FIELD EVALUATION OF PROMISING JACKFRUIT (*Artocarpus heterophyllus* Lam.) TYPES

By

AJEESH B R

(2016-12-017)

THESIS

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF POMOLOGY AND FLORICULTURE
COLLEGE OF AGRICULTURE
PADANNAKKAD, KASARGOD 671 314
KERALA, INDIA
2018

DECLARATION

I, hereby declare that this thesis entitled **"FIELD EVALUATION OF PROMISING JACKFRUIT (*Artocarpus heterophyllus* Lam.) TYPES"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Padannakkad

Date:

Ajeesh B R

(2016-12-017)

CERTIFICATE

Certified that this thesis entitled **"FIELD EVALUATION OF PROMISING JACKFRUIT (*Artocarpus heterophyllus* Lam.) TYPES"** is a record of research work done independently by Mr. Ajeesh B R 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 him.

Padannakkad

Date: 29/10/2018

Dr. A. Rajagopalan
(Major Advisor, Advisory Committee)
Professor and Head
Department of Pomology and Floriculture
College of Agriculture, Padannakkad

CERTIFICATE

We, the undersigned members of the advisory committee of Mr. Ajeesh B R, a candidate for the degree of **Master of Science in Horticulture** with major in Pomology and Floriculture, agree that the thesis entitled **"FIELD EVALUATION OF PROMISING JACKFRUIT (*Artocarpus heterophyllus* Lam.) TYPES"** may be submitted by Mr. Ajeesh B R, in partial fulfillment of the requirement for the degree.

12/10/18

Dr. A. Rajagopalan
(Chairman, Advisory Committee)
Professor and Head
Department of Pomology and Floriculture
College of Agriculture, Padannakkad

Dr. K. N. Satheeshan
(Member, Advisory Committee)
Professor (Horticulture) and ADR,
RARS, Pilicode

12/10/18

Dr. Meera Manjusha A. V.
(Member, Advisory Committee)
Assistant Professor (Horticulture)
RARS, Pilicode

Dr. G. V. Sudarsana Rao
(Member, Advisory Committee) 12/10/2018
Professor and Head
Department of Plant Physiology
College of Agriculture, Padannakkad

EXTERNAL EXAMINER 12/10/2018

ACKNOWLEDGEMENT

With great pleasure, let me express my sincere gratitude from the bottom of my heart to those helping hands, whose words, advice, presence or blessings helped me in this venture.

I wish to place on record with utmost sincerity my deep sense of profound gratitude to ***Dr. A. Rajagopalan****, Professor and Head Department of Pomology and Floriculture, College of Agriculture, Padannakkad and Chairman of Advisory Committee, for his valued guidance, ever willing help, constructive ideas, unfailing patience, sustained support, constant encouragement, meticulous care, and above all the understanding enthusiasm during the entire course of study. This work would not have been possible without his valuable help and support.*

I would like to express my sincere gratitude to ***Dr. K. N. Satheeshan****, Professor (Horticulture), Regional Agriculture Research Station, Pilicode and Member of Advisory Committee for his insightful comments and encouragement which helped me to widen my research from various perspectives.*

I feel inadequacy of words to express my deep sense of gratitude and profound indebtedness to ***Dr. Meera Manjusha A. V.,*** *Assistant Professor (Horticulture), RARS, Pilicode and Member of my Advisory Committee for her unstinted attention, valuable suggestions, scholarly counsel, meticulous care and friendly approach during the entire course of study period.*

It is my privilege to express my heartfelt thanks to ***Dr. G. V. Sudarsana Rao****, Professor and Head, Department of Plant Physiology, College of Agriculture, Padannakad and Member of Advisory Committee for his overwhelming support and valuable suggestions rendered during the course of my investigation.*

*I wish to express my sincere gratitude to **Dr. M. P. Giridharan,** Professor (Horticulture), Krishi Vigyan Kendra, Manjeshwar for his valuable suggestions and guidance throughout the research work and course of study.*

*My respectful thanks are due to **Dr. M. Govindan**, Associate Dean (Retd.) and **Dr. P. R. Suresh**, Associate Dean i/c for their help and support during the course of study.*

No word can truly express my deep sense of gratitude for the unconditional cooperation of the farmers who held the jack trees under study in various locations of Kasargod district.

*No word can truly express my deep sense of gratitude for the timely and eternal help offered by **Mr. Ashok Madala** and **Ms. Nimisha** during the course work, field experiment, data processing and preparation of thesis. I owe a lot to him for the inspiring support and perpetual encouragement given for the completion of this effort.*

*Words cannot describe my thanks to the strength of our department **Ms. Anju M Sunny**, **Ms. Dona**, **Mrs. Deepa** and lab assistant **Smt. Anitha** who have always given encouragement and support with love and care during my struggled period.*

*I take this opportunity to express sincere thanks to teachers **Dr. Yamini**, **Dr. Sujatha. R**, **Dr. Sudarsana Rao**, **Dr. Raji**, **Dr. Sreekumar**, **Dr. Ramesha**, **Dr. Sangheetha**, **Dr. Rajesh**, **Dr. Ajitha**, **Mr. Anees**, **Mr. Shivamoorthy**, **Mr. Lijesh**, **Mr. Kiran**, **Mr. Ashique**, **Dr. Rajeeb Das**, **Mrs. Rajitha, Ms. Nethu, Mrs. Beena**, **Ms. Amrutha** and who have always given encouragement and support. Their personal involvement at times of need was highly valuable.*

*The good help and care extended to me from all the staff members and workers of our college and Instructional farm especially **Sharath chettan, Ashokettan**, **Santhoshettan** and **Prakashettan** are gratefully acknowledged.*

I feel happy to thank all my lovely batchmates, ***Mubarack***, ***Hassain***, ***Boss***, ***Shiva***, ***Ammu***, ***Chanchu***, ***Ashwini***, ***Eurekha***, ***Pk***, ***Sree***, ***Manju*** *and* ***Shana***, *my seniors,* ***Sunu***, ***Sherin, Reshma*** *and my juniors* ***Akhil***, ***Lammani***, ***FSS***, ***Sajay***, ***Amalendu***, ***Adarsh***, ***Shibu***, ***Chethan*** *for their everlasting source of inspiration and love.*

I express gratitude to my friends, colleagues, juniors especially ***Fallu***, ***Latheef***, ***Sooraj***, ***Ganesh***, ***Shankar***, ***Joy***, ***Subin***, ***Amal***, ***Nanthu***, ***Akhilesh***, ***Kulir***, ***Hemanth***, ***Akru***, ***Arya***, ***Neethu***, ***Fathima***, ***Jinsha***, ***Divya***, ***Joji***, ***Ashwin*** *for their ever willing Support and heartful help.*

Above all, I am forever indebted to my beloved parents, ***Sri. Bernard, Smt. Rosemary***, *elder sister,* ***Archana*** *brother in law* ***Mr. Sajeesh*** *and vava* ***Isha*** *for their continuous and unparalleled love, help and support throughout the educational endeavour. I would also like to gratefully remember all my friends and relatives for their kind blessings and well wishes showed on me.*

I sincerely acknowledge the ***Kerala Agricultural University*** *for financial support in the form of KAU Junior Research Fellowship during my studies.*

Last but not least I bow my head before my grandparents whose blessings were with me during every inch of study enabling me to undertake the venture successfully.

Ajeesh B R

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

Sl. No.	Title	Appendix No.
1	Details of farmers holding the promising jack types as well as check varieties	**I**
2	GPS reading of the location of the jack fruit types as well as check varieties	**II**
3	Map showing location of trees of jackfruit types in Kasargod District	**III**
4	Weather data during the period September 2017 to August 2018	**IV**
5	Questionnaire to get basic information on selected jack trees	**V**
6	Result on organoleptic scoring of jackfruit types during 2016 with score card	**VI**

LIST OF ABBREVIATIONS

AOAC	-	Association of Official Agricultural Chemists
%	-	Per cent
°	-	Degree
°B	-	Degree Brix
°C	-	Degree Celsius
CD	-	Critical Difference
cm	-	Centimetre
cm^2	-	Centimetre square
E	-	East
et al.	-	And others
Fig.	-	Figure
GPS	-	Global Positioning System
g	-	Gram
ha	-	Hectare
ha^{-1}	-	Per hectare
ie.,	-	That is
IPGRI	-	Intrnational Plant Genetic Resources Institute

KAU	-	Kerala Agricultural University
kg	-	Kilogram
KJ	-	Kasargod Jack
MSL	-	Mean sea level
m	-	Metre
µg	-	Microgram
mg	-	Milligram
MHa	-	Million hectare
mm	-	Millimetre
MMT	-	Million metric ton
N	-	North
NA	-	Not Applicable
No.	-	Number
RARS	-	Regional Agricultural Research Station
rpm	-	Revolutions per minute
SEm	-	Standard Error of mean
t	-	tons
TSS	-	Total Soluble Solids
viz	-	Namely

Introduction

1. INTRODUCTION

The jackfruit (*Artocarpus heterophyllus* Lam.), a member of Moraceae is indigenous to the rainforests of the Western Ghats. It can thrive under a variety of soil as well as climatic conditions of tropical and subtropical region. It is a major component of subsistence farming systems in the Southern and Eastern parts of India.

Jackfruit is a versatile crop which provides multiple products for food, fodder, fuel and timber. The wood is a superior timber and the leaves are used as fodder. Jack fruit often assumes the role of a secondary staple food among the poor classes (Maheswari and Nivetha, 2015) because of its less cost and wide availability. Immature fruit, unripe matured fruit, ripe fruit and seeds are used for various culinary purposes. Pectin present in the fruit makes it ideal for jelly making and preparation of other processed products.

The fruit also has high nutritional and medicinal values, (Chadha and Patel, 2007; Arung *et al.*, 2006). It is rich in fibre, calcium, phosphorous, potassium, magnesium, vitamin-C and carbohydrates. As the unripe fruit is having low glycemic index (Shahin *et al.*, 2012), it is recommended as a partial substitute for food grains in diabetic patients. The phytonutrients such as lignin, isoflavones, and saponins in jackfruit glorifies it with anticancerous, antihypertensive, anti-ulcer and anti-ageing properties (Soong and Barlow, 2004).

Eventhough it is widely grown in an area of 1.53 lakh ha with a production of 17 lakh t annum^{-1} and productivity of 11.25 t ha^{-1} (NHB, 2017), it is hardly considered as a commercial fruit crop in India. Area under jackfruit in Kerala is around 91982 ha, with an annual production of 281 million fruits (DES GOK, 2016). Now, it is recognized as the official fruit of Kerala and an important component in the homesteads.

A number of factors could be responsible for the low commercial utilization of jackfruit. Long gestation period, limited choice of suitable improved

varieties, large dimension of the fruit variability in the yield and quality, problems in harvesting etc., are some of the hurdles in cultivation of jackfruit (Nunjundaswamy and Mahadeviah, 1993).

The crop is an obligate cross pollinated fruit species exhibiting higher variability due to its heterogynous nature (Harshavardhan and Rajasekhar, 2012). Unlike other crops, jackfruit shows 'type variation' in seedlings. The cross pollination behavior of the crop leads to variability in off springs, as a result sometimes *varikka* type (with firm flakes) may produce *koozha* type (with soft flakes) plants and vice versa.

Being cross pollinated and predominantly propagated by seeds, jackfruit exhibits great variation in terms of vegetative, flowering, fruiting and quality characters. This heterogenous nature of the seedling population offers great potential for selection of superior types suitable for commercial cultivation.

Presently, demand for jack fruit is increasing because of the awareness among consumers regarding its nutritional benefits, taste and innovations in value addition. Consumers prefer jackfruit varieties with characters like precocity, sweetness, gumlessness and small sized fruits. Even though standard varieties in jackfruit are limited, there are good numbers of trees which are superior in yield with desirable fruit characters. Nimisha (2016) had identified certain promising jackfruit types in Kasaragod district with some desirable characters such as earliness in bearing, gumless fruits, off season bearing and clustering habit through survey and characterization. Hence, these promising jack types need to be evaluated and compared based on tree morphological characters, bearing behaviour, fruit and flake characters, maturity period, yield potential and fruit biochemical characters with that of already established varieties of the region to select the best jack types.

Therefore, the present study entitled "Field evaluation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types" was undertaken with the following objectives.

1. To evaluate the morphological and yield characters of the ten promising jackfruit types in the field
2. To select most promising jackfruit types with quality fruits through quality evaluation of fruits in the laboratory

Review of Literature

2. REVIEW OF LITERATURE

The jackfruit (*Artocarpus heterophyllus* Lam.) is an important indigenous multipurpose tropical fruit crop in the family Moraceae. A native to South-West India, it is the largest known edible fruit where the bearing is cauliflorous in nature. It can thrive under varied climates and on a variety of soil types of the tropical and subtropical region.

Jackfruit is a monoecious tree producing male and female inflorescence in separate parts of the tree which results in cross-pollination, leading to a large magnitude of genetic variability among seedling progenies.

Crop improvement through conventional hybridization is not ideal for jackfruit and other perennials because of their long breeding cycle, very large growth habit and heterozygosity. Hence, on-site selection strategy based on the individual tree performance, particularly fruit qualities and bearing habit is the most efficient approach towards variety development.

In this chapter, the literature on jackfruit and related species, in respect of variation in vegetative, fruiting and biochemical characters, based on which field evaluation and selection was done, are reviewed.

2.1 VARIABILITY

Muthulakshmi (2003) studied the genetic diversity in jackfruit and reported much variability in vegetative, floral, fruiting and biochemical characters. Characters like tree vigour, shape of canopy, tree growth habit, branching density and branching pattern showed wide variability. Variation was also noticed with respect to shape of fruit, junction of stalk attachment, rind colour, shape of spines, latex exudation intensity and flake shape. The biometric characters of fruit also exhibited significant variation.

Maiti *et al.* (2003) investigated genetic variability for various physico-chemical attributes of 44 jackfruit genotypes collected from different agro climatic zones of West Bengal. Among the characters, fruit weight showed highest magnitude of genotypic and phenotypic variance.

Jagadeesh *et al.* (2007) studied ninety five jackfruit types selected from Western Ghats of India and reported much variability for 22 quantitative characters. Significant differences were reported among 95 selections indicating the existence of variability.

Wang *et al.* (2009) studied 26 quantitative and qualitative fruit traits of 76 accessions of jackfruit collected from Leizhou Peninsula and found wide genetic diversity in fruit traits ranging from 11.13 per cent to 67.73 per cent.

2.2 SELECTION

According to Haq (1995), the most important characters of a jackfruit ideotype are: (a) architecture of canopy with acceptable form which is easy to manage, (b) vigorous and prolific plants compatible with one or more rootstocks with early flowering and regular bearing, (c) good quality fruits with acceptable flesh colour and texture, good flavour and sweetness, (d) fruits with symmetrical form and acceptable size, (e) wider adaptation, (f) time of fruit maturity, (g) off-season type, (h) long post-harvest life and (i) above all, high yield.

Azad (2000) studied the diversity of jackfruit in five regions of Bangladesh to select superior types based on farmers' information and field observations. Farmers' criteria included high yield, fruit quality, sweetness, early fruiting and off-season types. The study revealed that those considered superior by farmers also received high scores from laboratory analysis for quality. On the basis of this analysis and scoring, 10 trees were selected.

Mitra and Mani (2000) made detailed study in 1800 jack fruit trees of Eastern India over a period of seven years. Two types were identified with very

juicy flakes, suitable for processing. Some types exhibited TSS more than 25°Brix, ideal for dessert purpose.

Wangchu *et al.* (2013) carried out a survey in three districts of West Bengal viz. Nadia, 24 Parganas (N) and Koch Bihar. All together 1,500 trees were surveyed and 44 superior genotypes were selected based on IPGRI Jackfruit Descriptor (IPGRI, 2000) with 13 quantitative and 6 qualitative traits i.e., bearing habits, time required to first fruiting after planting, fruiting season, fruit bearing position, yield per tree, harvesting time, tree growth habit, fruit shape, fruit size (length and breadth), fruit rind colour, fruit weight, colour of flake (bulbs), taste of pulp, total soluble solids, titratable acidity, sugar (total and reducing), vitamin C, TSS/acid ratio and shelf life. Other quantitative traits used based on consumer's preference were small size fruit (2–3 kg/fruit for a family of five), firm flakes (crispy), less fiber and grower's preference viz; earliness in bearing, bearing twice a year and heavy bearing.

2.3 FIELD EVALUATION

With an objective 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, an extensive survey, followed by fruit evaluation was carried out by Muthulakshmi (2003) in four topographical regions of Thrissur district of Kerala state.

Rai *et al.* (2003) evaluated twenty one genotypes of jackfruit for two consecutive years during 2000-2002 as a part of Horticulture and Agro-Forestry Research Programme, Plandu, Ranchi. Genotypes under investigation differed in tree morphological characters, bearing behaviour, fruit and flake characters, maturity period, and yield potential. Based on overall performance with respect to bearing potential, maturity period and fruit and flake characters, the genotypes HPJS-4/5 and HPJS-3/10 were found promising for table purpose while HPJS-4/5 and HPJS-2/6 were found suitable for culinary purpose.

Ten existing jackfruit germplasm were evaluated at Regional Agricultural Research Station, Rangpur, Bangladesh during 2012-13 (Ali *et al.*, 2015). Ten existing jackfruit germplasm were selected and named consecutively from AH Bur-001 to AH Bur-010 and their age, growth, yield, yield attributes and qualitative characteristics were compared. The germplasm AH Bur-001 performed better in terms of earliness, fruit size, quality and yield followed by AH Bur-003 and AH Bur-007.

2.3.1 Tree growth characters

An extensive survey, followed by fruit evaluation was carried out by Muthulakshmi (2003) in four topographical regions of Thrissur district of Kerala. Out of all accessions irrespective of topography, about 25.95 per cent of the trees were older i.e. above 50 years of age, 25.93 per cent were 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. Among the surveyed trees, 15.93 per cent showed less vigour irrespective of topography. Medium vigorous trees were common and it was 55.31 per cent of the surveyed trees. Highly vigorous trees accounted about 28.75 per cent. Variation in canopy shape varied as pyramidal, broadly pyramidal, obovate, oblong, semi-circular, elliptical and irregular.

Rai *et al.* (2003) reported that plant height of different genotypes ranged from 5.6 to 9.05 m with minimum in HPJS-8/9 and maximum in HPJS-8/3. The trunk circumference at 30 cm height in different genotypes ranged from 83 cm in HPJS-3/10 to 161 .0 cm in HPJS-11/9. The genotypes HPJS-5/8 and HPJS-2/6 were medium tall and spreading genotypes, whereas, HPJS-8/9 and HPJS-10/1 were dwarf types and HPJS-8/3 and HPJS-2/6 were tall growing genotypes.

Ramakrishna *et al.* (2006) evaluated ten selections of jackfruit for their performance in Southern region of Andhra Pradesh. Vigorous growth was observed in Chitradurg selection (6.10 m) followed by Bagepalli (6.00 m) and

Hassanwhite (5.85 m), whereas the stem girth was maximum in Chitradurg selection (66.0 cm).

According to Haq (2006), the crown of jack tree was usually conical when the trees were young or grown under shaded conditions and reached a diameter of 3.5 to 6.7 m at five years, becoming rounded and somewhat irregular when older. The trunk of jack tree was unbuttressed and was usually about 80 to 120 cm in diameter but could be much wider in older trees and the bark of tree was somewhat scaly and greyish brown or dark grey.

Aswini *et al.* (2015) made morpho-molecular characterization of twenty jackfruit accessions serially numbered from Acc. 1 to Acc. 20 which was maintained at the orchard of Department of Pomology and Florculture, College of Horticulture, Vellanikkara. They differentiated the trees as pyramidal, broadly pyramidal, spherical, oblong, semicircular, elliptical and irregular and noted variation in branching density among various genotypes.

Ten existing jackfruit germplasm were evaluated at Regional Agricultural Research Station, Rangpur, Bangladesh during 2012-13 (Ali *et al.*, 2015). Tree height ranged from 12.0 to 15.8 m. The germplasm AH Bur-005 gave the tallest plants (15.8 m) while AH Bur-002 gave the shortest plants (12.0 m). Highest number of bulbs per fruit (130) was recorded in AH Bur-1 while minimum (85) was found in AH Bur-5. The bulb weight per fruit (3.6 kg) was maximum in germplasm AH Bur-7 and the germplasm AH Bur-9 gave minimum bulb weight per fruit (2.5 kg).

Yield and quality performances of three jackfruit genotypes were studied at the Agricultural Research Station, Bangladesh Agricultural Research Institute, Pahartali, Chittagong during 2013-2014 (Rahman *et al.*, 2016). The tallest plant height (8.85 m) was found in AHPah-1, closely followed by AHPah-2 (8.80 m).

Roy *et al.* (2018) evaluated the morphological traits of jackfruit germplasm under Tarai conditions of Uttarakhand in HRC, Patharchatta, GBPUA&T, Pantnagar, U.S. Nagar (Uttarakhand) from November 2015 to July

2016. The maximum height (9.66 m) of the tree was recorded in Jackfruit Germplasm-1 followed by Jackfruit Germplasm-2 (9.33 m), but these two germplasm were statistically on par with respect to plant height. The maximum girth (137.72 cm) of the tree was recorded in Jackfruit Germplasm-3 followed by Jackfruit Germplasm-9 (132.33 cm), but these two germplasm were statistically similar with respect to stem girth.

Chandrashekar *et al.* (2018) evaluated 35 local genotypes of jackfruit under coffee ecosystem of lower Pulney hills at Horticultural Research Station, Thadiyankudisai and its adjoining areas, during 2016-2017. Among the thirty five genotypes, tree height ranged from 10.94 to 23.64 m with the mean of 17.01 m. The tree height was the lowest in HRS TKD AH-24 (10.94 m) followed by HRS TKD AH-7 (11.96 m) and it was the highest in HRS TKD AH-23 (23.64 m) and HRS TKD AH-20 (22.27 m) which were on par. The trunk circumference ranged from 60.18 to 273.13 cm with a mean of 154.25 cm. It was minimum in HRS TKD AH-11 (60.18 cm) followed by HRS TKD AH-9 (82.77 cm) and it was the maximum in HRS TKD AH-23 (273.13 cm). The trunk height of the thirty five genotypes varied from 1.79 to 9.58 m with a mean of 3.76 m. The trunk height was significantly lowest in HRS TKD AH-27 (1.79 m) and significantly highest in HRS TKD AH-23 (9.58 m). While the crown diameter varied from 7.35 to 28.75 m with mean of 16.87 m and it was significantly lowest in HRS TKD AH-9 (7.35 m) and significantly higher in HRS TKD AH-23 (28.75 m). Out of the thirty five genotypes, 54.28 per cent genotypes had irregular canopy shape, 28.57 per cent were elliptical and 17.14 per cent were spherical. They observed that the presence of irregular canopy shape is a desirable factor from the point of fruit set and yield. Genotypes namely, HRS TKD AH-2, 5, 6, 7, 9, 11,18, 20, 21, 22, 23, 24, 25, 27, 28, 29, 31, 32, 35 have recorded irregular canopy shape.

2.3.2 Leaf characters

Muthulakshmi (2003) surveyed four different topographical regions of Thrissur district, namely plains, hills, coastal and riverside areas to select quality

jack types. Among the observed 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. The petiole length of these accessions varied from 16.50 cm to 57.50 cm with 28.36 percent co-efficient of variation.

Sharma *et al.* (2005) carried out an investigation on 10 genotypes of jackfruit collected from various locations in Uttar Pradesh during the year 2001 to 2002 and reported variations in leaf length, leaf width and leaf petiole length. The maximum leaf length (18.43 cm) was found in DS-1 and minimum was found in CS-6. With respect to the leaf petiole length, maximum petiole length was found in CS-7 (4.35 cm) and minimum was recorded in BS-7 (1.20 cm).

Khan *et al.* (2010) evaluated 900 jackfruit trees in multiple locations and reported maximum leaf length in forest/fallow (13.16 cm) and minimum (13.08 cm) in village areas. They also reported that leaf breadth was maximum in homesteads (13.13 cm) and minimum (8.97 cm) in forest/fallow areas.

Sarker and Zuberi (2011) carried out an investigation in jackfruit which were collected from the corporate city and an adjacent village area of Rajshahi and observed that genotypes from old village Madanhati possessed thick rough and thin rough leaf texture among old and young trees. Trees of Upashahar mostly had medium and thick rough leaf texture among old and young trees. The mean leaf lengths of old and young tress of Madanhati and of Upashahar were 21.82, 18.84, 16.42 and 13.26 cm respectively. The leaf lengths of old and young trees in Madanhati showed significantly higher values than those of Upashahar. Moreover, the mean leaf lengths were significantly different among old and young trees of Madanhati and of Upashahar. Leaf breadth among old and young tress of Madanhati and of Upashahar had mean values as 13, 10.04, 7.72 and 4.64 cm respectively. Old and young trees of Madanhati possessed significantly higher leaf breadths than those of Upashahar. On the other hand, leaf breadths among

old and young trees of Madanhati showed significant difference but that of Upashahar made no significant difference.

Roy (2017) reported significant differences in leaf length among the various jackfruit germplasm evaluated under Tarai condition of Uttarakhand. The maximum leaf length (14.69 cm) was found in Jackfruit Germplasm-5 followed by Jackfruit Germplasm-3 (14.16 cm) and they were statistically on par with each other while minimum leaf length (9.20 cm) was recorded in Jackfruit Germplasm-6. While the maximum leaf width was in Jackfruit Germplasm-5 (9.56 cm) followed by Jackfruit Germplasm-3 (9.13cm) and Jackfruit Germplasm-7 (13.26 cm) and they were statistically on par with each other while minimum leaf width (5.50 cm) was recorded in Jackfruit Germplasm-6.

The leaf apex was found to be acute and acuminate in 35 local genotypes of jackfruit under coffee ecosystem of lower Pulney hills at Horticultural Research Station, Thadiyankudisai and its adjoining areas, during 2016-2017 (Chandrashekar *et al.* 2018). Most of the trees under study showed acuminate leaf apex whereas only three genotypes had acute leaf apex. The frequency distribution of various leaf base shapes were 39.39, 17.14, 28.57 and 17.14 percent respectively for oblique, rounded, cuneate and shortly attenuate leaf base shapes.

2.3.3 Inflorescence characters

According to Moncur (1985), male inflorescences were produced first in jack trees, and they were usually more numerous than female inflorescence.

Among the jack fruit tree 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 studied populations had female flowers on main trunk, primary, secondary and tertiary branches (Muthulakshmi, 2003).

Ali *et al.* (2015) observed that the flowering time of various jack types varied from 4th week of January to 3rd week of February. The time of harvesting was within 4th week of May to 2nd week of July. The fruits of germplasm AH Bur-001 were harvested in the 4th week of May while the fruits of germplasm AH Bur-008 were harvested in the 2nd week of July.

Rahman *et al.* (2016) evaluated yield and quality of three jackfruit genotypes and recorded date of appearance of first male as well as female inflorescence in each tree. First they observed the male inflorescence in APHah-2 (24/10/2013), whereas APHah-1 (18/12/2013) bloomed last, while first female flower emerged on APHah-2, 40 days prior to that of APHah-1.

2.3.4 Fruit characters

Sharma *et al.* (2005) compared 10 genotypes of jackfruit from various locations in Uttar Pradesh during 2001 to 2002 and observed that it took about 110 to 150 days from flowering to fruit maturity.

Bhanu *et al.* (2006) extensively studied the developmental modifications during maturation of 10 jackfruit clones and best result in terms of fruit quality was obtained when NSP-1 took 150 days from flower emergence to fruit maturity.

According to Yap (1972), the fruit could mature in 79-163 days or might be as long as 180-240 days after the emergence of flowering spikes.

According to Haq (2006), fruit growth and maturation normally took 5 months after fruit set but harvesting could be done even after 4 months. In cooler places and higher altitudes, fruit maturation took longer time.

In North India, the optimum maturity period was around 180 days from the spike emergence, and these fruits gave good finished products (Teaotia and Awasthi, 1968).

According to Craig and Harley (2006), the jackfruit bore primarily on the trunk and interior part of main branches; usually weighed about 4.5 to 30 kg.

According to Gomez *et al.* (2015), the normal season of harvest of jackfruit in Kerala was from March to May. They did quality evaluation of 18 accessions of jackfruit at College of Horticulture, Thrissur and noted that all the accessions including two check varieties (Muttom Varikka and Sindhoor) were seemed to be regular in bearing. They reported variability in fruit shape as ellipsoid, oblong, long oblong, high spheroid and obovate. Rind percent was found to be minimum for AH-1 (11.13%) whereas core percentage in the fruits was at a range of 4.16 to 11.38 per cent. The texture of flakes of 5 accessions was crisp, 2 were firm, 9 were coarse and 2 were melting. The variations observed in shape of seeds were ellipsoid, oblong, spheroid and oval.

Medagoda (2011) extensively surveyed in Srilanka to identify superior jack trees and revealed that there were 2 fruiting seasons, a major season (March - June) and minor season (November - January). Fruits of different rind colour like green, green-yellow and reddish yellow were also reported.

Muthulakshmi (2003) grouped accessions into three based on flowering and bearing season, as (1) early flowering (September-October) and early bearing (December-February), (2) mid-season flowering (November-January) and mid-season bearing (March-Mary) and (3) late flowering (February-March) and late bearing (June-August). Variation was noticed with respect to jackfruit shape as broadly ellipsoid, oblong, high spheroid, spheroid, ellipsoid, obloid, clavate and irregular while variation in jackfruit rind thickness ranged from 0.28 cm to 3.93 cm. Flake shape was observed to be varied as cordate, twisted, spheroid, elongated-obovate, rectangular, oblong with curved tip and irregular.

Significant variation in fruiting season of ten open pollinated fruits of jackfruit collected from elite clones of Southern Karnataka were reported by Reddy *et al.* (2004). They observed early bearing (January - February) in Accession No. G7, mid season bearing (April) in Accession No. G12 and late bearing (July) in Accession No. G1. Fruit shape varied as oblong in Accession No. G1 and ellipsoid in Accession No. G15.

Influence of bearing position on fruit characteristics of jackfruit were investigated by Nazrul *et al.* (2004) at Hill Agricultural Research station, Khagrachari. They observed four bearing positions, i.e. main trunk, primary, secondary and tertiary branches. The fruits of main trunk possessed more number of flakes, percentage of edible portion and seed pulp ratio, whereas that of tertiary branches were superior in respect of TSS, pulp weight, taste and flavour.

Aswini *et al.* (2015) performed morpho-molecular characterization of jackfruit accessions and observed the fruit clustering habit of various accessions. Number of fruits per tree varied from 21 to 135 fruits per tree while the average fruit weights were in the range of 1.65 kg to 20.00 kg.

Ali *et al.* (2015) reported maximum number of fruits in AH Bur-001 (220 fruits) and minimum in AH Bur-004 (33). Single fruit weight of each germplasm was in the range of 5.0 to 7.5 Kg. Larger fruit (7.5 kg) was obtained in AH Bur-008 and smaller fruit (5.0 kg) in AH Bur-009. Out of the ten germplasms, four were reported to produce oblong shaped bulbs whereas remaining six produced long bulbs.

According to Rai *et al.* (2003), number of fruits per plant were found to be highest (52) in HPJS-4/5 whereas it was lowest (4) in HPJS-9/2. They reported various fruit shape such as ellipsoid, oblong, spheroid and clavate and noticed fruit diameter at a range of 29.8 to 46 cm. The number of flakes per fruit was noticed as 90 to 333 and average flake length varied from 10.3 to 33.5 cm. The flake width varied from 2.7 to 5.0 cm. Fruit rind weight was minimum (1.5 Kg) for both HPJS-3/2 and HPJS-3/2. They classified fruits as excellent, good, intermediate and poor based on attractiveness. The highest number of flakes per fruit (298) was observed in HPJS-10/1 and minimum (48) in HPJS-5/1.

Ibrahim *et al.* (2013) reported fruit shape as ellipsoid, oblong and spheroid and all the fruits under investigation showed spiny fruit surface.

As per the study conducted by Sarker and Zuberi (2011), fruit stalk length was found to be maximum in older trees (17.66 cm) and minimum in younger

trees (12.48 cm). The fruit stalk diameter was maximum in older trees (19.5 cm) and minimum in younger trees (16.04 cm, 11.26 cm).

Khan *et al.* (2010) evaluated 900 jack trees in multiple locations and observed maximum fruit stalk length in homesteads (7.60 cm) and minimum in forest/fallow areas (6.67 cm), whereas maximum fruit stalk diameter was observed in homesteads (13.53 cm) and minimum in forest or fallow areas (9.12 cm).

Jagadeesh *et al.* (2007) studied ninety five jackfruit types selected from Western Ghats of India and reported that the broadest fruit (24.11 cm) was placed in Cluster-D and the narrowest fruit (19.50 cm) was placed in Cluster-E. They reported highest fruit weight (14.86 kg) in Cluster-C followed by 11.74 kg in Cluster-B and minimum fruit weight (4.68 kg) in Cluster-E. While highest rind weight (4.85 kg) was observed in Cluster-B, followed by 4.05 kg in Cluster-C and the lowest rind weight was found in 2.06 kg in Cluster-E. They also reported that the thickest skin (1.44 cm) in Cluster-A followed by 1.30 cm in Cluster-E and the thinnest skin (1.03 cm) in Cluster-D.

Krishnan *et al.* (2015) conducted a study at Regional Agricultural Research Station, Kumarakom during 2011-2014 to assess the variation in fruit quality and bearing habit of jackfruit trees of 10 promising genotypes grown under agro-climatic conditions of Kuttanad. The evaluation showed significant difference in physical properties among the jackfruit selections. The individual fruit weight ranged from 1.69 kg to17.50 kg. The highest fruit weight (17.50 kg) was recorded in APJ-1 and lowest weight (1.69 kg) was observed in KKJ-2.

The number of days from flowering to fruit maturity was minimum (117) in AHPah-1 whereas it was maximum (169) in AHPah-2 (Rahman *et al.*, 2016). The number of fruits per plant was exceedingly higher (73) in AHPah-1 whereas minimum number (41) was found in AHPah-2. With respect to the length of fruit, AHPah-2 reportedly produced the longest fruit (37.25 cm) whereas AHPah-3 recorded the highest fruit diameter (27.00 cm). Maximum average fruit weight

(8.40 kg) per fruit was observed in AHPah-2 and minimum was in AHPah-1 (3.40 kg). Among the three genotypes, AHPah-2 had the maximum weight of rind and rachis as well as highest fruit rind thickness (1.00 cm). Number of flakes per fruit was maximum (116) in AHPah-1, whereas minimum (63) in AHPah-3. Maximum weight of flakes per fruit (4.24 kg) was noticed in AHPah-2. Highest seed weight (639g) was recorded in AHPah-2

Sabiha *et al.* (2006) conducted an experiment to evaluate 28 selected off season jackfruit germplasm of Bangladesh and significant variation was observed in fruit weight which ranged from maximum (13.63 kg) in Germplasm No. 6 to minimum in Germplasm No.16 (3.00 kg). The maximum weight of seed per fruit was noted (1.27 kg) in Germplasm No-6 followed by Germplasm No-27 (1.03 kg), Germplasm No-1 (0.99 kg) and lowest in Germplasm No-16 (0.33 kg).

According to Goswami *et al.* (2010), maximum seed weight of 1000 seeds (5.56 kg) was recorded from Modhupur Ghila followed by Valuka Khaja (5.15 kg) and Valuka Dorasha (5.14 kg) while lowest seed weight of 1000 seeds (3.59 kg) was found in Valuka Ghila.

Jagadeesha *et al.* (2010) reported that the maximum bulb mass was observed in UKB-24 (10.03 kg) followed by DKB-5 (9.28 kg), UKB-4 (7.46 kg), UDP-31 (6.24 g) and minimum in UDK-6 (0.59 kg) in Coastal Karnataka while highest seed weight was observed in DKB-5 (3.66 kg) followed by UKB-24 (2.19 kg), UDP-31 (2.12 kg) and lowest seed weight in UDK-6 (0.19kg) based on the study of different jackfruit germplasms.

Singh *et al.* (2011) reported maximum average number of flakes per fruit (342.2) in T-02 followed by T-09 (293.30) and least average number of flakes per fruit (162.8) was observed in TCJ-03. The maximum average length of flakes (5.54 cm) was noted in FSO-5 followed by T-02 (5.41 cm) and the least average length of flakes (3.04 cm) was recorded in T-05. Similarly, the maximum average width of flakes (3.25 cm) was found in T-09 followed by FSO-05 (3.09 cm). The least average width of flakes (1.84 cm) was observed in TCJ-03.

Characteristics such as weight, length, diameter and girth of fruits, number of bulbs per fruit, percentage of pulp, percentage of rachis and percentage of rind were found to be poorly correlated with environmental factors indicating that these characters might be genetically controlled. Other characters, such as seed weight, bulb weight, brix (%) were found to be affected by environmental and genetic factors (Azad and Jones, 2007).

2.3.5 Qualitative analysis

2.3.5.1 Moisture content of unripe and ripe flakes

Goswami *et al.* (2011) experimented the physical properties and chemical composition of three types of jackfruit (Khaja, Dorasha and Ghila) collected from Valuka and Modhupur region of Bangladesh. They compared the moisture contents of pulp and it was highest in Valuka Ghila (84.44%) where as it was least in Modhupur Ghila (79.62%).

According to Ibrahim *et al.* (2013) maximum moisture content (76.62%) was found in cultivar AH006 while minimum dry matter (23.38%) was found in AH006. Aswini *et al.* (2015) reported moisture content in ripe flakes ranged from 29 to 74 per cent in accession 9 & 17 respectively.

2.3.5.2 Total Soluble Solids (TSS)

Maiti *et al.* (2002) carried out an investigation on 44 genotypes of jackfruit and observed variation in the total soluble solids. They reported the maximum TSS in Cluster-13 (25.9°Brix) followed by Cluster-4 (21.6°Brix), Cluster-5 (21.5°Brix) and lowest value was observed in Cluster-9 (15.1°Brix).

Jagadeesh *et al.* (2007) reported variation of TSS while evaluating ninety-five jackfruit types selected from Western Ghats of India and it ranged from 19.87°Brix to 35°Brix, and maximum TSS was recorded in SMG-5 (35°Brix) followed by SMG-4 (34.33°Brix), SMG-2 (33.67°Brix) and lowest in SMG-3 (19.87°Brix).

Jagadeesha *et al.* (2010) carried out an evaluation of 30 jackfruit selections from Coastal zone of Karnataka and reported a variation of TSS from 16.13°Brix (UDK-7) to 35°Brix (UKH-22).

Goswami *et al.* (2010) conducted a study of three types of jackfruit (Khaja, Dorasha and Ghila) pulps and observed variations in total soluble solids of pulp of different types. The highest total soluble solid was observed in Valuka Dorasha (27.0%) whereas the lowest was found in Valuka and Ghila (19.3%).

Singh *et al.* (2011) carried out an evaluation of jackfruit germplasms and reported that the maximum average TSS (32.20°Brix) was recorded in germplasm TCJ-04 followed by T-08 (31.2°Brix) and the least (14.60°Brix) in germplasm T-02.

The germplasm AH Bur-001 and AH Bur-003 showed the greater sweetness (TSS value of 22°Brix) and the germplasm AH Bur-005, AH Bur-008 and AH Bur-010 had less sweetness indicating TSS value of 18°Brix (Ali *et al.*, 2015).

Krishnan *et al.* (2015) conducted a study in jackfruit germplasm at Regional Agricultural Research Station, Kumarakom during the year of 2011-2014 and total soluble solid was highest in the selection KCJ-1 (31.80°Brix) followed by KVJ-2 (26.50°Brix).

2.3.5.3 Acidity

The total titrable acidity in jackfruit was low (0.13% as citric acid) and it showed little change during ripening. Citric and malic acids are the non-volatile acids present. Their concentration declined, more for malic acid, and resulted in an increased citric:malic acid ratio in the ripe fruit (Selvaraj and Pal, 1989).

Jackfruit was known to have high titrable acidity in the top and middle portion of the fruit and the citric acid content observed throughout the ripening process was found to be in the range of 0.3–0.9%. The dominant organic acids present in jackfruit were malic acid and citric acid, with succinic and oxalic acids in traces (Saxena *et al.*, 2009).

Goswami *et al.* (2011) conducted a study of three types of jackfruit named Khaja, Dorasha and Ghila pulps collected from different growing areas for a period of 6 months. They reported greater value of titrable acidity of pulp in Valuka Ghila (0.91%) whereas the lowest was recorded in Modhupur Khaja (0.46%).

According to Singh *et al.* (2011), the maximum average acidity (0.22%) was observed in the cultivar T-02 followed by FSO-03 in jackfruit germplasm. The least average acidity (0.02%) was found in germplasm T-10. Ibrahim *et al.* (2013) reported highest acidity (0.075%) in AH-009 followed by AH-008 (0.068%) whereas AH-005 had the lowest value (0.037%).

2.3.5.4 Sugars

According to Ghosh (1996), the edible jackfruit bulb contained fructose, glucose and sucrose. While sucrose was the major sugar besides fructose and glucose in varikka type fruits. A threefold increase in sucrose content was observed during ripening whereas the concentration of glucose and fructose increased six and five-fold respectively during the maturity stage to ripe stage.

Jagadeesh *et al.* (2007) surveyed and studied 24 firm-type jackfruit clones in Western Ghats of India. Content of total sugars ranged from 19.1% to 32.1%. Jagadeesha *et al.* (2010) reported that the contents of total sugars of 30 jackfruit selections from coastal zone of Karnataka ranged from 18.10 per cent (UKB 25) to 25.10 per cent (UKH 22).

Goswami *et al.* (2010) carried out a study of three types of jackfruit named Khaja, Dorasha and Ghila pulps and reported that higher total sugar content was recorded in Ghila types than Khaja types and lowest total sugar content was observed in Valuka Dorasha (17.89%).

Ibrahim *et al.* (2013) reported highest total sugar content (17.01%) in AH-001 whereas least (11.84%) in AH-003. Maximum reducing sugar content

(4.59%) and maximum non reducing sugar content (12.42%) were found in AH-001.

Krishnan *et al.* (2015) carried out investigation on various jackfruit germplasms of Kuttanad region of Kerala and reported that the selection KVJ-1 (61.88%) showed highest value for percentage of total sugars. The reducing sugar was highest in KCJ (9.39%).

2.3.5.5 Carotenoid content

According to Selvaraj and Pal (1989) Vitamin A content of jackfruit was moderate (540 IU) and it increased during ripening.

Physico-chemical characters of 30 jack type were studied by Jagadeesha *et al.* (2010) in College of Horticulture, Arabhavi, Karnataka and they reported carotenoid content in ripe flakes in a range of 0.251 mg/100g pulp in UDK-5 to 0.701 mg/100g pulp in UDP-32.

Deb *et al.* (2013) made quality evaluation of 16 jackfruit genotypes in Eastern and North-Eastern India and reported β-carotene content as 311.2 to 496.7 µg/100g pulp. Aswini *et al.* (2015) reported that the β carotene content of fresh flakes ranges from 0.99 to 12.94 mg/100g.

Gomez *et al.* (2015) noted that total carotenoids varied significantly in all the accessions of jack fruit. Total carotenoid content varied from 209.5 to 3131.5 µg/100g pulp. Highest total carotenoid content was found in accession AH-2 while the lowest was observed in AH-1. Total carotenoids in AH-2 were higher than that in the check cultivar Muttom Varikka. Their findings indicated that the colour of flakes was directly correlated with the total carotenoid content.

2.3.5.6 Fiber content

Goswami *et al.* (2011) evaluated the physical properties and chemical composition of three jackfruit types (Khaja, Dorasha and Ghila) and reported that

the fiber content was more or less in the range of 0.50 to 0.65 per cent, with an exception of Modhupur khaja with a value of 0.90 per cent.

Proximate analysis of *Artocarpus odoratissimus* (Tarap) samples obtained from three different locations in Brunei Darussalam revealed a fiber content in a range of 2.8 to 4.2 g/100g flesh (Tang *et al.*, 2013).

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Field evaluation of promising jack fruit (*Artocarpus heterophyllus* Lam.) types" was conducted in Kasargod district during the period from December 2016 to July 2018. The experiment focused on field evaluation of already surveyed, identified and characterized jackfruit types by Nimisha (2016) in Kasaragod district with emphasis on special characters like early bearing, cluster bearing, seedlessness, free from latex and table quality.

3.1 LOCATION

Kasargod district is the northernmost district of Kerala, India. It is situated at latitude of N 12° 30' 5" and longitude of E 74° 59' 24". It lies 19 m above MSL and experiences a warm humid climate. The present evaluation was conducted *in-situ* in the farmer's field. The details of farmers holding the promising trees of jack types and the check varieties are shown in Appendix I.

3.2 GPS READING OF TREES

The location of trees of each jack type as well as check varieties were recorded by using GARMIN etrex 30 GPS recorder and recorded latitude and longitude is shown in Appendix II and the location of trees are plotted in map (Appendix III).

3.3 METEOROLOGICAL DATA DURING THE STUDY

Meteorological data during the study was collected from Regional Agricultural Research Station (North-Zone), Pilicode (Appendix-IV).

3.4 FIELD EVALUATION

Field evaluation was done by observing various characters of jack related to morphological and yield characters. Descriptor for jackfruit developed by IPGRI (2000) was used as the basis for evaluating morphological characters of the tree and fruit. The jackfruit types selected for the study are shown in the table below:-

Special characters of selected jackfruit types for field evaluation

Sl. No.	Jack type	Special character
1	KJ 121	Fruiting thrice in a year
2	KJ 173	Flakeless jack (Small fruits without flakes)
3	KJ 180	Seedless (flakes with rudimentary seeds)
4	KJ 182	Cluster jack (small to medium sized fruits produced in clusters), high TSS
5	KJ 183	Off season ripening (August-September) with good fruit quality
6	KJ 185	Very early ripening (December), high TSS, good flavor
7	KJ 186	Early ripening (February), attractive flake colour, high TSS
8	KJ 224	High TSS, medium sized fruits
9	KJ 356	High TSS, more number of fruits
10	KJ 397	Gumless
11	Muttom Varikka	Check variety
12	Singapore jack	Check variety

Three well developed fruits from each genotype were harvested and brought to Horticultural Laboratory of College of Agriculture, Padannakkad and cut after ripening to record observations on fruit characters.

Field evaluation was carried out based on following parameters.

3.4.1 Tree growth characters

3.4.1.1 Age of the tree

Age of tree of each jack type was collected through questionnaire from respective farmers. The questionnaire used is included as Appendix V.

3.4.1.2 Trunk height

Trunk height was recorded from the base of the tree to the point of emergence of first branch and expressed in centimetres.

3.4.1.3 Trunk circumference

Trunk circumference was recorded at 50 cm above ground level for trees raised through seedlings, as per IPGRI descriptor for jackfruit.

3.4.1.4 Tree vigour

Tree vigour was visually observed as per IPGRI descriptor (IPGRI, 2000) and classified as low, medium and high.

3.4.1.5 Trunk surface

The trunk surface character of each tree were observed and classified as smooth, rough and very rough as per IPGRI descriptor.

3.4.1.6 Crown shape

The tree crown shape was observed and differentiated based on IPGRI descriptor.

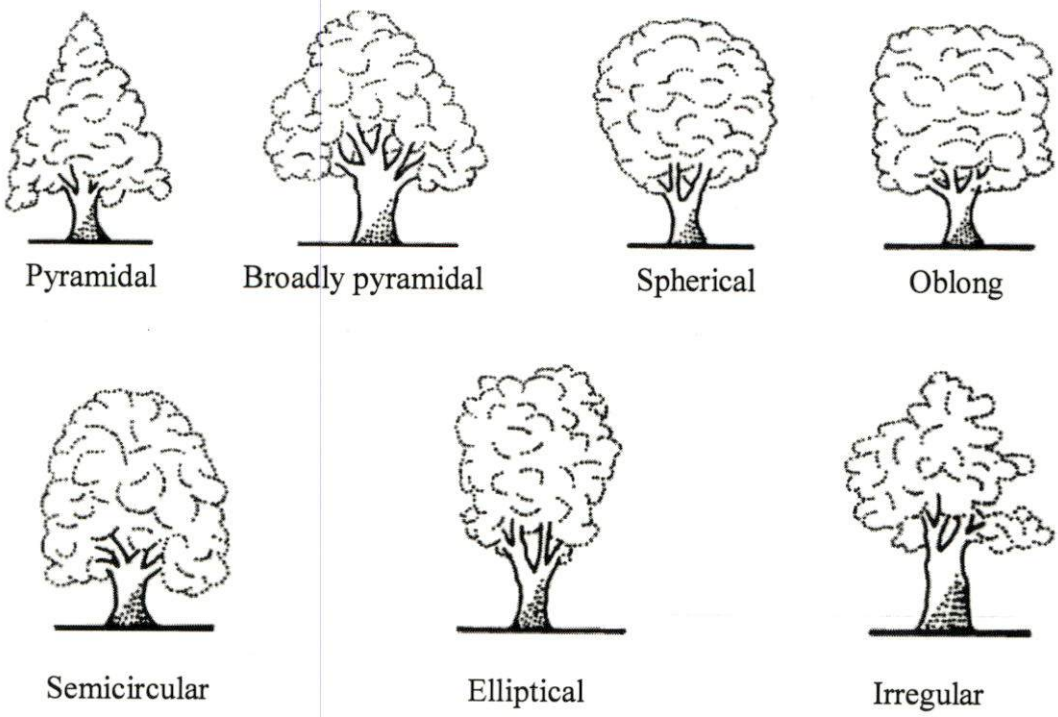


Fig. 1: Crown shapes of jackfruit as per IPGRI descriptor

3.4.1.7 Branching density

The branching density of each tree was assessed and grouped as sparse, medium and dense as per IPGRI descriptor.

3.4.2 Leaf characters

Leaf characters were recorded from 20 fully expanded healthy leaves collected from various parts of tree, when branches got lignified and the average was worked out.

3.4.2.1 Leaf length

Leaf length (cm) was measured from the base to the tip of the leaf blade.

3.4.2.2 Leaf width

Leaf width (cm) was measured at the widest portion of the leaf.

3.4.2.3Petiole length

Petiole length was measured from the base of petiole to the base of leaf blade in mature leaf and expressed in centimeters (cm).

3.4.2.4 Leaf shape

The leaf shape of individual trees was observed and classified as elliptic, narrowly elliptic and obovate based on IPGRI descriptor.

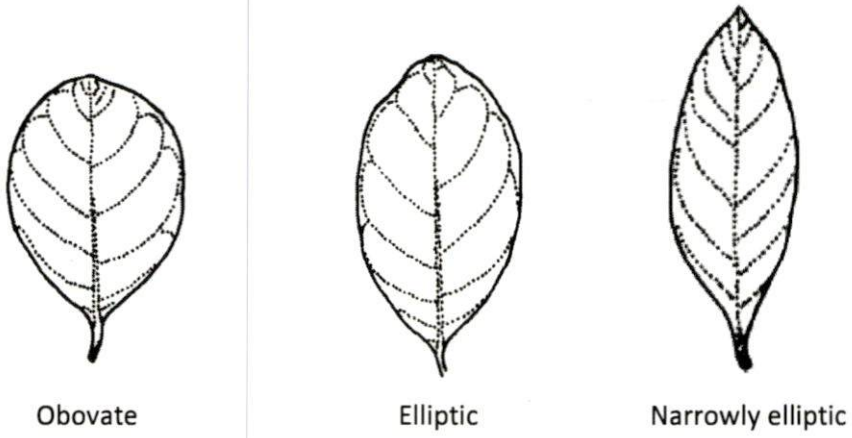


Fig. 2: Leaf blade shapes of jackfruit as per IPGRI descriptor

3.4.2.5 Leaf apex

Leaf apex shape of trees was observed and recorded as acute, acuminate, retuse and obtuse.

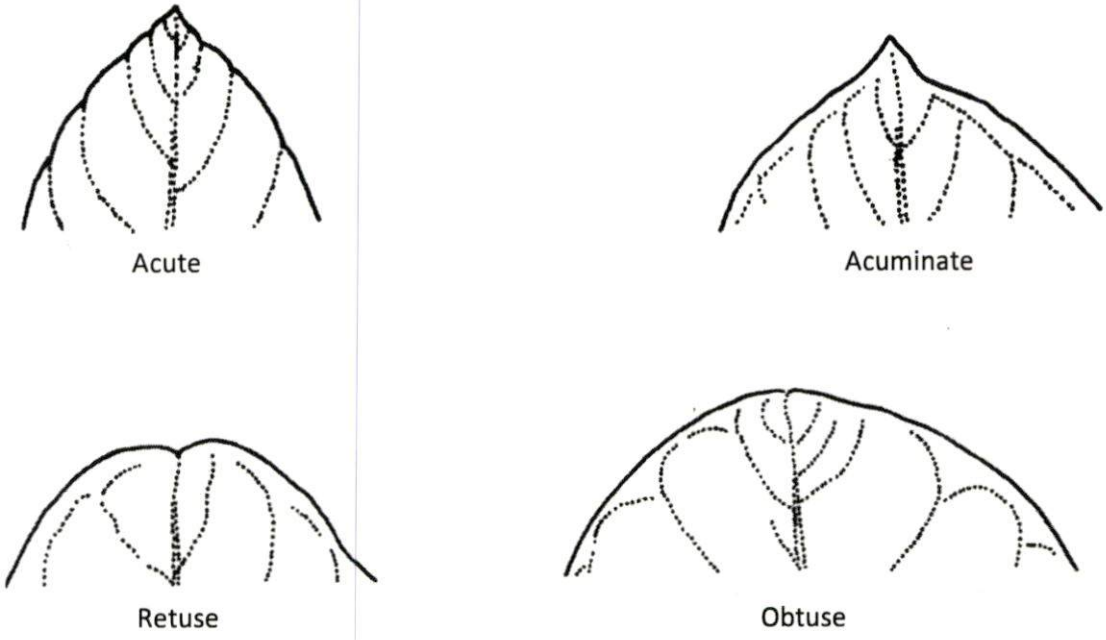


Fig. 3: Leaf apex shapes of jackfruit as per IPGRI descriptor

3.4.2.6 Leaf base

Leaf base shapes of the trees were recorded and classified as oblique, rounded, cuneate and shortly attenuate.

Fig. 4: Leaf base shapes of jackfruit as per IPGRI descriptor

3.4.2.7 Leaf margin

Leaf margin was observed and grouped as entire and undulate.

3.4.2.8 Leaf colour

Leaf colour was evaluated at the adaxial side of the fully matured leaf and categorized as light green, green and dark green based on IPGRI descriptor.

3.4.3 Inflorescence characters

Inflorescence characters were recorded by frequently visiting the trees and through visual observations.

3.4.3.1 Date of appearance of 1st male inflorescence

Date of appearance of first male flower in each tree was observed and recorded.

3.4.3.2 Date of appearance of 1st female inflorescence

Date of appearance of first female inflorescence in each tree was recorded.

3.4.4 Fruit bearing characters

3.4.4.1 Number of years to first fruiting after planting

The duration of pre-bearing period of each tree were collected from respective farmer by questionnaire.

3.4.4.2 Number of days from flowering to fruit maturity

Duration in days from date of appearance female flower to fruit maturity of each jack type was recorded.

3.4.4.3 Start of fruiting season

The date on which the first fruit of each jack type got matured or harvested was recorded.

3.4.4.4 End of fruiting season

The date on which the last fruit in each tree got matured or harvested was recorded.

3.4.4.5 Fruiting season

Time of fruiting was recorded in each jack type and classified as early, mid and late season bearing.

3.4.4.6 Fruit bearing habit

Regularity in bearing of each jack type was enquired from respective farmers through questionnaire, and classified as regular and alternate bearers as per IPGRI descriptor.

3.4.4.7 Fruit bearing position

Fruit bearing position of each tree was visually observed and recorded as main trunk, primary branch and secondary branch.

3.4.4.8 Fruit clustering habit and number of fruits per cluster

Fruit clustering habit of each jack type was observed and classified as solitary and clustering as per IPGRI descriptor. In the case of cluster bearing types, number of fruits per cluster was recorded.

3.4.5 Fruit characters

Fruits were harvested at mature unripe stage by cutting the peduncle with a sharp knife and by traditional methods, such as the use of ropes and sickles for upper fruit harvesting and hand picking for lower fruits. Then it was transported to the laboratory and kept for ripening. Ripened fruits were cut open to observe fruit characters. The minimum sample size in each jack type was three fruits and each fruit was considered as a replication.

3.4.5.1Fruit stalk length

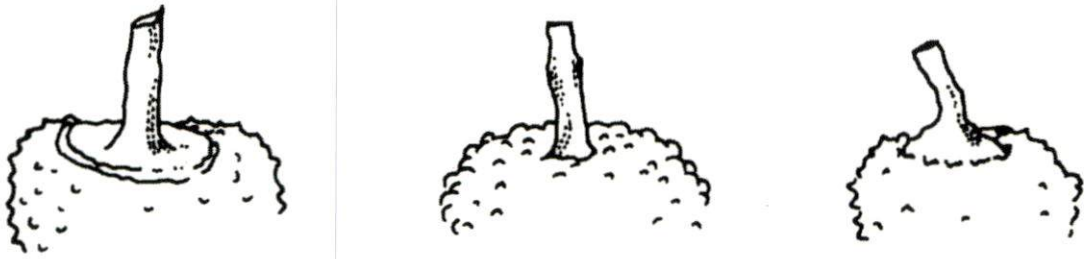
Stalk length of three fruits of each tree was measured from the base of the peduncle to the base of fruit at maturity and the average was worked out and presented in centimetres.

3.4.5.2 Fruit stalk diameter

Stalk diameter was measured at 5 cm from the base of fruit and worked out average of stalk diameter of three fruits per tree and presented in centimetres.

3.4.5.3 Stalk attachment to fruit

The way of attachment of fruit to the stalk is visually observed and classified as depressed, flattened and inflated as per IPGRI descriptor.



Depressed Flattened Inflated

Fig. 5: Stalk attachment to fruit in jackfruit as per IPGRI descriptor

3.4.5.4 Fruit length

Length of three individual fruits was measured by metre scale and that were analyzed statistically and expressed in centimetres.

3.4.5.5 Fruit diameter

Fruit diameter was measured at the widest point of fruit by metre scale and expressed in centimetres.

3.4.5.6 Fruit shape

Fruit shape of each jack type was observed visually and classified as obloid, spheroid, ellipsoid, clavate, oblong and irregular based on IPGRI descriptor.

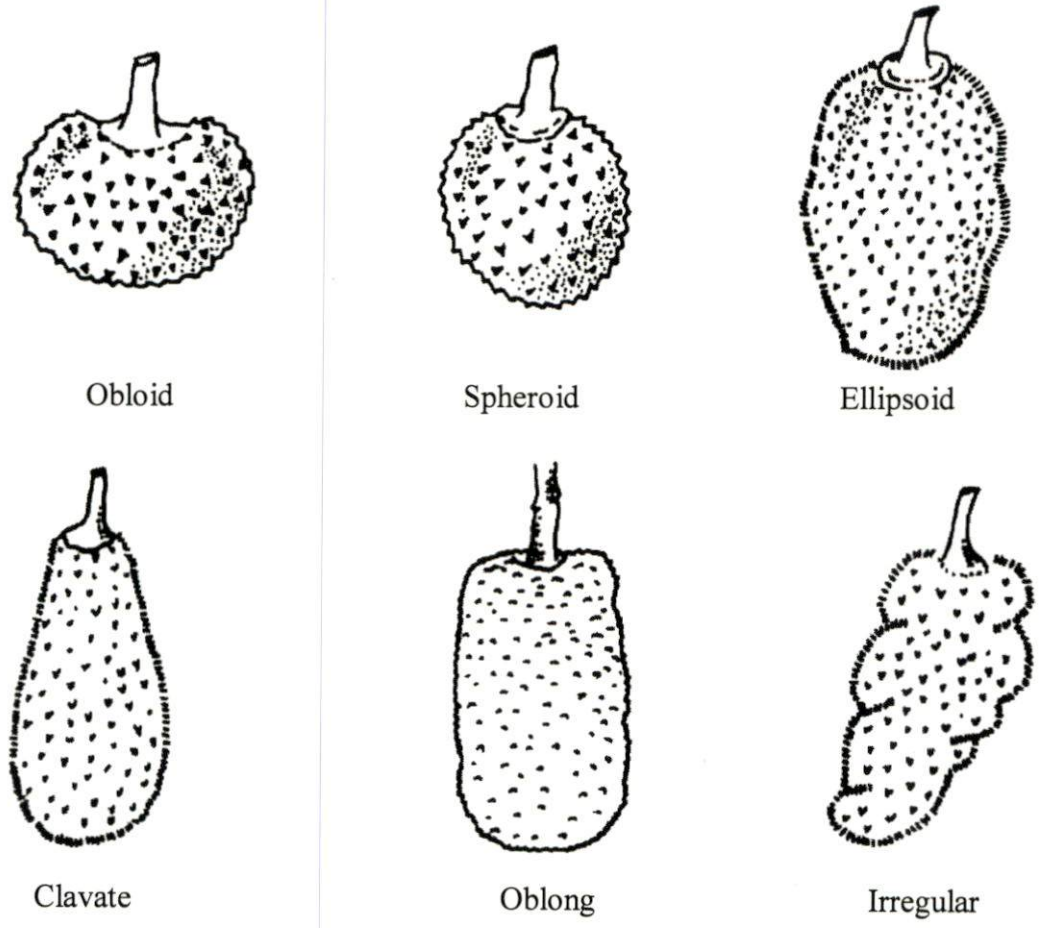


Fig. 6: Fruit shapes of jackfruit as per IPGRI descriptor

3.4.5.7 Fruit surface

The surface characteristics of fruit was observed and classified as smooth or spiny.

3.4.5.8 Fruit attractiveness

Fruit attractiveness was scored by considering the general appearance of fruit as a whole and classified as poor, intermediate, good and excellent.

3.4.5.9 Fruit weight

Three matured fruits from each jack type was used to find out the mean fruit weight. The ripened fruits where weighed by using electronic balance and weight expressed in kilograms (kg).

3.4.5.10 Number of fruits per tree

The number of fruits borne on each tree was recorded.

3.4.5.11 Fruit yield per tree

Fruit yield per tree was calculated by multiplying number of fruits per tree with the average fruit weight of each tree and expressed in kilograms.

3.4.6 Flake characters

3.4.6.1 Flake length

The length of 20 flakes of each fruit was measured by using meter scale and took average and expressed in centimeters.

3.4.6.2 Flake width

Width of 20 flakes from each fruit was measured and the average value expressed in centimeters.

3.4.6.3 Flake thickness

Thickness of flakes was measured at the middle portion of flakes by using screw gauge. The average value of 20 flakes was expressed in millimeters.

3.4.6.4 Flake shape

The flake shape of each jack type was observed visually and was differentiated as spheroid, cordate, twisted, obovate, rectangular, oblong with curved tip and irregular based on IPGRI descriptor.

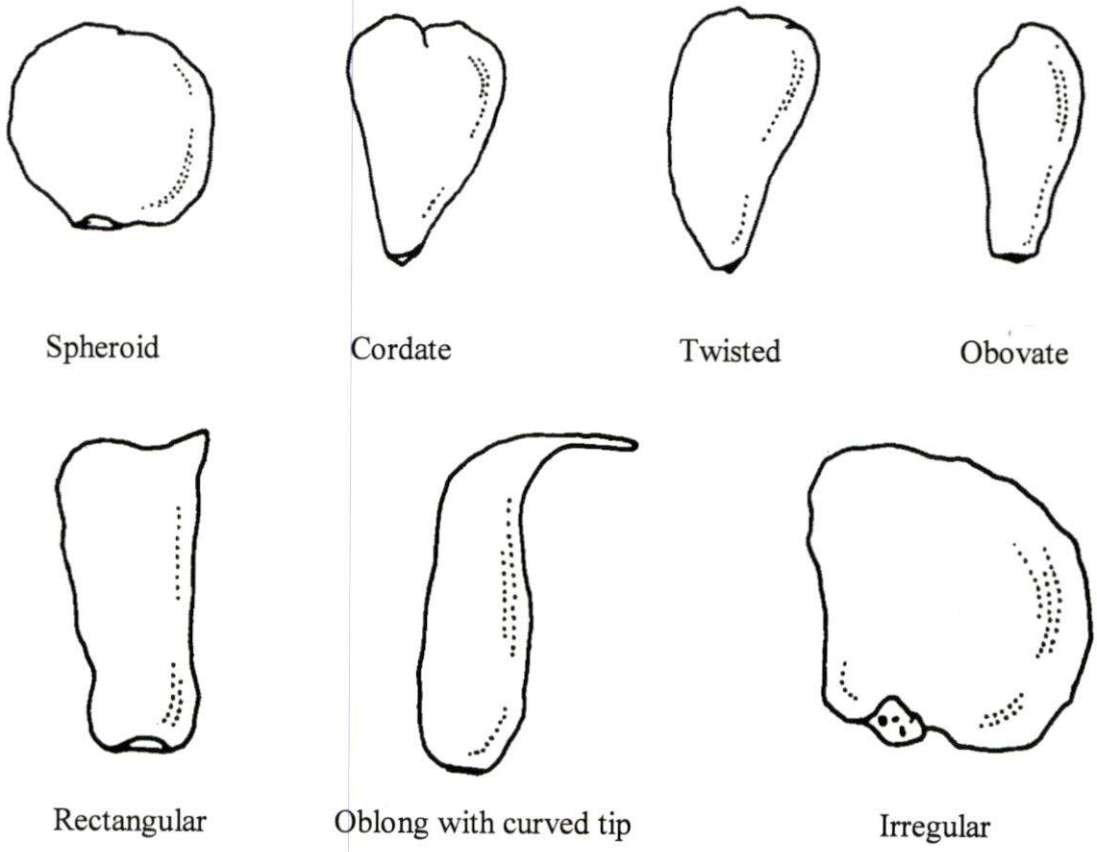


Fig. 7: Flake shapes of jackfruit as per IPGRI descriptor

3.4.6.5 Flake colour

Colours of the flakes were recorded by visual observation at ripened stage and classified into deep yellow, yellow, light yellow and creamy white as per IPGRI descriptor.

3.4.6.6 Flake texture

Flake texture of each jack type was recorded by organoleptic scoring as per IPGRI descriptor and classified as soft, firm, coarse, fibrous and melting.

3.4.6.7 Weight of flakes per fruit

The weight of flakes per fruit was obtained by weighing the bulbs in a fruit without seed and expressed in kilograms.

3.4.6.8 Number of flakes per fruit

The total number of flakes within a fruit was counted.

3.4.6.9 Flake/fruit ratio

Contribution of flake weight to the total fruit weight was worked out as given below:-

$$\text{Flake/fruit ratio} = \frac{\text{Weight of flakes per fruit (kg)}}{\text{Total fruit weight (kg)}}$$

3.4.6.10 Flake/seed ratio

Ratio of total weight of flakes and the total weight of seeds was worked out as :-

$$\text{Flake/seed ratio} = \frac{\text{Total weight of flakes per fruit (kg)}}{\text{Total weight of seeds per fruit (kg)}}$$

3.4.7 Seed characters

3.4.7.1 Seed shape

The shape of seeds of each jack types was observed visually as per IPGRI descriptor and classified as spheroid, ellipsoid, elongate, oblong, reniform and irregular.

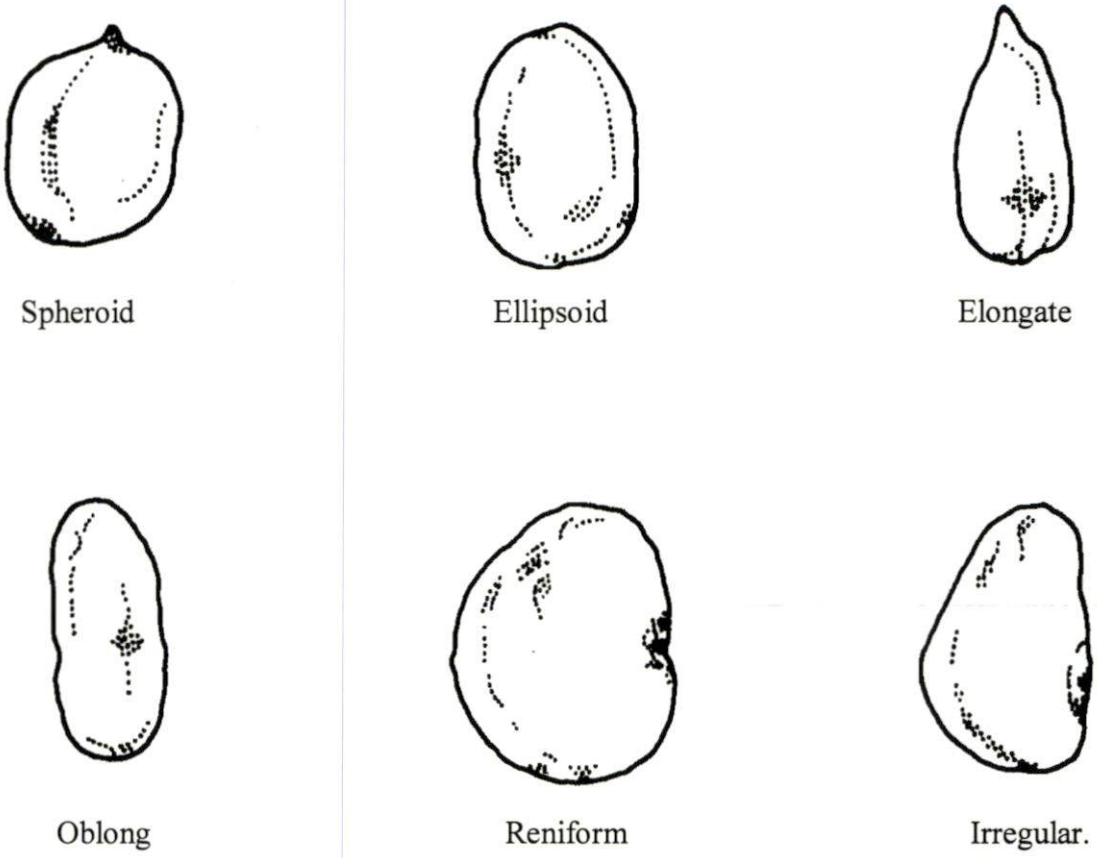


Fig. 8: Seed shapes of jackfruit as per IPGRI descriptor

3.4.7.2 Seed weight

The total weight of all seeds within a fruit was recorded by using electronic balance and expressed in kilograms (kg).

3.4.8 Edible and non-edible parts

Observations on the edible and non-edible parts of fruits were taken as described below:-

3.4.8.1 Weight of edible portion

Weight contribution of flakes and seeds together was weighed and expressed in kilograms (kg).

3.4.8.2 Fruit rind thickness

Rind thickness of each fruit was observed at the thickest point of rind of dissected fruit and expressed in cenimetres.

3.4.8.3 Fruit rind weight

Weight contribution of fruit rind was recorded by using electronic balance and expressed in kilograms (kg).

3.4.8.4 Perigone weight

The total weight of perigones (unfertilized female flowers) was recorded with electronic balance and expressed in kg.

3.4.8.5 Core weight

Total weight of peduncle/core content within in a fruit was weighed in electronic balance and expressed in kg.

3.4.9 Fruit quality parameters

3.4.9.1 Determination of moisture content of unripe and ripe flakes

Moisture content of flakes was determined by following the procedure given by Ranganna (1991). Two gram sample was taken in pre-weighed aluminium dish. It was kept in a vacuum air oven and dried for 6 hours at 70°C and 26-28 inch vacuum. After cooling in a dessicator the weight was recorded and moisture content was calculated as shown below:-

$$\text{Moisture content (\%)} = \frac{\text{Loss in weight x 100}}{\text{Weight of the sample}}$$

3.4.9.2 Determination of Total Soluble Solids

The juice of jackfruit flake was extracted by crushing the pulp of each fruit separately in each elite jackfruit tree and strained through muslin cloth. The total

soluble solid of the pulp was determined using an Erma Hand Refractometer (0 to 30°Brix range). The temperature corrections were made as described by Ranganna (1991), with the help of the temperature correction chart.

3.4.9.3 Determination of titrable acidity

Titrable acidity was estimated from the pulp of ripe jackfruits flakes belonging to different types. About 25 g fruit pulp was taken in a 250 ml beaker and boiled for 30 minutes after adding 100 ml water. The content was cooled and made upto 250 ml. About 50 ml of the prepared sample was taken and titrated against 0.1 N NaOH using phenolphthalein as indicator. The acidity was calculated by using following formula and expressed as percent of citric acid (AOAC, 1984).

$$\text{Acidity (\%)} = \frac{\text{Titre value x Normality of alkali (0.1) x 0.064 x Vol. made up x 100}}{\text{Volume of aliquot x Weight of sample}}$$

3.4.9.4 Determination of reducing sugar

Reducing sugar of fruit pulp was estimated by adopting a procedure put forth by AOAC (1984). A known weight of fruit sample was ground, filtered and transferred 25 g of filtered solution into a 250 ml volumetric flask. Added 100 ml distilled water and neutralized with 1 N NaOH. Then 2 ml lead acetate solution was added and excess lead acetate was removed by adding potassium oxalate solution and made up to 250 ml. The solution was filtered and titrated against the mixture of Fehling's solution A and B using methylene blue as indicator. The reducing sugar was calculated by following formula and expressed in per cent (%).

$$\text{Reducing sugar (\%)} = \frac{\text{0.05 x Volume made up (250 ml) x 100}}{\text{Titre value x Weight of fruit juice}}$$

3.4.9.5 Determination of total sugar

Total sugars in fruit pulp were estimated as per procedure given by AOAC (1984). About 50 ml of clarified solution, made for reducing sugar estimation was boiled for 10 minutes after adding 5 g citric acid and 50 ml water. It was neutralized using 1 N NaOH and made up to 250 ml. Then, the made up solution was titrated against a mixture of Fehling's solution A and B. The total sugar was calculated by following formula and expressed in per cent (%).

$$\text{Total sugar (\%)} = \frac{0.05 \times \text{Vol. made up} \times \text{Vol. made up after inversion} \times 100}{\text{Titre value} \times 50 \times \text{Weight of sample}}$$

3.4.9.6 Determination of non-reducing sugar

Non-reducing sugar (%) was obtained by subtracting the value of reducing sugar (%) from total sugar (%).

Non-reducing sugar (%) = Total sugar (%) – Reducing sugar (%)

3.4.9.7 Determination of carotenoid content

Carotenoid content was estimated by the method suggested by Ranganna (1991). One gram of finely cut and well mixed fruit sample was ground by pestle and mortar with addition of 20 ml of 80% acetone. Centrifuged (5000 rpm for 5 minutes) and the supernatant were transferred to 100 ml volumetric flask. Grinding with the residue was continued until the residue became colourless. Then the volume was made with 80% acetone and absorbance was recorded at 480 and 510 nm in UV- Spectrometer against the solvent (80% acetone) as blank. The carotenoid content was calculated using the following formula.

$$\text{Total carotenoid (mg/100g)} = [\,(7.6 \times A_{480}) - (1.49 \times A_{510})\,] \times \frac{V}{10 \times \text{Wt. of sample}}$$

3.4.9.8 Determination of crude fiber content

Estimation of crude fiber was done by following the methods described by Mynard (1970) and Misra *et al.* (1975). Two gram of ground dry flake was boiled with 200 ml of sulphuric acid for 30 min with bumping chips. Filtration was done through muslin cloth and washed with boiling water until washings were no longer acidic. Then, it was boiled with 200 ml sodium hydroxide solution for 30 min. Again filtration was done through muslin cloth and washed with 25 ml of boiling 1.25% sulphuric acid, three 50 ml portion of water and 25 ml alcohol. The residue was transferred to preweighed ashing dish (W_1) and then dried for 2 hrs at 130°C. The dish was cooled in a desiccator and weighed (W_2). Then, ignition was done for 30 min at 600°C, cooled in a desiccator and reweighed (W_3). The per cent of crude fiber in ground sample was calculated by using the formula,

$$\text{Crude fiber (\%)} = \frac{\text{Loss in weight on ignition}}{\text{Weight of the sample}} \times 100$$

Loss in weight on ignition = $(W_2-W_1) - (W_3-W_1)$

3.4.9.9 TSS: Acid ratio

TSS- acid ratio was calculated by dividing the total soluble solids with total titrable acidity and mean value were computed.

3.4.9.10 Sugar: Acid ratio

Sugar- acid ratio was calculated by dividing the total sugar with total titrable acidity and mean value was worked out.

3.5 STATISTICAL ANALYSIS

The data on morphological characters were recorded as per IPGRI (2000) descriptor and presented as such. The data with respect to quantitative and qualitative characters were subjected to statistical analysis using OPSTAT software (Sheoran *et al.*, 1998). The means for all the treatments were calculated

and the ANOVA worked out by F-test. The significance of difference between the pairs of means was compared by least significant difference (LSD) test at five per cent level of probability (Gomez and Gomez, 1984).

Results

RESULTS

The present study entitled "Field evaluation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types" was carried out at College of Agriculture, Padannakkad, Kasaragod during 2016-2018. The study included ten promising jackfruit types already surveyed, identified and characterized by Nimisha (2016) and two check varieties (Muttom Varikka and Singapore jack). *In-situ* evaluation of these jack types were carried out based on tree growth characters, leaf characters, inflorescence characters, fruit morphological characters and fruit quality parameters. The results of the study are presented below in this chapter.

4.1 TREE GROWTH CHARACTERS OF JACKFRUIT TYPES

4.1.1 Age of the tree

Age of the trees of various jackfruit types and check varieties are presented in Table 1. Tree age ranged from 15 to 34 years.

4.1.2 Trunk height

Ten jack types as well as check varieties showed varied trunk heights. It ranged from 45 cm to 600 cm among the twelve trees. Jack type KJ 224 recorded the highest trunk height (600 cm) and the lowest height was recorded in Muttom Varikka (45 cm). All other trees recorded intermediate values for trunk height (Table 1).

4.1.3 Trunk circumference

The trunk circumference of jack types varied from 84 cm to 245 cm, as shown in Table 1. Highest trunk circumference was observed in Singapore jack (245 cm) followed by KJ 121 (178 cm), whereas lowest trunk circumference was recorded in Muttom Varikka (84 cm).

Table 1. Tree growth parameters of jackfruit types

Sl. No.	Jack type	Age of tree (Year)	Trunk height(cm)	Trunk circumference (cm)	Tree vigour	Trunk surface	Crown shape	Branching density
1	KJ 121 - Fruiting thrice	34	410	178	Medium	Very rough	Broadly pyramidal	Medium
2	KJ 173 – Flakeless	27	188	122	Medium	Rough	Spherical	Sparse
3	KJ 180 – Seedless	20	180	115	Medium	Rough	Irregular	Medium
4	KJ 182 – Cluster	32	131	138	High	Rough	Semi circular	Medium
5	KJ 183 - Off season	24	410	109	Medium	Smooth	Irregular	Sparse
6	KJ 185 – Early	25	220	107	Low	Smooth	Irregular	Sparse
7	KJ 186 – Early	20	175	90	Low	Very rough	Irregular	Dense
8	KJ 224 - High TSS	24	600	120	High	Rough	Irregular	Medium
9	KJ 356 - High TSS	20	200	130	Medium	Smooth	Irregular	Dense
10	KJ 397 – Gumless	15	350	125	Medium	Smooth	Elliptical	Medium
11	Muttom Varikka*	15	45	84	High	Smooth	Irregular	Dense
12	Singapore jack*	31	55	245	High	Very rough	Broadly pyramidal	Medium
Range			45-600	84-245	* Trees of graft origin			
Average			247.00	130.25				
Standard Deviation			163.92	43.37				
C V (%)			66.36	33.29				

4.1.4 Tree vigour

Out of the ten jack type trees and two check varieties studied, four of them were observed to be highly vigorous (KJ 182, KJ 224, Muttom Varikka and Singapore jack) and two of them were less vigorous (KJ 185 and KJ 186). All other types were medium vigorous in growth (Table 1).

4.1.5 Trunk surface

The trunk surface of jack types were recorded as smooth, rough and very rough and presented in Table 1. Out of the twelve types, five were observed to be having smooth surface (KJ 183, KJ 185, KJ 356, KJ 397 and Muttom Varikka), four were having rough surface (KJ 173, KJ 180, KJ 182 and KJ 224) and remaining three were having very rough trunk surface (KJ 121, KJ 186 and Singapore jack).

4.1.6 Crown shape

With respect to crown shape, the jack types varied as broadly pyramidal, spherical, semicircular, elliptical and irregular (Table 1). Out of the twelve jack types, seven trees were having irregular crown shape.

4.1.7 Branching density

Based on the branching density, jack types were classified as trees with sparse, medium and dense branches. Among the twelve types, six were observed to be having medium branching density (Table 1).

4.2 LEAF CHARACTERS OF JACKFRUIT TYPES

4.2.1 Leaf length

The data in Table 2 revealed that the length of leaf differed in jackfruit types. Highest leaf length of 17.43 cm was observed in tree of KJ 185 and lowest in KJ 224 (9.87 cm).

4.2.2 Leaf width

The data on width of leaves indicated that there was difference in leaf width of various jack types (Table 2). The maximum leaf width was found in Muttom Varikka (9.43 cm) followed by KJ 182 (8.77 cm) while the minimum width (5.43 cm) was observed in KJ 397.

4.2.3 Petiole length

A close examination of the data presented in Table 2 indicated that the leaf petiole length varied among jack types. Highest petiole length (2.47 cm) was observed in the leaves of Muttom Varikka and lowest petiole length (1.47 cm) was recorded in KJ 356.

4.2.4 Leaf shape

Jack types had varied leaf shape such as obovate, elliptic and narrowly elliptic. Most of the jack types except KJ 397 and check varieties had elliptic leaves. The leaf of KJ 397 was narrowly elliptic whereas that of Muttom Varikka and Singapore jack were obovate in shape (Table 2).

4.2.5 Leaf apex

The leaf apex of jack types varied as acute, acuminate and obtuse (Table 2). Jack types KJ 121, KJ 180, KJ 183 and KJ 397 had acute apex and Muttom Varikka had obtuse leaf apex whereas all other jack types had acuminate leaf apex.

Table 2. Leaf characters of jackfruit types

Sl No.	Jack type	Leaf length (cm)	Leaf width (cm)	Petiole length(cm)	Leaf shape	Leaf apex	Leaf base	Leaf margin	Leaf colour
1	KJ 121 - Fruiting thrice	14.63	8.00	1.73	Elliptic	Acute	Oblique	Entire	Dark green
2	KJ 173 – Flakeless	14.73	7.80	1.77	Elliptic	Acuminate	Cuneate	Entire	Green
3	KJ 180 – Seedless	10.57	5.70	2.03	Elliptic	Acute	Oblique	Entire	Green
4	KJ 182 – Cluster	13.27	8.77	1.87	Elliptic	Acuminate	Shorty attenuate	Entire	Green
5	KJ 183 - Off season	14.57	7.07	1.83	Elliptic	Acute	Oblique	Entire	Green
6	KJ 185 – Early	17.43	7.93	2.43	Elliptic	Acuminate	Oblique	Entire	Dark green
7	KJ 186 – Early	15.07	7.13	1.80	Elliptic	Acuminate	Oblique	Entire	Dark green
8	KJ 224 - High TSS	9.87	6.77	1.57	Elliptic	Acuminate	Oblique	Entire	Dark green
9	KJ 356 - High TSS	13.50	7.87	1.47	Elliptic	Acuminate	Oblique	Entire	Light green
10	KJ 397 – Gumless	10.70	5.43	1.53	Narrowly elliptic	Acute	Oblique	Entire	Green
11	Muttom Varikka	12.53	9.43	2.47	Obovate	Obtuse	Cuneate	Entire	Dark green
12	Singapore jack	11.03	5.77	2.03	Obovate	Acuminate	Oblique	Entire	Green

Mean value in each column with different superscript differs significantly ($P < 0.05$).

4.2.6 Leaf base

Jack types showed variation in leaf base as oblique, shortly attenuate and cuneate. Jack types KJ 173 and Muttom Varikka had cuneate leaf base and that of KJ 182 was shortly attenuate, while all other jack types had oblique leaf base (Table 2).

4.2.7 Leaf margin

All of the jack types had entire leaf margin (Table 2).

4.2.8 Leaf colour

Wide variation was observed in leaf colour of jack types (Table 2). Jack types such as KJ 121, KJ 185, KJ 186, KJ 224 and Muttom Varikka had dark green leaves and KJ 356 had light green leaves, while all other types had green leaves.

4.3 INFLORESCENCE CHARACTERS OF JACKFRUIT TYPES

4.3.1 Date of appearance of first male inflorescence

The first male inflorescence appeared on each jack type from October 2017 to February 2018. The data on date of appearance of first male inflorescence, presented in Table 3, showed that male inflorescence appeared first in KJ 185 (04th October 2017), followed by KJ 121 (10th October 2017), KJ 186 (17th October 2017) and KJ 173 (25th October 2017). While the inflorescence appeared later in KJ 180 and KJ 397 (03rd February 2018) after Singapore jack (14th January 2018), Muttom Varikka (21st January 2018) and KJ 183 (22nd January 2018) respectively.

4.3.2 Date of appearance of first female inflorescence

First female inflorescence became visible on jack types from October 2017 to February 2018. The data presented in Table 3 indicated that first female flower emerged earliest on KJ 185 on 19th October 2017, followed by KJ 186

(14thNovember 2017), KJ 121 (25th November 2017) and KJ 173 (16th December 2017). While the first female flower emerged later on KJ 397 (23rd February 2018) after KJ 180 (20th February 2018).

Table 3. Inflorescence characters of jackfruit types

Sl. No.	Jack type	Date of appearance of first male inflorescence	Date of appearance of first female inflorescence
1	KJ 121 - Fruiting thrice	10th October 2017	25th November 2017
2	KJ 173 - Flakeless	25thOctober 2017	16th December 2017
3	KJ 180 – Seedless	03rd February 2018	20th February 2018
4	KJ 182 – Cluster	18th December 2017	06th January 2018
5	KJ 183 - Off season	22nd January 2018	10th February 2018
6	KJ 185 – Early	04th October 2017	19th October 2017
7	KJ 186 – Early	17th October 2017	14th November 2017
8	KJ 224 - High TSS	13th November 2017	02nd January 2018
9	KJ 356 - High TSS	16th November 2017	04th January 2018
10	KJ 397 – Gumless	03rd February 2018	23th February 2018
11	Muttom Varikka	21st January 2018	17th February 2018
12	Singapore jack	14th January 2018	11th February 2018

4.4 FRUIT BEARING CHARACTERS OF JACKFRUIT TYPES

4.4.1 Number of years to first fruiting after planting

The pre-bearing period of jack types varied from three to seven years (Table 4). Among these, Muttom Varikka and Singapore jack were of graft origin and all others were seedling origin. Shortest pre- bearing period was recorded in Singapore jack (3 years), followed by KJ 186 (4 years), Muttom Varikka (4

years), KJ 182 (5 years) and KJ 173 (5 years). The longest pre-bearing period (7 years) was in KJ 121, KJ 180 and KJ 356.

4.4.2 Number of days from flowering to fruit maturity

The numbers of days from flowering to fruit maturity are presented in Table 4. It ranged from 63 days to 105 days. Jack type KJ 180 took minimum days (63 days) from flowering to fruit maturity, followed by KJ 397 (66 days) and Singapore jack (67 days). But KJ 224 took 105 days, which was maximum among all jack types.

4.4.3 Start of fruiting season

Data on start of fruiting season are presented in Table 4. Most of the jack types except KJ 183 (12/05/2018) and KJ 185 (31/12/2017) commenced fruiting from February to April 2018. KJ 185 started bearing from December 2017, showed its earliness whereas KJ 183 bore fruits only during first fortnight of May 2018, and revealed its off-season bearing nature.

4.4.4 End of fruiting season

The data presented in Table 4 revealed that most of the jack types ceased fruiting by June- July 2018. Jack types KJ 185 and KJ 186 had fruits only up to April whereas in KJ 183, fruits were available till 28/08/2018.

4.4.5 Fruiting season

According to the peak fruiting season, jack types were classified as early, mid and late bearers (Table 4). Out of the twelve types, KJ 185 and KJ 186 were early bearers, KJ 183 and Muttom Varikka were late bearers while all other jack types were mid season bearers.

4.4.6 Fruit bearing habit

All the jackfruit types including 2 check varieties (Muttom Varikka and Singapore jack) were seemed to be regular in bearing (Table 4).

Table 4. Fruit bearing characters of jackfruit types

Sl. No.	Jack type	Years to first fruiting (Yr.)	Days from flowering to fruit maturity (Days)	Start of fruiting season (Date)	End of fruiting season (Date)	Fruiting season	Fruit bearing habit	Fruit bearing position	Fruit clusturing habit (No. of fruit/ cluster)
1	KJ 121 - Fruiting thrice	7	83	16/02/2018	15/06/2018	Mid	Regular	Trunk, 1°, 2°, 3°	Solitary
2	KJ 173 - Flakeless	5	68	22/02/2018	11/06/2018	Mid	Regular	Trunk, 1°	Cluster (3)
3	KJ 180 - Seedless	7	63	24/04/2018	07/06/2018	Mid	Regular	Trunk, 1°, 2°, 3°	Solitary
4	KJ 182 - Cluster	5	69	16/03/2018	14/07/2018	Mid	Regular	Trunk, 1°, 2°, 3°	Cluster (8)
5	KJ 183 - Off season	6	91	12/05/2018	28/08/2018	Late	Regular	Trunk	Solitary
6	KJ 185 - Early	6	73	31/12/2017	05/04/2018	Early	Regular	Trunk, 1°, 2°	Solitary
7	KJ 186 - Early	4	93	15/02/2018	20/04/2018	Early	Regular	Trunk, 1°	Cluster (2)
8	KJ 224 - High TSS	6	105	17/04/2018	02/07/2018	Mid	Regular	Trunk, 1°	Cluster (3)
9	KJ 356 - High TSS	7	97	11/04/2018	26/06/2018	Mid	Regular	Trunk, 1°	Solitary
10	KJ 397 - Gumless	6	66	30/04/2018	02/06/2018	Mid	Regular	Trunk	Cluster (3)
11	Muttom Varikka	4	70	28/04/2018	18/07/2018	Late	Regular	Trunk, 1°	Solitary
12	Singapore jack	3	67	19/04/2018	28/07/2018	Mid	Regular	Trunk, 1°, 2°, 3°	Cluster (2)
Range			63-105						
Average			79.00						
Standard Deviation			14.12						
C V (%)			17.87						

4.4.7 Fruit bearing position

It was observed that the fruits were borne on whole stem including trunk, primary (1°), secondary (2°) and tertiary (3°) branches in three jack types (KJ 121, KJ 180, KJ 182 and Singapore jack) while on trunk, primary (1°) and secondary (2°) branches in KJ 185. But jack types KJ 173, KJ 186, KJ 224, KL 356 and Muttom Varikka produced fruits on both trunk as well as 1° branches where as KJ 183 and KJ 397 bore fruits only on tree trunk (Table 4 and Plate 1a and 1b).

4.4.8 Fruit clustering habit

Fruit clustering habit of each jackfruit type as well as check varieties (Muttom Varikka and Singapore jack) are indicated in Table 4 and Plate 2 and number of fruits per cluster is shown in parenthesis. Six out of twelve jack types such as KJ 173, KJ 182, KJ 186, KJ 224, KJ 397 and Singapore jack exhibited fruit clustering habit and the number of fruits varied from 2 to 8 per cluster. Highest number of fruits per cluster (8) was observed in KJ 182.

4.5 FRUIT CHARACTERS OF JACKFRUIT TYPES

4.5.1 Fruit stalk length

The fruit stalk lengths were significantly different among jack types and the data are presented in Table 5a. Longer stalk was observed in KJ 183 (8.27 cm) and lowest was in KJ 224 (4.03 cm).

4.5.2 Fruit stalk diameter

Jack types as well as check varieties differed in case of fruit stalk diameter (Table 5a). Jack type KJ 397 recorded maximum stalk diameter (3.57 cm) while, lowest stalk diameter were observed in KJ 180 (1.50 cm).

4.5.3 Stalk attachment to fruit

The stack attachment to fruit differed as depressed and flattened among jack types (Table 5a). Maximum jack types showed depressed stalk attachment except KJ 186 and KJ 224 which had flattened attachment.

4.5.4 Fruit length

Significant differences were found in the fruit length among the various jack types and are presented in Table 5a. The maximum fruit length was observed in Muttom Varikka (39.83 cm), while minimum fruit length was recorded in KJ 182 (16.77 cm).

4.5.5 Fruit diameter

It is evident from the data presented in Table 5a that the jack types as well as check varieties varied significantly with respect to fruit diameter. Among the jackfruit types, maximum fruit diameter was recorded in KJ 356 (24.23 cm) and it was on par with KJ 185 (23.30 cm). On the other hand, minimum fruit diameter was observed in KJ 182 (17.93 cm).

4.5.6 Fruit shape

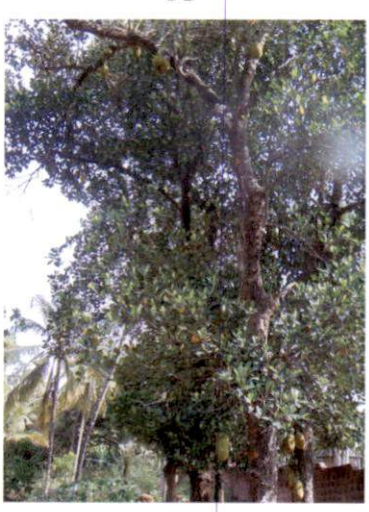
Different fruit shapes such as spheroid, ellipsoid, clavate and oblong were observed among jack types and check varieties (Table 5a, Plate 3a & 3b). Fruits of KJ 173, KJ 183, KJ 224, KJ 356 and Singapore jack were oblong whereas that of KJ 121, KJ 180 and KJ 186 were clavate. Jack types KJ 185, KJ 397 and check variety Muttom Varikka produced ellipsoid fruits and KJ 182 had spheroid fruits.

4.5.7 Fruit surface

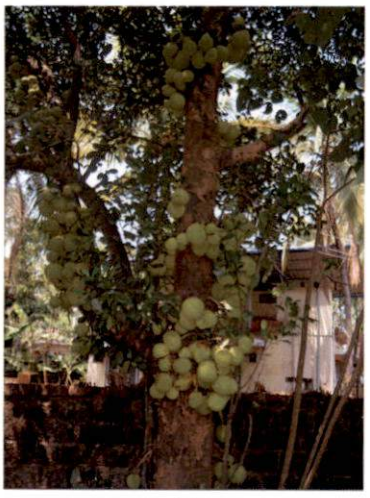
The surface of fruit (Table 5a, Plate 3a & 3b) at maturity was found to be spiny in most of the types except KJ 182, in which fruit surface was comparatively smooth.

A

B



C



D

E

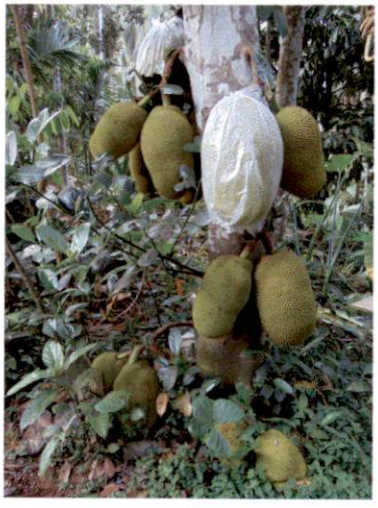
F

Plate 1a. Trees of jackfruit types showing fruit bearing position :
(A) KJ 121 (B) KJ 173 (C) KJ 180 (D) KJ 182 (E) KJ 183 (F) KJ 185

G

H

I



J

K

L

Plate 1b. Trees of jackfruit types showing fruit bearing position : (G) KJ 186 (H) KJ 224 (I) KJ 356 (J) KJ 397 (K) Muttom Varikka (L) Singapore jack

A

B

C

D

E

F

Plate 2. Fruit clusters on jackfruit types : (A) KJ 173 (B) KJ 182 (C) KJ 186 (D) KJ 224 (E) KJ 397 (F) Singapore jack

Table 5a. Fruit characters of jackfruit types

Sl. No.	Jack type	Stalk length (cm)	Stalk diameter (cm)	Stalk attachment to fruit	Fruit length (cm)	Fruit diameter (cm)	Fruit shape	Fruit surface	Fruit attractiveness
1	KJ 121 - Fruiting thrice	7.17	2.00	Depressed	33.73^{c}	22.24^{bcd}	Clavate	Spiny	Intermediate
2	KJ 173 – Flakeless	5.20	2.10	Depressed	25.07^{e}	18.00^{f}	Oblong	Spiny	Intermediate
3	KJ 180 – Seedless	4.33	1.50	Depressed	31.63^{d}	19.33^{e}	Clavate	Spiny	Intermediate
4	KJ 182 – Cluster	5.87	1.63	Depressed	16.77^{f}	17.93^{f}	Spheroid	Smooth	Excellent
5	KJ 183 - Off season	8.27	3.13	Depressed	34.13^{c}	22.80^{bc}	Oblong	Spiny	Good
6	KJ 185 – Early	4.17	2.93	Depressed	34.50^{c}	23.30^{ab}	Ellipsoid	Spiny	Good
7	KJ 186 – Early	4.23	2.47	Flattened	36.80^{b}	21.90^{cd}	Clavate	Spiny	Intermediate
8	KJ 224 - High TSS	4.03	2.23	Flattened	30.47^{d}	22.03^{cd}	Oblong	Spiny	Good
9	KJ 356 - High TSS	5.97	2.60	Depressed	34.77^{c}	24.23^{a}	Oblong	Spiny	Good
10	KJ 397 – Gumless	4.53	3.57	Depressed	31.63^{d}	21.40^{d}	Ellipsoid	Spiny	Good
11	Muttom Varikka	6.23	3.23	Depressed	39.83^{a}	22.83^{bc}	Ellipsoid	Spiny	Excellent
12	Singapore jack	4.63	1.83	Depressed	37.30^{b}	22.37^{bcd}	Oblong	Spiny	Excellent
SE(±m)					0.47	0.37			
C. D. at 5 % level					1.36	1.07			
C V (%)					2.51	2.95			

Mean value in each column with different superscript differs significantly ($P < 0.05$).

4.5.8 Fruit attractiveness

The attractiveness of fruits of KJ 182, Muttom Varikka and Singapore jack were recorded as excellent, that of KJ 183, KJ 185, KJ 224, KJ 356 and KJ 397 were good whereas, trees of KJ 121, KJ 173, KJ 180 and KJ 186 had intermediate fruit attractiveness (Table 5a, Plate 3a and 3b).

4.5.9 Fruit weight

Average weight of fruit varied significantly among jack types (Table 5b). The maximum average fruit weight was recorded in KJ 356 (10.30 kg) which was on par with Muttom Varikka (9.21 kg). Minimum fruit weight (2.03 kg) was found in KJ 173, followed by KJ 182 (2.57 kg) which were on par.

Table 5b. Fruit characters of jackfruit types

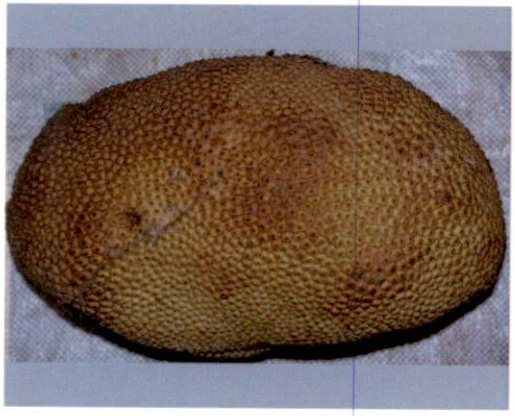
Sl. No.	Jack type	Fruit weight (kg)	No of fruits per tree		Total yield per plant (kg)
1	KJ 121 - Fruiting thrice	5.13^{de}	98		503.42
2	KJ 173 – Flakeless	2.03^{f}	85		173.23
3	KJ 180 – Seedless	5.82^{bcde}	12		69.92
4	KJ 182 – Cluster	2.57^{f}	342		881.67
5	KJ 183 - Off season	4.81^{e}	64		307.84
6	KJ 185 – Early	6.80^{bcd}	37		251.63
7	KJ 186 – Early	6.85^{bc}	28		192.05
8	KJ 224 - High TSS	5.55^{cde}	68		377.67
9	KJ 356 - High TSS	10.30^{a}	39		401.77
10	KJ 397 – Gumless	6.24^{bcde}	45		281.11
11	Muttom Varikka	9.21^{a}	22		202.75
12	Singapore jack	7.28^{b}	85		619.56
SE(±m)		1.71	Range	12-342	69.92-881.67
C. D. at 5 % level		0.59	Average	77.08	355.21
C V (%)		16.80			

Mean value in each column with different superscript differs significantly ($P < 0.05$).

74

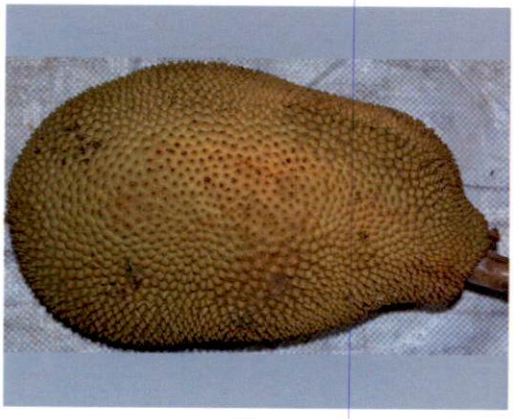
A

B



C

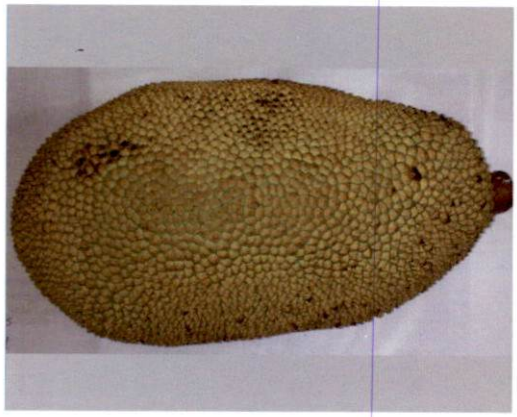
D



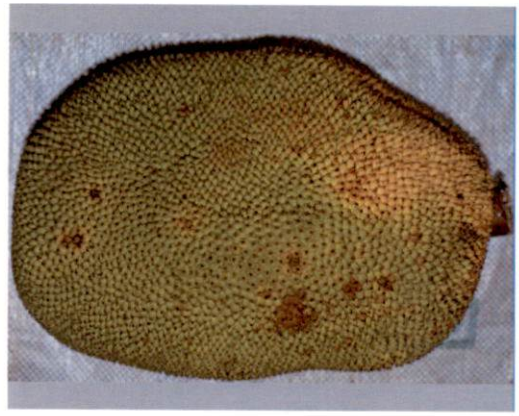
E

F

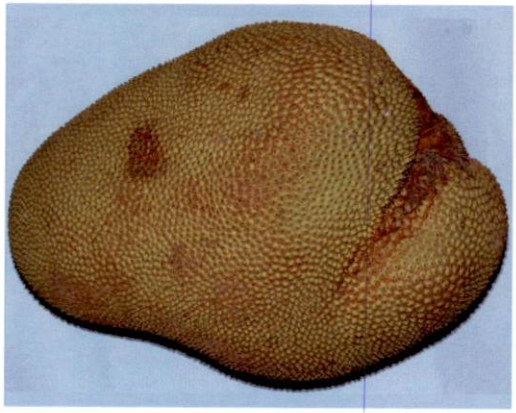
Plate 3a. Fruit of jackfruit types : (A) KJ 121 (B) KJ 173 (C) KJ 180 (D) KJ 182 (E) KJ 183 (F) KJ 185



G

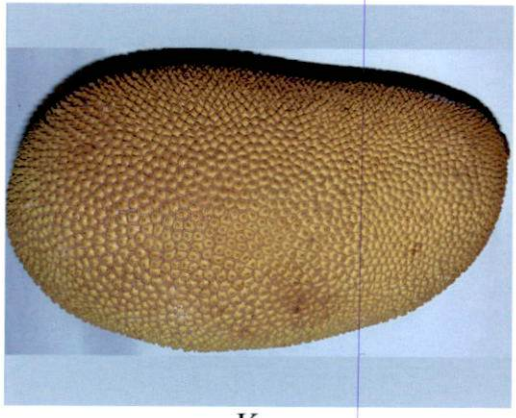


H

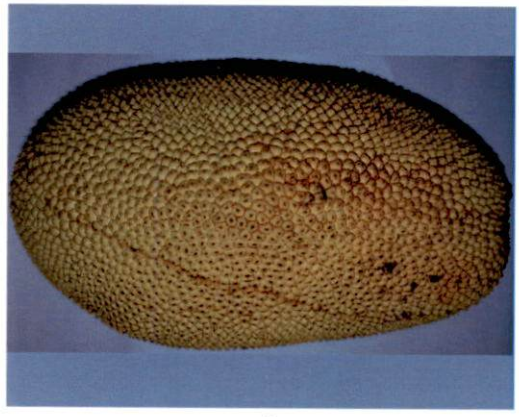


I

J



K



L

Plate 3b. Fruit of jackfruit types : (G) KJ 186 (H) KJ 224 (I) KJ 356 (J) KJ 397 (K) Muttom Varikka (L) Singapore jack

4.5.10 Number of fruits per tree

The data presented in Table 5b revealed that the number of fruits produced in jack types varied from 12 fruits in KJ 180 to 342 fruits in KJ 182.

4.5.11 Fruit yield per tree

Fruit yield ranged from 69.92 kg to 881.67 kg in various germplasms. The highest yield (881.67 kg/tree) was recorded in KJ 182 while the lowest yield (69.92 kg/tree) was recorded in KJ 180 (Table 5b).

4.6 FLAKE CHARACTERS OF JACKFRUIT TYPES

4.6.1 Flake length

A close examination of the data presented in Table 6a clearly indicated that the jackfruit types differed significantly with respect to the flake length. The maximum flake length (7.53 cm) was recorded in KJ 121 whereas least flake length (5.63 cm) was recorded in Singapore jack, which was on par with KJ 186 (5.67 cm), KJ 356 (5.67 cm), KJ 183 (5.73 cm), KJ 397 (5.77 cm) and KJ 180 (5.80 cm). All other jack types had intermediate flake lengths.

4.6.2 Flake width

The data given in Table 6a regarding flake width of jack types revealed that, there was significant difference among jack types with respect to flake width. The highest flake width (4.16 cm) was observed in KJ 182, and it was on par with Singapore jack (4.03 cm). On the other hand, KJ 180 recorded minimum flake width (2.87 cm) and it was found to be statistically similar to KJ 185 (3.03 cm).

4.6.3 Flake thickness

The thickness of flakes showed good variation in jack types (Table 6a, Plate 4a & 4b). Highest flake thickness (4.77 mm) was measured in KJ 182, whereas least thickness (1.84 mm) was observed in KJ 356. All other jack types recorded intermediate flake thickness.

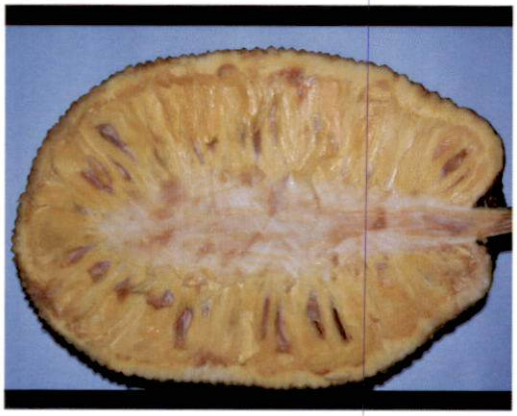
Table 6a. Flake characters of jackfruit types

Sl. No.	Jack type	Flake length (cm)	Flake width (cm)	Flake thickness (mm)	Flake shape	Flake colour	Flake texture
1	KJ 121 - Fruiting thrice	7.53 ^{a}	3.63^{de}	3.19^{cde}	Oblong with curved tip	Yellow	Firm
2	KJ 173 – Flakeless	NA	NA	NA	NA	NA	NA
3	KJ 180 – Seedless	5.80 ^{d}	2.87^{g}	2.98^{e}	Rectangular	Light yellow	Firm
4	KJ 182 – Cluster	6.07 ^{c}	4.16^{a}	4.77^{a}	Irregular	Yellow	Firm
5	KJ 183 - Off season	5.73 ^{d}	3.67^{cd}	3.43^{bc}	Oblong with curved tip	Light yellow	Firm
6	KJ 185 – Early	6.37 ^{b}	3.03^{g}	3.73^{b}	Oblong with curved tip	Yellow	Firm
7	KJ 186 – Early	5.67 ^{d}	3.53^{def}	3.32^{cd}	Oblong with curved tip	Deep yellow	Firm
8	KJ 224 - High TSS	6.37 ^{b}	3.87^{bc}	3.68^{b}	Obovate	Yellow	Firm
9	KJ 356 - High TSS	5.67 ^{d}	3.43^{ef}	1.84^{f}	Twisted	Light yellow	Firm
10	KJ 397 – Gumless	5.77 ^{d}	3.63^{de}	3.00^{de}	Obovate	Creamy white	Firm
11	Muttom Varikka	6.03 ^{c}	3.37^{f}	3.14^{cde}	Cordate	Light yellow	Firm
12	Singapore jack	5.63 ^{d}	4.03^{ab}	3.07^{de}	Irregular	Yellow	Firm
SE(±m)		0.06	0.08	0.11			
C. D. at 5 % level		0.18	0.22	0.33			
C V (%)		1.97	4.01	6.58			

Mean value in each column with different superscript differs significantly ($P < 0.05$).

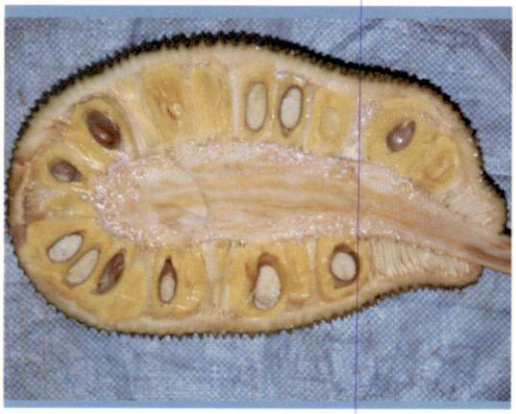
A

B



C

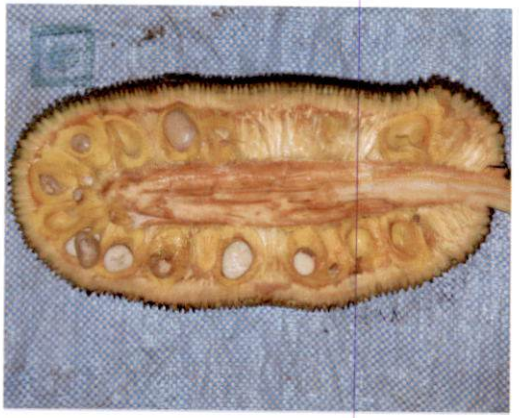
D



E

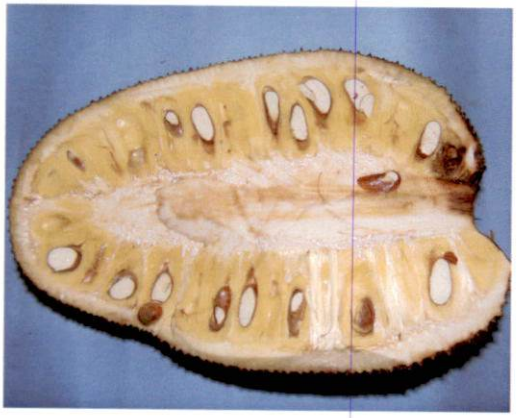
F

Plate 4a. Dissected fruit of jackfruit types : (A) KJ 121 (B) KJ 173 (C) KJ 180 (D) KJ 182 (E) KJ 183 (F) KJ 185

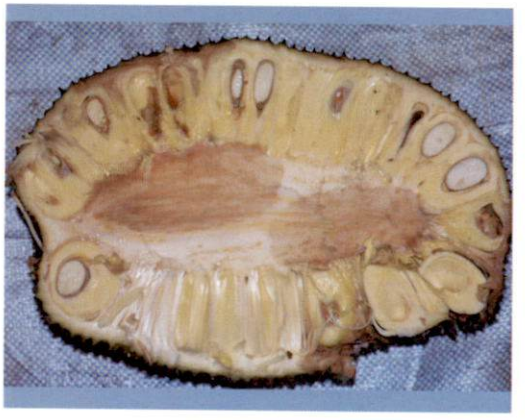


G

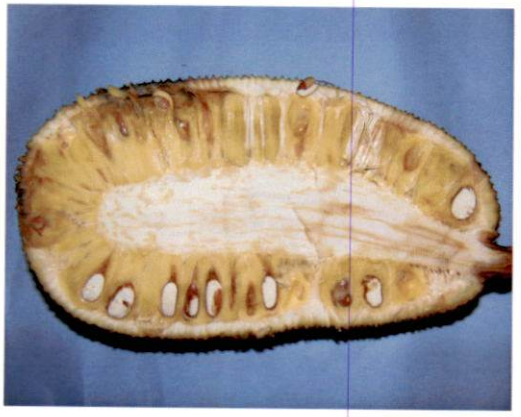
H



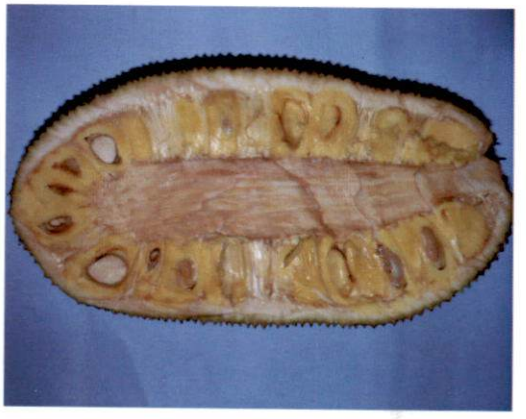
I



J



K



L

Plate 4b. Dissected fruit of jackfruit types : (G) KJ 186 (H) KJ 224 (I) KJ 356 (J) KJ 397 (K) Muttom Varikka (L) Singapore jack

4.6.4 Flake shape

Various flake shapes such as spheroid, cordate, twisted, obovate, rectangular, oblong with curved tip and irregular were observed. Flakes were found oblong with curved tip in four types (KJ 121, KJ 183, KJ 185 and KJ 186), obovate shaped in two types (KJ 224 and KJ 397), irregular shaped in two types (KJ 182 and Singapore jack), whereas the flakes of KJ 180, KJ 356 and Muttom Varikka were of rectangular, twisted and cordate shaped respectively (Table 6a, Plate 5a & 5b).

4.6.5 Flake colour

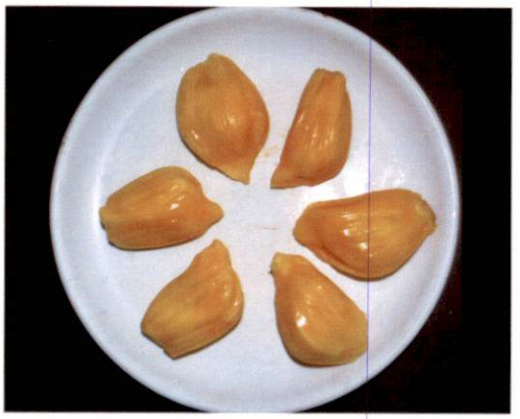
The flake colour varied as creamy white, light yellow, yellow and deep yellow among jack types. On close examination of Table 6a, it was clear that, flakes of KJ 397 recorded creamy white colour, KJ 180, KJ 183, KJ 356 and Muttom Varikka had light yellow flakes. The jack types KJ 121, KJ 182, KJ 185, KJ 224 and Singapore jack had yellow flakes whereas deep yellow flakes were observed in KJ 186.

4.6.6 Flake texture

All jack types as well as check varieties had fruits with firm textured flakes (Table 6a).

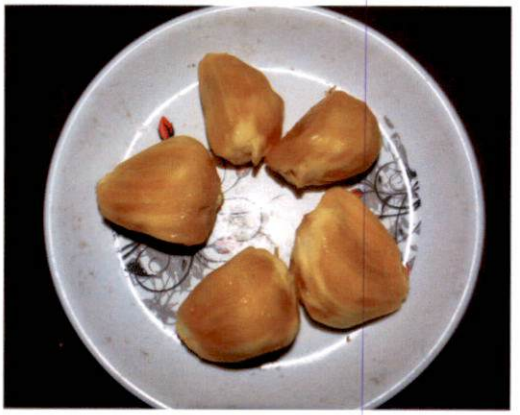
4.6.7 Flake weight

A close examination of data shown in Table 6b revealed that the flake weight per fruit of different jack types varied significantly. Among the various jack types, highest flake weight (3.45 kg) was recorded in KJ 356, followed by Muttom Varikka (3.30 kg), which were on par. While, the lowest flake weight (0.75 kg) was recorded in KJ 182 and it was found statistically similar with that of KJ 121 (0.92 kg). The remaining jack types recorded intermediate values for flake weight.



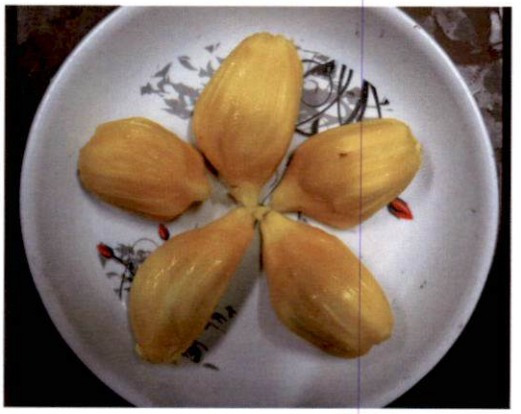
A

B



C

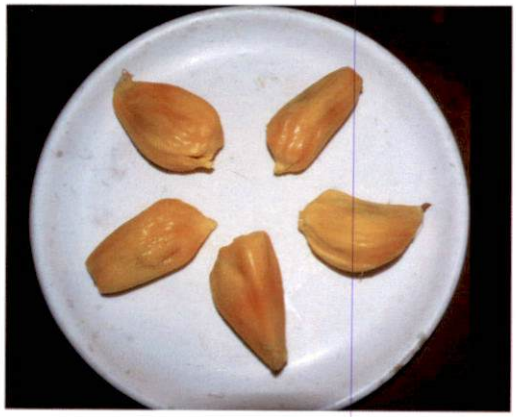
D



E

F

Plate 5a. Flakes of jackfruit types : (A) KJ 121 (B) KJ 180 (C) KJ 182 (D) KJ 183 (E) KJ 185 (F) KJ 186



G

H

I

J

K

Plate 5b. Flakes of jackfruit types : (G) KJ 224 (H) KJ 356 (I) KJ 397 (J) Muttom Varikka (K) Singapore jack

Table 6b. Flake characters of jackfruit types

Sl. No.	Jack type	Flake weight (kg)	No. of flakes per fruit	Flake-fruit ratio	Flake-seed ratio
1	KJ 121 - Fruiting thrice	0.92^{f}	45.67^{g}	0.17^{f}	3.07^{c}
2	KJ 173 – Flakeless	NA	NA	NA	NA
3	KJ 180 – Seedless	2.68^{bc}	344.33^{a}	0.45^{a}	6.39^{a}
4	KJ 182 – Cluster	0.75^{f}	35.67^{gh}	0.29^{cde}	1.83^{def}
5	KJ 183 - Off season	1.66^{de}	114.33^{ef}	0.34^{bc}	2.67^{cd}
6	KJ 185 – Early	2.39^{cd}	99.33^{f}	0.34^{bc}	4.40^{b}
7	KJ 186 – Early	2.29^{cd}	138.67^{de}	0.33^{bc}	1.98^{def}
8	KJ 224 - High TSS	1.46^{ef}	138.00^{de}	0.25^{e}	1.40^{ef}
9	KJ 356 - High TSS	3.45^{a}	237.00^{c}	0.33^{bc}	2.43^{cde}
10	KJ 397 – Gumless	1.70^{de}	148.00^{de}	0.27^{de}	1.09^{f}
11	Muttom Varikka	3.30^{ab}	293.67^{b}	0.35^{b}	2.09^{cdef}
12	Singapore jack	2.36^{cd}	157.33^{d}	0.32^{bcd}	1.50^{ef}
SE(±m)		0.73	12.41	0.02	0.36
C. D. at 5 % level		0.25	36.22	0.05	1.05
C V (%)		22.71	14.72	10.99	25.87

Mean value in each column with different superscript differs significantly ($P < 0.05$).

4.6.8 Number of flakes per fruit

The data pertaining to number of flakes per fruit of various jack types as well as check varieties indicated that number of flakes per fruit differed significantly with respect to jack types (Table 6b). KJ 180 (344.33 flakes/fruit) recorded significantly higher number of flakes per fruit than all other jack types and check varieties. On the other hand, minimum number of flakes per fruit (35.67 flakes/fruit) was observed in KJ 182 which was on par with that of KJ 121 (45.67 flakes/fruit).

4.6.9 Flake/fruit ratio

The results on flake-fruit ratio are presented on Table 6b and it was found to be significantly different among jack types. The maximum flake-fruit ratio (0.45) was observed in KJ 180, followed by Muttom Varikka (0.35), KJ 183 (0.34), KJ 185 (0.34), KJ 186 (0.33), KJ 356 (0.33) and Singapore jack (0.32),

whereas lowest ratio of 0.17 was found in KJ 121. All other jack types had intermediate flake-fruit ratios.

4.6.10 Flake/seed ratio

The data presented in Table 6b revealed that the flake-seed ratio differed significantly among jack types. Jack type KJ 180 (6.39) recorded highest flake-seed ratio, followed by KJ 185 (4.40), while minimum ratio was observed on fruits of KJ 397 (1.09), closely followed by KJ 224 (1.4), Singapore jack (1.5), KJ 182 (1.83), KJ 186 (1.98) and Muttom Varikka (2.09).

4.7 SEED CHARACTERS OF JACKFRUIT TYPES

4.7.1 Seed shape

Various shapes of seeds such as oblong, reniform and irregular were observed. Seeds were found reniform shaped in five germplasm (KJ 121, KJ 182, KJ 183, KJ 185, KJ 186 and KJ 356), irregular shape in four germplasm (KJ 180, KJ 224, KJ 397 and Singapore jack) whereas Muttom Varikka had oblong shaped seeds (Table 7, Plate 6a & 6b).

4.7.2 Seed weight

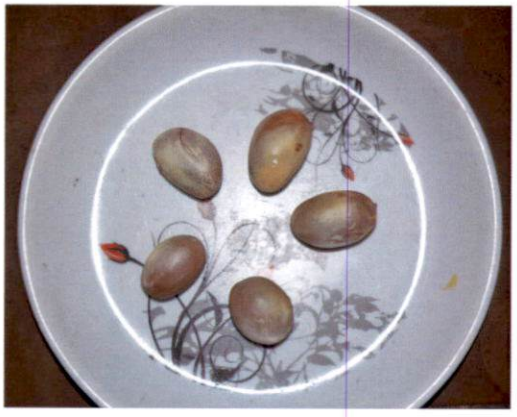
The data presented in Table 7 revealed significant differences in seed weight among the different jackfruit types. The highest seed weight (1.59 kg) was recorded in Muttom Varikka which was on par with Singapore jack (1.58 kg) and KJ 397 (1.56 kg). While the lowest seed weight (0.30 kg) was recorded in KJ 121 which was on par with KJ 182 (0.41 kg), KJ 180 (0.43 kg) and KJ 185 (0.54 kg).

A

B

C

D

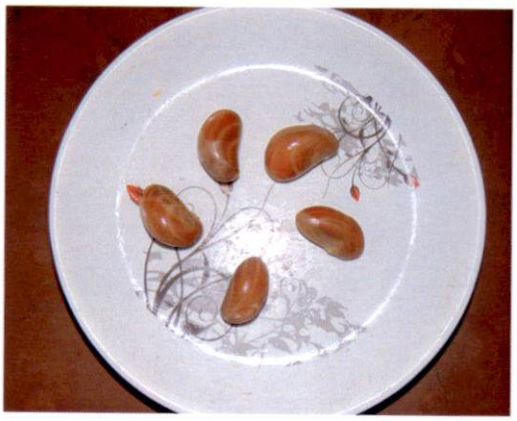


E

F

Plate 6a. Seeds of jackfruit types : (A) KJ 121 (B) KJ 180 (C) KJ 182 (D) KJ 183 (E) KJ 185 (F) KJ 186

G



H

I

J

K

Plate 6b. Seeds of jackfruit types : (G) KJ 224 (H) KJ 356 (I) KJ 397 (J) Muttom Varikka (K) Singapore jack

Table 7. Seed characters of jackfruit types

Sl. No.	Jack type	Seed shape	Seed weight (kg)
1	KJ 121 - Fruiting thrice	Reniform	0.30[a]
2	KJ 173 – Flakeless	NA	NA
3	KJ 180 – Seedless	Irregular	0.43[ab]
4	KJ 182 – Cluster	Reniform	0.41[ab]
5	KJ 183 - Off season	Reniform	0.62[b]
6	KJ 185 – Early	Reniform	0.54[ab]
7	KJ 186 – Early	Reniform	1.18[cd]
8	KJ 224 - High TSS	Irregular	1.01[c]
9	KJ 356 - High TSS	Reniform	1.42[de]
10	KJ 397 – Gumless	Irregular	1.56[e]
11	Muttom Varikka	Oblong	1.59[e]
12	Singapore jack	Irregular	1.58[e]
SE(±m)			0.28
C. D. at 5 % level			0.10
C V (%)			18.88

Mean value in each column with different superscript differs significantly ($P < 0.05$).

4.8 EDIBLE AND NON-EDIBLE PORTION CHARACTERS OF JACKFRUIT TYPES

4.8.1 Weight of edible portion

It is evident from Table 8 that the observation on weight of edible portion of fruit was found significantly different in jack types. Maximum weight of edible portion (4.90 kg) was recorded with the fruits of Muttom Varikka, followed by KJ 356 (4.88 kg), which were found to be on par. Minimum edible portion (1.16 kg) was recorded in KJ 182, followed by KJ 121 (1.22 kg) and they were found to be statistically on par.

4.8.2 Fruit rind thickness

It is evident from Table 8 that the rind thickness of fruits differed significantly with respect to the jackfruit types. Among the jack types, minimum rind thickness (1.17 cm) was recorded in KJ 182 and it was on par with KJ 397

(1.27 cm) and KJ 173 (1.37 cm). Maximum rind thickness (3.63 cm) was observed in KJ 121.

4.8.3 Fruit rind weight

The data presented in Table 8 showed significant differences in fruit rind weight among the various jack types. KJ 356 recorded maximum fruit rind weight (2.77 kg) followed by KJ 121 (2.54 kg) and Muttom Varikka (2.40 kg) which were statistically similar. The minimum fruit rind weight was recorded in KJ 182 (0.92 kg) which was found to be on par with KJ 173 (1.17 kg) and KJ 183 (1.30 kg).

Table 8. Edible and non-edible portion characters of jackfruit types

Sl. No.	Jack type	Weight of edible portion (kg)	Fruit rind thickness (cm)	Fruit rind weight (kg)	Perigone weight (kg)	Core weight (kg)
1	KJ 121 - Fruiting thrice	1.22^{f}	3.63^{e}	2.54^{f}	1.13^{e}	0.23^{a}
2	KJ 173 - Flakeless	NA	1.37^{a}	1.17^{ab}	0.67^{bc}	0.17^{a}
3	KJ 180 - Seedless	3.11^{bcde}	2.43^{c}	1.47^{bc}	0.81^{cd}	0.43^{ab}
4	KJ 182 - Cluster	1.16^{f}	1.17^{a}	0.92^{a}	0.31^{a}	0.17^{a}
5	KJ 183 - Off season	2.28^{e}	1.93^{b}	1.30^{abc}	0.74^{bcd}	0.48^{ab}
6	KJ 185 - Early	2.94^{cde}	2.73^{d}	2.01^{d}	0.90^{cde}	0.93^{cd}
7	KJ 186 - Early	3.48^{bc}	1.73^{b}	2.11^{de}	0.80^{cd}	0.45^{ab}
8	KJ 224 - High TSS	2.47^{de}	1.93^{b}	2.06^{de}	0.67^{bc}	0.33^{a}
9	KJ 356 - High TSS	4.88^{a}	2.70^{d}	2.77^{f}	1.58^{f}	1.06^{d}
10	KJ 397 - Gumless	3.29^{bcd}	1.27^{a}	1.56^{c}	0.46^{ab}	0.92^{cd}
11	Muttom Varikka	4.90^{a}	1.90^{b}	2.40^{ef}	1.01^{de}	0.89^{cd}
12	Singapore jack	3.95^{b}	2.23^{c}	1.96^{d}	0.70^{bc}	0.66^{bc}
SE(±m)		0.92	0.08	0.39	0.30	0.31
C. D. at 5 % level		0.32	0.24	0.13	0.10	0.11
C V (%)		19.47	6.83	12.34	21.73	32.97

Mean value in each column with different superscript differs significantly ($P < 0.05$).

89

4.8.4 Perigone weight

A perusal of the data presented on Table 8 revealed significant difference among jack types in case of fruit perigone weight. Perigone weight was found significantly higher (1.58 kg) in KJ 356 and was lower (0.31 kg) in KJ 182.

4.8.5 Core weight

Significant differences were found in core weight among the various jack types and check varieties (Table 8). The maximum core weight (1.06 kg) was recorded in KJ 356 and it was on par with that of KJ 185 (0.93 kg), KJ 397 (0.92 kg) and Muttom Varikka (0.89 kg). The minimum weight of core (0.17 kg) was recorded in KJ 173 and KJ 182 followed by KJ 121 (0.23 kg), KJ 224 (0.33 kg), KJ 180 (0.43 kg), KJ 186 (0.45 kg) and KJ 183 (0.48 kg) which were found to be on par. The remaining jack types recorded intermediate values.

4.9 QUALITY PARAMETERS OF JACKFRUIT TYPES

4.9.1 Moisture content and dry matter percentage of unripe flakes

The data presented in the Table 9a revealed that there was significant variation among jack types with respect to moisture content of unripe flakes. The highest moisture content (64.92%) and the lowest dry matter percentage (35.07%) was recorded in flakes of Muttom Varikka, followed by KJ 356 (64.58% moisture and 35.41% dry matter), KJ 397 (64.23%, 35.76%) and KJ 180 (63.70%, 36.29%), which were found to be on par.

On the other hand, minimum moisture content (52.47%) as well as maximum dry matter percentage (47.53%) was recorded in unripe flakes of KJ 183 and it was noticed to be on par with KJ 185 (52.60% moisture and 47.40% dry matter), KJ 121 (53.02%, 46.97%) and Singapore jack (55.23%, 44.76%).

4.9.2 Moisture content and dry matter percentage of ripe flakes

Close examination of the Table 9a revealed that there was significant variation among jack types in case of moisture content of ripe flakes. The highest moisture content (80.20%) as well as lowest dry matter percentage (19.79%) was recorded with flakes of Muttom Varikka, whereas minimum moisture content (56.56%) as well as maximum dry matter percentage (43.43%) was recorded in ripe flakes of KJ 183 which was significantly different from all other jack types.

Table 9a. Moisture content and dry matter percentage of jackfruit types

Sl. No.	Jack type	Moisture content (unripe) (%)	Dry matter content (unripe) (%)	Moisture content (ripe) (%)	Dry matter content (ripe) (%)
1	KJ 121 - Fruiting thrice	53.02^{a}	46.97^{a}	61.24^{b}	38.76^{b}
2	KJ 173 – Flakeless	NA	NA	NA	NA
3	KJ 180 – Seedless	63.70^{cd}	36.29^{cd}	70.54^{d}	29.46^{d}
4	KJ 182 – Cluster	60.78^{b}	39.22^{b}	65.05^{c}	34.94^{c}
5	KJ 183 - Off season	52.47^{a}	47.53^{a}	56.56^{a}	43.43^{a}
6	KJ 185 – Early	52.60^{a}	47.40^{a}	60.70^{b}	39.29^{b}
7	KJ 186 – Early	60.83^{b}	39.16^{b}	65.93^{c}	34.06^{c}
8	KJ 224 - High TSS	61.26^{bc}	38.73^{bc}	66.60^{c}	33.39^{c}
9	KJ 356 - High TSS	64.58^{d}	35.41^{d}	74.16^{e}	25.83^{e}
10	KJ 397 – Gumless	64.23^{d}	35.76^{d}	76.16^{e}	23.83^{e}
11	Muttom Varikka	64.92^{d}	35.07^{d}	80.20^{f}	19.79^{f}
12	Singapore jack	55.23^{a}	44.76^{a}	61.56^{b}	38.43^{b}
SE(±m)		0.97	0.97	1.05	1.02
C. D. at 5 % level		2.84	2.84	3.07	3.22
C V (%)		3.09	4.52	2.96	5.89

Mean value in each column with different superscript differs significantly ($P < 0.05$).

91

4.9.3 Total soluble solids (TSS)

Critical examination of the data on TSS in Table 9b showed that there was significant variation in TSS (°Brix) content of flakes of different jack types and it ranged from 24.56°B to 31.47°B. The results revealed that the maximum (31.47°B) amount of total soluble solids was found in KJ 182 which was on par with KJ 185 (31.13°B) and KJ 224 (30.67°B). On the other hand, minimum TSS (24.56°B) was found in KJ 183, followed by KJ 121 (25.46°B) and Muttom Varikka (26°B) which was found to be statistically on par.

4.9.4 Acidity

Data presented in Table 9b showed that acidity in the flakes of jackfruit types varied significantly. The maximum amount (0.53%) of acidity was found in KJ 121 and Muttom Varikka, whereas minimum acidity (0.19%) was registered in the KJ 182 which was statistically on par with KJ 185 (0.23%).

4.9.5 TSS-Acid ratio

In the present investigation, TSS-acid ratio differed significantly among the jack types (Table 9b). The highest TSS: acid ratio (160.63) was obtained from KJ 182, closely followed by KJ 185 (135.71) while minimum TSS-acid ratio (47.60) was found in KJ 121 and it was on par with Muttom Varikka (48.60), Singapore jack (54.17), KJ 224 (54.35), KJ 183 (62.32) and KJ 180 (70.03).

4.9.6 Total sugar content

It is evident from the data presented in Table 9b that the total sugar content in jack types varied significantly. The higher percentage of total sugars (25.16%) was recorded in KJ 224 followed by KJ 182 (24.89%) which was statistically similar with each other and the lowest amount of total sugar was recorded in KJ 183 (19.97%).

92

Table 9b. Fruit quality parameters of jackfruit types

Sl. No.	Jack type	TSS (°B)	Acidity (%)	TSS-acid ratio	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Sugar-Acid ratio	Total carotenoid content (mg/100g)	Fiber content (%)
1	KJ 121 - Fruiting thrice	25.46^{f}	0.53^{e} (4.19)*	47.60^{f}	21.17^{f}(27.39)*	9.09^{e} (17.54)*	12.08^{bcd}	39.60^{g}	2.38^{e}	0.39
2	KJ 173 - Flakeless	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	KJ 180 - Seedless	26.83^{e}	0.38^{d} (3.55)	70.03^{def}	23.35^{d} (28.89)	11.07^{c} (19.43)	12.28^{abcd}	60.96^{ef}	3.28^{c}	0.61
4	KJ 182 - Cluster	31.47^{a}	0.19^{a} (2.54)	160.63^{a}	24.89^{ab} (29.92)	12.43^{a} (20.64)	12.45^{abc}	126.99^{a}	4.58^{a}	0.41
5	KJ 183 - Off season	24.56^{g}	0.39^{d} (3.60)	62.32^{ef}	19.97^{g} (26.51)	8.42^{f} (16.86)	11.52^{d}	50.53^{fg}	2.96^{cd}	0.42
6	KJ 185 - Early	31.13^{ab}	0.23^{ab} (2.76)	135.71^{ab}	23.46^{cd} (28.96)	10.34^{d} (18.75)	13.12^{a}	102.20^{b}	4.56^{a}	0.44
7	KJ 186 - Early	29.80^{c}	0.30^{c} (3.15)	99.28^{cd}	23.26^{d} (28.83)	11.32^{c} (19.66)	11.94^{bcd}	77.45^{c}	4.86^{a}	0.46
8	KJ 224 - High TSS	30.67^{ab}	0.39^{d} (3.60)	54.35^{f}	25.16^{a} (30.10)	12.48^{a} (20.68)	12.68^{ab}	63.67^{de}	4.06^{b}	0.45
9	KJ 356 - High TSS	29.33^{cd}	0.32^{c} (3.24)	91.50^{cde}	24.14^{bc} (29.42)	11.89^{b} (20.16)	12.25^{abcd}	75.29^{cd}	2.72^{de}	0.66
10	KJ 397 - Gumless	29.06^{d}	0.26^{cd} (2.96)	108.73^{bc}	22.04^{e} (27.99)	10.29^{d} (18.70)	11.75^{cd}	82.46^{c}	2.68^{de}	0.63
11	Muttom Varikka	26.00^{f}	0.53^{e} (4.19)	48.60^{f}	22.39^{e} (28.24)	10.56^{d} (18.75)	11.83^{bcd}	41.85^{g}	1.59^{f}	0.38
12	Singapore jack	29.33^{cd}	0.38^{d} (3.53)	54.17^{f}	20.80^{f} (27.13)	8.56^{f} (17)	12.24^{abcd}	54.95^{ef}	2.61^{de}	0.38
SE(±m)		0.23	0.02	11.21	0.27	0.16	0.31	3.82	0.14	Range= 0.38-0.66
C. D. at 5 % level		0.68	0.05 (0.26)	34.34	0.78 (0.55)	0.47 (0.45)	0.90 (NS)	11.14	0.42	NS
C V (%)		1.55	9.61	24.97	2.21	2.85	4.75	10.22	8.21	25.48

Mean value in each column with different superscript differs significantly ($P < 0.05$). *Transformed values

4.9.7 Reducing sugar content

The percentage of reducing sugar of jackfruit pulp significantly differed among jack types (Table 9b). The maximum reducing sugar (12.48%) was found in KJ 224, closely followed by KJ 182 (12.43%) while the minimum (8.42%) was found in KJ 183 and it was on par with Singapore jack (8.56%).

4.9.8 Non-reducing sugar content

The percentage of non-reducing sugar of jackfruit pulp differed significantly among the jack types. The maximum non-reducing sugar (13.12%) was found in KJ 185 followed by KJ 224 (12.68%), KJ 182 (12.45%), KJ 180 (12.28%), KJ 356 (12.25%) and Singapore jack (12.24%), which were on par (Table 9b).

4.9.9 Sugar-Acid ratio

The data presented in Table 9b revealed that the sugar-acid ratio varied significantly among different jack types. The highest sugar-acid ratio (126.99) was recorded in the pulp of KJ 182 and lowest sugar-acid ratio (39.60) was obtained from KJ 121, which was closely followed by Muttom Varikka (41.85) and KJ 183 (50.53).

4.9.10 Total carotenoid content

The total carotenoid content of the flakes of various jack types are presented in Table 9b. The highest carotenoid content (4.86 mg/100g) was recorded in flakes of KJ 186, followed by KJ 182 (4.58 mg/100g) and KJ 185 (4.56 mg/100g), which were found to be on par. On the other hand, less carotenoid content of 1.59 mg/100g was found in Muttom Varikka.

4.9.11 Fiber content

It is evident from the Table 9b that the results on percentage fiber content of flakes were not significantly different in jack types. The fiber content varied from 0.38% to 0.66% among jackfruit types.

Discussion

5. DISCUSSION

Jackfruit, being a cross-pollinated and mostly seed propagated crop, exhibited great variation in economic traits, which is considered as a pre-requisite for any crop improvement programme.

Consumers prefer jackfruit varieties with characters like precocity, sweetness, gumlessness and small sized fruits. Eventhough standard varieties in jackfruit are limited, there are good number of trees which are superior in yield with desirable fruit attributes.

The results of the study entitled "Field evaluation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types" are discussed in this chapter.

5.1 EXPERIMENT 1: FIELD EVALUATION

5.1.1 Tree growth characters

The age of jackfruit trees under study ranged from 15 to 34 years. Trunk height of trees ranged from 45 to 600 cm. KJ 224 recorded the maximum trunk height (600 cm) and the minimum height (45 cm) was recorded by Muttom Varikka. Similar findings were reported by Morton (1987); Rai *et al.* (2003) and Singh *et al.* (2011).

Trunk circumference was maximum in Singapore jack (245 cm) followed by KJ 121 (178 cm), whereas minimum trunk circumference was recorded in Muttom Varikka (84 cm). The result is in conformity with Roy (2017) who observed trunk circumference in a range of 85.23 cm to 137.72 cm. The variation in trunk circumference of different germplasm might be due to genetic variability as well as climatic conditions.

Out of the ten jack types and two check varieties studied, four of them were observed to be highly vigorous (KJ 182, KJ 224, Muttom Varikka and Singapore jack). The trees differed with respect to crown shape, branching

density and trunk surface. These variations might be due to the genetic makeup of the trees and climatic conditions.

5.1.2 Leaf characters

Maximum leaf length of 17.43 cm was observed in tree of KJ 185, while the minimum leaf length was recorded in KJ 224 (9.87 cm). Width of leaf varied from 5.43 cm to 9.43 cm, whereas leaf petiole length ranged from 1.47 to2.47 cm among jackfruit types. Genetic variability might be the cause of this variation. The results coincided with the findings of Selvaraj and Pal (1989) and Chandrasekhar (2014). These results are also supported by Sarker and Zuberi (2011) who reported that the leaf width of jackfruit ranged from 4.64 cm to 13 cm.

Out of the 12 jack types studied nine of them had elliptic leaves. Leaf apex as well as leaf base also varied among them. All the types were observed to be having entire leaf margin. Leaf colour of jack types varied as dark green, green and light green. This variability might me due to genetic makeup of jack types. Similar variability was earlier reported in jack trees of seed origin by Mitra and Maity (2002) and Sharma *et al.* (2006).

5.1.3 Inflorescence characters

The first male inflorescence appeared on each jack type from October 2017 to February 2018. First female inflorescence became visible on jack types from October 2017 to February 2018. First female flower emerged on KJ 185 on 19th October 2017, followed by KJ 186 (14th November 2017), KJ 121 (25th November 2017) and KJ 173 (16th December 2017). The results had slight deviation from Gomez *et al.* (2015) who observed flowering in various jack types from January-March to May-June. This difference might be due to the genetic variation and climatic conditions of the growing region.

97

5.1.4 Fruit characters

Shortest pre-bearing period was observed in Singapore jack (3 years), followed by KJ 186 (4 years), Muttom Varikka (4 years), KJ 182 (5 years) and KJ 173 (5 years). Among these, Singapore jack and Muttom Varikka were of graft origin and others were of seed origin. The precocious nature of KJ 186, KJ 182 and KJ 173 might be due to the genetic makeup of those jack types.

The number of days from flowering to fruit maturity of various jack types ranged from 63 days to 105 days. KJ 180 took minimum days (63) from flowering to fruit maturity, while KJ 224 took 105 days, which was maximum among all jack types. The findings are in accordance with the findings of Berry and Kalra (1988) and Punan *et al.* (2000), whereas the number of days was much shorter as compared to the observations of Bhanu *et al.* (2006) and Haq (2006). This deviation might be due to the warmer climate of the location of study, where the jackfruits were observed to be mature within shorter period as compared to cooler places and higher altitudes where it took longer time (Haq, 2006).

Most of the jack types except KJ 183 and KJ 185, commenced fruiting from February to April 2018. KJ 185 and KJ 186 had fruits only upto April whereas in KJ 183, fruits were available till August. The observations are in close conformity with that of Phaomei *et al.* (2018) who reported fruiting season from March-May to June-September.

Normal season of harvest of jackfruit in Kerala is from March to May. However, in the present investigation, some jack types came to maturity as early as December end (KJ 185) and February (KJ 121, KJ 173 and KJ 186). Early bearing ones are mostly preferred by growers as good quality fruits are obtained before monsoon season.

On the other hand, fruits matured in KJ 183 during May to August, with good fruit quality. This type could be consumed by growers during off-season.

All the jack types including 2 check varieties (Muttom Varikka and Singapore jack) were observed to be regular in bearing. Six out of twelve jack types such as KJ 173, KJ 182, KJ 186, KJ 224, KJ 396 and Singapore jack exhibited fruit clustering habit and the number of fruits varied from 2 to 8 in clusters whereas maximum number of fruits per cluster was observed in KJ 182 (8). In KJ 182, within a cluster, the fruits were observed to be matured one after another, which ensured a long harvesting period.

Number of fruits produced in jack types varied from 12 fruits in KJ 180 to 342 fruits in KJ 182. Fruit yield ranged from 69.92 kg to 881.67 kg in various germplasms. The highest yield (881.67 kg /tree) was recorded in KJ 182 while the lowest yield (69.92 kg/tree) was recorded in KJ 180. The findings are in accordance with that of Aseef *et al.* (2017) who observed a yield range of 144.29 to 560.79 kg per tree. Similar findings were reported by Rai and Reddy (2000) and Khan *et al.* (2010). The highest yield recorded in jack type KJ 182 was due to the numerous numbers of fruits borne on clusters (8) even though the individual fruit weights (2.57 kg) were low.

Maximum average fruit weight (10.13 kg) was recorded in KJ 356 (10.30 kg) which was on par with Muttom Varikka (9.21 kg). While the minimum fruit weight (2.03 kg) was found in KJ 173, followed by KJ 182 (2.57 kg) which were on par. The results are in conformance with the earlier reports of Azad (2000); Reddy *et al.* (2004); Gomez *et al.* (2015) and Chandrashekar *et al.* (2018).

5.1.5 Flake and seed characters

Among the various jack types, the highest flake weight per fruit (3.45 kg) was recorded in KJ 356, followed by Muttom Varikka, which were on par. While the lowest flake weight per fruit (0.75 kg) was recorded in KJ 182 and it was found statistically similar with that of KJ 121 (0.925 kg). The results are in agreement with Gomez *et al.* (2015) who observed that the bulb weight of various jackfruit germplasm ranged from 0.99 kg to 3.12 kg.

Maximum flake length (7.53 cm) was recorded in KJ 121 whereas least flake length (5.63 cm) was recorded in Singapore jack, which was on par with KJ 186 (5.67 cm), KJ 356 (5.67 cm), KJ 183 (5.73 cm), KJ 397 (5.77 cm) and KJ 180 (5.80 cm). Highest flake width (4.16 cm) was observed in KJ 182, and it was on par with Singapore jack (4.03 cm) while KJ 180 recorded minimum flake length (2.87 cm) and it was found to be statistically similar to KJ 185 (3.03 cm). The results are in agreement with Rai *et al.* (2003).

Maximum flake thickness (4.77 mm) was measured in KJ 182, whereas minimum thickness (1.84 mm) was observed in KJ 356. The results are more or less in similar range with earlier reports of Krishnan *et al.* (2015) who observed flake thickness from 3.1-6.3 mm. Usually the fruits with thick flakes are preferred for dessert purpose.

The highest flake-fruit ratio (0.45) was observed in KJ 180, followed by Muttom Varikka (0.35), KJ 183 (0.34), KJ 185 (0.34), KJ 186 (0.33), KJ 356 (0.33) and Singapore jack (0.32), whereas lowest ratio of 0.17 was found in KJ 121. The highest value observed in KJ 180 (seedless jack) was attributed to its seedless nature. All other jack types had intermediate flake-fruit ratios.

Jack type KJ 180 (6.39) recorded highest flake-seed ratio, followed by KJ 185 (4.40), while minimum ratio was observed on fruits of KJ 397 (1.09), closely followed by KJ 224 (1.4), Singapore jack (1.5), KJ 182 (1.83), KJ 186 (1.98) and Muttom Varikka (2.09). The highest flake-seed ratio of KJ 180 (seedless jack) was due to its seedless nature.

The highest seed weight (1.59 kg) was recorded in Muttom Varikka which was on par with Singapore jack (1.58 kg) and KJ 397 (1.56 kg). While the lowest seed weight (0.30 kg) was recorded in KJ 121 which was on par with KJ 182 (0.41 kg), KJ 180 (0.43 kg) and KJ 185 (0.54 kg). A wide variability in seed weight per fruit was earlier reported by Krishnan *et al.* (2015).

5.1.6 Non-edible portion

Minimum rind thickness (1.17 cm) was recorded with KJ 182 and it was on par with KJ 397 (1.27 cm) and KJ 173 (1.37 cm). The results are in agreement with Muthulakshmi (2003).

KJ 356 recorded maximum fruit rind weight (2.77 kg) followed by KJ 121 (2.54 kg) and Muttom Varikka (2.40 kg) which were statistically similar. The minimum fruit rind weight was recorded in KJ 182 (0.92 kg). Similar reports have been made by Gomez *et al.* (2015) which supported the present study.

Perigone weight was found significantly higher (1.58 kg) in KJ 356 and was lowest (0.31 kg) in KJ 182. This is an indication that the unfertilized female flowers weighed maximum in KJ 356 and minimum in KJ 182. Perigones are good source of pectin which could be extracted and used for jelly making (Patil *et al.*, 2011).

The maximum core weight (1.06 kg) was recorded in KJ 356 and it was on par with that of KJ 185 (0.93 kg), KJ 397 (0.92 kg) and Muttom Varikka (0.89 kg). Minimum weight of core (0.17 kg) was recorded in KJ 173 and KJ 182. The results of present study differed from the findings of Nazrul *et al.* (2004) who reported that the highest weight of rachis was 0.32 kg and the lowest was 0.28 kg. The variation is justifyable as it depends on the total fruit size and fruit weight, which is genetically variable.

5.2 EXPERIMENT 2: FRUIT QUALITY EVALUATION

The highest moisture content (80.20%) as well as lowest dry matter percentage (19.79%) was recorded with flakes of Muttom Varikka, whereas minimum moisture content (56.56%) as well as maximum dry matter percentage (43.43%) was recorded in ripe flakes of KJ 183. The results observed were in broad range, as compared to the observations of Acedo (1992); Galvez and Dizon (2017). This might be due to the variability of jack types with respect to permeability to rain water and prevailing weather during fruit development.

The maximum amount of total soluble solids (31.47°B) was observed in fruits of KJ 182, which was on par with KJ 185 (31.13°B) and KJ 224 (30.6°B). These higher values of TSS might be due to the genetic variation among the jack types and differences in the growing condition. On the other hand, minimum (24.56°B) TSS was obtained from KJ 183, followed by KJ 121 (25.46°B) and Muttom Varikka (26°B) which were found statistically similar.

Jagadeesha *et al.* (2010) recorded 16.13 to 35°B TSS in 30 jackfruit types studied in coastal Karnataka. TSS range of 24.8 to 40.5°Brix was reported by Reddy *et al.* (2004) in elite clones of South Karnataka.

The maximum acidity (0.53%) was found in KJ 121 and Muttom Varikka, whereas minimum acidity (0.19%) was registered in the KJ 182 which was statistically on par with KJ 185 (0.23%). These results are almost similar to the findings of Gomez *et al.* (2015). An almost similar range of variation in acidity (0.18–0.88%) had been reported by Reddy *et al.* (2004). The findings of Nandini (1989) and Goswami *et al.* (2011) also supported the present findings.

TSS-acid ratio is an economically important biochemical parameter as it determines the taste and acceptability of jackfruits. Highest TSS-acid ratio (160.63) was observed in KJ 182, closely followed by KJ 185 (135.71) while minimum TSS-acid ratio (47.60) was found in KJ 121 and it was on par with Muttom Varikka (48.60), Singapore jack (54.17), KJ 224 (54.35), KJ 183 (62.32) and KJ 180 (70.03). Similar results were earlier reported by Selvaraj and Pal (1989) (23.3 to 153.2) and Jagadeesh *et al.* (2007) (37.9 to 170).

The highest percentage of total sugars (25.16%) was recorded in KJ 224 followed by KJ 182 (24.89%) which was statistically similar with each other and the lowest amount of total sugar has been recorded in KJ 183 (19.97%). The values are in conformity with the various previously published works of Maiti *et al.* (2002) and Reddy *et al.* (2004), where total sugar content ranged from 14.23 to 32.33 per cent.

102

The maximum reducing sugar (12.48%) was found in KJ 224, closely followed by KJ 182 (12.43%) while the minimum (8.42%) was found in KJ 183 and it was on par with Singapore jack (8.42%). The results are in accordance with the earlier reported values by Haque (1979) which ranged from 0.03 to 18.12 per cent.

The highest carotenoid content (4.86 mg/100g) was recorded in flakes of KJ 186, followed by KJ 182 (4.58 mg/100g) and KJ 185 (4.56 mg/100g), which were found to be on par. On the other hand, less carotenoid content of 1.59 mg/100g was found in Muttom Varikka.

The results are in agreement with Gomez *et al.* (2015) who reported carotenoid content of jack as 0.21 to 3.13 mg/100g pulp. But the values were higher in the present study compared to that of Jagadeesha *et al.* (2010), who reported total carotenoid content in the range of 0.25 to 0.70 mg/100g in jackfruit accessions of central zone of Karnataka. This variation might be due to the genetic makeup of these jack trees. Higher carotenoid content of the genotypes indicated the possibility of selecting elite genotypes rich in Vitamin A.

Summary

6. SUMMARY

The study entitled "Field evaluation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types" was undertaken in the Department of Pomology and Floriculture, College of Agriculture, Padannakkad during 2016-18. The study consisted of two parts; 1) evaluation of jackfruit types in field level and 2) fruit quality evaluation in laboratory. The findings of the study are summarized below:-

- Pre-bearing period of jack types KJ 186 (4 years), KJ 182 (5 years) and KJ 173 (5 years) were comparable to that of check varieties [Singapore jack(3 years) and Muttom Varikka(4 years)], which were of graft origin. This shows the precocious nature of KJ 186, KJ 182 and KJ 173.
- Some jack types came to maturity early, i.e., December end (KJ 185) and February (KJ 121, KJ 173 and KJ 186). Early bearing ones are mostly preferred as it could fetch high price in the market. As the fruits can be harvested well before commencement of monsoon, good quality fruits are obtained.
- Fruits mature in jack type KJ 183 during May to August, with good fruit quality. This type could be exploited for the availability of fruits during off season.
- Maximum number of fruits per cluster was observed in KJ 182 with 8 fruits per cluster. Within a cluster, the fruits were observed to be matured one after another, which ensured a long harvesting period in clustered jack types. Size of the fruit is also good for domestic consumption.
- Number of fruits produced in jack types varied from 12 fruits in KJ 180 to 342 fruits in KJ 182. The highest yield (881.67 kg /tree) was recorded in KJ 182 while the lowest yield (69.92 kg/tree) was recorded in KJ 180.
- Maximum average fruit weight (10.30 kg) and highest flake weight per fruit (3.45 kg) was recorded in KJ 356 which was on par with Muttom Varikka (9.21 kg). Hence, this type can be exploited for industrial uses.

105

- Highest flake thickness (4.77 mm) was measured in KJ 182, followed by KJ 185, KJ 224, KJ 183 and KJ 186. Usually the fruits with thick flakes are preferred for dessert purpose.
- Highest flake-fruit ratio (0.49) and flake seed ratio (6.39) observed in KJ 180 revealed its seedless nature.
- The maximum amount of total soluble solids (31.47°B) was observed in fruits of KJ 182, which was on par with KJ 185 (31.13°B) and KJ 224 (30.6°B). These values were superior as compared to that of check varieties.
- Jack types KJ 182 and KJ 185 recorded minimum titrable acidity which was significantly lower as compared to check varieties.
- TSS-acid ratio, an economically important biochemical parameter, as it determined the taste and acceptability of jackfruits was highest (160.63) in KJ 182, closely followed by KJ 185 (135.71).
- The highest percentage of total sugars (25.16%) was recorded in KJ 224 followed by KJ 182 (24.89%).
- Jack type KJ 224 recorded maximum reducing sugar (12.48%), closely followed by KJ 182 (12.43%).
- Highest carotenoid content (4.86 mg/100g) was recorded in flakes of KJ 186, followed by KJ 182 (4.58 mg/100g) and KJ 185 (4.56 mg/100g), which were found to be significantly higher than that of check varieties.
- Future research in this direction should focus on:
    - Conservation of these promising jackfruit types
    - Standardization of propagation method for each jack type
    - Incorporation of KJ 180 (seedless), KJ 182 (cluster) and KJ 397 (gumless) in future breeding programmes.
    - Apart from the use of KJ 173 (flakeless) for tender jack purpose, possibility of exploiting it as a potential source of pectin should be explored.

References

7. REFERENCES

Acedo, A.L. 1992. Jackfruit biology, production, use and Philippine research. Monograph number 1. Forestry/ Fuel wood research and development (F/FRED) project. Winrock International Institute for Agricultural Development, USA.

Ali, A.S.M.Y., Reza, H., Samsuzzaman., Rashid, H., Anwari, A., and Islam, Z. 2015. Evaluation of existing jackfruit germplasm. *Int. J. Nat. and Social Sci.* 2(4): 108-112.

Arung, E.T., Shimizu, K., and Kondo, R. 2006. Inhibitory effect of artocarpanone from *Artocarpus heterophyllus* on melanin biosynthesis. *Biol. Pharma. Bull.* 29: 1966-1969.

Aseef, R.M., Manikandan, K ., Kavino, M., Vijayakumar, R.M., and Ganesan, N.M. 2017. Biochemical evaluation of local genotypes of jackfruit (*Artocarpus heterophyllus* Lam.) in Pudukkotai District. *J. Pharmacognosy Phytochem.* 6(5): 2533-2536.

AOAC [Association of Official Analytical Chemists]. 1984. *Oficial Methods of Analysis*. (14th Ed.). Association of Official Analytical Chemists Inc, Virginia, 1141p.

Aswini, A., Mathew, K.L., Radha, T., Babylatha, A.K., Abida, P.S., and Krishnan. 2015. Morphological characterization of jackfruit (*Artocarpus heterophyllus* Lam.) accessions. *Int. J Trop. Agric.* 33(2): 1611-1615.

Azad, A.K. 2000. Genetic diversity of jackfruit in Bangladesh and development of propagation methods. Ph. D. Thesis, University of Southampton, UK.

Azad, A.K. and Jones, J.G. 2007. Assessing morphological and isozyme variation of jackfruit *(Artocarpus heterophyllus* L.) in Bangladesh. Centre for Environmental Sciences, School of Civil Engineering and the

Environment, The University of Southampton, High Field, Southampton, UK. 71(2): 109-125.

Berry, S.K. and Kalra, C.L. 1988. Chemistry and technology of jackfruit (*Artocarpus heterophyllus*) - A review. *Indian Food Pack* 42(3): 62-76.

Bhanu, M.U., Melanta, K.R., and Gowda, A.P.M. 2006. Developmental changes during growth and maturation in few elite jackfruit (*Artocarpus heterophyllus* Lam.) clones. *J. Asian Hortic.* 2(3): 176-181.

Chadha, K.L. and Patel, V.B. 2007. Prospects of indigenous perennial plant as source of vegetable. In: Chadha, M.L., Kuo, G., and Gowda, C.L.L. (eds.), *Proceedings of the 1st International Conference on Indigenous Vegetables and Legumes Prospects for Fighting Poverty, Hunger and Malnutrition*, 12-15 Dec. 2006, Hyderabad, India, pp. 49-54.

Chandrashekar, K.G., Vijayakumar, R.M., Subramanian, S., Kavino, M., and Joel, A. J. 2018. Morphological characterization of jackfruit (*Artocarpus hetrophyllus* Lam.) local genotypes under coffee ecosystem of lower Pulney hills. *Int. J. Curr. Microbiol. Appl. Sci.*7(3): 2210-2224.

Chandrasekhar, V. 2014. Survey and characterization of Jackfruit germplasm available in Andhrapradesh to identify elite trees. M.Sc Thesis, Dr. Y. S. R. Horticultural University, West Godavari, Andhrapradesh.

Craig, R.E. and Harley, I.M. 2006. *Artocarpus heterophyllus* (Jackfruit). In : *Species Profiles for Pacific Island Agroforestry.* p. 2-11.

Deb, P., Munsi, P. ., and Bhowmick, N. 2013. Quality evaluation of some jackfruit genotypes of Eastern and Noth-Eastern India. In: *Proceedings of Second International Symposium on Minor Fruits and Medicinal Plants for Better Llives (2nd ISMF & MP)*, 20 December 2013, University of Ruhana, Sri Lanka, Sri Lanka, pp. 68-73.

DES GOK [Department of Economics and Statistics, Government of Kerala]. 2016. Economics and statistics department home page [on-line]. Available: http://www.ecostat.kerala.gov.in/index. php/agriculture. [24 June 2018].

Galvez, L.A. and Dizon, E.I. 2017. Physico-chemical and functional properties of two jackfruit (*Artocarpus heterophyllus* Lam.) varieties in Eastern Visayas, Philippines. An. Trop. Res. 39(2): 100-106.

Ghosh, S.P. 1996. Technical Report for Use of Underutilised Tropical fruits in Asia Network. UTFANET, Southampton University, UK.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*. John Wiley and Sons. Inc., New York, pp. 67-215.

Gomez, S., Joseph, P.M., Sheela, K.B., Sruthi C.V., and Lal, L. 2015. Variability in fruiting season and quality attributes of jackfruit (*Artocarpus heterophyllus* Lam.) accessions of Kerala. *Int. J. Trop. Agric.* 33:1249-1255.

Goswami, C., Hossain, M.A., Mortuza, M.G., and Islam, R. 2010. Physico-chemical parameters of jackfruit (*Artocarpus heterophyllus* Lam.) seeds in different growing areas. *Int. J. Biores*. 2(10): 1-5.

Goswami, C., Hossain, M.A., Kader, H.A., and Islam, R. 2011. Assessment of physicochemical properties of jackfruits (*Artocarpus heterophyllus* Lam.) pulps. *J. Hortic. For. and Biotechnol.* 15(3): 26-31.

Haq, N. 1995. Analysis of questionnaire to select priority species for research and development in Asia. In: Arora, R.K. and Rao, V.R. (eds). Proceedings of Expert Consultation on Tropical Fruit Species of Asia, IPGRI, Singapore.

Haq, N. 2006. Jackfruit, *Artocarpus heterophyllus*, Southampton Centre for Underutilised Crops, University of Southampton, Southampton, UK.

Haque, M.A. 1979. Nutritive value of jackfruit. *Bangladesh J. Agric. Sci.* *4*(1): 9-2.

Harshavardhan, A. and Rajasekhar, M. 2012. Eect of pre-sowing seed treatments on seedling growth of jackfruit (*Artocarpus heterophyllus* Lam.). J. Res. ANGRAU. 40(4): 87-89.

Ibrahim, M., Islam, M.S., Helali, M.O., Alam, A.K.M.S., and Shafique, M.Z. 2013. Morphological fruit characters and nutritional food value of different ackfruit (*Artocarpus heterophyllus* Lam.) cultivars in Rajshahi region of Bangladesh. *Bangladesh J. Sci. Ind. Res.* 48(4): 287-292.

IPGRI [International Plant Genetic Resource Institute]. 2000. *Descriptors for Jackfruit* (*Artocarpus heterophyllus* Lam.). International Plant Genetic Resource Institute. Rome, Italy, 64p.

Jagadeesh, S.L., Reddy, B.S., Swamy, G.S.K., Kirankumar, G., Laxminarayan, H., and Raghavan, G.S.V. 2007. Chemical composition of jackfruit (*Artocarpus heterophyllus* Lam.) selections of Western Ghats of India. *Food Chem.* 102(1): 361-65.

Jagadeesha, S.L., Reddy, B.S., Basavaraj, N., and Swamy, G.S. 2010. Variability studies in physico-chemical qualities of jackfruit (*Artocarpus heterophyllus* Lam.) of coastal zone of Karnataka. *Karnataka J. Agric. Sci.* 23(2): 293-297.

Khan, R., Nyree, Z., Salma, H., and Zuberi, M.I. 2010. Jackfruit (*Artocarpus heterophyllus* Lam.) diversity in Bangladesh: land use and artificial selection. *Econ. Bot.* 64(2): 124-136.

Krishnan, A.G., Jayalekshmi, G., Joseph, E., and Sabu, T.S. 2015. Assessment of physico-chemical properties of jackfruit collections from Kuttanad region of Kerala. *Asian J. Hortic.* 10(2): 262-266.

Maheswari, T.U. and Nivetha, K. 2015. Effect of age of the rootstock on the success of softwood grafting in jack (*Artocarpus heterophyllus* Lam.). *Plant Arch.* 15(2): 823-825.

Maiti, C.S., Wangchu, L., and Mitra, S.K. 2002. Genetic divergence in jackfruit (*Artocarpus heterophyllus* Lam.). *Indian J. Genet.* 62(4): 369-370.

Maiti, C.S., Wangchu, L., and Mitra, S.K. 2003. Genotypic variability of physico chemical attributes in jackfruit (*Artocarpus heterophyllus* Lam.) genotypes of West Bengal. *Indian Agric.* 47(3/4): 193-199.

Medagoda, I. 2011. Jackfruit in Sri Lanka. In: Valavi, S.G., Peter, K.V., and Thottappilly, G. (eds.) The jackfruit, Stadium Press LLC, Texas, pp. 369-392.

Misra, P.S., Mertz, E.T., and Gloves, D.V. 1975. A rapid method for quantification of fiber. *Cereal Chem.* 52: 844.

Mitra, S.K. and Mani, D. 2000. Conservation and utilization of genetic resources in jackfruit (*Artocarpus heterophyllus* Lam.) – a potential underutilized fruit. In: Verdonck, O., Mathe, A., Relf, P.D., Matsuo, E., Groening, G., and Rammeloo, J. (ed), *Proceedings of the XXV International Horticultural Congress Part 13. New and specialized crops and products, botanic gardens, and human-horticulture relationship*, 1-2 August 1998, Brussels, Belgium, *Acta Hortic.* pp. 229-233.

Mitra, S.K. and Maity, C.S. 2002. A summary of the genetic resources in jackfruit (*Artocarpus heterophyllus* Lam.) in West Bengal, India. *Acta Hortic.* 575: 269-271.

Moncur, M. W. 1985. Floral ontogeny of the jackfruit. *Aust. J. Bot.* 33: 585-593.

Morton, J.F. 1987. *Fruits of warm climates*. Creative resources system, Winterville, North Carolina, USA. p.58-64.

Muthulakshmi, P. 2003. Genetic diversity and canopy management in jackfruit (*Actocarpus heterophyllus* Lam.), Ph.D. Thesis, Kerala Agricultural University, Thrissur, 232p.

Mynard, A.J. 1970. *Methods in Food Analysis*. Academic press, New York.176p.

Nandini, S. 1989. The comparative study on the preservation of jackfruit. M.Sc. thesis, University of Agricultural Sciences, Dharwad, India. pp 41-44.

NHB [National Horticulture Board]. 2017. Horticultural Statistics At A Glance 2017 [on-line]. Available: http://nhb.gov.in/statistics/Publication/Horticulture%20At%20a%20Glance%202017%20for%20net%20uplod%20(2).pdf [24 June 2018].

Nazrul, M.I., Alam, M.S., Hossain, M.S., and Rahman, M.A. 2004. Fruit characteristics of jackfruit as influenced by bearing positions. *J. Subtropical Agric. Res. Dev.* 2(3): 63-66.

Nimisha, C. 2016. Identification and characterizationof jackfruit types(*Actocarpus heterophyllus* Lam.) in Kasargod district.M Sc Hort. Thesis, KAU, Thrissur, 213p.

Nunjundaswamy, A.N. and Mahadeviah, M. 1993. Fruit processing. Advances in Hort. 4. In: Chadha, K.L. and Pareek, O.P (eds.). Malhotra Publishing House, New Delhi, pp.1835-1875.

Patil, R., Joshi, G.D., Haldankar, P.M., and More, M. 2011. Estimation of pectin content in jackfruit (*Artocarpus heterophyllus*). *Asian J. Hortic.* 6(2): 536-537.

Phaomei, G., Pereira, L.S., and Mathew, B. 2018. Variability of fruit characters of jackfruit in Rongram block of West Garo hills of Meghalaya. *Environ. Ecol.* 36(2A): 611-615.

Punan, M.S., Rahman, A.S.A., Nor, L.M., Muda, P., and Sapii, A.T. 2000. Establishment of a quality assurance system for minimally processed

jackfruit. In: Johnson, G.I., To, L.V., Duc, N.G., and Webb, M.C. (Eds.). *Quality assurance in agricultural produce*. MARDI, Kuala Lumpur, Malaysia, 115-122.

Rahman, M.H., Patwary, M.M.A., Barua, H., Nahar, S., and Ahmmed, A.N.F. 2016. Evaluation of yield and quality of three jackfruit (*Artocarpus heterophyllus* Lam.) genotypes. *The Agric.* 14(1): 107-111.

Rai, M. and Reddy, N.N. 2000. Jackfruit cultivation in India. Recent Trends in Horticultural Research. CHES, Ranchi. p. 144-152.

Rai, M., Visha, I.N., Das, B.R., and Kumar, B. 2003. Evaluation of jackfruit genotypes for yield and quality attributes under Eastern Indian condition. *The OrissaJ. Hortic.* 31(1): 1-5.

Ramakrishna, M., Madhumathi, C., Sadarunnisa., and Purushotham, K. 2006. Performance of different varieties of jackfruit (*Artocarpus heterophyllus* Lam.) in Southern zone of Andhra Pradesh. In: *Proceedings of the National Symposium on Production, Utilization and Export of Underutilized Fruits with Commercial Potentialities,* 22-24 November 2006,West Bengal. Bidhan Chandra Krishi Viswavidyalaya, West Bengal, pp. 42-44.

Ranganna, S. 1991. *Manual of Analysis of Fruit and Vegetable Products.* (2nd Edn.), Tata M.C., Graw Hill Pub. Co. Ltd., New Delhi.

Reddy, B.M.C., Patil, P., Kumar, S.S., and Govindaraju, L.R. 2004. Studies on physic-chemical characteristics of jackfruit clones of South Karnataka. *Karnataka J. Agric. Sci.* 17(2): 279-282.

Roy, A. 2017. Studies on morphological and reproductive traits of jackfruit germplasm under *tarai* conditions of Uttarakhand.M.Sc.(Ag.) thesis, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, 116p.

Roy, A., Pratibha., Choudhary, M., and Dongariyal, A. 2018. Studies on morphological traits of jackfruit (*Artocarpus heterophyllus* Lam.) germplasm under *tarai* conditions of Uttarakhand, India. *Int. J. Curr. Microbiol. Appl. Sci*. 7(1): 3119-3125.

Sabiha, M., Sultana, M.A., and Khan, S.A.K.U. 2006. Evaluation of physical characteristics of some off-season jackfruit germplasms from South-Western region of Bangladesh. *Agrotechnology Discipline*. 7(2): 71-76.

Sarker, S.R. and Zuberi, M.I. 2011. Assesment of morphological characters and ethnobotanical survey of jackfruit germplasm in two sites of Rajshahi, Bangladesh. *Geneconserve* 10(40): 110-128.

Saxena, A., Bawa, A.S., and Raju, P.S. 2009. Optimization of a multitarget preservation technique for jackfruit (*Artocarpus heterophyllus* Lam.) bulbs. *J. Food Eng.* 91: 18-28.

Selvaraj, Y. and Pal, D.K. 1989. Biochemical changes during the ripening of jackfruit (*Artocarpus heterophyllus* Lam.). *J. Food Sci. Technol.* 26: 304-307.

Shahin, N., Alam, S., and Ali, M. 2012. Pharmacognostical standardisation and antidiabetic activity of *Artocarpus heterophyllus* Lam. leaves. *Int. J. Drug. Dev. Res*. 4, 346–352.

Sharma, S.K., Singh, A.K., and Singh, O.P. 2005. A study on genetic variability and germplasm evaluation in jackfruit (*Artocarpus heterophyllus* Lam.). *Adv. Plant Sci*. 18(2): 549-553.

Sharma, S.K., Singh, A.K., and Singh, O.P. 2006. Character association among various quantitative traits in jackfruit (*Artocarpus heterophyllus* Lam.). *Adv. Plant Sci*. 19(11): 633-638.

Sheoran, O.P., Tonk, D.S., Kaushik, L.S., Hasija, R.C., and Pannu, R.S. 1998. Statistical Software Package for Agricultural Research Workers. In:

Hooda, D.S. and Hasija, R.C. *Recent Advances in information theory, Statistics & Computer Applications*, Department of Mathematics Statistics, CCS HAU, Hisar. pp.139-143.

Singh, S.R., Narayanaswamy, P., Banik, B.C., Shyamalamma, S., and Simon, L. 2011. Evaluation of cracking and non-cracking genotypes of jackfruit (*Artocarpus heterophyllus* Lam.). *Crop Res.* 42(1, 2 & 3): 157-162.

Soong, Y.Y. and Barlow, P.J. 2004. Antioxidant activity and phenolic content of selected fruit seeds. *Food Chem.* 88(3): 411-417.

Tang, Y.P., Linda, B.L.L., and Franz, L.W. 2013. *Int. Food Res. J.* 20(1): 409-415.

Teaotia, S.S.K. and Awasthi, R.K. 1968. Dehydration studies in jackfruit (*Artocarpus heterophyllus* Lam.). *Indian Food Packer* 22(5): 6-14.

Wang, Y., Chunhai, Y., Feng,F., and Yingzhi, L. 2009. Morphological markers and principal components analysis of jackfruit germplasm in Leizhou Peninsula. *Chinese J Trop. Crops* 30(6): 761-768.

Wangchu, L., Singh, D., and Mitra, S.K. 2013. Studies on the diversity and selection of superior types in jackfruit (Artocarpus heterophyllus Lam.). *Genet. Resour. Crop Evol.* 60(5): 1749-1762.

Yap, A.R. 1972. Jackfruit (*Artocarpus heterophyllus* Lam.). In: Cultural Directions for Philippine Agricultural Crops, Vol. 1: Fruits. Public Affairs Office Press, Bureau of Plant Industry, Department of Agriculture, Malate, Manila, Philippines, Pp. 137-141.

116

FIELD EVALUATION OF PROMISING JACKFRUIT (*Artocarpus heterophyllus* Lam.) TYPES

by

AJEESH B R

(2016-12-017)

Abstract of the thesis
Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF POMOLOGY AND FLORICULTURE
COLLEGE OF AGRICULTURE
PADANNAKKAD, KASARGOD 671 314
KERALA, INDIA
2018

ABSTRACT

The study entitled "Field evaluation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types" based on morphological, yield and quality characters was undertaken in the Department of Pomology and Floriculture, College of Agriculture, Padannakkad during 2016-18. The study consisted of ten jackfruit types such as KJ 121 (fruiting thrice), KJ 173 (flakeless), KJ 180 (seedless), KJ 182 (cluster), KJ 183 (off-season), KJ 185 (early), KJ 186 (early), KJ 224 (high TSS), KJ 356 (high TSS) and KJ 397 (gumless), located in farmers' field in Kasargod district, already identified and characterized by Nimisha (2016) and two check varieties - Muttom Varikka and Singapore jack.

Among the jackfruit types subjected to evaluation, KJ 185, KJ 121, KJ 173 and KJ 186 were observed to be early season bearers (December to February), while KJ 183 was observed to bear fruits during off season (upto August). These types could be used to fulfill the need of fruits during off season.

Jack type KJ 356 and KJ 397 could be suggested for value-addition as KJ 356 possessed highest fruit weight (10.30 kg) and flake weight per fruit (3.45 kg) and KJ 397 had gumless fruits.

Jackfruit types like KJ 173 (flakeless) could be used for culinary purpose whereas KJ 180 (seedless) with rudimentary seeds could be conserved for future breeding programme in jackfruit.

Highest flake thickness (4.77 mm) observed in KJ 182, followed by KJ 185 (3.73 mm) and highest TSS recorded in KJ 182 (31.47°B) and KJ 185 (31.13°B) suggested the suitability of these types for dessert purposes.

Jackfruit types, KJ 182, KJ 185 and KJ 186 were found to be superior in most of the quality parameters like TSS, titrable acidity, TSS-acid ratio, reducing sugar percent and carotenoid content.

Hence, KJ 173 (flakeless), KJ 183 (off-season), KJ 182 (cluster), KJ 185 (early), KJ 186 (early) and KJ 397 (gumless) need to be popularized for cultivation.

സംക്ഷിപ്തം

ബാഹ്യ രൂപവും, വിളവും, പഴഗുണ ഘടകങ്ങളും അടിസ്ഥാനമാക്കി മികവുള്ള പ്ലാവുകളുടെ കൃഷിയിടത്തിലുള്ള വിലയിരുത്തലിനായി പടന്നക്കാട് കാർഷിക കോളേജിലെ പഴവർഗ്ഗ-പുഷ്പവർഗ്ഗ ശാസ്ത്ര വിഭാഗത്തിൽ 2016-2018 കാലയളവിൽ പഠനം നടത്തുകയുണ്ടായി. ഈ പഠനത്തിൽ കാസർഗോഡ് ജില്ലയിൽ നിരീക്ഷിച്ച്, തിരിച്ചറിഞ്ഞതും, വർണ്ണിച്ചതുമായ (നിമിഷ, 2016) പത്തു മികച്ച പ്ലാവുകളായ കെ.ജെ.121 (വർഷത്തിൽ മൂന്നു പ്രാവശ്യം കായ്ക്കുന്നത്), കെ.ജെ.173 (ചുളയില്ലാത്തത്), കെ.ജെ.180 (കുരുവില്ലാത്തത്), കെ.ജെ.182 (കുലയിൽ ചക്ക പിടിക്കുന്നത്), കെ.ജെ.183 (കാലം മാറി കായ്ക്കുന്നത്), കെ.ജെ.185 (കാലത്തിനു മുൻപ് കായ്ക്കുന്നത്), കെ.ജെ.186 (കാലത്തിനു മുൻപ് കായ്ക്കുന്നത്), കെ.ജെ.224 (മധുരമേറിയത്), കെ.ജെ.356 (മധുരമേറിയത്), കെ.ജെ.397 (കറയില്ലാത്തത്) എന്നിവയും, ഒത്തുനോക്കാനായി മുട്ടം വരിക്ക, സിങ്കപ്പൂർ ജാക്ക് എന്നീ പ്ലാവിനങ്ങളും ഉൾപ്പെടുത്തി.

വിലത്തിരുത്തിയ പ്ലാവുകളിൽ കെ.ജെ.185, കെ.ജെ.121, കെ.ജെ.173, കെ.ജെ.186 എന്നിവയിൽ ഡിസംബർ-ഫെബ്രുവരി മാസങ്ങളിലേ ചക്ക പിടിക്കുന്നതായും, കെ.ജെ.183 ൽ ഓഗസ്റ്റ് മാസം വരെ ചക്ക ലഭിക്കുന്നതായും കാണപ്പെട്ടു. ഇത്തരം പ്ലാവുകൾ സാധാരണ ചക്ക ലഭിക്കാത്ത കാലത്തെ ചക്ക ലഭ്യത ഉറപ്പുവരുത്താൻ ഉപയോഗിക്കാവുന്നതായി കണ്ടു.

ഭാരം കൂടിയ ചക്കകൾ (10.30 കിലോഗ്രാം) ഉല്പാദിപ്പിക്കുന്ന കെ.ജെ.356 ഉം, കറയില്ലാത്ത ചക്കകൾ കാണപ്പെട്ട കെ.ജെ.397 ഉം ചക്കപ്പഴത്തിൻറെ വ്യാവസായിക മൂല്യവർദ്ധനത്തിന് നിർദ്ദേശിക്കാവുന്നതാണ്.

ചുളയില്ലാത്ത ചക്ക ഉല്പാദിപ്പിക്കുന്ന കെ.ജെ.173 പച്ചക്കറിയായി ഉപയോഗിക്കാം. പൂർണ്ണ വികാസം പ്രാപിച്ചിട്ടില്ലാത്ത വിത്തുകൾ ഉൾക്കൊണ്ട കെ.ജെ.180 പ്ലാവിൻറെ ഭാവി പ്രജനനത്തിനായി സംരക്ഷണം അർഹിക്കുന്നു.

ചുളയുടെ കനം, ചുളയുടെ മധുരം എന്നീ ഗുണങ്ങളിൽ മികച്ചുനിന്ന കെ.ജെ.182, കെ.ജെ.185 എന്നിവ തീൻമേശയിലെ മേന്മയും സാധ്യതയും വിളിച്ചോതുന്നു.

പഠനവിധേയമാക്കിയ ഒട്ടുമിക്ക പഴഗുണ ഘടകങ്ങളിലും കെ.ജെ.182, കെ.ജെ.185, കെ.ജെ.186 എന്നീ പ്ലാവുകളിലെ ചുളകൾ മികച്ചുനിൽക്കുന്നതായി കണ്ടു.

ആയതിനാൽ കെ.ജെ.173 (ചുളയില്ലാത്തത്), കെ.ജെ.183 (കാലം മാറി കായ്ക്കുന്നത്), കെ.ജെ.182 (കുലയിൽ ചക്ക പിടിക്കുന്നത്), കെ.ജെ.185 (കാലത്തിനു മുൻപ് കായ്ക്കുന്നത്), കെ.ജെ.186 (കാലത്തിനു മുൻപ് കായ്ക്കുന്നത്), കെ.ജെ.397 (കറയില്ലാത്തത്) തുടങ്ങിയ മികച്ച പ്ലാവിനങ്ങൾ കർഷകരുടെ ഇടയിൽ പ്രചാരത്തിലാക്കാമെന്ന് കണ്ടെത്തി.

Appendices

APPENDIX I

Details of farmers holding the promising jack types as well as check varieties

Jackfruit type	Name of farmer	Address	Panchayat/ Municipality
(A) Promising jack types			
KJ 121	Smt. Janaki	Kadayangal House, Kanhangad South, Padannakkad	Kanhangad
KJ 173	Sri. Lakshmanan. K	Konnoth House, Udhinoor P.O, Padanna	Padanna
KJ 180	Sri. Ramakrishnan	R. S. Nilayam, Koottakkani, Pakkam P.O	Pallikkara
KJ 182	Sri. Abdul Rasak	Noushad Manzil, Chirappuram	Nileshwar
KJ 183	Sri. Ramdas. P. M	Puthukkai Madam, Chirappuram	Nileshwar
KJ 185	Sri. Kunjabdulla	Sahidha Manzil, Pallikkara	Nileshwar
KJ 186	Sri. Pramod. M	Taliyathil House, Karuvacheri, Nileshwar P.O	Nileshwar
KJ 224	Smt. Radha	Vattak (H), Palayi, Puthariyaduka	Nileshwar
KJ 356	Sri. Kunjamma. K	Kelam Valappil, Bevuri, Uduma P.O	Udhuma
KJ 397	Sri. Kesava Bhatt	Kanadhenu Farm, Ramdas Nagar P.O, Kudlu	Mogral Puthur
(B) Check varieties			
Muttom Varikka	College of Agriculture, Padannakkad	Instructional Farm, College of Agriculture, Padannakkad	Nileshwar
Singapore jack	College of Agriculture, Padannakkad	College of Agriculture, Padannakkad	Nileshwar

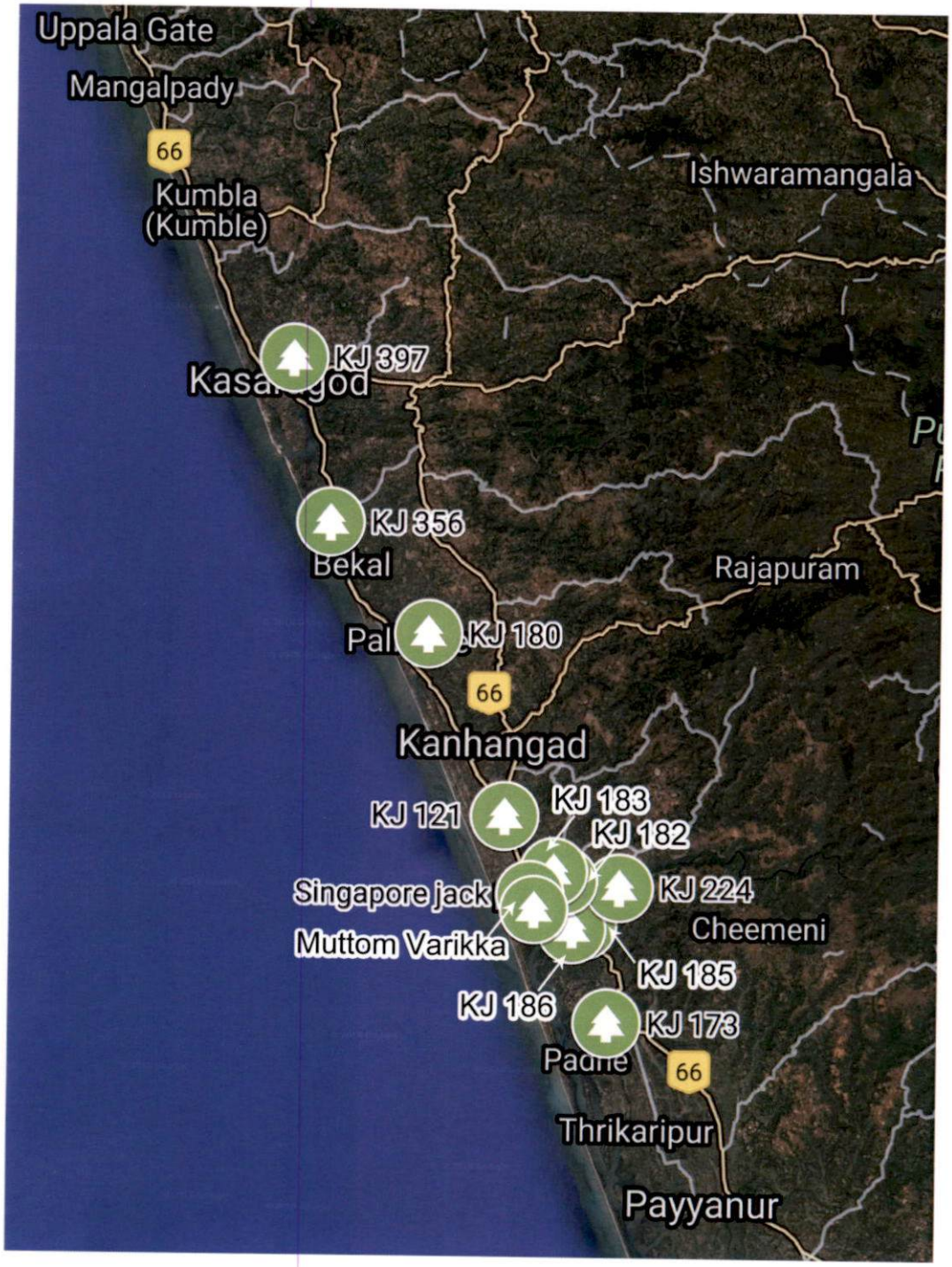
APPENDIX II

GPS reading of the location of the jackfruit types as well as check varieties

Sl. No.	Jack type	Latitude	Altitude
1	KJ 121	12° 17.777'N	75° 06.153'E
2	KJ 173	12° 14.523'N	75° 08.311'E
3	KJ 180	12° 26.552'N	75° 00.700'E
4	KJ 182	12° 15.897'N	75° 08.072'E
5	KJ 183	12° 15.897'N	75° 07.597'E
6	KJ 185	12° 15.462'N	75° 06.969'E
7	KJ 186	12° 14.524'N	75° 08.305'E
8	KJ 224	12° 14.525'N	75° 08.307'E
9	KJ 356	12° 26.551'N	75° 00.699'E
10	KJ 397	12° 32.335'N	74° 59.942'E
11	Muttom Varikka	12° 15.117'N	75° 06.947'E
12	Singapore jack	12° 15.473'N	75° 06.945'E

APPENDIX III

Map showing location of trees of jackfruit types in Kasaragod District



APPENDIX IV

Weather data during the period September 2017 to August 2018

Date	Maximum Temperature (°C)	Minimum Temperature (°C)	Relative humidity (%)			Monthly rainfall (mm)
			I	II	Average	
October 2017	30.41	22.37	92.42	72.65	82.53	179.2
November 2017	31.63	21.58	92.13	65.30	78.71	23.3
December 2017	31.54	20.171	92.64	61.67	77.16	30.6
January 2018	30.98	20.13	93.29	61.61	77.45	0.00
February 2018	31.68	21.14	92.07	59.61	75.83	0.06
March 2018	32.47	23.62	90.38	62.83	76.61	36.9
April 2018	33.13	24.68	87.47	64.53	76	10.1
May 2018	32.36	24.51	88.48	67.74	78.11	277.14
June 2018	29.55	24.11	94.07	83.80	88.93	925.2
July 2018	29.99	24.48	94.45	81.06	87.75	868
August 2018	29.34	23.95	94.87	80.94	87.90	692.54

APPENDIX V

Questionnaire to get basic information on selected jack trees

Name of farmer	:
Address	:
Origin of tree (Seedling / graft)	:
Age of tree	:
Number of years from planting to 1st fruiting	:
Fruiting season	:
Fruit quality and acceptability	:
Special character or purposes, if noticed	:

APPENDIX VI

Result on organoleptic scoring of jackfruit types during 2016 with score card

Jackruit type	Taste	Flavour	Colour	Texture	Sweetness	Appearance	Overall acceptability
KJ 121	6.55	6.40	7.40	6.30	5.75	6.40	6.55
KJ 180	5.45	5.50	6.20	6.60	5.30	6.75	6.30
KJ 182	7.75	6.35	6.45	7.10	7.65	6.85	7.35
KJ 183	7.60	7.45	7.95	7.55	7.95	7.65	7.70
KJ 185	7.75	7.70	7.90	7.45	8.45	7.85	7.80
KJ 186	8.45	8.45	8.45	8.00	8.60	8.20	8.60
KJ 224	8.20	8.15	8.50	8.54	8.30	7.40	8.45
KJ 356	8.50	7.80	7.80	8.15	8.65	8.25	8.45
KJ 397	8.55	8.05	7.60	8.15	8.50	7.95	8.30
Muttom Varikka	6.50	7.05	6.95	7.15	6.10	7.55	6.65
Singapore jack	7.65	6.90	7.05	6.60	7.45	6.80	7.15

Source: Nimisha (2016)

Score card

Score		Taste	Flavour	Colour	Texture	Sweetness	Appearance	Overall acceptability
Like	extremely							
	very much							
	moderately							
	slightly							
Neither like nor dislike								
Dislike	slightly							
	moderately							
	very much							
	extremely							

Source: Nimisha (2016)