *The Flowering Plants of Western India.* W.H. Allen and Co., London, p.309

NBPGR. 1986. *Annual Report.* National Bureau of Plant Genetic Resources, New Delhi, p.26

NBPGR. 1988. *Annual Report.* National Bureau of Plant Genetic Resource, New Delhi, p.26

Norton, R.L. 1980. Managing pruning problems in high density plantings. *Annual Report. New York State Horticultural Society* 110: 35-47

Olszewski, T. and Slowik, K. 1982. Effect of pruning on the calcium contents in apple leaves and fruits of cv. Mc Intosh. *Proc. 21st Int. Hort. Congr.* p.1114

Oosthuizen, J.H. 1994. Control of the size of litchi trees by pruning and chemical growth regulators. *Year book S. African Litchi Growers Assoc.* 6: 7

Oosthuyse, S.A. 1993. Evaluation of winter pruning to synchronize the flowering of Sensation mango trees. *Year book S. African Mango Growers Assoc.* 13: 54-57

Oosthuyse, S.A. 1994. Pruning of sensation mango trees to maintain their size and flowering. *Year book S. African Mango Growers Assoc.* 14: 2-8

Oosthuyse, S.A. 1997. Tree size maintenance: Pruning of mango trees after harvest. *Year Book S. African Mango Growers Assoc.* 17: 33-36

Panse, V.G. and Sukhatme, P.V. 1975. *Statistical Methods for Agricultural Workers.* ICAR, New Delhi, p.263

Pareek, O.P. and Panwar, H.S. 1981. Vegetative, floral and fruit characteristic of two phalsa (*Grewia subinequalis*) types. *J. Ann. Arid. Zone* 20: 281-90

Pareek, O.P. and Sodagar, N.N. 1986. Date palm grooves of kachchh. *Indian Hort.* 31: 21

Pareek, O.P. and Vashishtha, B.B. 1983. Delicious ber varieties of Rajasthan. *Indian Hort.* 28: 13-16

Ponnuswamy, V. and Irulappan, I. 1989. Study of range, mean and co-efficient of variability in sapota varieties (*Achras zapota* L.). *S. Indian Hort.* 37: 112-114

Preston, A.P. 1969. Pruning and fruit thinning trials with Lakton's superb apple on two rootstocks. Annu. Rep.E. Malling Res. Station - 1968. pp.75-79

Ram, S. 1993. Factors affecting mango tree architecture. *Acta Hort.* 341: 183-197

Ramu, B.S.S., Reddy, P.N., Hussain, S.A. and Patel, P.B. 1996. A new seedless selection from Pomegranate cv. Alandi. *Curr. Res.* 25: 72-73

Ranganna, 1986. *Manual of Analysis of Fruits and Vegetable Products*. Tata Mc Graw Hill Publishing Co. Ltd., New Delhi, p.224

Rao, V.N.M. 1971. A note on pruning as a remedy for irregular bearing mango. *Andhra Agric. J.* 18: 242-45

Rao, V.N.M. and Khader, J.B.M.M.A. 1980. Effect of pruning and thinning of young shoot clusters of mango. *Sci. Culture* 46: 71-72

Rao, V.N.M. and Shanmugavelu, K.G. 1975. Pruning a new technique for mango growers. *Agric. Agro Industries J.* 7: 44-50

Rendle, A.B. 1971. *The Classification of Flowering Plants Vol.II - Dicotyledons*. Cambridge University Press, London, pp.51-55

Roy, P.K. 1999. Orchard management. *Tropical Horticulture Vol.I* (eds. Bose, T.K., Mitra, S.K., Farooqui, A.A. and Sadhu, M.K.). Nayaprakash, Calcutta, pp.39-45

Sadasivam, S. and Manickam, A. 1992. *Biochemical Methods for Agricultural Sciences*. Wiley Eastern Limited and Tamilnadu Agricultural University, Coimbatore, pp.213-215

Sambamurthy, K. [illegible]. 1954. Preliminary studies in blossom biology of jack (*Artocarpus heterophyllus* Lam.) and pollination effects. *Indian J. Hort.* 11: 24-29

Sammadar, N. 1990. Jack fruit. *Fruits: Tropical and Subtropical* (eds. Bose, T.K. and Mitra, S.K.). Naya Prakash, Calcutta, pp.84-90

Sarma, R. and Mohan, N.K. 1999. Flake-less Jackfruit: a unique natural gift. *Indian Hort.* 44: 6

Sarma, R., Mohan, N.K. and Nath, J.C. 1997. Evaluation of yield potential and physico-chemical compositions of some local types of jack fruit of Assam. *Hort. J.* 10: 23-30

Shaikh, M.K. and Hulmani, N.C. 1997. Effect of pruning on shoot growth, leaf area and yield in guava. *Karnataka J. agric. Sci.* 10: 93-97

Sharma, J.P., Singh, R.V. and Rathore, S.V.S. 1975. Responses of phalsa to severity of pruning and level of nitrogen. *Agra Univ. J. Res.* 25: 151-158

Sharma, K.K., Jawanda, J.S., Singh, M.P. and Bajwa, M.S. 1979. Effect of different spacings and pruning intensities on the growth and fruit yield of Umran ber. *Punjab Hort. J.* 19: 142-146

Sharma, M.R. 1962. Morphological and anatomical investigations on *Artocarpus*. *Proc. Ind. Acad. Sci.*, 56: 243-58

Sharma, M.R. 1964. Jack fruit. *Proc. Indian Acad. Sci. Soc.* 60: 380-393

Shate, M.B., Karale, A.R., Kale, P.N., Kadam, D.D. 1993. Variation in seedling progeny of cashew. *S. Indian Hort.* 41: 106-107

Shaikh, M.K. and Hulmani, N.C. 1994. Effect of pruning on yield and chemical properties in Navalur guava selections. *Karnataka J. Agric. Sci.* 7: 473-475

Singh, A. 1996. *Fruit Physiology and Production*. Kalyani Publishers, Ludhiana. p.52

Singh, R.N. 1978. *Phal Vigyan*. ICAR, New Delhi, p.40

Singh, R.N. 1990. *Mango*, ICAR, New Delhi, p.49

Singh, S., Krishnamoorthy, S. and Katyal, S.L. 1967. *Fruit Culture in India*. ICAR, New Delhi, p.27

Singh, U.R., Pandey, I.C., Tripathi, B.M. and Upadhyay, N.P. 1978. Effect of pruning on growth, yield and quality of ber cv. Karaka. *Prog. Hort.* 1: 12-10

Sinha, M.M. and Singh, S.N. 1971. Growth studies (vegetative phase) in jack fruit (*Artocarpus heterophyllus* Lam.). *Indian J. Hort.* 78: 203-205

Srihari, D. and Rao, M.M. 1998. Induction of flowering and cropping in off phase Alphonso mango trees by pruning of fruited shoots. *Karnataka J. agric. Sci.* 11: 260-262

Srinivasan, K. 1970. Muttam varikka - A promising jack fruit variety. *Agric. Res. J. Kerala* 8: 51-52

Subramanyam, M.D. and Iyer, C.P.A. 1981. Studies on variability, heritability and genetic advance in *Carica papaya* cultivars. *S. Indian Hort.* 29: 167-174

Taylor, B.H. and Feree, D.C. 1981. Influence of summer pruning on photosynthesis, transpiration, leaf abscession and dry weight accumulation of young apple trees. *J. Am. Soc. Hort. Sci.* 106: 389-393

Tessy, J. 1982. Floral biology and fruit development in varikka and koozha types of jack. M.Sc.(Ag.) thesis, Kerala Agricultural University, Thrissur, India, p.101

Thimmaraju, K.R., Reddy, M.A.N., Samy, N. and Sulladmath, V.V. 1977. Studies on floral biology of tamarind (*Tamarindus indica* L.). *Mysore J. agric. Sci.* 11: 293-98

Thorp, T.G. and Sedgley, M. 1993. Manipulation of shoot growth patterns in relation to early fruit set in 'Hass' avocado (*Persea americana* Mill.). *Sci. Hort.* 56: 147-156

*Tong, F., Medina, D. and Esparza, D. 1991. Variability on populations of guava in the Mara Municipality of Zulia State. *Ravista de la Facilitad de Agronomia* 8: 15-27

Tubbs, F.R. 1955. The control of the vegetative growth and reproduction of perennial plants. *Proc. Fourteenth Int. Hort. Congress.* pp.39-59

Vashishtha, B.B. and Pareek, D.P. 1989. Identification key for the cultivars of Indian jojuba (*Zizyphus mauritiana* Lamk.). *Indian J. Hort.* 46: 183-188

Veeraraghavadattam, D., Jeeva, S. and Rabindran, R. 1996. *Scientific Fruit Culture.* Suri Associates, Coimbatore, p.129

*Walt, M., Davie, S.J., Stessen, P.J.C. and Van, M. 1996. Further development of the mango growth model. 1. The effect of pruning to different structural forms on the yield and carbohydrate resources of the mango tree. 2. Determination of total tree mass without excavation. *Inligtingsbulletin Instituut-vir-tropiese-en-Subtropiese-Gewasse.* 284: 10

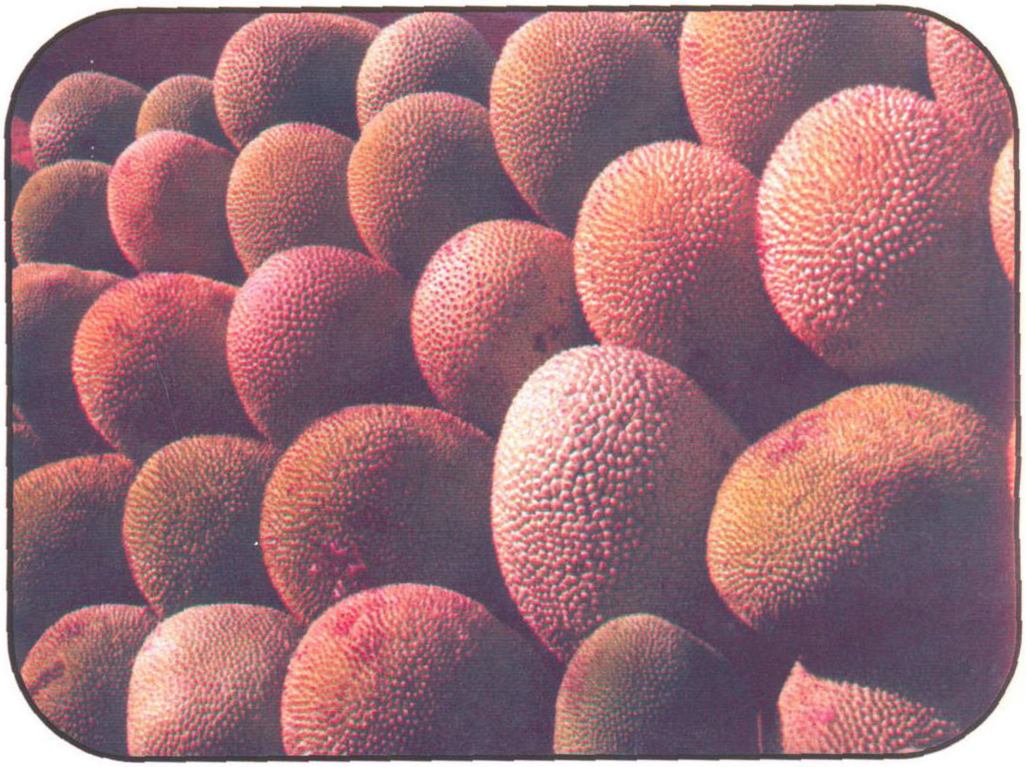
Whiley, A.W. and Schaffer, B. 1997. Stress Physiology. Mango-Botany, Production and Uses (ed. Litz, R.A.). CAB International, p.167-178

Wong, K.C., Lim, C.L. and Wong, L.L. 1992. Volatile flavur constituents of chempedek (*Artocarpus polyphema* Pers.) fruit and jack fruit (*Artocarpus heterophyllus* Lam.) from Malaysia. *Flavour and fragrance J.* 7: 307-311

Yadav, L.S. and Godera, N.R. 1989. Effect of planting distance and severity of pruning on flowering, fruit set and fruit retention in ber (*Zizyphus mauritiana* Lamk.) cv. Umran. *Prog. Hort.* 21: 325-328

* Originals not seen

Appendices



APPENDIX-I
DESCRIPTOR FOR JACK FRUIT (*Artocarpus heterophyllus* Lam.)

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF HORTICULTURE

1.	Accession number	:	
2.	Acquisition date	:	
3.	Collecting institute	:	Dept. of Pomology & Floriculture College of Horticulture Kerala Agricultural University Vellanikkara
4.	Name of the panchayat	:	
5.	Topography	:	Plains/River side/Hills/Coastal areas
6.	Name and address of the farmer	:	
A.	Plant Descriptors		
I.	Growth descriptors		
1.	Tree age (years)	:	
2.	Tree height (m)	:	
3.	Tree vigour	:	Low/Medium/High
4.	Tree shape	:	Pyramidal/Broadly pyramidal/Obovate/ Oblong/Semi-circular/Elliptical/Irregular
5.	Tree growth habit	:	Erect/Semi-erect/Spreading/Drooping
6.	Branching density	:	Low/Intermediate/High
7.	Branching pattern	:	Erect/Opposite/Verticilliate/Horizontal/ Irregular
8.	Trunk height (m) (from base to the point of emergence of first branch)	:	
II.	Leaf descriptors		
1.	Leaf length (cm)	:	

2. Leaf blade width (cm)	:	
3. Leaf blade length/width ratio	:	
4. Leaf blade shape	:	Obovate/Elliptic/Broadly elliptic/ Oblong/Lanceolate/Irregular/Others
5. Leaf apex shape	:	Acute/Cuspidate/Retuse/Obtuse/Others
6. Leaf base shape	:	Oblique/Rounded/Cuneate/Shortly attenuate/Others
7. Petiole length (mm)	:	
III. Flowering descriptors		
1. Season of flowering	:	
2. Female inflorescence position	:	Mainly on trunk/mainly on trunk and 1° branches/mainly on trunk, 1° and 2° branches/on the whole stem including 1°, 2° and 3°
IV. Fruit descriptors		
1. Fruiting season		
a) Starting date	:	
b) Ending date	:	
2. Fruit bearing		
a) Fruit bearing habit	:	Regular/Alternate/Others
b) Fruit bearing position	:	Mainly on trunk/mainly on trunk and 1° branches/mainly on trunk, 1° and 2° branches/on the whole stem including 1°, 2° and 3°
3. Fruit clustering habit	:	Solitary/Clusters/Specify
4. Fruit shape	:	Obloid/Spheroid/High spheroid/ Ellipsoid/Clavate/Oblong/Broadly ellipsoid/Irregular

5.	Stalk length (mm)	:	
6.	Junction of stalk attachment to fruit	:	Depressed/Flattened/Inflated/Others
7.	Fruit length (cm)	:	
8.	Fruit girth (cm)	:	
9.	Fruit weight (kg)	:	
10.	Fruit rind weight (kg)	:	
11.	Fruit rind thickness	:	Thin/Medium/thick/Very thick
12.	Fruit rind colour (at maturity)	:	Green/Greenish yellow/Yellow/Reddish yellow/Others
13.	Fruit surface	:	Smooth/Spiny
14.	Shape of spine	:	Sharp pointed/intermediate/flat
15.	Spine density	:	Sparse/Dense
16.	Latex exudation	:	Low/Medium/High
17.	No. of flakes per fruit	:	
18.	Weight of flakes per fruit (kg)	:	
19.	Weight of fresh flake with seed (g)	:	
20.	Weight of fresh flake without seed (g)	:	
21.	Flake/fruit ratio	:	
22.	Flake length (cm)	:	
23.	Flake width (cm)	:	
24.	Flake thickness	:	Thin/Medium/Thick
25.	Flake shape	:	Spheroid/Cordate/Twisted/Elongated/Obovate/Rectangular/Oblong with curved tip/Irregular/Others

26. Flake nutritive value

a) Total sugars (%) :
b) Reducing sugars (%) :
c) Non-reducing sugars (%) :
d) Total soluble solids (°Brix) :
e) Acidity :
f) Sugar-acid ratio :

28. Rachis length (cm) :

29. Rachis diameter (cm) :

V. Seed descriptors

1. Seed length (cm) :

2. Seed width (cm) :

3. 100 seed weight (g) :

4. Seed shape : Spheroid/Ellipsoid/Elongate/Oblong/ Reniform/Irregular/Others

5. Seed surface pattern : Uniform/Regular striations/Patches/ Others

6. Seed coat colour : Off-white/Creamish/Dull brown/ Brownish/Others

VI. Yield descriptors

1. Yield per tree :

2. No. of fruits per tree :

B. Soil Descriptors

1. Organic matter content :
2. N content :
3. P content :
4. K content :

APPENDIX-II

SENSORY EVALUATION SCORE CARD

Sample:

Date :

WELCOME:

- You are before a pleasing task!
- Your task is simple; you need to evaluate the sensory quality attributes of the coded samples served before you.
- Kindly assign your preferred scores as given below for each quality attributes of the samples in the respective columns.
- Please rinse your mouth after each sample you taste.

Code No.	Quality attributes					
	Appearance	Colour	Firmness	Flavour	Sweetness	Overall accepta-bility

Scores	Word description
0-2	Very poor
2.1-4	Poor
4.1-6	Satisfactory
6.1-8	Good
8.1-10	Excellent

SIGNATURE

NAME

DESIGNATION

Appendix - III

Monthly weather data of Mannuthy during the period 1998-2001

Sl. No.	Weather parameters	Year	January	February	March	April	May	June	July	August	September	October	November	December
1	Mean minimum temperature (°C)	1998	27.8	23.6	23.6	25.6	25.2	23.3	23.6	23.9	23.3	22.8	23.1	22.9
		1999	21.5	23.3	25.6	24.5	24.7	23.0	23.0	22.9	23.4	23.2	22.7	22.7
		2000	23.2	22.8	23.9	24.6	24.4	22.8	21.9	22.6	23.0	22.7	23.1	22.0
		2001	23.2	22.9	24.0	24.7	24.5	23.1	22.7	23.1	23.2	23.0	23.1	22.2
2	Mean maximum temperature (°C)	1998	33.1	34.4	36.2	36.5	34.1	30.2	29.2	29.8	30.2	28.0	31.5	30.1
		1999	32.4	34.5	35.5	33.4	30.7	29.4	28.4	29.8	31.6	30.5	31.4	30.7
		2000	32.9	33.3	35.6	34.0	33.7	29.6	28.8	29.1	30.7	30.7	33.3	30.4
		2001	32.6	34.5	34.9	34.2	32.3	28.4	29.0	27.5	30.8	30.7	31.6	29.5
3	Mean relative humidity (per cent)	1998	64	64	67	68	77	87	88	86	87	85	78	69
		1999	58	56	68	73	82	85	89	84	76	85	69	60
		2000	60	67	67	74	72	86	82	87	81	80	66	59
		2001	56	67	69	75	81	87	85	87	79	81	72	60
4	Rainfall (mm)	1998	0.0	0.0	11.0	61.4	203.0	809.3	752.9	433.6	571.3	452.8	109.4	33.0
		1999	0.0	22.8	0.0	39.0	430.5	500.2	823.3	260.1	28.4	506.2	9.1	0.0
		2000	0.0	4.6	0.0	67.9	117.2	602.0	354.0	518.8	198.1	262.2	41.3	11.2
		2001	0.0	12.2	4.4	243.1	192.6	676.2	477.7	253.2	200.9	215.8	115.8	0.0

GENETIC DIVERSITY AND CANOPY MANAGEMENT IN JACK FRUIT (*Artocarpus heterophyllus* Lam.)

By

P. MUTHULAKSHMI

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Doctor of Philosophy in Horticulture

Faculty of Agriculture

Kerala Agricultural University

Department of Pomology and Floriculture

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2003

ABSTRACT

The present investigations on genetic diversity and canopy management in jack fruit (*Artocarpus heterophyllus* Lam.) was undertaken in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, during 1998 to 2002. Major objectives of the study were to explore the variability in vegetative, floral, fruiting and biochemical characters of jackfruit through a comprehensive survey in four different topographical regions of Thrissur district, namely, plains, hills, coastal and riverside areas and to select quality types, to ascertain the optimum degree and frequency of canopy manipulation and to characterize the firm and soft fleshed types through morphological observations, anatomical and biochemical analysis.

Variation was noticed with respect to tree vigour (low, medium and high), canopy shape (pyramidal, broadly pyramidal, obovate, oblong, semi-circular, elliptical and irregular), tree growth habit (erect, horizontal and drooping), branching density (low, intermediate and high) and branching pattern (erect, opposite, verticiliate, horizontal and irregular).

A wide variation was noticed in all the four topographical levels with respect to leaf characters like length, width, length / width ratio, shape, apex shape and base shape.

Surveyed accessions were grouped into three based on flowering and bearing season, namely, (1) early flowering (September-October) and bearing (December-February), (2) mid-season flowering (November-January) and bearing (March-Mary) and (3) late flowering (February-March) and bearing (June-August). A sporadic flowering and bearing type was also spotted.

Variation was noticed with respect to fruit shape (broadly ellipsoid, oblong, high spheroid, spheroid, ellipsoid, obloid, clavate and irregular), junction of stalk attachment (depressed, inflatened and flatened), fruit rind colour (greenish, greenish brown and greenish yellow), shape of spines (sharp pointed, intermediate and flat),

intensity of latex exudation (low, medium and high) and flake shape (cordate, twisted, spheroid, elongated-obovate, rectangular, oblong with curved tip and irregular).

Wide variation was noticed in terms of biometric characters of fruit. The length of the fruits varied from 18.50 to 80.30 cm; girth 30.12 to 110.00 cm; fruit weight 1.05 to 22.30 kg; fruit rind weight 0.30 to 4.26 kg; fruit rind thickness 0.28 to 3.93 cm; number of flakes 1.00 to 456.00; weight of flakes per fruit 0.51 to 8.21 kg; weight of fresh flake with seed 7.15 to 63.50 g; weight of fresh flake without seed 5.36 to 46.4 g; flake fruit ratio 0.69 to 4.30; flake length 3.15 to 13.68 cm; flake girth 4.25 to 13.95 cm; flake thickness 0.1 to 0.4 cm; rachis length 13.5 to 63.58 cm; rachis diameter 3.55 to 12.83 cm; perigone weight 0.43 to 4.16 kg and peduncle weight 0.21 to 2.93 kg.

Significant variation was noticed with respect to biochemical characters of fruit like total sugar (8.16 to 19.30%), reducing sugar (1.63 to 5.23%), non reducing sugar (5.96 to 14.98%), total soluble solids (14.63 to 33.00°Brix), total acidity (0.69 to 4.95%) and sugar acid ratio (2.32 to 20.81%). The jack collections had widely varied sensory attributes of flakes like appearance, colour, firmness, flavour, sweetness and overall acceptability.

Seed characters like shape, surface pattern, length, girth and hundred seed weight showed wide variation among the accessions.

Surveyed accessions showed wide variation regarding yield per tree (21.23 to 1710.00 kg) and number of fruits per tree (3.60 to 230.60).

Significant correlation was noticed between the biometric characters of fruits like length, diameter, etc. Path analysis revealed that fruit length, fruit weight, seed length and fruit number had direct effect on yield. Non-hierarchical eucleadian cluster analysis revealed the existence of genetic diversity in jack. 80 collections in each topography could be grouped into ten clusters.

Nine firm fleshed accessions namely AC-7, 224, 306 and 307 from plains, AC-254 and 285 from the river side, AC-102 and 293 from the coastal regions and AC-203 from the hilly tract were selected.

Pruning trials in jack trees resulted in reduction in number of days taken for flushing and flowering with decreasing order of severity. On pruned trees more number of shoots with increased vigour was emerging with increasing severity of pruning. No significant difference in duration of male and female spike development, flowering and fruiting span was noticed among various pruning treatments. However, all the pruning treatments showed reduction in span of flowering and fruiting.

All the pruning treatments showed enhanced percent of fruit set during first and second year of pruning. Medium pruned trees showed maximum increase in fruit set (3-6%) than severe (1-2%) and light pruned trees (2-3%).

During first year of pruning all the pruning treatments showed reduction in fruit number and yield and the reduction was increasing with increasing severity of pruning. In the second and third year of pruning, an increase in fruit number and yield was observed.

No significant difference was noticed in total sugar, reducing sugars and non-reducing sugars of flakes. However, in severely pruned trees, a slight increase in the sugar content was noticed.

There were no significant differences between soft and firm fleshed types in terms of morphological, anatomical and biochemical characters studied.