VEGETATIVE PROPAGATION OF PROMISING JACKFRUIT (*Artocarpus heterophyllus* Lam.) TYPES

by

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(2015-12-017)

THESIS

Submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF POMOLOGY AND FLORICULTURE

COLLEGE OF AGRICULTURE

PADANNAKKAD, KASARAGOD – 671 314

KERALA, INDIA

2018

DECLARATION

I, hereby declare that this thesis entitled **"VEGETATIVE PROPAGATION 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

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CERTIFICATE

Certified that this thesis entitled **"VEGETATIVE PROPAGATION OF PROMISING JACKFRUIT (*Artocarpus heterophyllus* Lam.) TYPES"** is a record of research work done independently by Mr. Ashok Madala under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associ ateship to him.

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

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EXTERNAL EXAMINER

ACKNOWLWDGEMENT

This thesis would not have been possible without the inspiration and support of a number of wonderful individual – my thanks and appreciation to all of them for being a part of this journey and making this thesis possible.

I avail this opportunity to express my deep sense of gratitude and devotion to my research guide, ***Dr. A. Rajagopalan****, Professor and Head, Department of Pomology and Floriculture, College of Agriculture, Padannakad, Chairman of Advisory Committee and for sensory studies of the investigation. I am deeply thankful for his excellent guidance and keen interest at every stage was the boost for this investigation. Without his enthusiasm, continuous encouragement and optimism this thesis would hardly have been completed.*

I would like to express my sincere gratitude to ***Dr. K.N. Satheeshan****, Professor (Horticulture), RARS, 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. N. Raji Vasudevan****, Assistant Professor, Department of Plant Breeding and Genetics, College of Agriculture, Padannakad and Member of Advisory Committee for her overwhelming support and valuable suggestions rendered during the course of my investigation.*

I owe a debt of gratitude to ***Dr. M. Govindan****, former Associate Dean, College of Agriculture, Padannakkad for his ever willing help and support rendered at various phase of post graduate programme.*

I am deeply obliged to all teachers of College of Agriculture, Padannakkad, ***Dr. M. P. Giridharan, Dr. G.V. Sudarsana Rao, Dr. A.S. Anil Kumar, Dr. P. R. Suresh, Dr. K. M. Sreekumar, Dr. Sujatha N., Dr. Yamini Varma, Dr. T.K. Bridgit, Dr. N.K. Binitha, Mrs. Sangeetha K. G., Dr. Reshmi. C.R., Mrs. Rejitha, Dr. Chinju V. S., Mr. Mohammed Anees, Mr. Ashique, , Ms. Anju M Sunny, Mrs. Namitha*** *and* ***Ms. Anusha Anwar*** *for their valuable suggestions and timely advices and for giving access to the laboratory and research facilities.*

No words can fully express my sincere thanks and obligations to ***Sri. Ashokan, Smt. Leena and Smt. Shantha****, Grafting experts, Instructional Farm College of Agriculture, Padannakkad, for their dedicated service. Without their service I couldn't complete my work.*

It is my pleasure to extend my sincere thanks to all the ***Farmers*** *who were co-operated with me throughout my research work.*

I specially thank all the administrative, non-teaching staff, farm officers, labourers who all were directly or indirectly involved during the conduct of the research programme.

I am forever thankful to my batchmates ***Sunayana, Swaroop, Ashiba, Sherin, Aswathy, Santhi, Ebimol, Vishnupriya, Vineetha, Nusruth, Giridhari,*** *and my juniors* ***Ajeesh, Shiva, Mubarak, , Hassain, Anto, Amrutha, Chanchala, Vinayak, Akhil, Shibin, Adarsh, Amalendhu, Sajay*** *and my seniors* ***Nimisha, Abhimanue, Kokila, Saravana Kumar, Yusuf Abbas, Arun Kumar*** *and my friends* ***Madhu soodhanan, Arjun, Nimisha, Ajnu, Swathi, Neethu, Unnimaya*** *and all my seniors, juniors of UG batch for their friendship and support and for creating a cordial working environment.*

Above all, I am forever indebted to my beloved parents, ***Sri. M. Ayyappan, Smt. U. Janaki*** *and my elder brother,* ***Ajith Madala*** *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 fellowship during the tenure of the M.Sc. (Horticulture) programme.

Above all, I humbly bow my head before God almighty for the essential strength, support, good health and well-being that are necessary for the completion of this work.

Ashok Madala

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LIST OF ABBREVIATIONS

%	-	Percent
°	-	Degree
°B	-	Degree Brix
°C	-	Degree Celsius
CD	-	Critical Difference
cm	-	Centimeter
cm^2	-	Centimeter square
cv.	-	Cultivar
DAG	-	Days after grafting
DAS	-	Days after sprouting
et al	-	And others
Fig.	-	Figure
FYM	-	Farmyard manure
g	-	Gram
ha	-	Hectare
ha^{-1}	-	Per hectare
hr	-	Hour
ie.,	-	That is

KAU	-	Kerala Agricultural University
kg	-	Kilogram
KJ	-	Kasaragod Jackfruit
m	-	Meter
m^2	-	Meter square
mm	-	Millimeter
mm^2	-	Millimeter square
NA	-	Not Applicable
No.	-	Number
RARS	-	Regional Agricultural Research Station
SEm	-	Standard Error
t	-	tons
viz	-	Namely

INTRODUCTION

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam.) is an evergreen fruit crop of the tropical region, belonging to the family Moraceae. The tree bears largest and heaviest fruit among the edible fruits and also known as poor man's food (Sturrock, 1959). It is a versatile crop which provides multiple products for food, fodder, fuel, timber, medicine and industry.

Jackfruit is believed to be native of India, originated in rain forests of the Western Ghats (APAARI, 2012) and is widely cultivated in Bangladesh, Malaysia, Myanmar, Indonesia, Sri Lanka, West Indies, Vietnam, Pakistan and other tropical countries (Bose and Mitra, 2002) and it is the National fruit of Bangladesh. It is hardly considered as a commercial fruit crop in India, though it is widely grown in the country 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). The crop is quite popular in the eastern and southern parts of India and it is a popular food, ranking next to the mango and banana in total production (Baskaran *et al.*, 2008).

Jackfruit is an important component of homesteads in Kerala. Jackfruit often assumes the role of a secondary staple food among the poor classes and house wives for culinary preparation (Maheswari and Nivetha, 2015) because of its less cost and wide availability. There are two types of jackfruits, *koozha* (soft fleshed) and *varikka* (firm fleshed). *Varikka* types are commercialized because of its superior taste and fruit quality whereas *koozha* types are prominent in making processed products like jam, squash, wine etc.

The whole tree itself is having immense medicinal values. Fruit is a rich source of nutrients. Seeds are rich in carbohydrate; it can be used to make various food items (Kittur *et al.*, 2015). Langford (2014) reported that jackfruit could be a replacement of wheat, corn and other staple crops which were threatened by global warming and unpredictable rainfall. So without having a doubt it could be simply said that jackfruit is a forgotten 'Kalpavriksha' (Padre, 2017). Still it remains as an underutilized fruit mainly due to the wide variability in fruit quality.

Presently, demand for jack fruit is increasing because of its versatile uses and health benefits. However, long gestation period, limited choice of suitable varieties and non availability of elite planting materials, variability in the yield and quality are some of the hurdles in cultivation of jackfruit (Nunjundaswamy and Mahadeviah, 1993). Among the various constraints, lack of suitable clonal planting materials is the major impediment in cultivation. Though, seed propagation is the most common method of propagation, it will not produce true-to-type progenies, besides having longer gestation period (Baskaran *et al.*, 2008). The crop is an obligate cross pollinated fruit species exhibiting higher variability due to its heterozygous nature (Harshavardhan *et al.*, 2011). Unlike other crops, jackfruit shows 'type variation' in seedlings. The cross pollination behavior of the crop leads to variability in offsprings, as a result sometimes *varikka* type may produce *koozha* type plants and vice versa. Hence, vegetative propagation methods are inevitable to supply genetically superior and uniform planting materials.

People prefer jack fruits with characters like precocity, sweetness, gumless nature, small size and cluster bearing habit. Though standard varieties in jackfruit are less, there are good numbers of trees which are superior in yield and desirable fruit characters. Nimisha (2016) had identified certain promising types of jackfruit in Kasaragod district having the characters like earliness in bearing, latex free fruits, seedless nature and clustering habit through a survey and further procedures of characterization. Thus, there is immense need to find out a suitable method of vegetative propagation for quick multiplication of such selected jack plants.

Vegetative propagation in jackfruit is usually achieved through approach grafting. This method of grafting is cumbersome, consumes more labour and requires larger area for maintenance of mother plants. Continuous activity may also lead to non availability of suitable shoots for grafting and gradual denudation of mother plant (Singh *et. al.*, 2012). Even though there are reports on success of

other propagation methods like cuttings, layering and tissue culture, they are not practiced commercially as they face many difficulties.

Now a day, vegetative propagation methods like epicotyl and softwood grafting offers a viable alternative for approach grafting. These methods are more easy, efficient, economic and rapid for production of grafts and to maintain good characters, and results in speedy fruiting (El-Zaher, 2008).

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

1. To evaluate the success of epicotyl and softwood grafting in promising types of jackfruit from northern Kerala.
2. To study the response of grafting in five jack fruit types.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The jackfruit, originated in the Western Ghats of Kerala is the largest fruit crop. Being monoecious, it is an obligate cross-pollinated fruit crop exhibiting high variability. Because of its heterozygous nature, production of quality planting materials is not possible by means of seed propagation. There are two types of jackfruits viz., *koozha* (soft fleshed) and *varikka* (firm fleshed). The cross pollination behavior of the crop leads to wide variability among progenies, as a result sometimes *varikka* type may produce *koozha* type plants and *vice versa*. The significance of vegetative propagation is the maintenance of genetic uniformity and preservation of identity of a clone or cultivar. Hence, standardization of vegetative propagation methods will serve as one of the major tool for boosting up the production and quality of this crop.

Though many clonal propagation methods are reported in jackfruit, grafting methods like epicotyl and softwood grafting are the easiest and cheapest methods. Grafting can be defined as the natural or deliberate fusion of plant parts so that vascular continuity is established between them (Pina and Errea, 2005) and the resulting genetically composite organism functions as a single plant (Mudge *et al.*, 2009). Various studies carried out regarding the advanced propagation technique of fruit crops for last decade proved that vegetative propagation methods gave better results when practiced suitably with the crop with respect to time and localities. Normally, grafting may not register cent per cent success; however the choice of scion wood and the alignment of cambia of stock and scion contribute the highest percentage of grafting success (Crasweller, 2005). Beyond this, situation of favorable climatic conditions as well as the experience of the person practicing the method also decides the success per cent of grafts.

The scientific literature pertaining to the present study with special reference to jackfruit and other fruit crops are reviewed and presented in this chapter.

2.1 Number of days to scion sprout

Harshavardhan *et al.* (2014) tried softwood and veneer grafting in two jackfruit cultivars viz., Singapore and Palur during different months under two environmental conditions and softwood method of grafting recorded number of days for scion sprouting as 23.63 days. Among the cultivars, days taken for scion sprouting were found to be less in cv. Singapore (21.68 days) over cv. Palur (22.52 days).

Jackfruit showed a varying range of days taken to sprouting when it was grafted by epicotyl method during different period of time and different conditions as reported by Sweta (2012). It was observed in a range of 19.80 days in May to 18.61 days in June while the days required to sprouting were 17.98, 19.33 and 20.43 days under mist chamber, green house and open condition respectively.

Islam *et al.* (2003) studied epicotyl grafting in jackfruit under Bangladesh condition, during different seasons with the use of different aged scions. Days required to bud break were 18.78 days in 14 days old rootstock and a maximum of 26.33 days in 21 days old rootstock. Among different season, the minimum days taken was 21.22 days during June and maximum as 40.77 days during July.

Softwood grafting tried in jackfruit under Mudegere condition, using different aged rootstocks of 2 to 7 months age resulted in number of days taken to bud sprouting in a range of 21.50 days with 7 months old to 23.52 days with 5 months old rootstocks (Priyanka *et al.*, 2017b).

Shwetha (2016) studied softwood grafting in jackfruit during November to March under three conditions. Days taken to sprouting were 20.31 days in January to 22.14 days in December during different seasons tried. Days taken for sprouting were 19.77, 21.57 and 22.75 days under mist chamber, green house and open conditions respectively.

Priyanka *et al.* (2017a) studied epicotyl, softwood and approach grafting in jackfruit with different scion precuring periods (without precuring, precuring 10 days and 20 days before grafting). The number of days taken to sprouting was found to be 17.99 days in epicotyl and 26.05 days in softwood grafting while it was 43.14, 38.59 and 39.68 days in treatments of scions without precuring, precuring 10 days and 20 days before grafting respectively.

Epicotyl grafting in mango showed varietal variation in number of days taken to sprouting. Varieties BARI Aam-1, BARI Aam-3 and Langra resulted days to first sprouting as, 14.49, 15.47 and 12.96 days respectively (Alam *et al.*, 2006).

Islam and Rahim (2010) studied the performance of epicotyl grafting in commercial mango varieties (BAU Aam-1 to 11) and days required to emergence of first flush found in a range of 9.36 days in BAU Aam-6 to 11.4 days in BAU Aam-4.

Mandal *et al.* (2011) observed varying range of time taken for sprout initiation in softwood grafting among mango varieties with a minimum of 13.54 days recorded in variety Zardalu and a maximum of 13.99 days in variety Chousa and Krishnabhog.

Prajapati *et al.* (2014) evaluated softwood grafting in different mango varieties; Kesar, Badam, Totapuri, Dashehari, Langra, Local-1, Local-2, Local-3 and Local-4 and days taken to first sprout were 12.33 days in Dashehari and 14.67 days in Rajapuri.

Ajal and Kizito (2012) found a highest level of sprouting (bud appearance) with softwood grafting in three mango varieties at 10 to 21 days after grafting.

Mandal *et al.* (2012) studied softwood grafting in 12 mango cultivars and number of days to sprout was found in a varying range of 12.11 days in cv. Duldhia Madah to 12.41 days in cv. Krishnabhog.

Nanditha *et al.* (2017) studied the effect of different growing conditions and varieties on graft-take in guava varieties. The number of days taken to sprouting was 14.18, 15.07, 17.11 and 16.21 days in Sardar (Lucknow-49), Allahabad Safed, Lalit and Arka Kiran respectively.

2.2 Percentage of sprouting

Harshavardhan *et al.* (2011) evaluated softwood and veneer grafting methods in two jackfruit cultivars viz., Singapore and Palur under different conditions and a success of 32.26 per cent was recorded with softwood grafting. Among the cultivars tried, Singapore resulted with a success of 47.21 per cent and 38.14 per cent by Palur and also cv. Singapore recorded 28.40 and 44.60 per cent of success under open and poly house conditions respectively in softwood grafting where as cv. Palur showed a success of 18.86 per cent under open condition and 37.36 per cent under poly house in softwood method of grafting.

Islam (2001) conducted an experiment at Bangladesh to find the influence of age of rootstock and time of grafting on the success of epicotyl grafting in jackfruit. A maximum success of 49.55 per cent and a minimum of 19.08 per cent were found when grafting conducted during June and April respectively. Among the age of rootstocks, highest success of 39.84 per cent was obtained with 14 days old rootstocks and it was 33.93 and 28.3 per cent with 7 days and 21 days old rootstocks respectively.

Epicotyl grafting in jackfruit recorded a success of 34.33, 24.33 and 21.17 per cent when it was done with 10 days, 15 days and 20 days old rootstocks respectively (Islam *et al.*, 2004). Varying success rate of 16.11 to 49.56 per cent was recorded when defoliated scions were used.

Aralikatti (2005) studied on softwood grafting in jackfruit to find the appropriate age of rootstock for softwood grafting. A varying success of 58.67 per cent to 43.80 per cent was observed with using 7 months and 10 months old rootstocks respectively.

Baskaran *et al.* (2008) studied softwood grafting in jackfruit under 50 per cent shade (shade net) condition using different aged rootstocks (20-25 days old and two, three and four month old seedlings). Highest success of 75.23, 72.15 and 72.05 per cent were found in 2 month, 3 month and 4 month old rootstocks respectively. Grafting done with 20-25 days old rootstock resulted in 60.27 per cent of success.

Das (2013) conducted an experiment to find out the effect of different seasons (fortnight intervals of May to September), length of scion and age of rootstock on the success of softwood grafting in jackfruit and obtained a success rate of 46.32 to 86.09 per cent in various seasons. A varied range of success also observed with other two conditions as, 55.33 to 87.68 per cent in different aged rootstocks and 69.05 to 86.33 per cent with different lengths of scion.

Softwood grafting in jackfruit showed a different success rate when it was tried using different aged rootstocks with a maximum success of 82.09 per cent with 4 month old rootstock and minimum of 48.78 per cent with 1 month old scion (Maheswari and Nivetha, 2015).

Swamy and Melanta (1994) tried softwood grafting in jackfruit using three to twelve month old rootstocks and recorded a varying range of percentage of success. A maximum success of 40.0 per cent was observed with 6 month old rootstocks and a least success of 10 per cent was found in grafts practiced with 3, 4 and 11 month old rootstocks.

Gunjate *et al.* (1980) recorded a varying success of 50 to 90 per cent with epicotyl grafts in jackfruit when it was done during April to mid-June.

Shwetha (2016) studied softwood and epicotyl grafting in jackfruit to investigate the suitable month (November to March) for grafting under suitable conditions. A maximum success of 46.83 per cent in February and a minimum of 36.73 per cent in March found among softwood grafts.

Epicotyl grafting practiced in different months (May to August) under different conditions (Green house, mist chamber and open condition), the maximum and minimum success of grafts recorded as 78.44 and 76.11 per cent respectively during the months June and August.

Priyanka *et al.* (2017a) studied epicotyl, softwood and approach grafting in jackfruit along with different scion precuring period. Among the methods, epicotyl and softwood grafting showed a maximum success of 48.08 and 35.55 per cent respectively. Per cent of success also showed a variation in scion precuring period as 25.24, 37.75 and 29.81 per cent in without precuring, precuring 10 days and 20 days before respectively.

Sulkhe (2014) obtained a varying rate of success in jackfruit when it was grafted in wedge method with a maximum success of 53.33 per cent and a minimum of 31.11 per cent when practiced at different intervals during September to April.

Different percentage of sprouting has recorded in jackfruit when softwood grafting practiced under different conditions (Selvi *et al.*, 2008). Percentage sprouting of 25.62, 28.86 and 24.12 was registered with the conditions of mist chamber, agro shade net and tree shade respectively.

Khatun *et al.* (2006) examined cleft and veneer method of grafting in jackfruit to find the effect of time and age of scion on success of grafts and obtained a success of 38.14 and 37.04 per cent in cleft and veneer method respectively. A varying rate of success also observed with grafting practiced during different seasons; 58.89 per cent in August, 45.56 per cent in July and 8.33 per cent in June.

Jose and Valsalakumari (1991) made an attempt to standardize epicotyl and softwood grafting in jackfruit with using different aged rootstocks during a period of May to August under open and mist chamber condition under Kerala conditions. They found that, sprouting was more in mist condition (30.83 per

cent) against 18.89 per cent under open condition. Among the various seasons tried, sprouting of epicotyl grafts was observed as 83.3 per cent in June, 7.22 per cent in July, 5 per cent in May and 3.89 per cent in August with precured scions while 17.92 per cent in 15 day old and 29.58 per cent in 5 day and 10 day old rootstocks. Softwood grafting does not result much success under all conditions.

A varied percentage of success was reported in jackfruit with modified cleft grafting when it was done in different seasons (Khatun *et al.*, 2008). A maximum success of 39.00 per cent was recorded on 14th August and a minimum success of 5.66 per cent was found during the 29th April and May respectively and also observed a zero success with some seasons especially during the hot summer.

Softwood grafting recorded a maximum success 53.40 per cent in guava when compared to patch budding, softwood cutting, and air layering (Rani *et al.*, 2015).

Kumar *et al.* (2003) studied wedge grafting in tamarind using moisture chamber to find out the effect of season on percentage of success and observed a varying per cent of success with a maximum success of 48.16 per cent in the month of January and 12.03 per cent during December.

2.3 Percentage of survival

Nivetha and Maheswari (2015) reported that, softwood grafting tried on different jackfruit genotypes using different seed weight (4,5,6 and 7g) related root stock production had resulted a per cent graft survival between 64.78 to 75.17 per cent in genotypes G3 (AH-3) and G1 (AH-1) respectively.

Softwood grafting in jackfruit using different aged rootstocks recorded graft survival in a range of 59.89 per cent as a minimum with 1 month old rootstock and 95.45 per cent as a maximum with 4 month old rootstock (Maheswari and Nivetha, 2015).

Islam *et al.* (2003) observed varying per cent of survivability among epicotyl grafts of jackfruit tried under different seasons and using different aged

scions. Survival of grafts found in a range of, 13.92 per cent in April to 45.47 percent in July. Among the different aged scion tried it was found as 29.17, 34.41 and 24.31 per cent with respect to 7, 14 and 21 days old scions.

Epicotyl grafting in jackfruit using different aged rootstocks and defoliation periods showed a varying survivability among grafts (Islam *et al.*, 2004). At 120 DAG per cent of survivability was 64.33 per cent with 10 days old, 53.33 per cent with 15 days old and 47.33 per cent with 20 days old rootstocks. Survival of grafts also found in a varying range among various defoliation periods tried; it was observed in a range of 16.67 per cent in defoliation of scion before 20 days to 79.44 per cent in defoliation before 10 days.

According to Sweta (2012) softwood grafting in jackfruit practiced during different season under different conditions showed a varying range on percentage of survival. Among the different conditions tried per cent of graft survival at 75 DAG was 36.11, 40.42 and 30.23 per cent in green house, mist chamber and open conditions respectively while it was observed in a range of 31.53 per cent in March to 41.63 per cent in February.

Epicotyl grafting in jackfruit practiced during May to August under different conditions resulted a varying percentage of graft survival Sweta (2012). After 75 days of grafting, the percentage of survival found under different conditions as 67.72, 67.19 and 65.76 per cent under green house, mist chamber and open conditions respectively and with respect to seasons, it was observed in a range of 64.63 per cent in August to 68.87 per cent in July.

Islam *et al.* (2004) studied cleft, modified cleft and veneer grafting during April to September among three popular mango varieties. The per cent of survival of grafts at 120 DAG found with respect to the methods were 64.46, 68.86 and 60.73 per cent in cleft, modified cleft and veneer grafting respectively.

Epicotyl grafting practiced in mango var. Amrapali using four different aged rootstocks resulted in varying survival percentage in a range of 40.0 per cent by 20 days old to 53.4 per cent by 5 days old rootstocks (Singh *et al.*, 2014).

Singh and Bons (2016) studied side, veneer and wedge grafting in sapota cv. Kalipatti during February, March, July and August. Survival percentage with wedge grafting at 60 DAG was in a range of 44.9 per cent in March to 33.3 per cent in February.

In guava, softwood grafting practiced under different conditions showed a varying percentage in survival of grafts at 120 DAG; 51.87 per cent under open and 60.69 per cent under poly house condition respectively (Gotur *et al.*, 2017).

Softwood grafting in sapota had resulted a varying range on survival of grafts when tried at monthly intervals using precured and without precured scion sticks. The percentage of survival ranged from 23.33 per cent during May using without procured scions to 90.00 per cent in August using precured scions (Maske *et al.*, 2010).

Bharad and Mahorkar (2011) studied softwood grafting in jamun along with patch budding in different seasons and final survival of grafts found at 120 DAG was 31.25 per cent in softwood grafting and 8.33 per cent in patch budding.

Beer *et al.* (2013) evaluated wedge grafting in guava under open and controlled conditions during 15th December to April and obtained a survival percentage in the range of 46.82 per cent during 15th February in controlled condition and 14.33 per cent duirng 15th January under open condition.

Radha and Aravindakshan (2000) evaluated survival percentage of epicotyl grafts among commercial mango varieties under Kerala conditions. Great variation in the response of different varieties to the method was observed in varieties like Alphonso, Banglora, Banganapally, Bennet Alphonso, Chandrakaran, Imam Pasand, Kalapady, Mulgoa, Mundappa, Jehangir, Nadasala, Neelum, Prior and Suvarnarekha. The per cent of survival of grafts at six months

after grafting was observed in a range of 39.6 per cent in Mulgoa to 84.5 per cent in Kalapady.

Grafting on three local mango varieties have resulted in a varying per cent of graft survivability after four weeks of grafting; 30 per cent in Bire, 46 per cent in Ssu/Lubere, and 70 per cent in Kate variety (Ajal and Kizito, 2012).

Varietal variation on the percentage graft survival was reported in aonla (Choudhary *et al.*, 2016). Among different varieties grafted, survival percentage was observed in a range of 89.25 per cent in Anand-2 to 100.00 per cent in Banarasi and NA-7.

Softwood grafting in different mango varieties recorded a varying survival percentage at 60 DAG in a range of 48.14 per cent in Chousa to 56.04 per cent in Dudhia Maldah (Mandal *et al.*, 2011).

Varietal variation on survival of grafts was observed in commercial mango cultivars with softwood grafting (Prajapati *et al.*, 2014). Survival per cent at 2 month after grafting was found in a range of 61.18 per cent in Local-3 to 76.29 per cent in Kesar.

2.4 Shoot length and diameter

Priyanka *et al.* (2017a) studied epicotyl, softwood and approach grafting in jackfruit with the time of precuring of scion. Among the method of grafting, after 90 days of grafting, length of shoot observed was 21.57 cm in epicotyl and 14.54 cm in softwood grafting while in different precuring time tried, the shoot length was found to be 14.42, 16.86 and 15.02 cm in treatments without precuring, precuring 10 days and 20 days before respectively.

Sulkhe (2014) studied softwood grafting in jackfruit in different seasons using poly cap and without using poly cap. Shoot length at 90 DAG found in a range of 4.30 cm in 20th March and 3.66 cm in 20th November. Among the different conditions, it was observed as 4.24 cm with the use of poly cap and 3.81 cm without the use of poly cap.

Softwood grafting in jackfruit tried during November to March under different conditions have showed varied length in scion (Shwetha, 2012). After 70 days of grafting it was observed as 2.97, 3.39 and 2.47 cm under green house, mist chamber and open conditions respectively while it was in a range of 2.44 cm in December to 3.67 cm in November during various season tried.

Varied sprout length was observed with epicotyl grafting tried in jackfruit during May to August months under different conditions (Sweta, 2012). At 70 DAG it was observed as 3.44, 3.88 and 3.04 cm under green house, mist chamber and open conditions respectively while the length of shoots observed in a range of 4.03 cm in June and 2.90 cm in May.

Priyanka *et al.* (2017b) examined softwood grafting in jackfruit using different aged rootstocks and the length of shoot at 90 DAG found in a range of 16.88 cm with 5 months old to 19.50 cm with 7 months old rootstocks.

Baskaran *et al.* (2008) studied softwood grafting in jackfruit under 50 per cent shade condition using different age groups of rootstock. The longest shoot was observed with softwood grafts compared with inarch grafts. Among softwood grafts, length of scion observed in a range of 0.46 cm in 20-25 days old to 0.75 cm in 2 months old rootstocks.

Islam *et al.* (2004) studied epicotyl grafting in jackfruit using different aged rootstocks and defoliation periods. Scion height at 120 DAG found as 9.51 cm in 10 days old, 8.41 cm in 20 days old and 8.71 cm in 15 days old rootstocks while among different defoliation period tried it was found in a range of 12.78 cm in 10 days before and 3.13 cm in 20 days before defoliated scion.

A varying length of sprouts was found in jack grafts when it practiced under softwood method of grafting with using different age of rootstocks (Swamy, 1993). Length of sprouts observed at 90 DAG in a range of 2.76 cm with 11 month old rootstocks to 10.45 cm with 6 month old rootstocks.

Ghosh *et al.*, (2010) observed varietal response to scion growth with softwood grafting in sapota. Among the ten cultivars grafted, extended new growth of scion recorded in a range of 1.1 cm in Kalipatti to 6.0 cm in CO-2.

Hiwale *et al.* (2008) studied softwood grafting in wood apple varieties under nursery conditions. A varied mean height of grafts was observed after in one year of growth in a range of 18.2 cm in CHES-5 to 25.2 cm in CHES-2.

Radha and Aravindakshan (2000) studied epicotyl grafting in fourteen commercial mango varieties grown in Kerala to compare the growth rate of grafts. The height of the plants varied from 26.3 cm in Chandrakaran to 36.5 cm in Banglora after six months of grafting.

Epicotyl grafting tried in three mango varieties resulted a varying growth on shoot length after 150 days of grafting as 20.75 cm in BARI Aam-1, 19.03 cm in BARI Aam-3 and 21.88 cm in Langra (Alam *et al.*, 2006).

Islam *et al.* (2004) studied cleft, modified cleft and veneer grafting among two popular mango varieties during a period of April to September. After 120 days of growth, on a varietal basis Amrapali and Gopalbhog showed a scion growth of 10.89 and 12.31 cm respectively while among the methods tried it was observed as 11.89,15.20 and 7.17 cm correspondingly in cleft, modified cleft and veneer method of grafting

Priyanka *et al.* (2017b) examined softwood grafting in jackfruit using different aged rootstocks ranging from 2 to 7 months old. Girth of shoot at 90 DAG found in a range of 0.86 cm in 7 months old to 0.52 cm in 2 months old rootstocks.

The performance of epicotyl, softwood and approach grafting in jackfruit with different scion precuring periods have studied by Priyanka *et al.* (2017a) and found that, girth of shoots at 90 DAG was 0.36 cm in epicotyl and 0.57 cm in softwood grafting. Among the different precuring treatments, it was 0.44, 0.51

and 0.46 cm in without precuring, precuring 10 days and 20 days before respectively.

Baskaran *et al.* (2008) examined softwood grafting in jackfruit under 50 per cent shade (using shade net) condition with the use of different age groups of rootstock. Girth of scion was found in a range of 0.95 cm in 3 months old rootstock to 0.33 cm in 20-25 days old rootstocks.

Islam *et al.* (2004) studied epicotyl grafting in jackfruit using different aged rootstocks and defoliation periods. After 120 days of grafting, girth of scion found as, 0.41 cm in 10 days old, 0.40 cm in 15 days old and 0.39 cm in 20 days old rootstocks while it was in a range of 0.14 cm in 20 days to 0.56 cm 10 days before defoliation scions.

Khatun *et al.* (2006) compared cleft and veneer grafting in jackfruit during different time period and with using different aged scion sticks and diameter of scion found as 0.11, 0.51 and 0.68 cm during June, July and August respectively and 0.22, 0.60 and 0.48 cm with 10, 20 and 30 old scions. Among the methods, veneer grafting recorded 0.35 cm and cleft grafting recorded 0.52 cm in diameter of scion.

Modified cleft grafting in jackfruit during a period of March to August showed diameter of scion at 90 DAG in a range of 0.14 cm in 29th April to 0.47 cm in August (Khatun *et al.* (2008).

Softwood grafting in jackfruit during different seasons under different conditions have resulted a varied girth in scion (Sweta, 2012). After 70 days of grafting it was observed in a range of 1.13 cm in December to 1.27 cm in February. Among the conditions, the girth of scion found as 1.16, 1.27 and 1.13 cm in green house, mist chamber and open conditions respectively.

Sweta (2012) observed varying girth of scion in epicotyl grafting in jackfruit practiced during different seasons under different conditions. Among the various season, girth of scion at 70 DAG observed in a range of 1.13 cm in June

to 1.20 cm in August and it was 1.15, 1.20 and 1.16 cm under green house, mist chamber and open conditions respectively.

Epicotyl grafting in mango variety Amrapali using four different aged rootstocks found a different girth of scion among grafts at 120 DAG; in a range of 6.3 mm in 10 days old to 5.9 mm in 20 days old rootstocks (Singh *et al.*, 2014).

Singh and Bons (2016) compared side wedge and veneer method of grafting in sapota cv. Kaipatti during February, March, July and August and girth of grafts obtained at 90 DAG in a range of 5.7 mm in August to 6.1 mm in February and March.

A varying radial growth of shoot has been reported in mango cultivars grafted in softwood method (Mandal *et al.*, 2012). Among 12 varieties grafted, radial growth of scion after 90 days of grafting found in a range of 1.56 cm in cv. Prabhashankar to 1.78 cm in cv. Amrapali and Mahmood Bahar.

In guava, the variation on scion diameter in different cultivars under softwood grafting has reported by Nanditha *et al.* (2017). After 90 days of grafting, scion diameter have recorded in a range of 3.73 mm in cv. Lalit to 6.75 mm in cv. Sardar.

Islam and Rahim (2010) studied the performance epicotyl grafting among mango varieties and scion diameter 150 DAG were in a range of 0.61 cm in BAU Aam-6 to 0.45 cm in BAU Aam-10.

A varying diameter of shoots has reported in different mango varieties (Ram *et al.*, 2012). Among the six varieties grafted, shoot diameter at 90 DAG found as 5.22 cm in Amrapai and 4.44 in Lucknow Safeda.

Pereira *et al.* (2004) studied different grafting methods in three mango varieties. The stem diameter after second vegetative flush was observed as 8.3 mm, 6.5 and 6.3 mm in Haden, Tommy Atkins and Palmer respectively with cleft method and 7.0, 6.4 and 7.3 in Haden, Tommy Atkins and Palmer respectively with splice method of grafting.

2.5 Number of nodes and branches

Priyanka *et al.* (2017a) evaluated epicotyl, softwood and approach grafting in jackfruit under different scion precuring periods. Among the method of grafting, number of branches after 90 days of grafting have found as 1.55 in epicotyl and 1.54 in softwood grafting and among the different precuring periods tried, it was observed as 1.24, 1.44 and 1.24 in without precuring, precuring 10 days and 20 days before grafting respectively.

Priyanka *et al.* (2017b) examined softwood grafting in jackfruit using different aged rootstocks ranging from 2 to 7 months old. Number of branches at 90 DAG was observed in a range of as 1.91 among 4 months old to 1.42 in 5 months old rootstocks.

Softwood grafting in mango practiced during a period of June to May was resulted a varying number of branches among the grafts (Sridhar, 2014). After 90 days of grafting it has found in a range of 0.15 in November to 0.66 in June month.

Sridhar and Akshay (2014) studied softwood grafting in mango under open shade net and green house conditions during a time frame of June to May and obtained a number of branches in grafts at 90 DAG as, 0.29 under open shade net and 0.35 under green house conditions.

Softwood grafting practiced in guava during June to September had resulted in varying number of shoots per plant. After 90 days of grafting, it have observed in a range of 3.17 in June and 4.07 in August month with a mean value of 3.80 number of shoots per plant (Rani *et al.*, 2015).

2.6 Number of leaves

Softwood grafting in jackfruit using different aged rootstocks recorded number of leaves in a range of 3.70 with 5 months old to 5.60 with 7 months old rootstocks at 90 DAG (Priyanka *et al.*, 2017b).

Priyanka *et al.* (2017a) compared epicotyl, softwood and approach grafting in jackfruit with different scion precuring periods. Among the methods, number of leaves after 90 days of grafting was observed as, 6.66 in epicotyl and 3.48 in softwood grafting while it was 3.32, 3.99 and 3.88 in without precuring, precuring 10 days and 20 days before respectively in the different precuring treatments.

Aralikatti *et al.* (2011) examined softwood grafting in jackfruit to find out the appropriate age of rootstock for softwood grafting and number of leaves at 90 DAG was found in a range of 2.46 with 10 months old to 5.20 with 7 months old rootstocks.

Baskaran *et al.* (2008) studied softwood grafting in jackfruit under 50 per cent shade (shade net) condition using different aged rootstocks. Number of leaves was found to be in a range of 0.36 with 20-25 days old to 0.65 with 3 months old rootstocks.

Jackfruit showed a variation in number of leaves among the grafts when it was conducted in epicotyl method using different aged rootstocks with different defoliation periods. Number of leaves after 120 days of grafting was found to be 12.53 with 10 days, 11.60 with 15 days and 10.80 with 20 days old rootstocks. Among the various defoliation period tried, it was in a range of 4.22 with 20 days to 16.33 with 10 days before defoliated scion (Islam *et al.*, 2004).

Islam *et al.* (2003) observed a varying number of leaves in epicotyl grafts of jackfruit during different seasons and using different aged scions. After 90 days of grafting, number of leaves was 7.86, 8.12 and 7.43 with 7, 14 and 21 days old rootstocks respectively and it was found in a range of 6.83 in October to 8.87 in June months.

Khatun *et al.* (2006) evaluated cleft and veneer grafting in jackfruit with different time of operation and age of scion. Number of leaves found as, 4.67, 16.66 and 20.37 during in June, July and August months respectively. Among

grafting methods, a minimum number of 12.15 leaves have observed in veneer grafting and a maximum of 15.64 in cleft method of grafting while it was observed as 4.84, 20.59 and 16.26 in scion with an age of 10, 20 and 30 days old scion respectively.

Number of leaves in jackfruit grafts was observed in a range of 3.33 during 29th May to 14.37 in 14th August when modified cleft grafting was done during a period of March to August (Khatun *et al.*, 2008).

Maheswari and Nivetha (2015) studied effect of age of rootstocks in softwood grafting of jackfruit using 1 to 7 month old rootstocks and number leaves after final observation was found in a range of 10.53 with 4 month old to 2.87 with one month old rootstocks.

Prajapati *et al.* (2014) evaluated softwood grafting among mango varieties; Kesar, Badam, Totapuri, Dashehari, Langra, Local-1, Local-2, Local-3 and Local-4 and number of leaves after 3 months of grafting found in a range of, 10.27 in Local-1 to 13.00 in Dashehari.

Varying number of leaves was observed with epicotyl grafting in mango cutivars (Ram *et al.*, 2012). Among the six varieties tried viz., Amrapali, Dashehari, Mallika, Langra, Chausa and Lucknow Safeda grafted number of leaves at 90 DAG found in a range of 4.78 in cv. Lucknow Safeda to 7.67 in cv. Amrapali.

2.7 Length and Breadth of leaves

Khatun *et al.* (2006) evaluated cleft and veneer grafting in jackfruit to find the effect of time and age of scion. As a final observation, leaf length was recorded as 1.16, 6.73 and 7.32 cm during June, July and August respectively in various seasons tried. Among the methods, it was observed as 4.15 cm in veneer grafting and 5.99 cm in cleft grafting while it was 2.76, 7.04 and 5.41 cm when 10, 20 and 30 days old scion were tried.

Length of leaf at 90 DAG was observed in a varying range of 8.79 cm in August to 2.43 cm in 29th April when modified cleft grafting was done during March to August (Khatun *et al.*, 2008).

Sweta (2012) studied softwood grafting under green house, mist chamber and open condition during a period of November to March and length of leaf at 70 DAG was observed as 8.36, 8.40 and 7.34 correspondingly under green house, mist chamber and open conditions and it was in a range of 7.99 cm in December to 8.12 cm in March during different periods tried.

Epicotyl grafting in jackfruit tried in different seasons and under different conditions resulted a variation in length of leaf after 70 days of grafting (Sweta, 2012). Among the different conditions tried, the length of leaf observed as 8.33, 8.45 and 8.19 cm under green house, mist chamber and open conditions respectively while it was observed in a range of 8.29 cm in August to 8.35 cm in May under different periods tried.

Kumar *et al.* (2016) found a varying length of leaves after 6 months of grafting with epicotyl grafting in mango using 10 and 13 days old rootstocks in different potting mixtures. The length of leaf found as 14.97 and 14.57 cm in corresponding 10 days and 13 days old rootstocks respectively.

Varying length in leaf was observed among different mango varieties when it practiced in epicotyl grafting (Ram *et al.*, 2012). Among the six varieties viz., Amrapali, Dashehari, Mallika, Langra, Chausa and Lucknow Safeda grafted, leaf length after 90 days of grafting were in the range of 14.34 cm in Mallika to 16.17 cm in Amrapali.

Epicotyl grafting practiced in mango variety Amrapali using four different aged rootstocks showed length of leaf after 120 days of grafting in a range of 16.10 cm in 20 days to 17.12 cm in 10 days old rootstocks (Singh *et al.*, 2014).

Khatun *et al.* (2006) have evaluated cleft and veneer grafting in jackfruit, to find the effect of time and age of scion among the methods and a variation have

observed in breadth of leaf among the treatments. Among the seasons, leaf breadth observed as 0.58, 2.99 and 3.68 cm in June, July and August and among different aged rootstocks it was 1.35, 3.35 and 2.56 cm in 10, 20 and 30 days old scion. Cleft method of grafting resulted maximum leaf breadth of 2.87 cm than in veneer (1.97 cm).

Khatun *et al.* (2008) studied the effect of different time of operation on modified cleft grafting in jackfruit and a varying result on breadth of leaf was observed after 90 days of grafting; 1.22 cm in 29th April to 4.61 cm during 29th July.

Sweta (2012) examined softwood grafting in jackfruit under green house, mist chamber and open conditions during November to March and breadth of leaf 70 DAG was found to be 3.98, 4.35, 3.93 and 5.12 cm under green house, mist chamber and open conditios respectively while it was in a range of 3.61 cm in December to 5.12 cm during March under the various seasons tried.

Epicotyl grafting showed a varying range in breadth of leaves when it was done during different seasons under different conditions (Sweta, 2012). On 70 DAG, it was observed in a range of 3.94 cm in August to 4.41 cm in June during different seasons tried while it was 4.19, 4.23 and 4.01 cm under green house, mist chamber and open conditions respectively.

Varying range of leaf breadth with epicotyl grafting has been observed in mango (Ram *et al.*, 2012). Among the six varieties viz., Amrapali, Dashehari, Mallika, Langra, Chausa and Lucknow Safeda grafted, breadth of leaves after 90 days of grafting was found in a range of 2.40 cm in Langra to 3.80 cm in Amrapali.

Singh *et al.* (2014) observed variation among width of leaf in mango variety Amrapali, when stone grafting practiced in four different aged rootstocks. Leaf width at 120 DAG observed in a range of 4.18 cm in 5 days old to 4.80 cm in 10 days old rootstock.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study entitled 'Vegetative propagation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types' was conducted during the period from June 2017 to January 2018 at Department of Pomology and floriculture, College of Agriculture, Padannakkad, Kasaragod. The experiment was carried out with the main objective to find out the best grafting method and to investigate the varietal response of jackfruit types to these methods.

The experiment could not be started in time during 2016; hence the success per cent was very poor. During 2017, the study was carried out with all the required facilities in June.

3.1 GENERAL CONDITIONS OF PROPAGATION

3.1.1 Experimental site

The study was conducted in the Instructional farm of College of Agriculture, Padannakkad situated in the northern part of Kerala at an elevation of 20 m above mean sea level, at 12° 20' 30'' north latitude and 75° 04' 15'' east.

3.1.2 Climatic conditions

The monthly meteorological data pertaining average rain fall, mean maximum and minimum temperature and relative humidity during the period from 2017 June to 2018 January was recorded and presented in Appendix II.

3.1.3 Green house

Green house with 50 per cent shade of 10 X 6 m^2 size was used for keeping the grafted plants during the initial stage.

3.1.4 Moisture chamber

Within the green house, a moisture chamber of dimension 3 x 1 m^2 was used for keeping the grafted plants immediately after grafting. It was made completely air tight firmly by fixing the sides with bricks. After a period of one month, when the scions started sprouting, the grafts were kept outside.

3.2 EXPERIMENTAL DETAILS

Experiment: Vegetative propagation of promising jack types

Design: 5x2 factorial experiment in Completely randomized design (CRD)

Treatments:

Factor one: five types of jackfruit

V_1 -Varikka early bearing type (KJ 186)

V_2 – Gumless type (KJ 397)

V_3 - Seedless type (KJ 180)

V_4 -Cluster type (KJ 182)

V_5 –Muttam varikka (KJ 231) – Local check

Factor two: two methods of grafting:

M_1 – Epicotyl grafting

M_2 – Softwood grafting

Replications: 3 (10 numbers per replication)

Total number of propagules: 300

3.3 MATERIALS

3.3.1 Crop and types

Certain promising types of jackfruit have identified in Kasaragod district through a survey and further characterization procedures Nimisha (2016). From the above mentioned study, five types of jackfruit with special character as earliness in bearing, gummlessness, seedlessness and clustering habit from farmer's field and a muttom varikka type from the Instructional farm of the College of Agriculture, Padannakkad were selected to evaluate epicotyl and softwood grafting. Details regarding the morphological characters of selected jack types are given in Figure 1 and Table 3.1, also the details of farmers who holding jackfruits are given in Appendix I.

3.3.2 Collection of seeds

Locally available fully matured seeds of healthy fruits were collected from different locations. Seeds were washed and cleaned to get the seeds free from adhering pulp.

3.3.3 Raising of rootstocks

For softwood grafts, seeds were sown during the month of April in a prepared nursery bed of 4 x 2 m^2 after adding sufficient FYM. The bed was irrigated daily. Two weeks after germination, seedlings showed vigorous growths were selected for raising rootstocks. Polythene bags of 15 x 20 cm^2 size of 300 gauge thickness were used for raising rootstocks. The bags were filled with a pot mixture of FYM, sand and soil in a ratio of 1:1:1.

For epicotyl grafting, the seedlings were raised directly in the poly bag itself. Seeds collected from different locations were sown in the poly bag of size 20 x 15 cm^2 during the month May. Daily irrigation was given.

Table 3.1. Morphological characters of selected five jackfruit types.

Jackfruit type	V_1 - Varikka early bearing type	V_2 - Gumless type	V_3 - Seedless type	V_4 - Cluster type	V_5 - Muttom varikka
Tree characters					
Tree growth habit	Semi erect	Erect	Erect	Erect	Erect
Branching pattern	Opposite	Irregular	Verticillate	Verticillate	Erect
Leaf blade shape	Elliptic	Narrowly elliptic	Elliptic	Elliptic	Obovate
Leaf length (cm)	14.30	11.50	15.20	14.10	11.30
Leaf breadth (cm)	8.00	6.50	8.20	9.20	8.10
Female inflorescence position	On the whole stem including primary, secondary and tertiary branches	Mainly on trunk and primary branches	Mainly on trunk, primary and secondary branches	On the whole stem including primary, secondary and tertiary branches	Mainly on trunk and primary branches
Fruit characters					
Fruiting season	December - February	March – May	May - August	March - May	December - February
Number of fruits per tree	6 - 19	25 - 30	8 - 15	200 - 450	18 - 30
Fruit shape	Clavate	Ellipsoid	Clavate	Spheroid	Ellipsoid
Mean fruit weight (kg)	12.02	10.00	10.53	2.31	7.91
Number of fakes per fruit	200	346	459	44	210
Flake colour	Deep yellow	Creamy white	Light yellow	Light yellow	Light yellow
Flake texture	Firm	Firm	Firm	Firm	Firm
Flake percentage	48.09	47.80	55.70	36.36	39.95
Rind percentage	24.46	22.20	27.64	30.30	27.94
Perigone percentage	13.81	8.10	12.87	20.78	15.55
Seed percentage	13.64	21.90	3.79	12.56	16.56
Fruit Quality parameters					
TSS (°B)	31.00	25.00	18.50	30.50	20.00
Total sugars (%)	23.95	24.77	17.68	24.95	19.49
Reducing sugar (%)	11.87	11.30	7.12	12.37	7.79
Non reducing sugar (%)	12.08	13.47	10.56	12.58	11.70
Acidity (%)	0.11	0.11	2.50	0.07	0.12

V_1 -Varikka early bearing type (KJ 186)

V_2 – Gumless type (KJ 397)

V_3 - Seedless type (KJ 180)

V_5 – Muttam varikka (KJ 231)

V_4 - Cluster type (KJ 182)

Plate 1. Fruit characters of selected jackfruit types

3.3.4 Care of Rootstock

The fresh seeds sown in the polythene bags as well as transferred seedlings were watered regularly. The polythene bags were kept under the shade to protect the seedlings from direct solar radiation. General prophylactic plant protection measures were taken by spraying with pesticides and fungicides to control the pests and diseases. Weeding was done as and when required. The rootstocks were transferred into sunlight one week before grafting.

3.3.5 Selection of rootstock

Vigorously growing uniform seedlings of specified age were used for grafting. For epicotyl grafting, seedlings having a growth of 15 days were used as rootstocks and for softwood grafting rootstocks of 60 days old were used.

3.3.6 Selection of scion

The scions from selected promising jack types of one year old having a dormant bud of pencil thickness, free from pest and diseases were selected for grafting. For epicotyl grafting, four to five month old scion and for softwood grafting scion in an age of one year old was selected for grafting.

3.3.7 Collection of scion

The scion shoots were collected directly without curing from selected jackfruit trees in the morning hours on the day of grafting. The scion shoots were separated from the mother tree with sharp secateur and wrapped in moistened news paper just after separation.

3.4 GRAFTING METHOD

3.4.1 Epicotyl grafting

For epicotyl grafting, 15 days old rootstock and 4 to 5 month old scion were used. About 5 to 10 cm above the cotyledons a transverse cut was made. A cleft of 3 to 4 cm depth was made in the middle of the decapitated rootstock by giving a longitudinal cut with sharp knife. The shoot selected as scion material was trimmed into a wedge shape by giving a slanting cut on either side. Latex exudes from the cut portion of both scion and rootstock was removed safely with the use of a neat cotton cloth before their insertion. The lengths of the wedge was similar to that made on the rootstock and inserted the wedge of the scion into the cleft of the stock and secured the joint firmly with polythene strip.

3.4.2 Softwood grafting

For softwood grafting, two month old rootstock and 4 to 5 month old scion were used. The top growth on the rootstock was decapitated at a height of 15 cm from the soil level with the help of a sharp knife. The girth of rootstock in that region was almost equal to that of the scion. After that, a longitudinal 'V' shape cut of 4 to 5 cm length was given on the terminal trimmed rootstock.

Scion of about the same thickness as that of the rootstock was selected. The lower end of the scion was cut into gently sloping wedge of about 4 to 5 cm by removing the bark and a little wood from the two opposite side, in such a way that, cut end of the scion was that of paper thickness. Latex exudes from the cut portion of both scion and rootstock was removed safely with the use of a neat cotton cloth before their insertion.

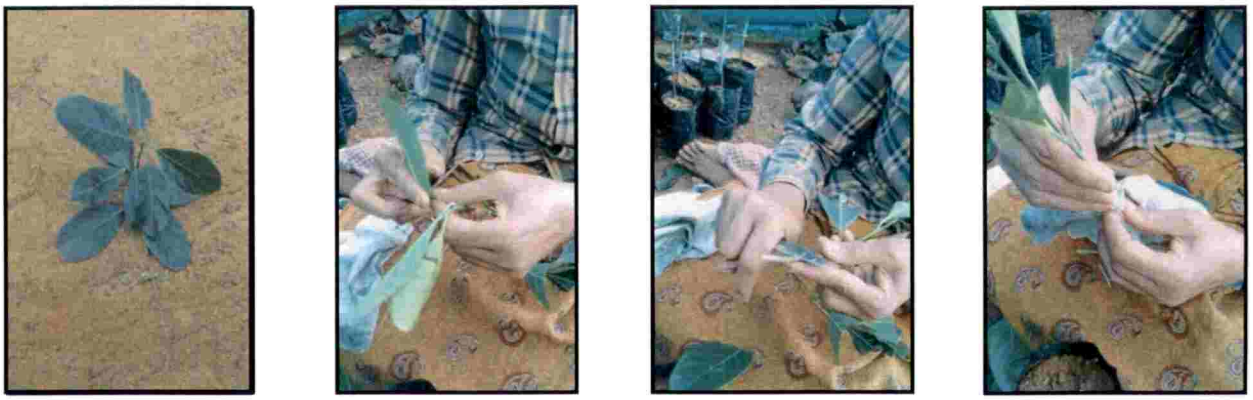
The wedge shaped scion thus prepared was inserted into the 'V' shaped slit of the stock come in perfect contact with each other and tied firmly with 200 gauge transparent polythene strip of 2 x 30 cm^2 size.

i. Preparation of scion

ii. Preparation of rootstock

iii. Insertion of scion into stock

Plate 2. Procedure of epicotyl grafting followed in jackfruit types



i. Preparation of scion

ii. Preparation of rootstock

iii. Insertion of scion into stock

Plate 3. Procedure of softwood grafting followed in jackfruit types

3.5 AFTER CARE OF GRAFTS

In order to obtain a uniform favorable growth condition and to achieve maximum success the grafts were kept inside a moisture chamber for a period of one month. Sixty grafts from each treatment were kept under a chamber of 3 x 1 m^2 sizes and covered with 300 gauge transparent polythene sheet. Two to three handful of lime was added in the chamber floor and the grafts were irrigated well before placing it inside.

At one month after grafting, the chamber was opened gradually. On first day a corner of the covered sheet was opened slowly and the following day the remaining portions also opened. Optimum irrigation was provided after opening the chamber.

The grafts were kept in the green house for one week. After one week, they were transferred to an open condition with availability of full sunlight. New sprouts (side shoots) arising from any portion of rootstock were removed regularly. Necessary plant protection measures were adopted to combat the disease and pest incidence as and when noticed.

3.6 OBSERVATIONS RECORDED

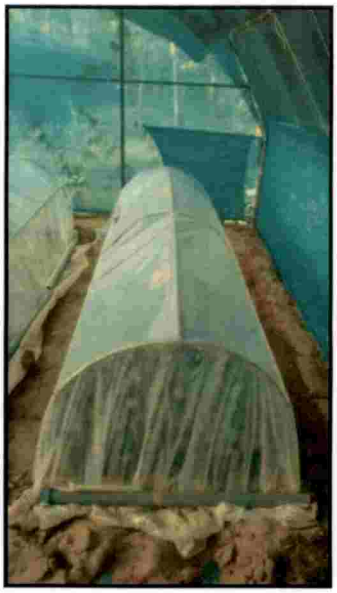
Visual observations were made on the grafts. After one month of sprouting, periodically observations was recorded at 30^{th}, 60^{th} and 90^{th} days after sprouting on all the parameters except percentage of success, days to sprout and percentage of survival. The observation on parameters of percentage of success and days to sprout were recorded during the initial stages of sprouting and percentage of survival of grafts was recorded after 90 days of sprouting. For taking observations, grafted plants showing a uniform growth were selected from each jack types.

3.6.1 Days to sprout

Number of days taken from grafting to emergence of first sprout was recorded from all grafted plants.

(i)

(ii)



(iii)

(**i**. Structure of moisture chamber, **ii.** Grafts shifted under the chamber, **iii.** Air tightly closed chamber)

iv. After the opening of moisture chamber at 30 DAG

v. After transferring to open condition

Plate 4. Various stages of after care operations

3.6.2 Percentage of sprouting

The per cent of graft success was recorded 30 days after grafting at the time of opening of moisture chamber. Total grafts remained with sprouts were recorded and the data converted into percentage of success with using the following formulae.

$$\text{Percentage of sprouting} = \frac{\text{Number of sprouted grafts}}{\text{Total number of grafts done}} \times 100$$

3.6.3 Percentage of survival

Percentage of survival was recorded on 90 days after sprouting by using the following formula.

$$\text{Percentage of survival} = \frac{\text{Total number of successful grafts - Number of dead grafts}}{\text{Total number of successful grafts}} \times 100$$

3.6.4 Length of shoot (cm)

The length of new sprouts was recorded as shoot length after one month of sprouting at 30 days interval up to 90^{th} day by using a centimeter scale. A point at the base of new sprout was marked by using a ball point pen in the selected plants and monthly growth rate from the point marked was recorded as length of sprout.

3.6.5 Girth of shoot (cm)

Girth of new sprouts was recorded as shoot girth. The point of indication was marked with a ball point pen at the base of the sprout. The girth of sprout was measured by using a thread at the marked point in each selected plant. The reading for the girth of sprouts was recorded after 30 days of grafting and continued up to 90^{th} days at 30 days interval.

3.6.6 Number of nodes

Newly developed nodes among the selected grafts were recorded after one month of sprouting at 30 days intervals up to 90th day.

3.6.7 Number of leaves

The number of leaves was recorded at 30 days interval from each selected plants up to 90 days.

3.6.8 Length of leaf (cm)

Length of leaf was recorded using a centimeter scale. For taking observations, a second leaf emerged among the selected plants were marked with a ball point pen and the middle portion of the leaf showing maximum length was recorded as length of leaf. Monthly growth rate in length was observed after one month of sprouting at 30 days interval and continued up to 90th day.

3.6.9 Breadth of leaf (cm)

The breadth of leaf was recorded at 30 days interval after one month of sprouting by using centimeter scale. The middle portion of the leaf showing maximum width was recorded as the breadth of leaf. Selected leaves in each treatment were used to take the observations. The observation was continued up to 90th day.

3.6.10 Number of branches

A single observation on number of branches was recorded at 90 days after sprouting since the plants did not produce any branches at first two months after sprouting.

3.7 STATISTICAL ANALYSIS

The data collected as per the observations were subjected to statistical analysis to find out the significant differences between the treatments and treatment combinations. The means of all the treatments were calculated and the analysis of variance for all the characters was performed by F-test. Main factors as well as their interaction have analyzed separately. The significant differences of the means of treatments were compared with least significant difference (LSD) test (Gomez and Gomez, 1984). Analysis was done using OPSTAT software (Sheoran *et al.*, 1998)

RESULTS

4. RESULTS

The present investigation entitled 'Vegetative propagation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types' was conducted at College of Agriculture, Padannakkad, Kasaragod. The study comprised of five promising types viz., Varikka- early bearing (KJ 186), Gumless (KJ 397), Seedless (KJ 180), Cluster type (KJ 182) and Muttam varikka (KJ 231) and two methods of grafting i.e., epicotyl and softwood grafting. The results of the study are presented in this chapter. Effect of method of grafting on jackfruit types and their interaction found significant in almost all the observations.

4.1 Days to sprout

The data pertaining to number of days taken to sprouting of grafts as influenced by the jackfruit types and the method of grafting (Table 4.1 and Fig. 1) indicates that there was a significant difference between the jackfruit types and method of grafting while there was no any significant difference among their interactions.

The observations on days taken for first sprouting among the jackfruit types showed that, early sprouting was observed with type V_2 (26.50 days) while it was on par with the types V_3 and V_4 (27.17 and 27.33 days respectively). On the other hand, the maximum number of days taken to sprouting was observed in type V_5 (30.33 days) followed by type V_1 (28.83 days).

Among the two methods tried, epicotyl grafts took minimum days to sprout (26.00 days) while softwood grafts took duration of 30.07 days to emerge the first sprouts.

The interaction of jackfruit types and method of grafting did not make any significant effect among the results.

Table 4.1: Response of jackfruit types and method of grafting on days to sprouting.

Treatments	M_1 (Epicotyl grafting)	M_2 (Softwood grafting)	Mean
V_1 - Early bearing type	27.33	30.33	28.83
V_2 - Gumless	24.33	28.67	26.50
V_3 - Seedless	25.00	29.33	27.17
V_4 - Cluster type	25.00	29.67	27.33
V_5 - Muttom varikka	28.33	32.33	30.33
Mean	26.00	30.07	28.03
	Jackfruit types	**Method of grafting**	**Interaction**
SEm±	0.38	0.24	0.54
C.D. at 5% levels	1.13	0.71	NS

4.2 Percentage of sprouting

Results on percentage of sprouting of grafts have been presented in Table 4.2 and Figure 2 indicating that the sprouting percentage of jackfruit was showed a significant difference between types of jackfruit and interaction of types and methods, while it was found as non significant in method of grafting.

Among different types of jackfruit tried, a highest sprouting percentage of 41.91 per cent was obtained with type V_2 which was on par with 40.13 per cent in

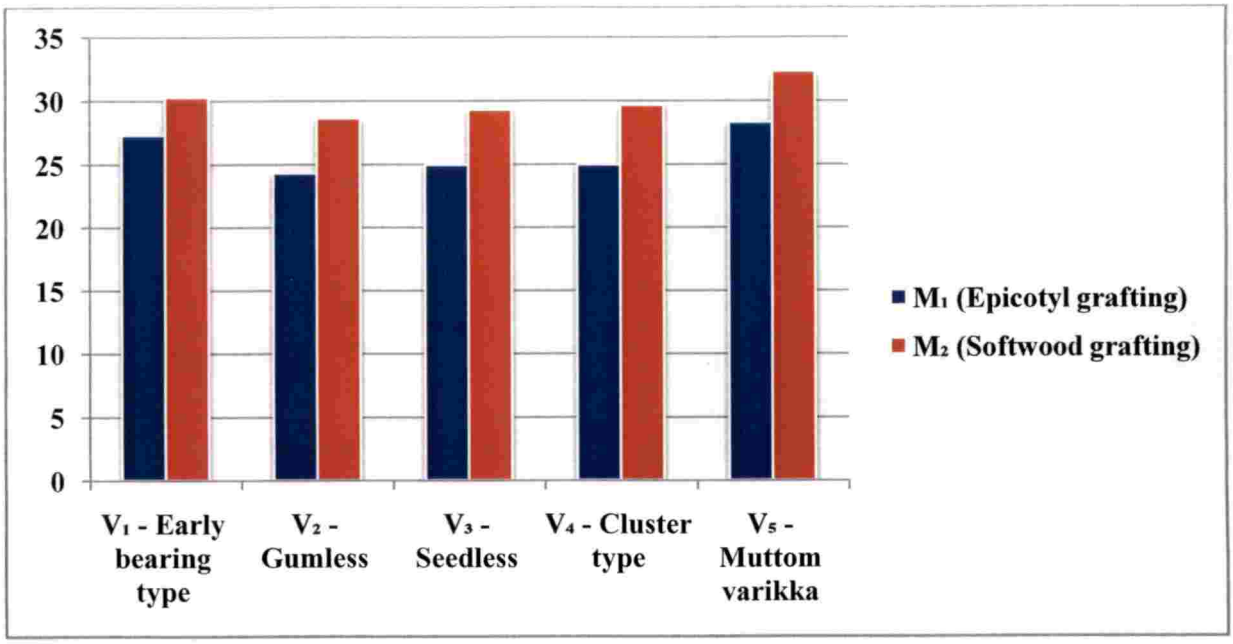


Fig. 1. Number of days taken to sprout in different jackfruit types

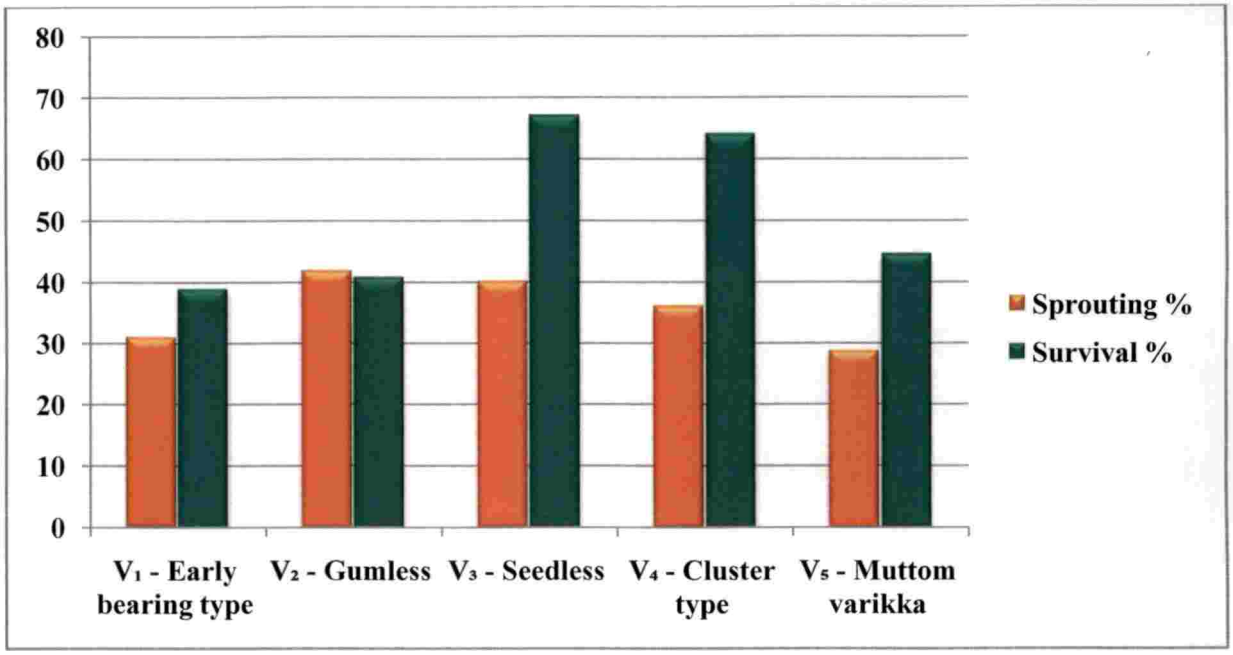


Fig. 2. Sprouting and survival percentage of different jackfruit types

type V_3 and 36.12 per cent in type V_4. Lowest sprouting percentage was found with type V_5 (28.77 per cent) and it was on par with type V_1 (30.98 per cent).

As regards to interaction, V_2 x M_2 recorded maximum sprouting percentage (46.90 per cent) which was on par with V_3 x M_1 and V_4 x M_2 (43.06 and 39.21 per cent respectively). A minimum sprouting percentage of 26.55 per cent was found in V_5 x M_2 which was on par with 32.99 per cent in V_4 x M_1 and 30.98 per cent in V_1 M_1, V_2 x M_2 and V_5 x M_1 each.

Table 4.2: Effect of jackfruit types and method of grafting on percentage of sprouting

Treatments	**M_1** (Epicotyl grafting)	**M_2** (Softwood grafting)	**Mean**
V_1 - Early bearing type	30.98	30.98	30.98
V_2 - Gumless	36.92	46.90	41.91
V_3 - Seedless	43.06	37.21	40.14
V_4 - Cluster type	32.99	39.22	36.10
V_5 - Muttom varikka	30.98	26.55	28.77
Mean	34.99	36.17	35.58
	Jackfruit types	**Method of grafting**	**Interaction**
SEm±	1.85	1.18	2.63
C.D. at 5% levels	5.52	NS	7.81

4.3 Percentage of survival

It is evident from table 4.3 and Figure 2 that the results on percentage of survival after 90 days were found significant in jackfruit types and their interaction, while the data was found not significant in case of method of grafting.

Among the jackfruit types, maximum percentage of survival was recorded with type V_3 (66.94 per cent) and it was on par with V_4 (63.88 per cent). On the other hand, the lowest survival percentage was observed with type V_1 (38.88 per cent) which was on par with V_2 and V_5 (40.83 and 44.44 per cent respectively).

The method of grafting did not show any significant difference. With that of interactions, V_3 x M_1 showed a superior survival percentage of 86.67 per cent followed by 52.77 per cent in V_4 x M_1 while the lowest survival of grafts found with V_2 x M_1 (31.67 per cent).

Table 4.3: Effect of jackfruit types and method of grafting on percentage of survival of grafts at 90 days after sprouting.

Treatments	M_1 (Epicotyl grafting)	M_2 (Softwood grafting)	Mean
V_1 - Early bearing type	38.89	38.89	38.89
V_2 - Gumless	31.67	50.00	40.83
V_3 - Seedless	86.67	47.22	66.94
V_4 - Cluster type	52.78	75.00	63.89
V_5 - Muttom varikka	38.89	50.00	44.44
Mean	49.78	52.22	51.00

	Jackfruit types	Method of grafting	Interaction
SEm±	6.95	4.40	9.83
C.D. at 5% levels	20.65	NS	29.20

4. 4 Length of shoot

The observations regarding shoot length of grafts at 30, 60 and 90 days after sprouting, of different jackfruit types in different grafting methods are presented in Table 4.4 and Figure 3.

The length of sprouted shoot of grafts after 30, 60 and 90 days of sprouting showed significant difference among different types of jackfruit grafted. The shoot length after 30 days and 90 days of sprouting was observed maximum in type V_3 (3.95 cm and 8.13 cm respectively) it was on par with V_1 during the similar growth intervals (3.94 cm at 30 DAS and 7.82 cm at 90 DAS), while the length of shoots at 60 days of sprouting was recorded maximum in type V_1 (5.93 cm) at par with V_3 (5.91 cm). Similarly the length of shoot after 30, 60 and 90 days of growth found minimum in type V_5 (2.53 cm at 30 DAS, 4.12 cm at 60 DAS and 6.43 cm at 90 DAS) where as it was on par with V_2 (3.06 cm) at 30 days of growth and on par with V_4 at 60 days (4.50 cm) and 90 days (6.98 cm) of growth.

Among the methods, on observation on length of shoots found as significant only at 30 days after sprouting. The observations recorded at 60 and 90 days after sprouting didn't resulted any significant in length of shoot. At 30 days after sprouting, softwood grafts results maximum shoot length (3.66 cm) and it was minimum in epicotyl grafts (3.06 cm).

The interaction of jackfruit types and methods showed significant results with the observation recorded at 30 days and 90 days of growth, while it was non

Table 4.4: Effect of jackfruit types and method of grafting on shoot length (cm) of grafts

Treatments	After 30 days of sprouting			After 60 days of sprouting			After 90 days of sprouting		
	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean
V_1 - EB	3.33	4.55	3.94	5.62	6.25	5.93	7.27	8.37	7.82
V_2 - Gumless	3.32	2.80	3.06	5.32	4.82	5.07	7.48	7.30	7.39
V_3 - Seedless	3.67	4.23	3.95	5.88	5.93	5.91	8.18	8.08	8.13
V_4 - Cluster	2.45	4.08	3.27	4.37	4.63	4.50	6.63	7.33	6.98
V_5 - MV	2.43	2.63	2.53	4.70	3.53	4.12	7.25	5.67	6.43
Mean	3.04	3.66	3.35	5.18	5.03	5.10	7.36	7.34	7.35
	V	M	V x M	V	M	V x M	V	M	V x M
SEm±	0.21	0.13	0.29	0.22	0.14	0.32	0.20	0.12	0.28
C.D. (0.05)	0.61	0.39	0.87	0.67	NS	NS	0.58	NS	0.83

M_1 - EG: Epicotyl grafting, **M_2 - SG:** Softwood grafting, **V_1 - EB:** Early bearing type and **V_5 - MV:** Muttom varikka

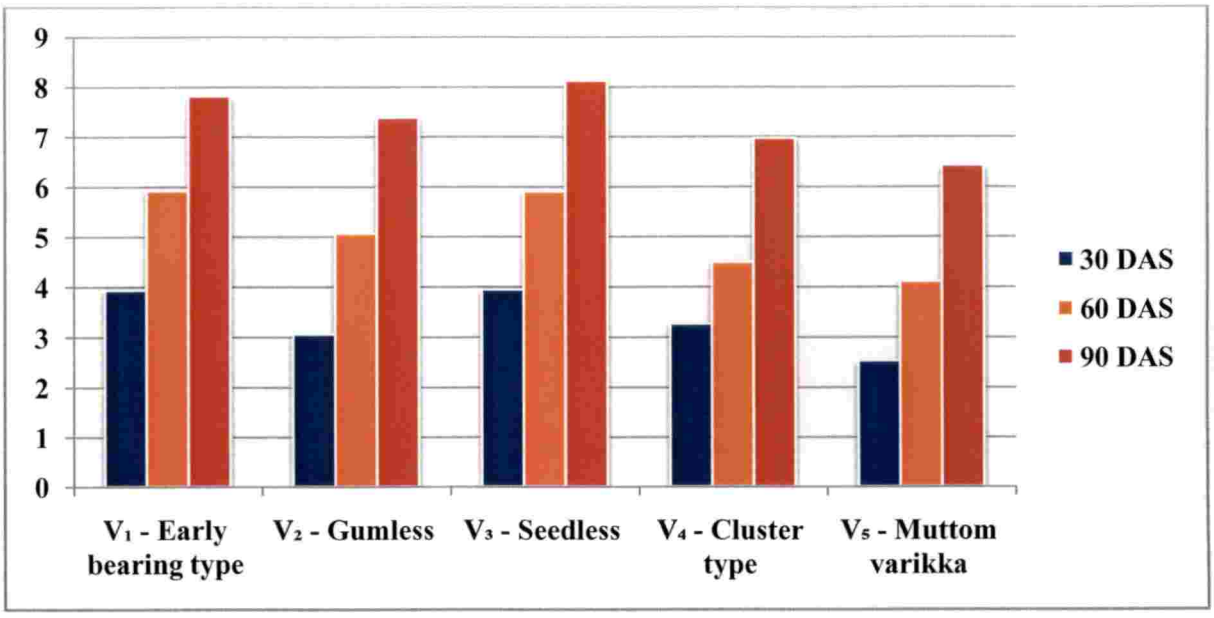


Fig. 3. Variation in shoot length (cm) of different jackfruit types

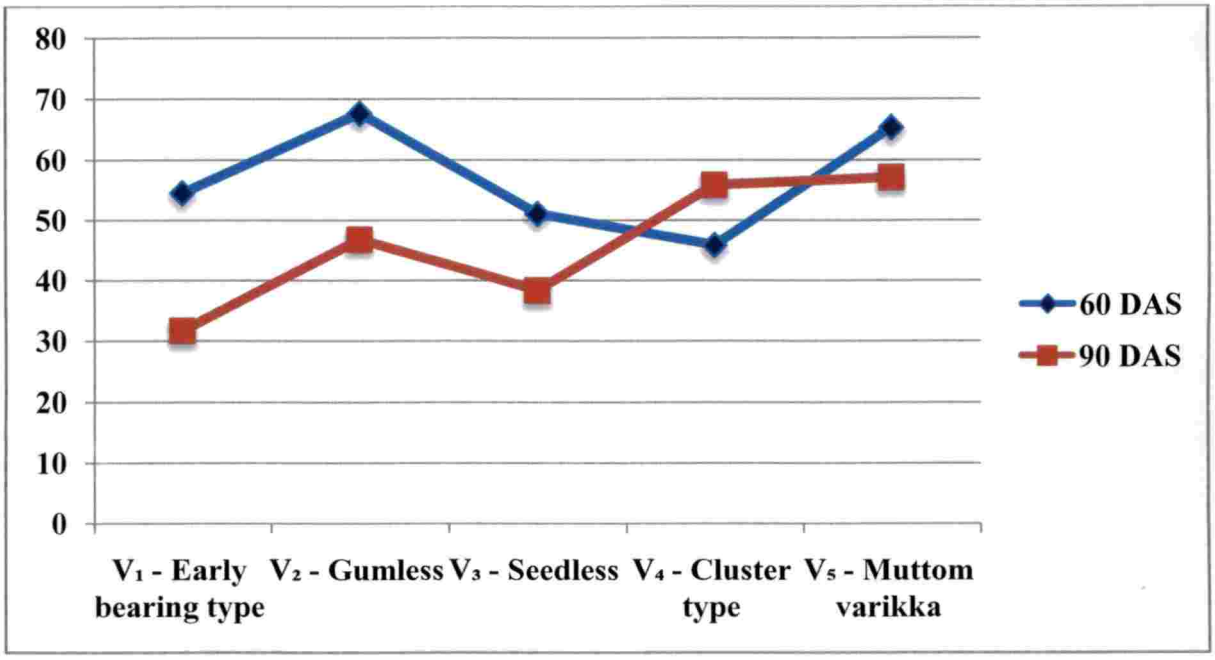


Fig. 4. Percentage increase in shoot length of different jackfruit types

significant at observation on 60 days of growth. The interaction, V_1 x M_2 showed maximum shoot length at 30 days and 90 days of growth (4.55 cm and 8.37 cm respectively) it was on par with V_3 x M_2 and V_4 x M_2 (4.23 cm and 4.08 cm respectively) at 30 days of growth and on par with V_3 x M_2 and V_3 x M_1 (8.08 cm and 8.18 cm respectively) after 90 days of growth. Similarly the lowest shoot length at 30 DAS was found with V_5 x M_1 (2.43 cm) it was on par with V_4 x M_1, V_5 x M_2, V_2 x M_2 and V_2 x M_1 whereas, the shoot length at 90 DAS was found minimum in V_5 x M_2 (5.67 cm) followed by V_4 x M_1 (6.60 cm).

4.5 Girth of scion

The data on girth of scion at 30, 60 and 90 days after sprouting (Table 4.5 and Fig. 5) was highly affected by different jackfruit types and method of grafting.

The perusal of data presented in table 4.5 showed that, different jackfruit types significantly influenced on the scion girth from 30 to 90 days after sprouting. The maximum scion girth at 30, 60 and 90 DAS was recorded in type V_4 (1.07 cm, 1.28 cm and 1.50 cm respectively) followed by V_3 (0.98 cm, 1.17 cm and 1.37 cm at 30, 60 and 90 DAS respectively) and V_5 (0.97 cm, 1.11 cm and 1.32 cm at 30, 60 and 90 DAS respectively). Whereas the minimum girth of scion at all the intervals observed in type V_1 (0.81 cm, 0.96cm and 1.15 cm) it is on par with V_2 (0.83 cm and 1.00 cm) at 30 and 60 DAS.

Significant differences among the method of grafting have been found on girth of scion at 30 to 90 days after sprouting shown. Softwood method of grafting registered the maximum girth of scion at all the intervals of growth (0.99 cm, 1.16 cm and 1.36 cm at 30, 60 and 90 DAS respectively) and minimum was observed with epicotyl method (0.87 cm, 1.05 cm and 1.28 cm at 30, 60 and 90 DAS respectively).

Among the interactions, significant differences were recorded at 30 and 60 days of observation while, it was found as non significant at 90 days of observation.

Table 4.5: Effect of jackfruit types and method of grafting on shoot girth (cm) of grafts

Treatments	After 30 days of sprouting			After 60 days of sprouting			After 90 days of sprouting		
	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean
V_1 - EB	0.69	0.93	0.81	0.85	1.07	0.96	1.08	1.22	1.15
V_2 - Gumless	0.72	0.95	0.83	0.90	1.10	1.00	1.18	1.30	1.24
V_3 - Seedless	0.93	1.03	0.98	1.13	1.20	1.17	1.33	1.42	1.38
V_4 - Cluster	1.05	1.10	1.07	1.23	1.33	1.28	1.45	1.50	1.48
V_5 - MV	0.98	0.95	0.97	1.12	1.10	1.11	1.33	1.30	1.32
Mean	0.87	0.99	0.93	1.05	1.16	1.10	1.28	1.36	1.32
	V	M	V x M	V	M	V x M	V	M	V x M
SEm±	0.03	0.02	0.03	0.02	0.01	0.03	0.02	0.02	0.03
C.D. (0.05)	0.08	0.05	0.11	0.06	0.04	0.09	0.07	0.05	NS

M_1 - EG: Epicotyl grafting, **M_2 - SG:** Softwood grafting, **V_1 - EB:** Early bearing type and **V_5 - MV:** Muttom varikka

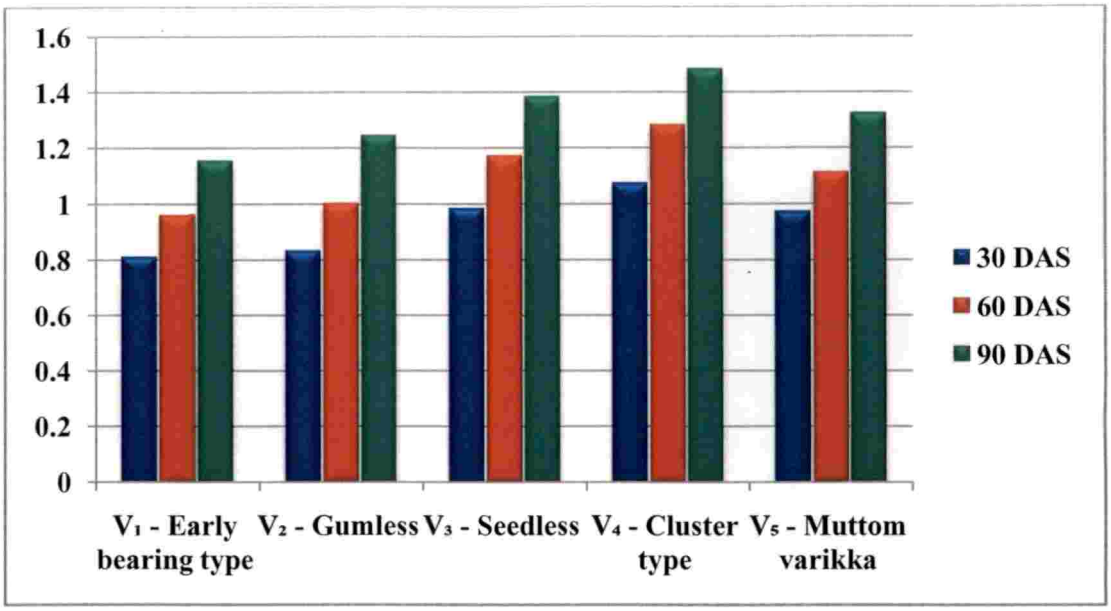


Fig. 5. Variation in shoot girth (cm) of different jackfruit types

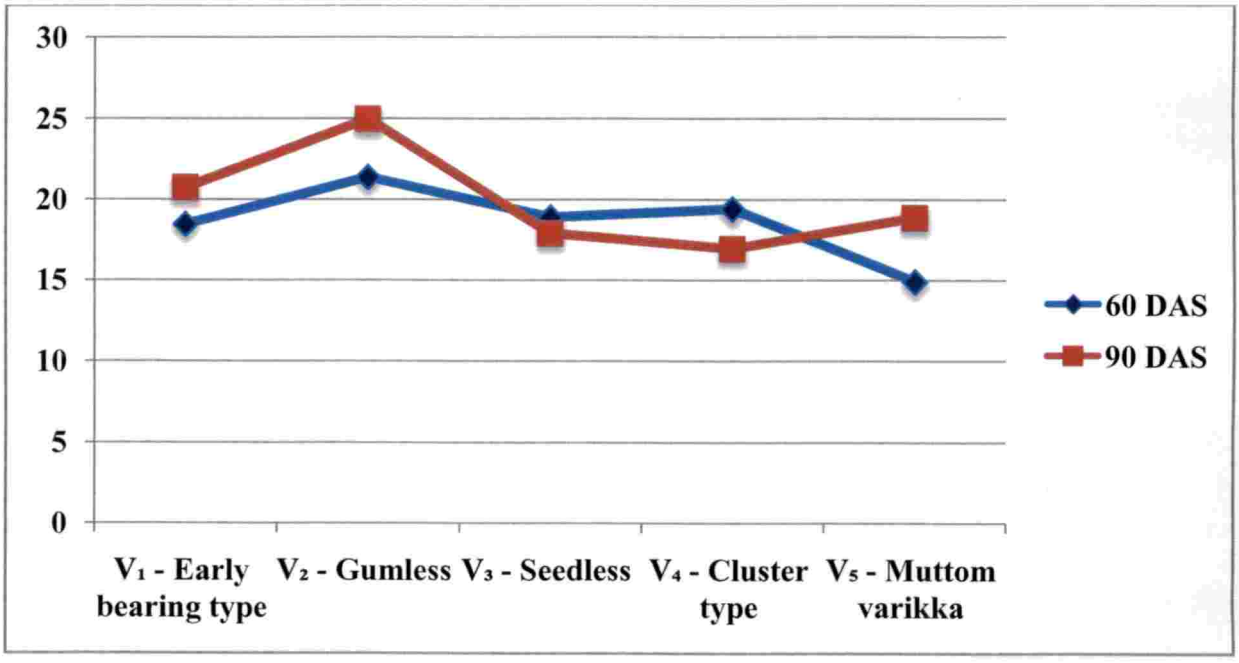


Fig. 6. Percentage increase in shoot girth of different jackfruit types

The interaction of V_4 x M_2 resulted maximum girth of scion at all the intervals (1.10 cm, 1.33 cm and 1.50 cm at 30, 60 and 90 DAS respectively) it is on par with V_4 x M_1 (1.05 cm and 1.23 cm at 30 and 60 DAS respectively) and V_3 x M_2 (1.03 cm and 1.20 cm at 30 and 60 DAS respectively) while the minimum scion girth was resulted with V_1 x M_1 (0.69 cm and 0.85 cm at 30 and 60 DAS) it is on par with V_2 x M_1 (0.72 cm, 0.90 cm at 30 and 60 DAS).

4.6 Number of nodes

Number of nodes recorded after 30 and 60 days of sprouting (Table 4.6 and Fig. 7) found significantly different among all the treatments whereas after 90 days of observation it was found significant only among the jackfruit types while the methods and the interaction found non-significant.

Regarding types of jackfruit, type V_4 produces maximum number of nodes at 30 to 90 days of observation (4.83, 5.67 and 7.50 at 30, 60 and 90 DAS) it was on par with V_3 and V_1 (4.50 and 4.17 respectively) at 30 DAS and V_3 (5.33) at 60 DAS. At 30 DAS the minimum number of nodes found with type V_5 (3.17) it was on par with V_2 (3.50) where as the observation at 60 and 90 DAS found minimum with type V_2 (3.83 and 4.67 respectively) while, it was on par with type V_5 (4.00 and 5.33 respectively).

Observation at 30 and 60 DAS, maximum number of nodes was found with softwood grafts (4.40 and 5.20 respectively) and epicotyl grafts recorded minimum number of nodes (3.67 and 4.27) at 30 and 60 DAS.

Among the interaction, V_4 x M_2 results maximum numbers of nodes at 30 and 60 DAS (6.00 and 7.00 respectively) followed by V_3 x M_1, V_3 x M_2 and V_1 x M_1 (4.67, 4.33 and 4.33 respectively) at 30 DAS and V_3 x M_1 and V_3 x M_2 (5.33 each) at 60 DAS. The minimum number of nodes found with V_5 x M_1 (2.67) at 30 DAS it was

Table 4.6: Effect of jackfruit types and method of grafting on number of nodes of grafts

Treatments	After 30 days of sprouting			After 60 days of sprouting			After 90 days of sprouting		
	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean
V_1 - EB	4.33	4.00	4.17	5.00	4.67	4.83	6.00	5.67	5.83
V_2 - Gumless	3.00	4.00	3.50	3.33	4.33	3.83	4.33	5.00	4.67
V_3 - Seedless	4.67	4.33	4.50	5.33	5.33	5.33	6.33	6.00	6.17
V_4 - Cluster	3.67	6.00	4.83	4.33	7.00	5.67	6.67	8.33	7.50
V_5 - MV	2.67	3.67	3.17	3.33	4.67	4.00	5.00	5.67	5.33
Mean	3.67	4.40	4.03	4.27	5.20	4.73	5.67	6.13	5.90
	V	M	V x M	V	M	V x M	V	M	V x M
SEm±	0.29	0.18	0.41	0.21	0.13	0.30	0.34	0.22	0.48
C.D. (0.05)	0.86	0.54	1.21	0.63	0.40	0.89	1.01	NS	NS

M_1 - EG: Epicotyl grafting, **M_2 - SG:** Softwood grafting, **V_1 - EB:** Early bearing type and **V_5 - MV:** Muttom varikka

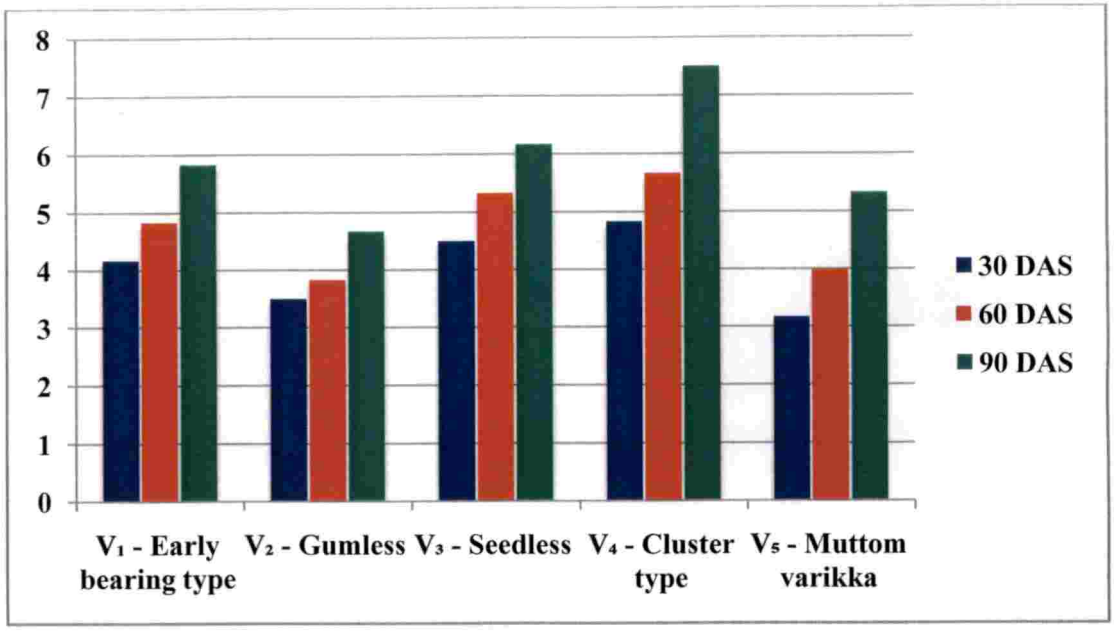


Fig. 7. Variation in number of nodes in different jackfruit types

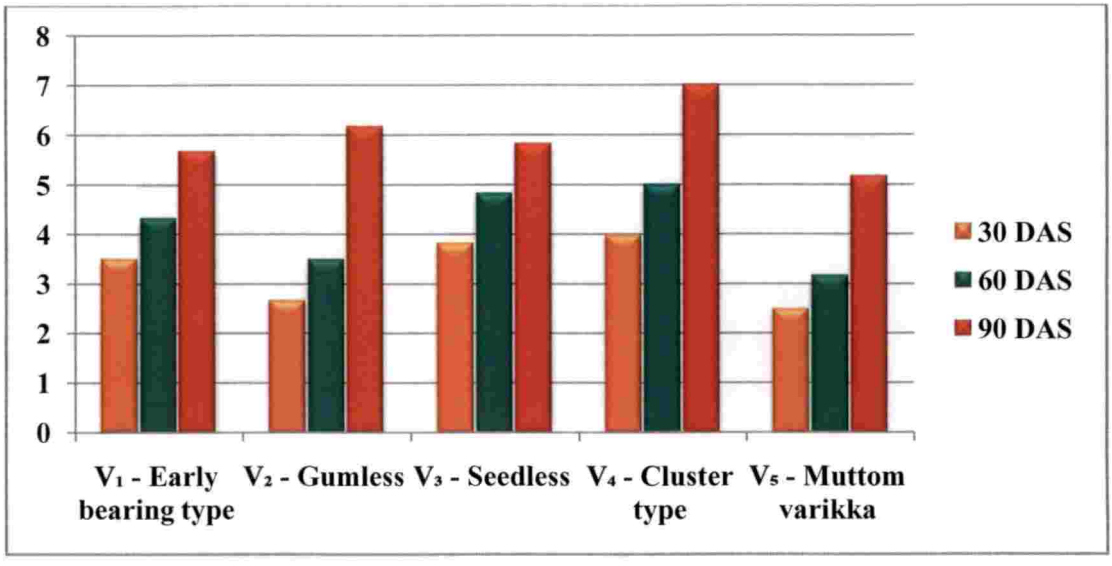


Fig. 8. Variation in number of leaves in different jackfruit types

on par with V_2 x M_1, V_4 x M_1 and V_5 x M_2 (3.00, 3.67 and 3.67 respectively) whereas, V_5 x M_1 and V_2 x M_1 resulted minimum number of nodes (3.33 each) at 60 DAS.

4.7 Number of branches

The observation on total number of branches produced per each graft also recorded at 90 days after sprouting (Table 4.7). Even though the number of branches was observed in some treatments, the result didn't show any significant difference between types of jackfruit, method of grafting and their interactions.

Table 4.7: Effect of jackfruit types and method of grafting on number of branches at 90 days after sprouting

Treatments	M_1 (Epicotyl grafting)	M_2 (Softwood grafting)	Mean
V_1 - Early bearing type	1.00	0.00	0.50
V_2 - Gumless	0.00	0.00	0.00
V_3 - Seedless	1.33	0.67	1.00
V_4 - Cluster type	0.00	0.00	0.00
V_5 - Muttom varikka	1.67	0.67	1.17
Mean	0.80	0.27	0.53
	Jackfruit types	**Method of grafting**	**Interaction**
SEm±	0.32	0.20	0.46
C.D. at 5% levels	NS	NS	NS

4.8 Number of leaves

The number of leaves per grafts as influenced by jackfruit types and method of grafting (Table 4.8 and Fig. 8) indicates that there was significant difference between the types, method of grafting and their interaction at 30, 60 and 90 days of sprouting.

Grafting tried on type V_4 resulted in maximum number of leaves at all the intervals (4.00, 5.00 and 7.00 at 30, 60 and 90 DAS respectively) it was on par with type V_3 and V_1 at 30 and 60 DAS and with V_1, V_3 and V_2 at 90 DAS. A minimum number of leaves was observed in type V_5 at 30 to 90 DAS (2.50, 3.17 and 5.17 at 30, 60 and 90 DAS respectively) which is on par with type V_2 at 30 and 60 DAS (2.67 and 3.50 respectively) and with V_2 and V_3 at 60 DAS (5.67 and 5.83 respectively).

It is clear from the table that, softwood grafts produced significantly higher number of leaves (3.73) at 30, 60 and 90 days of growth (3.73, 4.60 and 6.33 respectively) than that of epicotyl grafts (2.87, 3.73 and 5.60 at 30, 60 and 90 DAS).

Among the interactions, V_4 x M_2 recorded a maximum number of leaves at 30, 60 and 90 DAS (5.33, 6.33 and 8.33 respectively) followed by V_3 x M_1 at 30 and 60 DAS (4.00 and 5.00 respectively) V_2 x M_2 and V_3 x M_1 at 90 DAS (6.67 and 6.33 respectively). The minimum number of leaves registered with the interactions V_5 x M_1 and V_2 x M_1 at 30 and 60 DAS whereas it was found minimum with V_5 x M_1 at 90 DAS.

4.9 Length of leaves

The results on length of leaves at 30 to 90 DAS (Table 4.9 and Fig. 9) found as significantly different between jackfruit types, method of grafting and their interaction.

Table 4.8. Effect of jackfruit types and method of grafting on number of leaves of grafts.

Treatments	After 30 days of sprouting			After 60 days of sprouting			After 90 days of sprouting		
	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean
V_1 - EB	3.67	3.33	3.50	4.67	4.00	4.33	5.67	5.67	5.67
V_2 - Gumless	2.00	3.33	2.67	2.67	4.33	3.50	5.67	6.67	6.17
V_3 - Seedless	4.00	3.67	3.83	5.00	4.67	4.83	6.33	5.33	5.83
V_4 - Cluster	2.67	5.33	4.00	3.67	6.33	5.00	5.67	8.33	7.00
V_5 - MV	2.00	3.00	2.50	2.67	3.67	3.17	4.67	5.67	5.17
Mean	2.87	3.73	3.30	3.73	4.60	4.16	5.60	6.33	5.96
	V	M	V x M	V	M	V x M	V	M	V x M
SEm±	0.22	0.32	0.22	0.31	0.19	0.43	0.37	0.24	0.53
C.D. (0.05)	0.66	0.42	0.94	0.91	0.58	1.29	1.11	0.70	1.53

M_1 - EG: Epicotyl grafting, **M_2 - SG:** Softwood grafting, **V_1 - EB:** Early bearing type and **V_5 - MV:** Muttom varikka

At 30 and 40 DAS maximum leaf length was recorded in type V_4 (6.92 cm and 9.01 cm at 30 and 60 DAS respectively) followed by V_3 (6.07 cm and 8.17 cm at 30 and 60 DAS respectively) and at 90 DAS also the result was maximum in V_4 (12.34 cm) while it was on par with the type V_3 (12.23 cm). The minimum length of leaf was found with type V_1 in all the intervals (4.34 cm, 6.36 cm and 8.41 cm at 30, 60 and 90 DAS respectively) followed by V_2 (5.38 cm, 7.49 cm and 10.04 cm at 30, 60 and 90 DAS respectively).

Regarding method of grafting, the maximum leaf length at 30 to 90 DAS was observed with softwood grafts (6.10 cm, 8.14 cm and 11.16 cm at 30, 60 and 90 DAS respectively) and it was found minimum with epicotyl grafts (5.19 cm, 7.34 cm and 10.27 cm at 30, 60 and 90 DAS respectively).

The interaction V_4 x M_2 resulted maximum length of leaf at 30, 60 and 90 DAS (6.95 cm, 9.08 cm and 12.67 cm respectively) it was on par with V_4 x M_1 (6.88 cm, 8.93 cm and 12.55 cm respectively) and V_3 x M_2 (6.55 cm, 8.58 cm and 12.02 cm respectively) whereas it was found minimum in V_1 x M_1 (3.32 cm, 5.37 cm and 7.20 cm at 30, 60 and 90 days respectively) followed by V_2 x M_1 (4.45 cm, 6.63 cm and 9.48 cm at 30, 60 and 90 DAS respectively).

4.10 Breadth of leaf

The data presented on table 4.10 and Fig. 11 showed that, breadth of leaf found significantly different between jackfruit types and method of grafting at 30 to 90 DAS while, their interaction was found significant only at 60 and 90 DAS and it was non significant at 30 DAS.

Maximum leaf breadth was found in type V_4 at 30, 60 and 90 DAS (3.22 cm, 4.34 cm and 5.64 cm respectively) it is on par with V_3 (3.02 cm) at 30 DAS and with V_5 (4.27 cm and 5.49 cm respectively) and V_3 (4.07 cm and 5.30 cm respectively) at 30 and 60 DAS. Minimum breadth of leaf found with type V_2 (2.02 cm and 2.97 cm

Table 4.9: Effect of jackfruit types and method of grafting on leaf length (cm) of grafts.

Treatments	After 30 days of sprouting			After 60 days of sprouting			After 90 days of sprouting		
	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean
V_1 - EB	3.32	5.37	4.34	5.37	7.35	6.36	7.20	9.62	8.41
V_2 - Gumless	4.45	6.32	5.38	6.63	8.35	7.49	9.48	10.60	10.04
V_3 - Seedless	5.60	6.55	6.07	7.75	8.58	8.17	11.92	12.55	12.23
V_4 - Cluster	6.88	6.95	6.92	8.93	9.08	9.01	12.02	12.67	12.34
V_5 - MV	5.72	5.33	5.52	8.00	7.32	7.66	10.73	10.37	10.55
Mean	5.19	6.10	5.64	7.34	8.14	7.74	10.27	11.16	10.71
	V	M	V x M	V	M	V x M	V	M	V x M
SEm±	0.13	0.08	0.18	0.13	0.08	0.18	0.14	0.09	0.20
C.D. (0.05)	0.38	0.24	0.54	0.38	0.24	0.54	0.42	0.27	0.60

M_1 - EG: Epicotyl grafting, **M_2 - SG:** Softwood grafting, **V_1 - EB:** Early bearing type and **V_5 - MV:** Muttom varikka

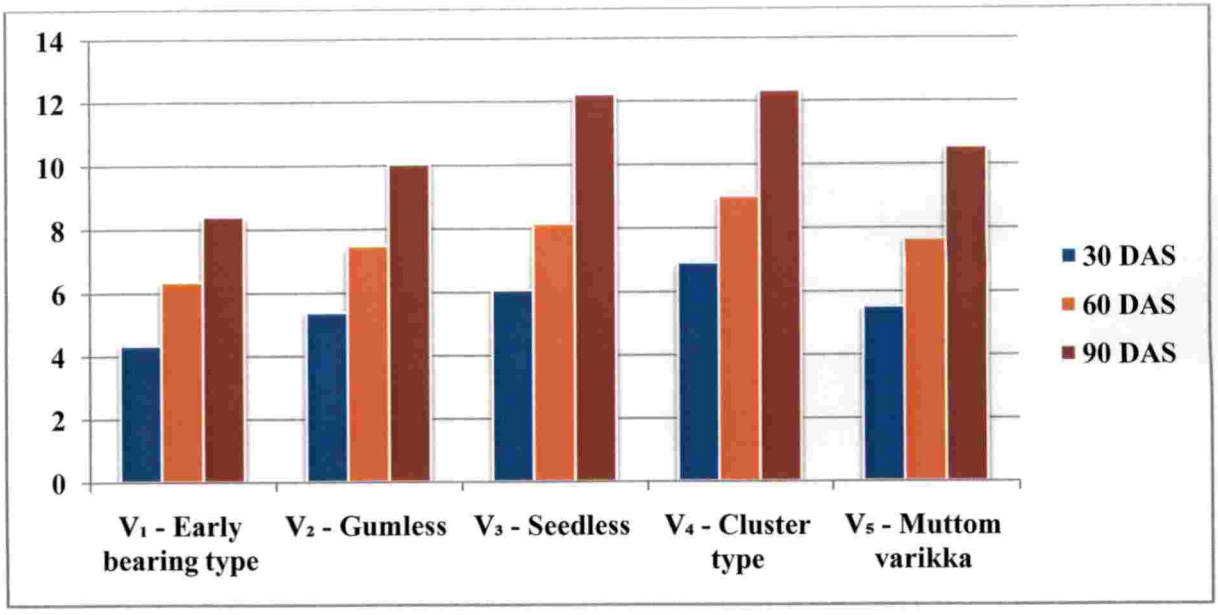


Fig. 9. Variation in leaf length (cm) of different jackfruit types

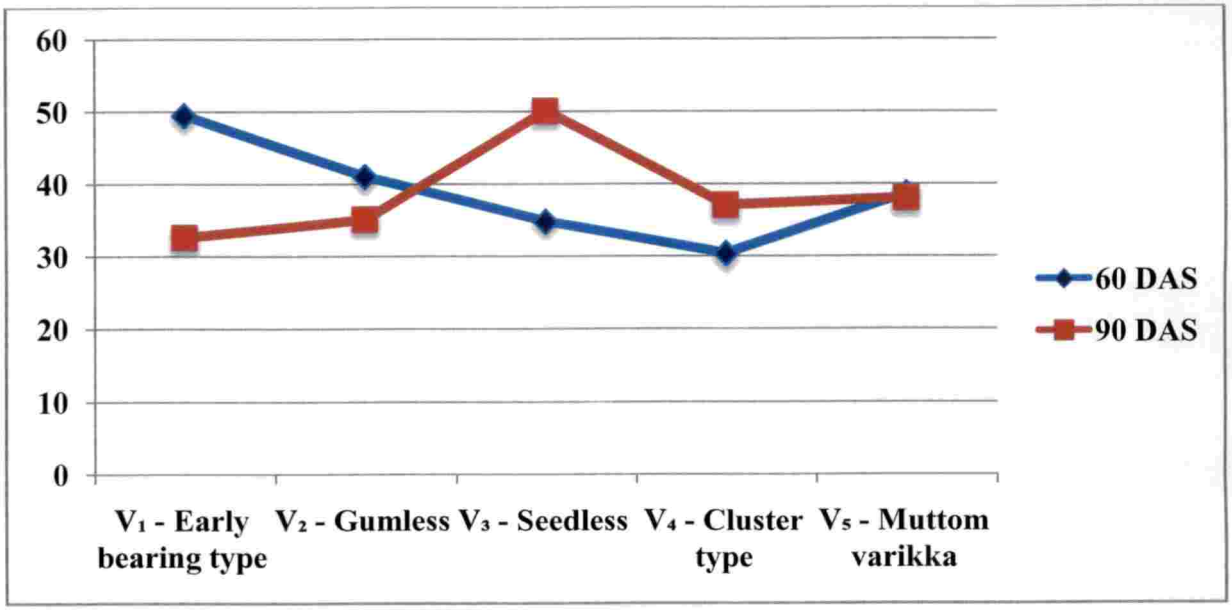


Fig. 10. Percentage increase in leaf length of different jackfruit types

respectively) at 30 and 60 DAS on par with V_1 (2.08 cm and 3.25 cm respectively). While after 90 days of growth, it was found minimum in type V_1 (4.22 cm) and which was at par with V_2 (4.27 cm).

4.10 Breadth of leaf

The data presented on table 4.10 showed that, breadth of leaf found significantly different between jackfruit types and method of grafting at 30 to 90 DAS while, their interaction was found significant only at 60 and 90 DAS and it was non significant at 30 DAS.

Maximum leaf breadth was found in type V_4 at 30, 60 and 90 DAS (3.22 cm, 4.34 cm and 5.64 cm respectively) it is on par with V_3 (3.02 cm) at 30 DAS and with V_5 (4.27 cm and 5.49 cm respectively) and V_3 (4.07 cm and 5.30 cm respectively) at 30 and 60 DAS. Minimum breadth of leaf found with type V_2 (2.02 cm and 2.97 cm respectively) at 30 and 60 DAS on par with V_1 (2.08 cm and 3.25 cm respectively) while after 90 days of growth, it was found minimum in type V_1 (4.22 cm) at par with V_2 (4.27 cm).

The maximum breadth of leaf in case of method of grafting was found with softwood grafts at all the intervals (2.86 cm, 4.02 cm and 5.29 cm at 30, 60 and 90 DAS respectively) and it was lowest in epicotyl grafts (2.35 cm, 3.55 cm and 4.69 cm at 30, 60 and 90 DAS respectively).

Among the interaction, maximum breadth of leaf found with V_3 x M_2 (3.55 cm) at 30 DAS and it was with V_5 x M_1 (4.55 cm and 5.82 cm respectively) at 60 and 90. The minimum breadth was found with V_1 x M_1 (1.72 cm, 2.47 cm and 3.28 cm respectively) at 30, 60 and 90 DAS.

Table 4.10: Effect of jackfruit types and method of grafting on leaf breadth (cm) of grafts.

Treatments	After 30 days of sprouting			After 60 days of sprouting			After 90 days of sprouting		
	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean
V_1 - EB	1.72	2.45	2.08	2.47	4.03	3.25	3.28	5.17	4.22
V_2 - Gumless	1.85	2.20	2.02	2.72	3.23	2.97	3.88	4.67	4.27
V_3 - Seedless	2.5	3.55	3.02	3.63	4.52	4.07	4.85	5.75	5.30
V_4 - Cluster	3.22	3.22	3.22	4.37	4.32	4.34	5.60	5.68	5.64
V_5 - MV	2.47	2.87	2.67	4.55	3.98	4.27	5.82	5.17	5.49
Mean	2.35	2.86	2.60	3.55	4.02	3.78	4.69	5.29	4.99
	V	M	V x M	V	M	V x M	V	M	V x M
SEm±	0.12	0.08	0.17	0.11	0.07	0.15	0.09	0.06	0.13
C.D. (0.05)	0.36	0.23	NS	0.32	0.20	0.46	0.27	0.17	0.38

M_1 - EG: Epicotyl grafting, **M_2 - SG:** Softwood grafting, **V_1 - EB:** Early bearing type and **V_5 - MV:** Muttom varikka

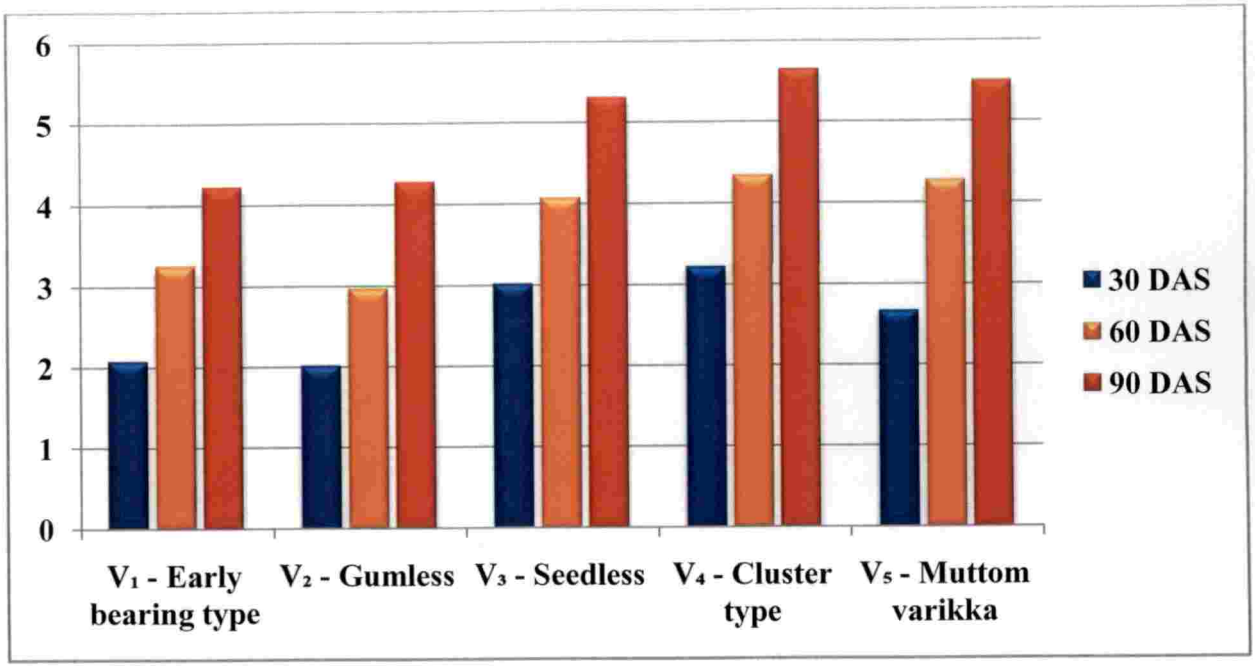


Fig.11. Variation in leaf breadth (cm) of different jackfruit types

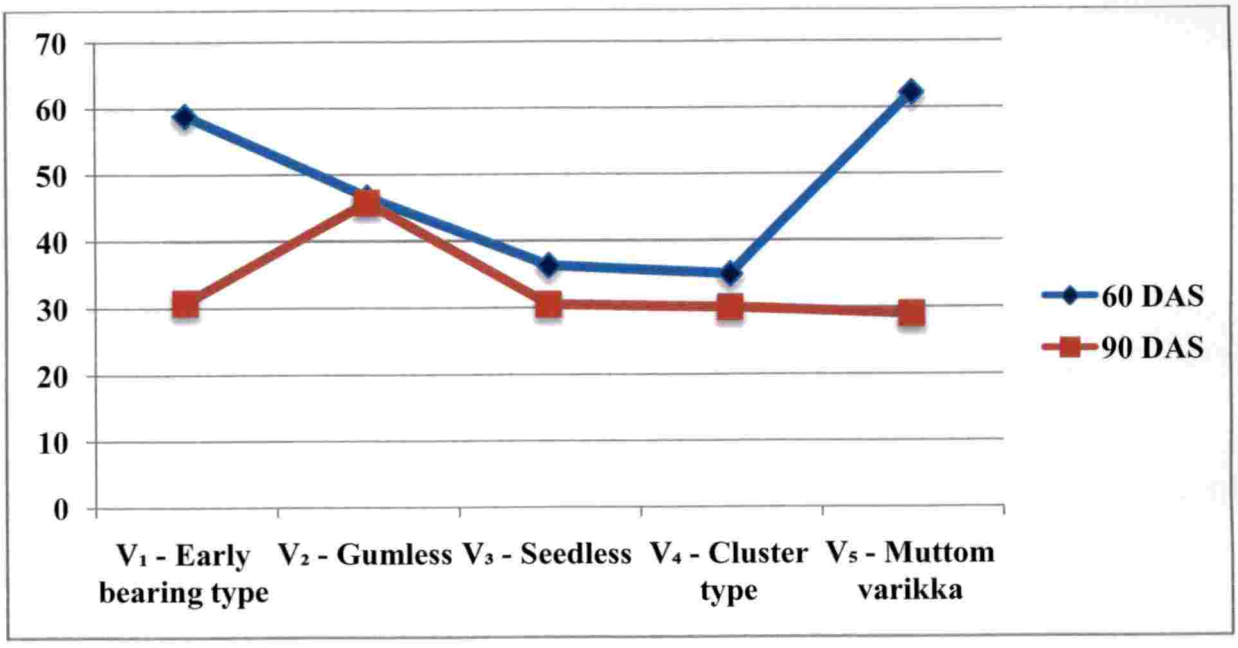


Fig. 12. Percentage increase in leaf breadth of different jackfruit types

4.11: Effect of jackfruit types and method of grafting on sprouting and survival of grafts.

The data given in table 4.11 and Fig. 13 regarding days to sprouting, percentage of sprouting and percentage of survival of jack grafts revealed that, there was a significant difference among the jackfruit types.

Type V_2 and V_3 was found superior with having a maximum per cent of sprouting (41.91and 40.14 per cent) as well as earliness in sprouting of grafts (26.50 days and 27.17 days respectively) whereas type V_3 and V_4 found superior in maximum survival of grafts at 90 DAS (66.94 and 63.88 per cent respectively). Similarly, type V_5 found as inferior in late sprouting as well as less sprouting percentage of grafts (30.33 days and 28.77 per cent respectively) and type V_1 found with less percentage of survival (38.89 per cent).

Considering the methods of grafting, earlier sprouting of buds was obtained with epicotyl grafts (26.00 days) than that in softwood grafts (30.07 days) while the results on percentage of sprouting and survival was found as non significant.

Among the interactions, sprouting percentage was found maximum in $V_2 \times M_2$ (46.90 per cent) and maximum survival percentage was recorded in grafts of $V_3 \times M_1$ (86.67 per cent) while the results on days to sprout was not significant. On the other hand, minimum percentage of sprouting (26.55 per cent) was recorded in $V_5 \times M_2$ while a minimum survival percentage of 31.67 per cent was observed with $V_2 \times M_1$.

Table 4.11: Effect of jackfruit types and method of grafting on sprouting and survival of grafts

Treatments	Days to sprout			Sprouting percentage			Survival percentage		
	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean	M_1 - EG	M_2 - SG	Mean
V_1 - EB	27.33	30.33	28.83	30.98	30.98	30.98	38.89	38.89	38.89
V_2 - Gumless	24.33	28.67	26.50	36.92	46.90	41.91	31.67	50.00	40.83
V_3 - Seedless	25.00	29.33	27.17	43.06	37.21	40.14	86.67	47.22	66.94
V_4 - Cluster	25.00	29.67	27.33	32.99	39.22	36.10	52.78	75.00	63.89
V_5 - MV	28.33	32.33	30.33	30.98	26.55	28.77	38.89	50.00	44.44
Mean	26.00	30.07	28.03	34.99	36.17	35.58	49.78	52.22	51.00
	V	**M**	**V x M**	**V**	**M**	**V x M**	**V**	**M**	**V x M**
SEm±	0.38	0.24	0.54	1.85	1.18	2.63	6.95	4.40	9.83
C.D. (0.05)	1.13	0.71	NS	5.52	NS	7.81	20.65	NS	29.20

M_1 - EG: Epicotyl grafting, **M_2 - SG:** Softwood grafting, **V_1 - EB:** Early bearing type and **V_5 - MV:** Muttom varikka

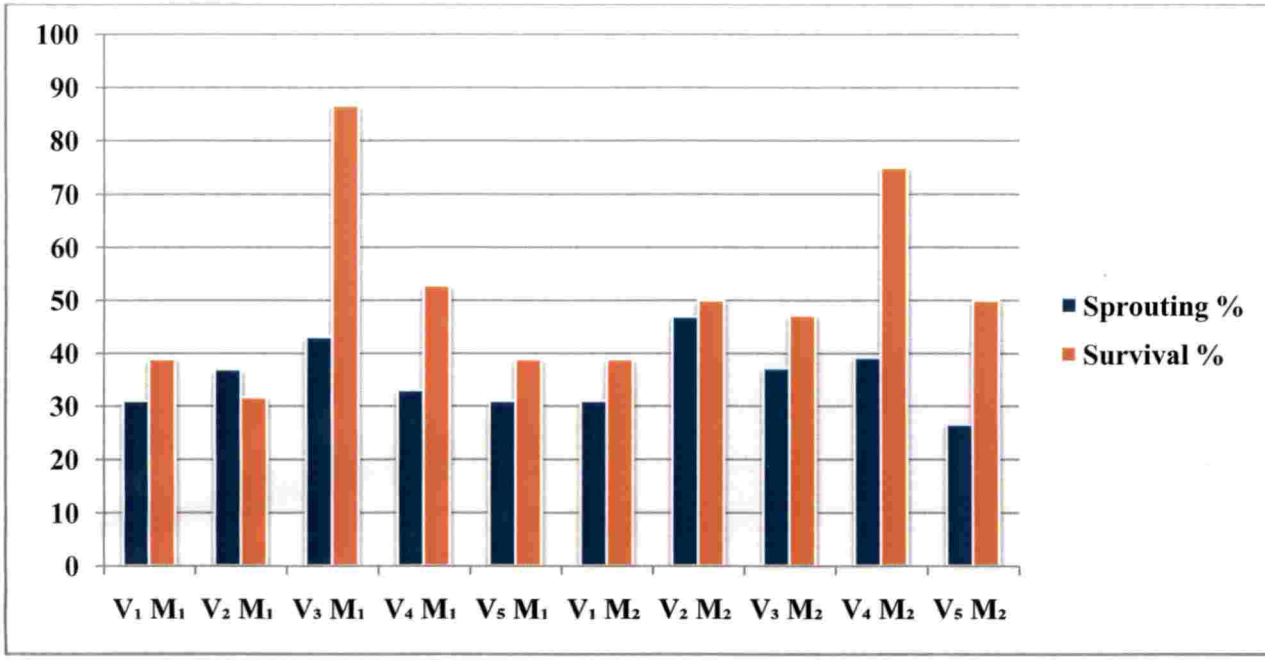


Fig. 13. Interaction of jackfruit types and method of grafting on sprouting and survival percentage

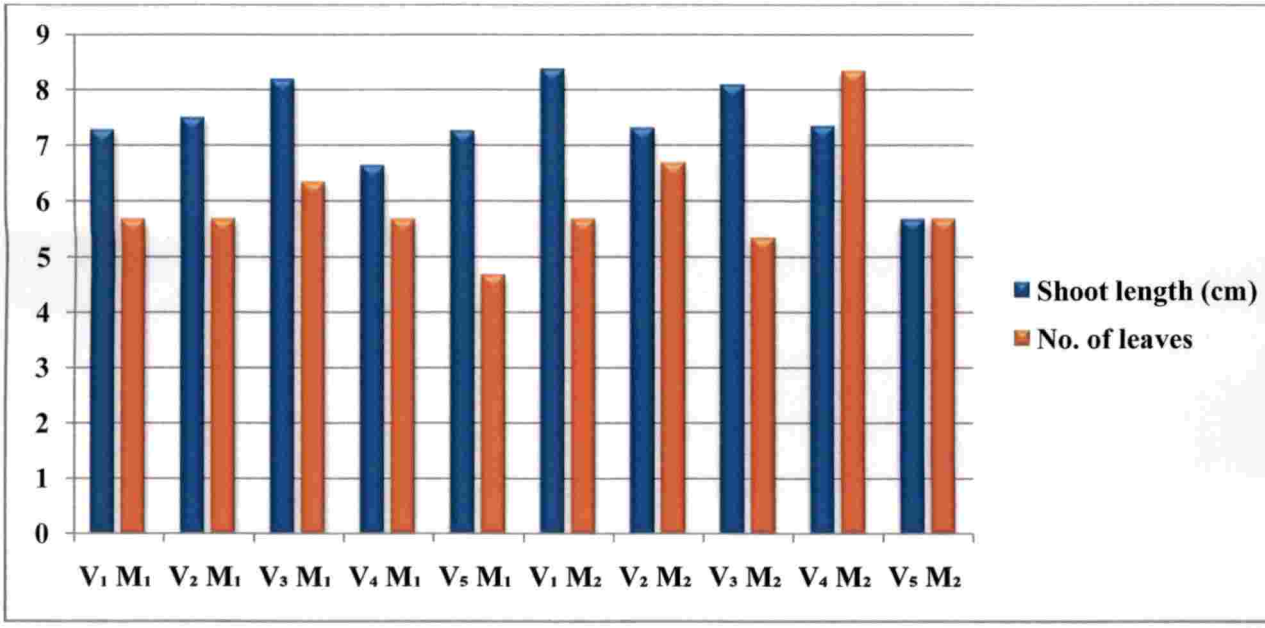


Fig. 14. Interaction of jackfruit types and method of grafting on morphological characters

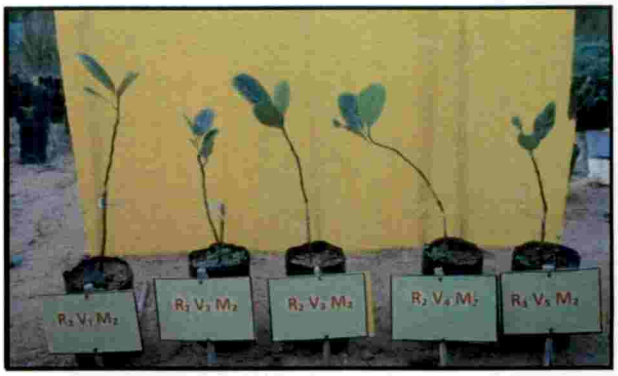
4.12: Effect of jackfruits types and method of grafting on morphological characters of grafts after 90 days of sprouting

The perusal of data regarding morphological characters of grafts at 90 DAS (Table 4.12 a and b) indicate that, type V_4 was found as better after the final establishment with good growth characters like highest shoot girth (1.50 cm), number of nodes (7.50), number of leaves (7), length (12.34 cm) and breadth (5.64 cm) of leaves while it was on par with V_2 in number of leaves (6.17), with V_3 in length of leaf (12.23 cm) and with V_5 in breadth of leaf (5.49 cm). The shoot length was found maximum in type V_3 (8.13 cm) and it was on par with V_1 - Early bearing type (7.82 cm).

The morphological characters of grafts after final establishment were best in softwood grafts with maximum shoot girth (1.36 cm), number of nodes (6.13), number of leaves (6.33), length of leaf (11.16 cm) and breadth of leaf (5.29) while epicotyl grafts recorded maximum shoot length (7.36 cm).

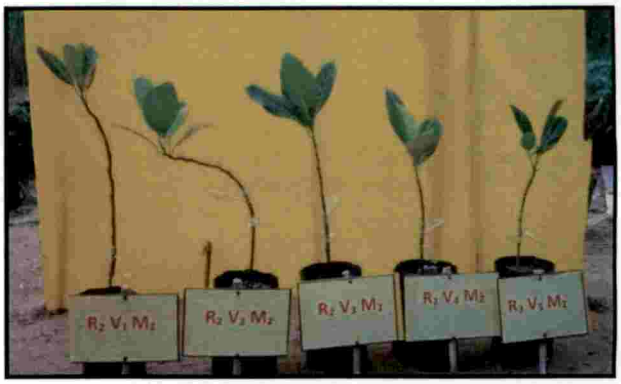
In respect of interactions, interaction V_4 x M_2 resulted in better in almost all the morphological parameters including maximum shoot girth (1.50 cm), number of nodes (8.33), number of leaves (8.33) and length of leaf (12.67 cm) whereas the maximum shoot length (8.37 cm) was found in V_1 x M_2 and the maximum leaf breadth (5.82 cm) was observed in epicotyl grafting and V_5 x M_1.

i. Epicotyl grafts of five jackfruit types at 30 days after sprouting



ii. Softwood grafts of five jackfruit types at 30 days after sprouting

iii. Epicotyl grafts of five jackfruit types at 60 days after sprouting



iv. Softwood grafts of five jackfruit types at 60 days after sprouting

v. Epicotyl grafts of five jackfruit types at 90 days after sprouting

vi. Softwood grafts of five jackfruit types at 90 days after sprouting

Plate 5. Growth of grafted plants at 30 days intervals

Table 4.12 a: Effect of jackfruit types and method of grafting on morphological characters of grafts after 90 days of sprouting

Treatments	Shoot length (cm)			Shoot girth (cm)			Number of nodes			Number of branches		
	M_1 (EG)	M_2 (SG)	Mean	M_1 (EG)	M_2 (SG)	Mean	M_1 (EG)	M_2 (SG)	Mean	M_1 (EG)	M_2 (SG)	Mean
V_1 - EB	7.27	8.37	7.82	1.08	1.22	1.15	6.00	5.67	5.83	1.00	0.00	0.50
V_2 - Gumless	7.48	7.30	7.39	1.18	1.30	1.24	4.33	5.00	4.67	0.00	0.00	0.00
V_3 - Seedless	8.18	8.08	8.13	1.33	1.42	1.37	6.33	6.00	6.17	1.33	0.67	1.00
V_4 - Cluster	6.63	7.33	6.98	1.45	1.50	1.50	6.67	8.33	7.50	0.00	0.00	0.00
V_5 - MV	7.25	5.67	6.43	1.33	1.30	1.32	5.00	5.67	5.33	1.67	0.67	1.17
Mean	7.36	7.34	7.35	1.28	1.36	1.32	5.67	6.13	5.90	0.80	0.27	0.53
	V	**M**	**V x M**	**V**	**M**	**V x M**	**V**	**M**	**V x M**	**V**	**M**	**V x M**
SEm±	0.20	0.12	0.28	0.02	0.02	0.03	0.34	0.22	0.48	0.32	0.20	0.46
C.D. (0.05)	0.58	NS	0.83	0.07	0.05	NS	1.01	NS	NS	NS	NS	NS

M_1 - EG: Epicotyl grafting, **M_2 - SG:** Softwood grafting, **V_1 - EB:** Early bearing type and **V_5 - MV:** Muttom varikka

Table 4.12 b: Effect of jackfruit types and method of grafting on morphological characters of grafts after 90 days of sprouting

Treatments	Number of leaves			Length of leaf (cm)			Breadth of leaf (cm)		
	M_1 (EG)	M_2 (SG)	Mean	M_1 (EG)	M_2 (SG)	Mean	M_1 (EG)	M_2 (SG)	Mean
V_1 - EB	5.67	5.67	5.67	7.20	9.62	8.41	3.28	5.17	4.22
V_2 - Gumless	5.67	6.67	6.17	9.48	10.60	10.04	3.88	4.67	4.27
V_3 - Seedless	6.33	5.33	5.83	11.92	12.55	12.23	4.85	5.75	5.30
V_4 - Cluster	5.67	8.33	7.00	12.02	12.67	12.34	5.60	5.68	5.64
V_5 - MV	4.67	5.67	5.17	10.73	10.37	10.55	5.82	5.17	5.49
Mean	5.60	6.33	5.96	10.27	11.16	10.71	4.69	5.29	4.99
	V	M	V x M	V	M	V x M	V	M	V x M
SEm±	0.37	0.24	0.53	0.14	0.09	0.20	0.09	0.06	0.13
C.D.	1.11	0.70	1.53	0.42	0.27	0.60	0.27	0.17	0.38

M_1 - SG: Epicotyl grafting, **M_2 - EG:** Softwood grafting, **V_1 - EB:** Early bearing type and **V_5 - MV:** Muttom varikka

V_1 - Varikka early bearing type
(KJ 186)

V_2 - Gumless type
(KJ 397)

V_3 - Seedless type
(KJ 180)

V_4 - Cluster type
(KJ 182)

V_5 - Muttomvarikka
(KJ 231)

Plate 6. Growth of five jackfruit types at 90 DAS under softwood grafting

V_1 - Varikka early bearing type
(KJ 186)

V_2 - Gumless type
(KJ 397)

V_3 - Seedless type
(KJ 180)

V_4 - Cluster type
(KJ 182)

V_5 - Muttomvarikka
(KJ 231)

Plate 7. Growth of five jackfruit types at 90 DAS under epicotyl grafting

DISCUSSION

5. DISCUSSION

Jack fruit is a nutritive and very popular fruit crop in the tropical regions of the world. In India, it is grown in southern and northeastern states. As a crop, jackfruit has not received much attention towards standardization of cultural practices and crop improvement. So the crop is still being considered as a minor fruit. Standardization of vegetative propagation methods will serve as one of the important tools for boosting up the production and quality of this crop. There are many grafting techniques found successful in this crop but the method like epicotyl and softwood grafting are found as easiest, efficient and economical methods of propagation.

Though standard varieties in jackfruit are less, there are good numbers of trees which are superior in yield and desirable fruit characters. Vegetative propagation of such selected trees assumes greater importance to ensure uniformity of planting material for enhancing fruit production.

The present study entitled 'Vegetative propagation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types' was conducted at College of Agriculture, Padannakkad, Kasaragod involving five promising types via., Varikka- early bearing (KJ 186), Gumless (KJ 397), Seedless (KJ 180), Cluster type (KJ 182) and Muttam varikka (KJ 231) and two methods of grafting i.e., epicotyl and softwood grafting. The salient findings of the study are discussed below.

5.1 Days to sprout

The data furnished regarding days taken to sprouting (Table 4.1) suggested that the time taken (days) for sprouting of buds varied significantly with varieties and method of grafting. Earlier sprouting was recorded with type V_2 (Gumless type) (26.50 days) which might be due to the early healing of grafts. Less latex content of the type probably lead to earliness in healing of grafts and further in sprouting. Alam *et al.* (2006) in mango, Nanditha *et al.* (2017) in guava, Kalalbandi *et al.* (2014) and Choudhary *et al.* (2016) in aonla observed significant variations

in the grafts of varieties towards number of days to sprouting. Similar findings o were reported in jackfruit (Harshavardhan *et al.*, 2014) where the cultivars Singapore and Palur took 21.68 and 22.52 days respectively for sprouting.

Among the methods, epicotyl grafting resulted earliness in sprouting (26.00 days). The findings are coinciding with the results of Ullah *et al.* (2017) in mango were epicotyl grafts resulted earlier bud sprout than that in softwood grafts. This might be due to the tender stage of stocks which brought high meristematic activity and supply of stored nutrients in the cotyledons, enhancing quick healing of grafts.

5.2 Percentage of sprouting

The percentage of sprouting was significantly influenced by the different types of jackfruit. Among the five types, maximum (41.91 per cent) percentage of sprouting was found with type V_2 (Gumless tye). The significant variations in sprouting percentages may probably due to the different levels of compatibility of the scions of five different types with the rootstock. This result is in agreement with the findings of Bhadra (2012), Ratna (2012) and Alam *et al.* (2006) in mango.

As regards to interactions, type V_2 in Softwood method recorded maximum percentage of sprouting. This result is coinciding with that of Ullah *et al.* (2017) where maximum success percentage of mango grafts was seen in softwood grafting than epicotyl grafting.

5.3 Percentage of survival

Among the five jackfruit types, maximum percentage of survivability (66.94 per cent) was found when the grafting operation was done with the scion of type V_3 (Seedless type). This might be due to having optimum nutrient and hormonal status as well as good callusing capability of seedless type. The survival ratio of the grafts is related to the different aspects concerning plant growth phase probably the variety may have good nutrient supply due to its

seedless nature. Radha and Aravindakshan (2000) observed the similar findings in different varieties of mango with epicotyl grafting under Kerala conditions. Such varietal influence on graft survivability is also have been proved by Prajapati *et al.* (2014), Mandal *et al.* (2011) and Alam *et al.* (2006) in mango.

Among interactions, type V_3 grafted in epicotyl method resulted in superior survivability (86.67 per cent). This might be due to the better supply of nutrients by the scion. Maximum survivability of epicotyl grafts when compared to veneer and softwood method were observed in mango (Ullah *et al.*, 2017).

5.4 Morphological characters

Significant variations were observed in all morphological parameters in respect of jackfruit types. Among the five types, highest shoot girth (1.50 cm), number of nodes (7.50), number of leaves (7), length (12.34 cm) and breadth (5.64 cm) of leaves were observed when V_4 (Cluster type) was used as scion while maximum shoot length was recorded with the type V_3 (Seedless type). The variations in different growth parameters could be due to the differences in the genetic makeup which influence the histological and physiological development within the shoot. Relationship between the response to a grafting technique and the growing habit of the varieties is also possible reason for such a differential response.

The maximum value in different parameters might be due to the favorable physiological condition of scion of the respective variety, which helped to maintain higher growth rate. Cluster type had maximum scion width compared to other varieties and it might have lead to the better growth of grafts. The varietal variation among morphological growth parameters were reported in other crops; Nandhitha *et al.* (2017) in guava, Ghosh *et al.* (2010) in sapota, Choudhary *et al.* (2016) in aonla, Alam *et al.* (2006) in mango and Hiwale *et al.* (2008) in wood apple.

Regarding the methods, softwood grafting was found superior in the growth parameters like shoot girth (1.36 cm), number of nodes (6.13), and number of leaves (6.33), length of leaf (11.16 cm) and breadth of leaf (5.29) while epicotyl grafting recorded maximum shoot length (7.36 cm). The girth of the scion was more in the case of softwood grafts compared to the scion of epicotyl grafts which might have provided more nutrients than that of epicotyl grafts. The maximum shoot length recorded by epicotyl grafts were on par with that of softwood grafts. The maximum shoot length might be due to the better initial growth in epicotyl grafts.

SUMMARY

6. SUMMARY

Jackfruit is one of the important minor indigenous fruit crops of India with multifarious uses. Due to cheap market price and wide availability, the fruit is very popular among the people of all levels. Compared with other fruit crops, jackfruit is considered as a more difficult species to maintain parameters of fruit quality through seed propagation since it shows type variation. Hence vegetative propagation methods like grafting and budding are becoming popular to produce true to type planting material of jackfruit.

The present Investigation on 'Vegetative propagation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types' was conducted at the College of Agriculture, Padannakkad, Kasaragod during the period 2017 June to 2018 January. The experiment comprised of five promising types of jackfruit viz., Varikka- early bearing (KJ 186), Gumless (KJ 397), Seedless (KJ 180), Cluster (KJ 182) and Muttam varikka (KJ 231) and two method of grafting i.e., epicotyl and softwood grafting.

The study were conducted to evaluate the success of epicotyl and softwood grafting in promising types of jackfruit as well as to examine the varietal variation of jackfruit among grafting methods. The salient findings of the present investigation are summarized as below.

Among the different types of jackfruit tried with two methods of grafting, type V_2 (Gumless type) resulted in earlier sprouting (26.50 days) and maximum sprouting of grafts (41.91 per cent) and it was on par with V_3 (Seedless type) in both the parameters of days to sprout (27.17 days) and sprouting percentage (40.14 per cent). The maximum survival percentage was recorded with type V_3 (66.94 per cent) and it was on par with type V_4 (Cluster type).

As regards to the morphological characters observed in the grafted jackfruit types, type V_4 (Cluster type) was found as better after the final establishment with good growth characters like highest shoot girth (1.50 cm),

number of nodes (7.50), number of leaves (7), length (12.34 cm) and breadth (5.64 cm) of leaves while it was on par with type V_2 (Gumless type) in number of leaves (6.17), with V_3 (Seedless type) in length of leaf (12.23 cm) and with V_5 (Muttom varikka) in breadth of leaf (5.49 cm). The shoot length was found maximum in type V_3 (8.13 cm) and it was on par with type V_1 (Varikka - early bearing type) (7.82 cm).

Among the methods of grafting, earlier sprouting of buds was obtained with epicotyl grafts (26.00 days) than that in softwood grafts (30.07 days) while the results on percentage of sprouting and survival was not significant among the methods.

The morphological characters of grafts after final establishment were best in softwood grafts with maximum shoot girth (1.36 cm), number of nodes (6.13), number of leaves (6.33), length of leaf (11.16 cm) and breadth of leaf (5.29 cm) while epicotyl grafts recorded maximum shoot length (7.36 cm).

Among the interactions, sprouting percentage was found maximum in softwood grafts of type V_2 (Gumless type) (46.90 per cent) and maximum survival percentage was recorded in epicotyl grafts of type V_3 (Seedless type) (86.67 per cent) while the results on days to sprout was not significant.

In respect of morphological parameters, interaction of softwood grafting and type V_4 (Cluster type) resulted in better values of maximum shoot girth (1.50 cm), number of nodes (8.33), number of leaves (8.33) and length of leaf (12.67 cm) whereas the maximum shoot length was found in softwood grafting with type V_1 (Varikka - early bearing type) and the maximum leaf breadth was observed in epicotyl grafting with V_5 (Muttom varikka).

The study clearly indicated significant differences in the five jack fruit types with respect to the two propagation methods. Detailed investigations on anatomical, physiological and biochemical factors would reveal the exact reasons to elucidate these findings.

For the mass multiplication of Seedless type, epicotyl grafting could be adopted and for early bearing Varikka, Gumless and Cluster types, softwood grafting could be recommended.

i. Final established growth of softwood grafts

ii. Final established growth of epicotyl grafts

iii. Field view

Plate 8. Final established growth of grafted plants in grow bag after 90 days of sprouting

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7. REFERENCES

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VEGETATIVE PROPAGATION OF PROMISING JACKFRUIT (*Artocarpus heterophyllus* Lam.) TYPES

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(2015-12-017)

Abstract of the Thesis

Submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

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PADANNAKKAD, KASARAGOD – 671 314

2018

ABSTRACT

The investigation on 'Vegetative propagation of promising jackfruit (*Artocarpus heterophyllus* Lam.) types' was conducted at the College of Agriculture, Padannakkad, Kasaragod during the period 2017 - 18 to evaluate the success of epicotyl and softwood grafting in promising types of jackfruit and to examine the variation among jackfruit types with respect to grafting methods. The experiment comprised of five promising types of jackfruits viz., V_1 - Varikka - early bearing (KJ 186), V_2 - Gumless (KJ 397), V_3 - Seedless (KJ 180), V_4 - Cluster (KJ 182) and V_5 - Muttam varikka (KJ 231) and two method of grafting i.e., M_1 - epicotyl grafting and M_2 - softwood grafting. The experiment was laid out in factorial CRD with three replications.

The different jackfruit types showed significant influence for all the parameters studied except number of branches. Type V_2 resulted in earliest sprouting (26.50 days) and maximum sprouting percentage of grafts (41.91 per cent) while type V_3 recorded maximum survival percentage (66.94 per cent) and shoot length (8.13 cm). Maximum shoot girth (1.50 cm), number of nodes (7.50), number of leaves (7), length of leaf (12.34 cm) and breadth of leaf (5.64 cm) were observed in type V_4. On the other hand, the maximum days to sprouting (30.33 days), minimum sprouting percentage (28.77 per cent), minimum shoot length (6.43 cm) and minimum number of leaves (5.17) were recorded in type V_5 while type V_1 showed minimum survival percentage (38.89 per cent), shoot girth (1.15 cm), leaf length (8.41 cm) and breadth of leaf (4.22 cm).

Among the methods of grafting, the results on percentage of sprouting and survival as well as number of branches were not significant while all other parameters showed significant effects. Epicotyl grafts resulted in early sprouting of buds (26.00 days) and maximum shoot length (7.36 cm) whereas maximum shoot girth (1.36 cm), number of nodes (6.13), number of leaves (6.33), length of leaf (11.16 cm) and breadth of leaf (5.29 cm) were observed in softwood grafts.

The interaction of varieties and methods of grafting were significant in most of the characters recorded. Interaction V_2 x M_1 was found better in early sprouting (24.33 days) and V_2 x M_2 resulted in maximum sprouting percentage (46.90 per cent) while V_3 x M_1 gave maximum survival of grafts (86.67 per cent).

Hence, for the mass multiplication of Seedless type epicotyl grafting could be adopted and for other types like early bearing varikka, Gumless and cluster, softwood grafting could be practiced.

സംക്ഷിപ്തം

കേരളത്തിലെ വീട്ടുവളപ്പുകളിൽ വളരെ പ്രാധാന്യമർഹിച്ചുകൊണ്ട് കാണപ്പെടുന്ന ഒരു ഫലവൃക്ഷമാണ് പ്ലാവ്. പച്ചക്കറിയായും ഫലമായും ഉപയോഗിക്കാൻ കഴിയുന്ന ചക്കയുടെ കുരുവിലടങ്ങിയിട്ടുള്ള ഗണ്യമായ ധാന്യകത്തിന്റെ തോത് നിലവിലെ നിത്യഭക്ഷണ പദാർത്ഥങ്ങളായ അരിയോടും ഗോതമ്പിനോടും കൂടെ നിൽക്കുന്നതാണ്. ചക്കയുടെ മുന്തിയ പോഷക ഗുണങ്ങളും, ഔഷധ ഗുണങ്ങളും വിപണിയിൽ ഫലത്തിന്റെ ആവശ്യം ഉയർത്തുകയും അതുവഴി ചക്ക സംസ്കൃത ഉൽപ്പന്നങ്ങളുടെ നിർമ്മാണം കൂടുന്നതിനും വഴിവെച്ചിട്ടുണ്ട്. അതുകൊണ്ട് തന്നെ ആളുകൾ മികച്ച ഗുണങ്ങളടങ്ങിയ തരങ്ങളായ പശയില്ലാത്തതും കുരുവില്ലാത്തതുമായ ചക്ക ഉൽപ്പാദിപ്പിക്കുന്നതും, വളരെ നേരത്തെ കായ്ക്കുന്നതും, മികച്ച സ്വാദും കൂടുതൽ ചക്ക കിട്ടുന്നതുമായ പ്ലാവിനങ്ങൾക്ക് ഊന്നൽ നൽകുന്നു. ഇത്തരത്തിലുള്ള മികച്ച ഗുണങ്ങൾ കാണിക്കുന്ന ചില പ്ലാവുകൾ കാസറഗോഡ് ജില്ലയിൽ കണ്ടെത്തിയിട്ടുണ്ട്. ആയതിനാൽ അവയുടെ പുനരുൽപ്പാദനത്തിന് വേണ്ടി ഏറ്റവും അനുയോജ്യമായ കായിക പ്രവർധന രീതി കണ്ടത്തേണ്ടത് അത്യാവശ്യമാണ്.

പ്രധാന കായിക പ്രവർധന രീതികളായ മുളച്ചു വരുന്ന വിത്തൊട്ടിക്കൽ, മൃദുകാണ്ഡം ഒട്ടിക്കൽ എന്നിവ തിരഞ്ഞെടുത്ത ചില മികച്ചയിനം പ്ലാവിനങ്ങളിൽ എത്രത്തോളം വിജയശതമാനം കൈവരിക്കുന്നുണ്ട് എന്ന് മനസ്സിലാക്കുന്നതിനും ഈ പ്രവർധന രീതികളിൽ പ്ലാവിനങ്ങൾ ചെലുത്തുന്ന വ്യതിയാനം പരിശോധിക്കുന്നതിനു വേണ്ടിയും പടന്നക്കാട് കാർഷിക കോളേജിലെ ഫല-പുഷ്പ വർഗ്ഗ ശാസ്ത്ര വിഭാഗത്തിൽ 2017-18 കാലയളവിൽ ''കായികപ്രവർധനം മികച്ചയിനം പ്ലാവുകളിൽ'' എന്ന തലക്കെട്ടോടെ ഒരു പഠനം നടത്തുകയുണ്ടായി. ഇതിനായി മികച്ച അഞ്ച് പ്ലാവിനങ്ങളിൽ (വളരെ നേരത്തെ കായ്ക്കുന്നത്, പഴുത്തു വരുമ്പോൾ പശയില്ലാത്ത ചക്കയുള്ളത്, കുരുവില്ലാത്ത ചുളയോട് കൂടിയ (വളരെ നേർത്ത കുരു) ചക്കയുള്ളത്, കുലകളായി ചക്ക ഉൽപ്പാദിപ്പിക്കുന്നത്, മുട്ടം വരിക്ക) രണ്ട് തരം ഒട്ടിക്കൽ രീതികൾ (മുളച്ചു വരുന്ന വിത്തൊട്ടിക്കൽ, മൃദുകാണ്ഡം ഒട്ടിക്കൽ) പരീക്ഷിക്കുകയുണ്ടായി.

മേൽ പറഞ്ഞ പ്ലാവിനങ്ങളിൽ ഒട്ടിക്കൽ രീതി വിജയ ശതമാനത്തിലും തുടർന്നുള്ള കായിക വളർച്ചയിലും വ്യത്യസ്തമായ ഫലം കാണിക്കുകയുണ്ടായി. കൂടുതൽ വിജയശതമാനവും അതുപോലെ തന്നെ ഒട്ടുതൈകളുടെ നേരത്തേയുള്ള കിളിർക്കലും പശയില്ലാത്ത ചക്ക ഉല്പ്പാദിപ്പിക്കുന്ന പ്ലാവിന്റെ ഒട്ടു തൈകളിൽ

രേഖപ്പെടുത്തി. എന്നാൽ ചെടികളുടെ അതിജീവന നിരക്കിന്റെ കാര്യത്തിലും തളിർത്ത കമ്പിന്റെ വളർച്ചയുടെ കാര്യത്തിലും കുരുവില്ലാത്ത ചക്ക ഉല്പാദിപ്പിക്കുന്ന പ്ലാവിന്റെ ഒട്ടു തൈകൾ മികച്ചതായി കണ്ടു. അതേസമയം മറ്റു കായികവളർച്ചാ തോതുകളായി നിരീക്ഷിക്കപ്പെട്ട കമ്പിന്റെ വണ്ണം, മുകുളങ്ങളുടെ എണ്ണം, ഇലകളുടെ എണ്ണം, ഇലകളുടെ നീളം, വീതി തുടങ്ങിയവ ഏറ്റവും മികച്ച രീതിയിൽ കുലകളായി ചക്ക ഉല്പാദിപ്പിക്കുന്ന പ്ലാവിന്റെ ഒട്ടു തൈകളിൽ കാണുകയുണ്ടായി.

രണ്ടു തരത്തിലുള്ള ഒട്ടിക്കൽ രീതി പരീക്ഷിച്ചതിൽ നിന്നും മുളച്ചു വരുന്ന വിത്തൊട്ടിക്കൽ വഴി വികസിപ്പിച്ചെടുത്ത തൈകൾ നേരത്തേ കിളിർക്കുകയും കമ്പുകളുടെ നീളത്തിലുള്ള വളർച്ചയും കാണിക്കുകയുണ്ടായി. എന്നാൽ മൃദുകാണ്ഡം ഒട്ടിക്കൽ വഴി വികസിപ്പിച്ചെടുത്ത തൈകൾ മറ്റു കായിക വളർച്ചാ തോതുകളുടെ കാര്യത്തിൽ മികച്ചതായി കാണപ്പെട്ടു.

പഠനത്തിന്റെ ഫലമായി കണ്ടെത്തിയിട്ടുള്ള നിരീക്ഷണങ്ങൾ വെച്ചുകൊണ്ട് മേൽ പറഞ്ഞിട്ടുള്ള പ്ലാവുകളിൽ കുരുവില്ലാത്ത ചക്ക ഉല്പാദിപ്പുക്കുന്ന പ്ലാവിന്റെ മികച്ച പുനരുല്പാദനത്തിനായി മുളച്ചു വരുന്ന വിത്തൊട്ടിക്കൽ രീതി പ്രയോഗിക്കാവുന്നതാണ്. അതുപോലെ മറ്റു പ്ലാവുകളുടെ മികച്ച പുനരുല്പാദനത്തിനായി മൃദുകാണ്ഡം ഒട്ടിക്കൽ രീതിയും ഉപയോഗിക്കാവുന്നതാണ്.

APPENDICES

APPENDIX I

Details of farmers who holding the promising types of jackfruit

Jackfruit type	Name of farmer	Address	Panchayath/ Municipality
V_1 - Varikka early bearing type (KJ 186)	Sri. Pramod. M	Taliyathil House, Karuvacheri, Nileswar P.O, Kasaragod	Nileswar
V_2 - Gumless type (KJ 397)	Sri. Kesava Bhatt	Kanadhenu Farm, Ramdas Nagar P.O, Kudlu, Kasaragod	Mogral Puthur
V_3 - Seedless type (KJ 180)	Sri. Ramakrishnan	R. S. Nilayam, Koottakkani, Pakkam P.O, Kasaragod	Pallikkara
V_4 - Cluster type (KJ 182)	Sri. Abdul Rasak	Noushad Manzil, Chirappuram, Nileswar P.O, Kasaragod	Nileswar
V_5 - Muttom varikka (KJ 231)	College of Agricultre, Padannakkad	Instructional Farm, College of Agricultre, Padannakkad	Nileswar

APPENDIX II

Weather data during the period 2017 June to November

Date	Maximum Temperature (°C)	Minimum Temperature (°C)	Humidity (%)	Rainfall (mm) Last 24hr.
01-06-2017	29.9	22.2	82	8.5
02-06-2017	30	23	83	20.2
03-06-2017	31	23	92	17.2
04-06-2017	28.5	22	83.5	136
05-06-2017	29	22	98	1.5
06-06-2017	28	22.5	83.5	55.3
07-06-2017	30.5	23	85	16.7
08-06-2017	29	23	80.5	1.7
09-06-2017	30.5	21.5	86	14.9
10-06-2017	29.2	22	98	49.1
11-06-2017	28.5	22	96	79.3
12-06-2017	28	21.5	97	133.7
13-06-2017	26.2	23.5	89	36.4
14-06-2017	29.8	23.5	85	28.5
15-06-2017	31	23	86.5	58
16-06-2017	31	23.5	92	15.2
17-06-2017	29.2	22	86	47.7

18-06-2017	29.5	22	81.5	8.8
19-06-2017	31	22.5	83.5	7.4
20-06-2017	31.5	23.5	92	20.8
21-06-2017	30.3	21	88.5	21.6
22-06-2017	29.2	23	83	13.8
23-06-2017	30.5	23.5	82.5	7.8
24-06-2017	30.3	22	94	18.2
25-06-2017	28.5	21.5	94	34.5
26-06-2017	28	20.5	94	139.8
27-06-2017	27.5	21.5	93	29
28-06-2017	28	21	88	46.6
29-06-2017	29.5	21	87.5	28.2
30-06-2017	29.2	22.5	94	41
Average	**29.41**	**22.29**	**88.62**	**37.91**
01-07-2017	27	22	84.5	33.2
02-07-2017	29	21.9	87	28.4
03-07-2017	29.5	21.5	95.5	74.6
04-07-2017	27	22	89.5	25.5
05-07-2017	28	23	90.5	13.5
06-07-2017	29	23	87	18.2
07-07-2017	30.2	22.5	87	8.2
08-07-2017	30	22.5	88	22.1

09-07-2017	28	22.5	85	9.6
10-07-2017	29	22.5	86	28.3
11-07-2017	29	23	87.5	16
12-07-2017	30	22	86.5	6.7
13-07-2017	29.5	22.5	98.5	11.5
14-07-2017	27	20.5	87	103.2
15-07-2017	28	22	87.5	75.1
16-07-2017	28	22.5	82.5	26.4
17-07-2017	29.5	22.5	83	16.8
18-07-2017	30.5	21	89	31.2
19-07-2017	30	22.5	91.5	39.4
20-07-2017	29	24.5	88	8.7
21-07-2017	30.5	21.5	94	20
22-07-2017	30	22.5	86	45.5
23-07-2017	31.5	22.5	82	8
24-07-2017	32	22.5	85.5	15
25-07-2017	31	23	83.5	4
26-07-2017	30.5	22.5	83.5	3.2
27-07-2017	30.5	22.5	87	10.2
28-07-2017	30.5	22.5	83.5	17.4
29-07-2017	31	22.5	91	22.2
30-07-2017	29.5	23	82.5	3.5

31-07-2017	31	23.5	84	1
Average	**29.52**	**22.42**	**87.21**	**24.08**
01-08-2017	29.5	24	83.5	1
02-08-2017	30.5	23.5	82	5
03-08-2017	31	23	84.5	1
04-08-2017	29	22.5	95	84.6
05-08-2017	28	23.5	89	39
06-08-2017	28.5	23.5	85	10.8
07-08-2017	31	23	92	12.8
08-08-2017	28.8	22	87	10.4
09-08-2017	30	23	87	5.7
10-08-2017	30.5	22.5	86.5	2.3
11-08-2017	29	23.5	96	0
12-08-2017	27.8	22	81.5	4.7
13-08-2017	31	23	85.5	0
14-08-2017	30	23	85.5	0
15-08-2017	30	23.5	81.5	0
16-08-2017	30.5	23.5	85	2.8
17-08-2017	30	22.5	86.5	0
18-08-2017	29.2	22	90.5	16.2
19-08-2017	29.5	22	89	54.3
20-08-2017	27.5	22.5	88	38.4

21-08-2017	29	22.5	83	24.1
22-08-2017	29.5	22.5	91	56.9
23-08-2017	28	22.5	87	19.1
24-08-2017	29.5	23.5	86.5	0
25-08-2017	28.2	22	94	12
26-08-2017	29.2	23.5	88	5.3
27-08-2017	28.5	22	90.5	91.2
28-08-2017	28.5	22	99	61.7
29-08-2017	26.5	22	98	67.8
30-08-2017	26.8	23	88.5	36.5
31-08-2017	29.5	23	85.5	0
Average	**29.18**	**22.79**	**88.11**	**21.41**
01-09-2017	30.5	24	83	0
02-09-2017	30	24	81.5	0
03-09-2017	30.5	24	80	0
04-09-2017	31	24	81.5	0
05-09-2017	30	25	81.5	0
06-09-2017	30.5	23.5	87	3
07-09-2017	30.3	22	90.5	0
08-09-2017	30.5	22.5	85.5	0
09-09-2017	30.8	23.5	87	4.4
10-09-2017	29.5	23.5	87	2.3

11-09-2017	30	23.5	83.5	0
12-09-2017	30.5	24	83	0
13-09-2017	31	22.5	83	114.8
14-09-2017	32	23.5	85.5	2.3
15-09-2017	30.5	23	87	8.3
16-09-2017	30	23.5	99	42.5
17-09-2017	25.5	22.5	100	104.1
18-09-2017	26	22	94	209.4
19-09-2017	28.8	22.5	87	43.3
20-09-2017	30.8	22	85	28.6
21-09-2017	30	22	86.5	19.3
22-09-2017	29	22	80	8.5
23-09-2017	30.5	21	83.5	0
24-09-2017	30.5	22.5	40.5	0
25-09-2017	31	24	86	0
26-09-2017	29.5	23	88.5	3.5
27-09-2017	29.5	24	89	1.1
28-09-2017	29	22.5	86.5	63.5
29-09-2017	29	22	85.39	17.6
30-09-2017	29.5	22	48	20.6
Average	**29.85**	**22.96**	**84.86**	**24.37**
01-10-2017	29.5	24	88.5	0

02-10-2017	29	23	87	2.2
03-10-2017	29.5	23	83.5	6.3
04-10-2017	30.2	23	85.5	10.7
05-10-2017	30.5	23.5	82	0
06-10-2017	30.4	23.5	95.5	0
07-10-2017	26.4	22	83.5	18.8
08-10-2017	30.5	23.2	86.5	0
09-10-2017	29	22.5	83	26.6
10-10-2017	30.5	23.5	83.5	1.6
11-10-2017	29.8	23	84.5	4.3
12-10-2017	31.3	23	80.5	0
13-10-2017	31	23	83.5	1.2
14-10-2017	30.5	22.5	86.5	3.1
15-10-2017	28	22	82.5	44
16-10-2017	30.8	22	86	22.2
17-10-2017	30.5	22.5	87	38.2
18-10-2017	31	22.5	83.5	0
19-10-2017	31	23	80.5	0
20-10-2017	31.5	22.5	81.5	0
21-10-2017	31	21	78.5	0
22-10-2017	31.5	21.5	81.5	0
23-10-2017	31	21	75	0

24-10-2017	31	20	76.5	0
25-10-2017	31	21	83	0
26-10-2017	31	22	79.5	0
27-10-2017	30.9	23	80.5	0
28-10-2017	30.5	22	80	2
29-10-2017	30.5	21.7	76	0
30-10-2017	31.5	21.5	77	0
31-10-2017	32	21.5	76.5	0
Average	**30.41**	**22.37**	**82.53**	**5.85**
01-11-2017	32.3	23.5	77	0
02-11-2017	31.7	22.2	76.5	0
03-11-2017	31	21.5	75	0
04-11-2017	31.8	22.5	75.5	0
05-11-2017	32	22	85	11
06-11-2017	31.5	22.5	87	6
07-11-2017	31	22	87	4.1
08-11-2017	30	21.5	74.5	0
09-11-2017	32	22.4	80.5	0
10-11-2017	31	20.5	74.5	0
11-11-2017	32.5	20	77.5	0
12-11-2017	32	21	74	0
13-11-2017	31	18	76	0

14-11-2017	31.5	20	78	0
15-11-2017	31	20.5	79	0
16-11-2017	30.5	20	78	0
17-11-2017	31.5	21.5	79.5	0
18-11-2017	31.5	23	83	0
19-11-2017	30.5	23	80.5	2.1
20-11-2017	31	22	82.5	0
21-11-2017	32	23	81	0
22-11-2017	32	23	80.5	0
23-11-2017	31.5	22	75	0
24-11-2017	32.2	21.5	78.5	0
25-11-2017	31.5	22	78.5	0
26-11-2017	32	21.5	81.5	0
27-11-2017	31.5	20.5	79.5	0
28-11-2017	32	21.8	78	0
29-11-2017	32.8	21	74	0
30-11-2017	34	21.5	74.5	0
Average	**31.63**	**21.58**	**78.72**	**0.77**