

**IDENTIFICATION OF ELITE CLONES OF KARI
ISHADA MANGO CULTIVAR IN MAJOR GROWING
PARTS OF UTTARA KANNADA DISTRICT AND
ITS GRAFTING STUDIES**

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JUNE, 2016

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*Thesis submitted to the
University of Horticultural Sciences, Bagalkot
in fulfillment of the requirements for the
Degree of*

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in

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By

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C E R T I F I C A T E

This is to certify that the thesis entitled “**IDENTIFICATION OF ELITE CLONES OF KARI ISHADA MANGO CULTIVAR IN MAJOR GROWING PARTS OF UTTARA KANNADA DISTRICT AND ITS GRAFTING STUDIES**” submitted by **SAMPATH P. M. (UHS14PGM430)** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE**, of the University of Horticultural Sciences, Bagalkot, is a record of research work carried out by him during the period of his study in this university under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

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JUNE, 2016

(SAMPATH P. M.)



*Dedicated to
My Parents,
Brothers, Teachers
and friends*

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1. INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important fruit crops of Anacardiaceae family that consists of dicotyledonous trees and shrubs. It is the most important fruit crop in India having socio-economic significance. Owing to the delicious quality of fruit and richness in vitamins and minerals, it is known as 'King of fruits'. Ancient Indians valued mango not merely for its sentiment or religious consideration, but they realized its importance in economics and cultural life of the society. Muslim Kings-Nawabs promoted the practice of planting best mango varieties. The long period of domestication of mango is well evidenced from its mention in ancient scripture. Ain-I-Akbari, an encyclopedia written during the period of 1590 AD amply gives the understanding of mango of that period (Mukherjee, 1952).

Mango originated as an allopolyploid from Eastern India, Assam and Burma (Popenoe, 1920). Mango is commercially grown in over 103 countries of the world but, nowhere is it so greatly valued as in India. It occurs as a domesticated or wild entity in complex biotic community of the ecosystem. It has been undoubtedly under cultivation for more than 4000 years in Eastern India and Burma (Mukherjee, 1952).

In India mango is cultivated in an area of 2.52 million ha with an annual production of 18.43 million tonnes with a productivity of 7.3 tonnes per ha. Mango occupies 20.7 per cent of total fruit production of the country. India is the largest mango producer in the world (Anon., 2014). Mango has become one of the most important fruit crop in Karnataka and is cultivated in an area of 0.18 million ha with annual production of 1.76 million tonnes with the productivity of 9.7 tonnes per ha. Karnataka occupies 7.15 per cent of total country's mango area and contribute to 9.5 per cent of total country's production. Karnataka is third largest mango producing state in the country (Anon., 2014). Although India is the largest mango producing country, accounting about 45 per cent of world production, the export of fresh fruit is limited to Alphonso and Dashehari varieties. India's share in the world mango market is about 15 per cent. Mango accounts for 40 per cent of the total fruit exports from the country (Anon., 2014).

Today mangoes are grown throughout the tropics of all continents and in many subtropical areas. Most of the varieties have arisen as chance seedlings and they belong to *Mangifera indica* L. The large germplasm wealth has not been fully identified and evaluated. Innumerable valuable indigenous varieties have already been lost in mango. Hence, there is a need to locate and identify the superior genotypes of mango.

When a cultivar is grown for a long period, though originated through vegetative propagation, variation may occur due to mutation at micro or macro level. This mutation is a possibility in a variety when cultivated for a prolonged period. Clonal variations are manifested many times in fruit characteristics besides other vegetative characteristics and yield attributes. Clonal selection within varieties can yield valuable results and hence, it is worth pursuing in countries where certain varieties are in cultivation for a long time.

Several procedures have been employed for the identification and characterization of intravarietal heterogeneity of mango based on morphological and genetic traits. In mango, conventional methods of intravarietal heterogeneity identification are based on objective description of fruit and stone characteristics. The considerable variation exists among trees of the same clone in an orchard of mango with respect to fruit shape, size, colour and quality. Morphological traits are subjective and visually evaluated in most cases. They can help in the identification and potential use of any genotype.

Kari Ishada is a popular mango variety cultivated in Uttara Kannada district of Karnataka. It is mainly grown in Ankola, Kumta, Honnavar and to a certain extent in Sirsi of the Uttara Kannada district. Kari Ishada is sweet and used for table purpose. Each panicle usually bears a single fruit only. Since it carries thick pulp, it is good for consumption. It is a famous variety for preparing a sweet drink locally called as 'Seekarni'.

Earlier, the breeders were content not to go much further for their material than the old landraces and varieties that were available in their own countries or from neighboring ones, but in the last 50 years or so, breeders are in requirement of a much wider range of genetic diversity (Paroda and Arora, 1991). In fact, most of the present

day commercial varieties are chance selection from natural seedlings. Distinct clonal differences have been observed in the same variety in different regions.

Identification of superior elite clones is therefore an important activity in the management of genetic resources in mango in the context of the present scenario of rapid extinction of such useful material. Still there is an immense potential of locating superior clones for collection, evaluation, conservation and utilization for the future crop improvement works. The present study aims to identify the superior clones of the Kari Ishada mango variety and to study their response to propagation by grafting based on the following objectives.

1. To identify the elite clones of Kari Ishada mango variety in major growing parts of Uttara Kannada District of Karnataka.
2. To study the morphological and qualitative parameters of fruits.
3. To study the grafting methods for the success and survival of the identified clones of Kari Ishada mango.

2. REVIEW OF LITERATURE

Mango has a very broad genetic diversity in the country representing a large gene pool. It is a clonally propagated fruit crop in Karnataka. Varietal and clonal variations are manifested many times in fruit characteristics besides other vegetative characteristics and yield attributes. Distinct clonal differences have been observed in the same variety in different regions. Identification of superior clones and elite seedlings are therefore, important activities in the management of genetic resources in mango in the context of the present scenario of rapid extinction of such useful material. Identification and conservation of these variations can help for the future crop improvement works. The review related to these aspects in mango and other fruit crops are presented in this chapter.

2.1 Genotypic variation

2.1.1 Variation among clones

A survey conducted in five communities for documenting the mango diversity found in native landraces revealed that, a clone from Bhuskaul community had fruit weight up to 420.0 g with very thin stone and maturing by the end of August. The fruit length varied from 6.70 cm in 'Pusa mango 7' to 12.10 cm in 'Pusa mango 2' and fruit width varied from 5.33 cm in 'Pusa mango-11' to 8.50 cm in 'Pusa mango-2' (Singh *et al.*, 2015).

Begum *et al.* (2014) conducted surveys covering three eco-geological regions of Andhra Pradesh during summer 2009 and thirty accessions of 'Cherukuram' (CKR Acc-1 to CKR Acc-30) were selected. Morphological characterization revealed variations in fruit morphology among 30 accessions and found significant variation in 9 quantitative fruit traits. Fruits of all accessions were found variable in size, weight, peel, pulp and stone content and total soluble solids. The fruit length ranged from 7.60 to 14.00 cm with an average of 11.20 cm. The fruit width ranged from 5.40 to 8.00 cm with an average of 6.31 cm. The fruit thickness ranged from 4.50 to 7.00 cm with an average of 5.76 cm. The fruit weight ranged from 130.00 to 380.00 g with an average of 266.55 g. The peel, pulp and stone contents ranged from 14.70 to 23.10 per cent, 54.30 to 67.40 per cent and 13.10 to 25.00 per cent, respectively. TSS ranged from 14.00 to 23.90 °B with an average of 17.26 °B.

Begum *et al.* (2013) selected 31 accessions of 'Beneshan' (BN Acc-1 to BN Acc-31) through an eco-geographic survey covering the three regions of Andhra Pradesh state, India. Their fruit and leaf samples were collected to study intracultivar heterogeneity based on morphological fruit traits and microsatellite markers, respectively. *In-situ* characterization and evaluation of fruit samples revealed phenotypic variations among 'Beneshan' accessions.

Studies carried out on the evaluation of certain clones of mango cv. Alphonso at the University of Agricultural Sciences, Bangalore have revealed that 'MA-1' clone was an outstanding progeny, as the plants were vigorous in growth habit; panicle density was highest and produced large sized panicles. Sex ratio in this clone was highest and as such fruit set was also highest. Fruits of 'MA-1' clone were of medium to large in size, firm pulp, highest pulp recovery, thin stone and medium peel. 'KHA-1' had fruit length of 8.15 cm and fruit width of 7.16 cm. Highest TSS, moderate acidity and excellent TSS to acid blend was noticed in the fruit pulp of 'MA-1' clone. Fruits of 'MA-1' clone had attractive skin color with red blush on the shoulders; flavor was delightful and superb in taste. Fruits of 'MA-1' were tolerant to spongy tissue (Mukunda, 2004).

A progeny test of '320' Kaew clones collected from the North, North-east and Central Thailand was conducted and a number of clones were selected with superior horticultural traits for further evaluation. Of these, 'SK007' clone produced the highest fruit yield of 65.4 kg per tree at the age of 7-8 years. A subsequent comparison yield trial of the previously selected clones indicated that the 'SK007', officially recommended by the Department of Agriculture, Bangkok, Thailand and currently known as 'Kaew Sisaket', has an average yield of 25.5 kg per tree at year 5-6 with the average fruit weight of 252 g, 81 per cent flesh and 0.049 per cent citric acid. The fine texture, low fiber content and firm flesh offer good quality for pickling (Chaikiattiyos *et al.*, 2000).

A large number of mango varieties of Goa state which are important either from commercial or from breeding point of view were studied for their physico-chemical and morphogenetic variations. These varieties differ in respect of bearing habit, fruit size, fruit color, flesh contents, pulp colour and quality. Pulp contents depending on fruit size varied from 67.5 per cent in Bemcorado to 83.21 per cent in

RC-MS-1 a clonal selection of Bemcorado. In general, the varieties namely Mankurad selection and Bomcarado selection were observed to be promising as these clones possessed most of the desired commercial traits meeting international standard (Desai and Dhandar, 2000).

A clone of mango 'Totapuri' has been selected at the Gujarat Agricultural University, Paria, Gujarat. This clone was identified from a private farmer's mango orchard of Babubhoi Bhagvanbhai Patel of Goima village, Pardi taluk, Valsad district. The age of the mother plant is 35 years and vigorous in nature with irregularly spreading primary and secondary branches. This clone flowers and fruits twice in a year, first week of October and second week of March. It yields 24,000 fruits per tree per year weighing about 700 kg per tree (Naik, 2000).

Two clones one each of Banganapalli, 'Rati Banganapalli' and 'Nuzvid' selected earlier performed well. Further, one clone each of Alphonso, Totapuri and Banganapalli has been selected at the Regional Fruit Research Station, Vengurla, Maharashtra; the Fruit Research Station, Anantharajupet, Andhra Pradesh, and the Agricultural Experimental Station, Paria, Gujarat, respectively (Anon., 1999).

An attempt was made to improve the existing commercial mango cultivars in Thailand by the clonal selection in Nam Dok Mai, Khiew Sawoey, Rad and Nang Klang Wan cultivars. Since 1990, the growth behavior, yield and quality of fruit characteristics such as fruit size, flesh color, sweetness, aroma and texture were evaluated. The data showed 'Clone No. 01' of Nam Dok Mai, 'Clone No. 04' and '05' of Khiew Sawoey, Clone No. 03 of Rad and 'Clone No. 03' of Nang Klang Wan clones were superior over the other clones (Jintanawongse *et al.*, 1999).

Chadha (1998) reported the clonal selection in mango ('Sunderraja') made at Rewa, Madhya Pradesh. Different clones of Alphonso cultivar, *viz.*, 'Alphonso of Behat' in Saharanpur (UP), 'Alphonso Batli' of Kirkee, Pune (Maharashtra), 'Alphonso Punjab', 'Alphonso White' (Bili Ishada) of North Kanara district of Karnataka, and found that they differ from one another in more than one character (Pandey, 1998).

A regular bearing and high yielding mango clone, "Dashehari-51" has been released by the Central Institute for Sub-tropical Horticulture, Lucknow, UP. This

clone produced good crop every year without off-bearing rhythm, the per year productivity being 38.8 per cent more than “Dashehari”. Even in an ‘off’ year, ‘Dashehari-51’ clone produced an average yield of 43.4 kg fruits per plant per year while Dashehari tree produced very poor fruits (Negi, 2000).

A survey of 85 locally available clones was carried out in South and North Andaman, and six clones having regular and early flowering habit and bearing good yield of quality fruits were selected for further study. Two years after planting of grafts in the field, it was noticed that clone No. 6-1-3 showed early flowering (early October), and in its first year of fruiting about 100 fruits were harvested in March. The fruits were of good quality with minimum thickness of peel and had minimum stone weight (Singh and Ranganath, 1997).

The mango clone Cardozo Mankurad was selected from the Mankurad variety of Goa. This new clone was described in detail and compared with the parent variety Mankurad. Cardozo Mankurad is regular bearer and produce large fruits of attractive color, high quality and yield (Mathew and Dhandar, 1997).

In North-Eastern region, selections Manipur-I and Manipur-II have been identified. These clones are dwarf, precocious, polyembryonic and regular bearer (Chadha and Yadav, 1996).

Siller *et al.* (1994) studied the fruit quality and post-harvest behavior of four mango clones, *viz.*, ‘Osteen’, ‘Palmer’, ‘Fabian’ and ‘S1-25’ in comparison with ‘Kent’, the commercial variety from Mexico. ‘Osteen’ and ‘Kent’ had similar fruit characteristics. ‘Osteen’ had the largest fruits and ‘Fabian’ the smallest (516 and 387.5 g per fruit, respectively). After storage, ‘Osteen’ had the highest pulp percentage (83.2 %) and the lowest percentage of seeds (5.80 %) and peel (10.90 %). ‘Osteen’ and ‘Fabian’ had a yellowish pulp color while the other clones had more orange colored pulp. It was concluded that ‘Osteen’ has potential as a commercial cultivar because when compared with ‘Kent’, it showed a comparable or higher values of fruit weight, pulp weight, sweetness and sugar per acid ratio.

Survey of local mango genotypes at Goa state has enabled collection of 68 different varieties. Big-fruited clones of ‘Hilario’ and ‘Udgo’ with outstanding fruit quality were screened (Anon., 1994).

'Paiyur 1' mango, a clonal selection from Neelum variety was developed at Tamil Nadu. This new clone is a dwarf plant, low spreading in nature and thus suitable for high density planting at a close spacing of 5m × 5m accommodating 400 trees per hectare. During the ninth year of planting the fruit yield of 'Paiyur 1' clone was 22.30 kg per tree accounting for 8,920 kg of fruits per hectare. The mean fruit weight was 121 g with 68 per cent pulp recovery and good taste (Vijayakumar *et al.*, 1992).

An intensive survey was undertaken by Vijayakumar *et al.* (1991) in Dharmapuri district of Tamil Nadu and exploited the natural variability present in Rumani and Neelum varieties of mango. 'DPI 55' a clone of Rumani and 'DPI 45' a clone of Neelum were dwarf in nature and suitable for high density planting. These clones possess precocity, regular bearing, attractive good quality fruit with high productivity.

An assessment of various vegetative and fruit characters was made by Subramanyam and Iyer (1989) in mango germplasm collected from different regions of India, to select suitable parents for hybridization. Accordingly, they identified two dwarf plants from collections made in Kerala state, which they named as 'Kerala Local' and 'Local Kalapady'. These selections have potential for incorporating dwarfness in vigorous growing commercial varieties as well as using as new clones to establish high density orchards.

Intensive survey made by Ramaswamy (1989) in the North-Western region of Tamil Nadu comprising Salem and Dharmapuri districts led to the isolation of three selections of 'plus trees'. Parameters like regular bearing, dwarfness, high yield, good fruit quality and field tolerance to pests and diseases formed the basis of selection. Dwarf clonal selections, one each in Rumani and Bangalora, and a high yielding elite Neelum clone were isolated. The estimated bark phenol contents were from 4,300 to 4,800 µg per gram of fresh weight. This physiological parameter appears to be linked with dwarfness. The selected clones lend scope for high density planting at a density of 500 trees per ha. The average weight of fruit in these elite clones of Rumani (362.00 g), Neelum (404.20 g) and Bangalora (639.40 g) was high, the pulp recovery was high (89.26, 87.74 and 93.93 %, respectively) and TSS of the fruit pulp was medium to good (16.85, 22.34 and 16.96 °B, respectively).

A survey was initiated by Singh *et al.* (1985) to find out relative superiority of selected clones from different orchards, *viz.*, Pilkhini, Motijhil and Nawalpur around Varanasi. One of the selected mango clones of 'Banarasi Langra' mango on the basis of overall performance, the 'Clone No. 2' from Pilkhini orchard and 'Clone No. 1' from Motijhil orchard were found to be most promising clones because of less fruit drop, better yield, light bottle green color of the skin with fairly high fruit quality and negligible incidence of malformation.

Based on the detailed surveys of mango orchards in eastern India, Mukherjee *et al.* (1983) have identified many superior clones. Based on their survey 23 elite clones were identified. Some of the clones which ranked excellent grade by them are 'Dawadi', 'Emrat Bhog', 'Shah Pasand', 'Sadik Pasand', 'Kali Bhog' (all from Murshidabad) and 'Misrikanta' (from Maldah). They also suggested that it would be worth putting these clonal selections in a varietal trial for comparison with the standard commercial variety for releasing as new superior selections for commercial exploitation and for utilization in the hybridization program.

2.1.2 Variation among varieties

2.1.2.1 Tree Morphology

Mango trees have different types of canopies, according to the propagation type, density, type of variety and eco-geographical conditions. Some varieties, such as "Latra", are considered to have a creeper-growth habit because of its spreading nature. The biggest mango tree in the world is found in India and has a spreading crown of 36.6 x 45.7 m (Singh, 1968). The tree height can reach 8-35 m, depending on cultivar, climate, soil type and rootstock (Human, 2008).

2.1.2.2 Fruit morphological parameters

Five mango accessions (collected from different governorates) characterized by Kheshin *et al.* (2016) exhibited a wide range of differences in fruit and stone characteristics. 'Sukkary-4' had highest fruit weight (351.40 g), 'Sukkary-1' had highest fruit diameter (8.11 cm) and fruit length (10.58 cm) whereas, 'Sukkary-5' had lowest fruit length (10.58 cm) and fruit diameter (7.29 cm). Similarly, variations were

noticed in stone characters like stone weight (39.72 to 57.30 g), stone length (7.57 to 8.62 cm), stone width (3.52 to 3.93 cm) and stone thickness (2.22 to 2.57 cm).

Ashine *et al.* (2015) studied the fruit trait variability in 34 wild 'appemidi' trees, 17 from Sirsi and 17 from Siddapur and found the strong relation between fruit mass and pulp mass which could be used as a strategy for selection. They also reported the variation among the accessions for the stone physical parameters.

Identification of 44 naati varieties (indigenous) having varied morphological traits was done in the Chittoor area of Andhra Pradesh in India. The fruit length varied from 14.87 cm in 'PKRN2' to 5.76 cm in 'TSAN8', fruit width varied from 5.26 cm in 'TSAN8' to 9.80 cm in 'TBRN1' and fruit thickness varied from 4.74 cm in 'TSAN8' to 8.36 cm in 'TBRTV1' (Dinesh *et al.*, 2015).

Evaluation of eight mango cultivars (Almas, Collector, Pope, Neelum, SS-II, Shahpasand, Alphonso and Sindhri) done by Jamil *et al.* (2015) for their differences relating to morphological characteristics found that, Alphonso and Almas exhibited highest fruit weight (281.21 g and 244.60 g) and pulp weight (172.10 g and 210.21 g).

Manohar *et al.* (2015) characterized the twelve farmers' identified aromatic pickle mango through a set of distinguishing traits like tree, leaf and fruit morphology. The varieties were delineated unambiguously adopting simple forking method to individual varieties. They differed in tree, leaf and fruit morphology.

Sixteen superior mango varieties of endemic value and importance were evaluated for table, sucking and pickling purposes on the basis of physical appearance and chemical attributes out of which six were found suitable for table, five for sucking, two for dual purpose (sucking and table) and three for pickle purpose (Singh *et al.*, 2015).

Kaur *et al.* (2014) studied the variability of mango germplasm at typical subtropical conditions in North-West India to conserve the elite ones and identify the superior genotypes based on fruit quality for multiplication and for future crop improvement. Fourteen genotypes were tested for their physical characteristics wherein maximum fruit weight (301.30 g), high pulp percentage (89.78 %) and pulp stone ratio (8.80) were found in Chousa. A wide variability in tree characters like tree

height, tree spread and trunk girth were observed wherein Kala Gola had maximum height (13.60 m) and minimum in Amarapalli (4.24 m). The tree spread ranged from 4.43-16.43 m to 5.10 - 17.50 m in North- South and East-West directions, respectively.

Among 103 mango accessions of the field germplasm collection of Embrapa semi-arid region, located in Juazeiro, Bahia, Brazil, the fruits in majority of the accessions showed flesh with low weight *i.e.*, up to 250 g.

Among the eight mango cultivars evaluated, Fajri produced the maximum green and ripe fruit weight, fruit length and perimeter and physiological weight loss (453.00 g, 403.00 g, 13.80 cm, 21.57 cm and 10.97 %), respectively (Naz *et al.*, 2014).

Sennhenn *et al.* (2013) sampled and characterized thirty-eight local mango trees by 75 selected qualitative (44) and quantitative (31) morphological descriptors selected from the descriptor list developed for mango by Biodiversity International (former IPGRI). Morphological characterization resulted in six distinct clusters. Outcomes of the study can help for the urgently needed future conservation efforts, including *circa situ* conservation on farms and the development of 'conservation through use' strategies for local mango landraces in Kenya.

A survey was conducted for documentation about the extent of diversity found in the native landraces or strains of mango in Punjab. Twenty eight elite strains enjoying local patronage were evaluated for table and sucking purposes, preparation of pickle, canning, beverages, amb leather on the basis of physical appearance and chemical attributes. Physico-chemical analysis of fruit samples revealed that, variability found in indigenous mango population in various qualitative and quantitative attributes not only contributes to biological diversity, nutritional security and livelihood but can also be used for crop improvement. The old mango trees present mostly growing along a strip of roads, riverbanks, undulated terrain in mountainous tracts, government revenue lands, mango groves *etc.*, exhibit a wide range of variability in desirable horticultural traits like fruit shape, size, juice consistency, bearing regularity, fruit yield, resistance to various biotic and abiotic stresses *etc.* (Singh *et al.*, 2012).

Morphological parameters of eight Florida and one Australian mango cultivars were studied by Pleguezuelo *et al.* (2012). Osteen fruits bore the greatest weight (697 g) with their pulp:seed ratio (20:2) significantly higher than those in the other cultivars tested. The lowest pulp:seed ratios were recorded for the cultivars Kensington (6.3) and Sensation (7.6). The fruits with the highest percentages of flesh belonged to Gleen, Palmer, and Osteen, each averaging 85 per cent. The seed-weight of the fruits of Osteen proved the lowest (4.2 %) among all the cultivars, confirming the most desirable relationship with the pulp.

Mussane *et al.* (2011) characterised 30 mango varieties from the Umbeluzi research station, including some commercial varieties and clustered varieties in three subgroups based on high fruit weight and low fruit weight.

Only five genotypes (Kala Chausa, Sufaid Chausa, Late Ratole No. 12, Camal Wala and Faiz Kareem) out of 17 genotypes studied showed distinctive fruit characters and market potential (Rajwana *et al.*, 2011). Higher average fruit weight was observed in Sufaid chausa (580.1 g) followed by Basti Nao (380.3 g) and Kala Chausa (350.0 g), while lowest in Chun Wala (200.0 g) followed by Syal Wala (201.1 g) and Late Ratole No. 12 (233.3 g).

Bhowmick and Banik, (2008) carried out an experiment with 9 mango cultivars at Mondouri, BCKV, Nadia, West Bengal. Magnitude of genotype coefficient was more than that of phenotypic correlation coefficient. There was a significant positive correlation of fruit weight with pulp content and fruit breadth.

Subedi *et al.* (2008) identified 132 different mango cultivars from 11 districts surveyed wherein a rich diversity of both commercial and local cultivars was found. Local mango cultivars possess unique characteristics, having both economic and cultural value. Important traits identified included ability to grow in marginal and drought areas, adaptation to high altitude, high rate of fruit setting, fruiting in off-season, special aroma, and fibreless pulp. They identified Dadeldhura, Parbat, Dhading, Kavre and Sirah districts as major areas of mango diversity.

Detailed explorations and studies were carried out in Andamans in five species of mango, *M. andamanica*, *M. griffithi* and *M. comptosperma* by Singh (2007). He

studied their habitat, botanical description, their use as rootstock and success of *M. indica* on these species.

Navprem and Sharma (2007) evaluated sucking types of mangoes under sub mountane zone of eastern Punjab (India) conditions and reported a wide variation in respect of fruit and stone characters.

Bibi *et al.* (2006) in their study on morphological characteristics of different cultivars of mango grown in D. I. Khan found that Alphanso produced the longest fruit followed by Fajri and Sindhri.

Morphological properties of the fruits of 31 mango genotypes from North Kerala were evaluated and four homogenous clusters of these genotypes were formed. Large table fruit varieties like 'Mulgoa', 'Phirangiladua', and 'Banganapalli' formed a single group, while 'Bangalora', 'Gudad', and 'Chotta Jehangir' deviated from that considerably. The highest significant correlation was noted between fruit length and pulp weight. Variability in fruit weight (195-723.5 g), stone weight (19.9 - 66.5 g), fruit length (7.7-16.9 cm), peel weight (7-75 g) and pulp weight (114 - 544 g) were observed (Pradeep *et al.*, 2006).

Shafique *et al.* (2006) reported the variation in ten varieties of mangoes for morphological characters such as the fruit weight, pulp content, weight of peel and stone.

An isozyme study showed genetic variation among cultivars with the same and different names collected from two adjoining districts of Nepal (Subedi *et al.*, 2005).

An evaluation of physical and morphological characters of four varieties and two hybrids of mango were made under Kerala conditions. It was observed that, Ratna fruits had the maximum length (10.69 cm), breadth (8.36 cm), weight (398.01 g), volume and circumference. The minimum contribution of stone to fruit weight was in Ratna and the maximum in Muvandan. The hybrid variety Ratna had all the desirable characteristics in terms of length, breadth, weight, volume, circumference, minimum stone weight. The stone weight ranged from 22.55 to 47.76 g and was maximum in Ratna, but the percentage contribution to fruit weight by stone was the minimum (12 %) in this variety (Anila and Radha, 2003).

Singh (1999) reported a new variety 'MDCH-1' (Madhulika) out of 41 species found in the world. Studies made from 1990 onwards at ICAR, Manipur Centre, Imphal showed that, this new species was the most promising one of the region besides its resistance to stone-weevil, which is the common pest for the region. Among the 17 genotypes studied in foothill conditions of Manipur, the genotypes 'MDCH-1' and 'STH-1' have been found to be very promising with most desirable characteristics such as regular bearer, dwarf, better fruit quality and resistance to stone weevil.

Reddy *et al.* (1994) studied eight mango cultivars and seven hybrids grown in Tungabhadra project area and revealed that, the members of hybrids in general possessed more desirable parameters. Fruits of Alampur Baneshan, Khadar, Neeleshan and Mallika had higher fruit weight and pulp content than those of Neeludin, Aurumani and Pairi.

Al-Edany *et al.* (1991) in an evaluation study on mango seedlings in Basra selected only five trees out of 43 after assessment for fruit weight, pulp to fruit ratio, fruit length, fruit diameter, ripening time and general qualities.

2.1.2.3 Quality paramaters

The evaluation of 44 naati varieties (indigenous) showed that, the variety Thumbavaripalli Munirathnam Reddy Manoranjitham had high total carotenoids (29.0 mg/100g) and high TSS (24 °B). Another naati variety Reddyvaripalli Ramamoorthy Reddy Naati 3 also showed high total carotenoids (26.44 mg/100g). The seedling (*naati*) types observed in this study *viz.*, 'TSAN4' and 'VRR3' were observed to have excellent peel color, indicating that good diversity exists for desirable traits in the seedlings (Dinesh *et al.*, 2015).

Eight mango cultivars (Almas, Collector, Pope, Neelum, SS-II, Shahpasand, Alphonso and Sindhri) were evaluated for biochemical attributes and reported that, total soluble solids (TSS) were found maximum (17 °B) in Almas, while, SS-II exhibited least TSS (9.3 °B). Titratable acidity was found minimum (0.19 %) in Collector whereas, SS-II exhibited lowest sugar acid ratio (26.57). Maximum ascorbic acid (43.5 mg/100 g) was observed in Neelum, while in case of sugars, maximum reducing sugars (6.18 %), non-reducing sugars (9.21) and total sugars (11.33) were

found in Pope. Sindhri and Pope exhibited maximum total carotenoids (3.43 $\mu\text{g/ml}$) whereas, total phenolic contents was found maximum (0.95 mg/100g) in Sindhri (Jamil *et al.*, 2015).

Kaur *et al.* (2014) tested the fourteen genotypes for their physiological and chemical characteristics where Alphonso, Malda and Chausa were identified for superior traits like total soluble solids to acid ratio. Rataul had excellent flavour.

The higher softness values were noticed in Aman Dushari. The appreciably higher total sugar contents were observed in pulp of Langra, Samar Bahisht Chausa and Anwar Rataul (20.67 %, 20.43 % and 20.33 %, respectively). 19.83 °B of TSS and 0.64 per cent of protein contents were recorded in Langra while Fajri contained higher fat contents. The sensory score for taste in mango varieties ranged from 4.41 in 'Fazri' to 8.78 in 'Anwar Rataul' whereas, Langra and Anwar Rataul were equally acceptable for overall acceptability (Naz *et al.*, 2014).

A study was carried out by Leghari *et al.* (2013) to evaluate quality attributes of immature fruits of four commercially grown varieties of mango namely Sindhri, Chausa, Langra and Desi revealed that, Sindhri had more moisture (88.60 %), ash (0.60 %) and fat (0.60 %), total sugars (6.99 %) and reducing sugars (2.78 %) as compared to rest of the varieties. However TSS (9.35 °B), protein (0.71 %), and non reducing sugars (4.86 %) were recorded the highest in Langra variety. Only the Chausa variety had maximum pH of 3.01 and vitamin-C (27.16 mg/100g). Regarding mineral elements, Desi was found potential in terms of sodium (453.93 mg/kg), calcium (403.79 mg/kg), Zinc (3.47 mg/kg) and iron (5.95 mg/kg).

Okoth *et al.* (2013) evaluated the physical attributes at three stages of ripeness (unripe, intermediate and fully ripe) and sensory quality at full ripe stage of Apple, Ngowe and Kent mango varieties grown in Lower Eastern Province (Machakos and Kitui) of Kenya. They were stored under ambient temperatures of 25 °C and relative humidity of 65-70 per cent. Apple and Ngowe ripened fully after seven days whereas, Kent took 10 days. The most preferred flesh colour, flavor, taste, texture and overall acceptability were in the Apple variety, followed by the Ngowe and lastly Kent variety.

Among 103 mango accessions of the field germplasm collection of Embrapa semi-arid region, located in Juazeiro, Bahia, Brazil, eight accessions did not show fruits with fibers, while nine other accessions presented flesh firmness, which is an important characteristic to improve breeding. The soluble solids content was high, above 14 °B for 95 per cent of the accessions with Tommy Atkins showing the lowest value (12.5 °B). A great diversity was found in the color of the epidermis ranging from green to red. The green color of the epidermis was the most frequent (28.8 %), followed by the yellow and pinkish color (17.3 %). The accessions Amrapali and Salitre presented a dark orange flesh color (Ribeiro *et al.*, 2013).

Vasugi *et al.* (2012) evaluated the genetic diversity of 43 mango genotypes consisting of 34 pickling accessions collected mainly from Uttara Kannada and Shimoga districts of Karnataka, five commercial accessions, three polyembryonic accessions and a pickling type from Andhra Pradesh for the characters like pulp texture, pulp juiciness, pulp per cent, TSS (°B), titrable acidity (%), vitamin C (mg/g), p^H and total sugar (%).

A study on the chemical parameters of eight Florida and one Australian mango cultivars revealed that, the highest acidity (0.22 %) was present Valencia Pride while Lippens contained the highest Total Soluble Solids (TSS). The TSS:TA ratios proved the highest for cvs. Kent and Lippens, which might be indicative of the effect on their flavour (Pleguezuelo *et al.*, 2012).

Jacynth *et al.* (2011) studied the influence of storage temperatures, O₂ concentrations and variety on the respiration of mangoes. Two varieties of mangoes namely, cvs 'Banganapalli' and 'Thothapuri' were used. Experiments were conducted on a single fruit, weighing approximately 500 g and kept in separate glass bottles stored. The respiration rate was faster in 'Banganapalli' than 'Thothapuri' as indicated by the CO₂ release rate.

Among the 17 genotypes, the highest TSS to acid ratio was in Kala Chausa (96.3) followed by Sufaid Chausa (83.9) and Basti Nao (82.7) whereas, lowest ratio was observed in Allah Abadi (56.4). The fruits of Sufaid Chausa were large in size, firm at ripe stage, possessed good shelf life and matured in September to mid October, while Kala Chausa, Camal Wala and Late Ratole are prolific bearers having late

maturity time. The taste varied like acidic taste of 'Gola', mild taste of 'Camal Wala' and sweet taste of 'Kala Chousa'. The overall acceptance was poor in 'Gola', fair in 'Adil Wala', ordinary in 'Shahansha', good in 'Faiz Kareem' and excellent in 'Safaid Chousa' (Razwana *et al.*, 2011).

A new hybrid named Faiz Kareem expressed better firmness, which indicates its potential for extended shelf life. Highest levels of total sugars (25.88 %), total soluble solids (26.75 °B) and total carotenoids (69.99 µg/g) were observed in Chausa while lowest in Faiz Kareem (23.71 %, 25.54 °B and 24.60 µg/g, respectively) which can be an advantage for extended storage and for sugar conscious consumers. Taste panel studies also showed clear preference for hybrid cultivar Faiz Kareem followed by Chausa and Anwar Ratole (Rajwana *et al.*, 2010).

There was significant negative co-relation with peel and acid content. Total soluble solids (TSS) showed high positive correlation with total sugar and non reducing sugar. Whereas, acidity showed high negative correlation with non reducing sugar, fruit weight, pulp content, TSS, sugar and reducing sugar content. These selection criteria indicated the basis for further improvement of mango (Bhowmick and Banik, 2008).

Nutritionally, *Mangifera andamanica* and *Mangifera griffithi* were found rich in vitamin C (99.5 mg/100 g and 37.9 mg/100 g, respectively), total sugars (17.80 and 9.09 %, respectively), which is comparable with traditional varieties of *Mangifera indica* (Singh, 2007).

Navprem and Sharma (2007) evaluated sucking types of mangoes under sub mountain zone of eastern Punjab (India) conditions and reported a wide variation in pulp colour, TSS, acidity, *etc.*

Zaied *et al.* (2007) evaluated some mango species for fruit characters and found high per cent of total sugars in mangoes of Egypt.

A study on the chemical properties of 31 genotypes of north Kerala revealed that, TSS of the genotypes ranged between 12.7 and 25.2° B and acidity ranged from 0.13 to 1.65 per cent. Fruits of 'Ratnagiri Alphonso' showed higher acidity and lower TSS than the popular variety 'Alphonso'. TSS of 'Alphonso' was 21.8° B. The

highest significant correlation was noted between fruit length and pulp weight. TSS of the genotypes ranged between 12.7 and 25.2° B and acidity ranged from 0.13 to 1.65 per cent (Pradeep *et al.*, 2006)

Ten varieties of mangoes differed from each other for biochemical characters like total soluble solid (TSS), pH, acidity, sugar content, vitamin C, flavour and taste. It was generally recognized that, quality fruits have higher TSS-acid ratio whereas, fruits of less quality have lower TSS-acid ratio, Khirsapat, Gopalbhog and Langra have sugar-acid ratio of 162.50, 150.00 and 131.25, respectively. On the other hand, Mohonbhog and Ashina have sugar-acid ratio of 114.67 and 96.25, respectively (Shafique *et al.*, 2006).

Yashoda *et al.* (2006) observed 10 per cent PLW in Fajiri mango variety which may be ascribed to cultivar difference and ripening conditions.

An evaluation of biochemical characters of four varieties and two hybrids of mango was made under Kerala conditions and it was observed that fruits of hybrids Ratna and H-151 recorded low titrable acidity (0.28 %), the highest values of TSS (24⁰ B), total sugar (20.66 %), reducing sugar (2.97 %), and ascorbic acid (31.3 mg/100 g). The hybrid Ratna had the desirable TSS and sugar content. No significant difference could be noticed between varieties in terms of specific gravity. Alphonso had a specific gravity of 1.02, H-151, 1.00 and the rest, 1.01. The total and reducing sugars were found to be high in H-151 and Alphonso next to Ratna. The sugar to acid ratio in Alphonso was 42.50. Muvandan and Neelum recorded the minimum values. The colour of skin was yellow in Alphonso, Ratna and H-151 and green yellow in Prior, Muvandan and Neelum. The pulp texture was juicy in Muvandan, soft in Ratna and Alphonso while it was firm in Neelum (Anila and Radha, 2003).

The excellent peel colour was reported in Mankurad, Salcete Mussarat, Malgash, Xavier, Udgo, Saccrchi, Colaco, Furtado and others in the study carried out with seedling progenies in Goa (Nagabhushanam and Mathew, 1994).

Biochemical parameters of eight mango cultivars and seven hybrids grown in Tungabhadra project area was studied and it was revealed that, the fruits of Neeludin, Aurumani, Pairi and Alampur Baneshan had high TSS. Neeluddin, Mallika and Aurumani had exceptionally high TSS to acid ratio (195.8, 73.2 and 68.1,

respectively). Most of them were optimally ripe 7 days after harvest. Mallika, Khadar, Neelgoa, Baneshan and Alampur Baneshan recorded retarded physiological loss in weight during ripening (Reddy *et al.*, 1994).

In Punjab, several selections of sucking mango with good sucking qualities, abundant juice, less fiber, small stone and red blush on cheeks have been made at the Regional Fruit Station, Gangian. These are numbered as GN 1, GN 2, GN 3, GN 4, GN 5, GN 6 and GN 7 (Sandhu *et al.*, 1990).

Salvi and Gunjate (1988) have reported the high TSS of fruits of Ratna (23° B), Alphonso (19 °B) and Neelum (17.5 °B). ‘Clone No-1’ and ‘Clone No-2’ of ‘Banarasi Langra’ cv. of mango isolated from Varanasi area for high fruit quality, attractive skin and delightful flavor (Singh *et al.*, 1985).

The evaluation of seedling types carried out by Teatota and Srivastava (1979) in Uttar Pradesh showed that, the variety ‘Gaurjit’ is a good sucking type and the variety Kare-Ka-Fazli is a very high yielder having good fruit size.

TSS of ripe fruits of local varieties of Kerala ranged between 10 and 24° B. ‘Heralappa’ (25.2°B) and ‘Kalapady’ (24.0 ° B) were the two top genotypes in this respect (Satyavati *et al.*, 1972).

2.2 Grafting

2.2.1 Grafting methods

An investigation on the effect of time and grafting methods on success and growth of mango grafts revealed that veneer grafting performed on 15th July recorded minimum time (13.00 days) for bud sprouting, highest graft-take success (96.66 %) and survival (90.00 %). Veneer grafting performed on 30th June, 15th July and 30th July produced maximum scion radial growth (12.14 cm), scion linear growth (26.25 cm) and number of leaves (24), respectively after 180 days of grafting (Singh *et al.*, 2012).

A study conducted in Sistan Balouchestan of Iran to identify the best of the mango grafting methods (side grafting, softwood grafting and shield budding), using 8 month old seedlings from local trees showed that, the side grafting and softwood

grafting produced higher success rates (65.8 and 63.7 %, respectively) than shield budding (47.5 %) after 90 days (Sabeky, 2005).

Three grafting types were evaluated in three commercial cultivars of mango tree accomplished over the winter season. The splice grafting presented 100 per cent establishment at the formation of mango plant seedlings. In 'Tommy Atkins', the cleft grafting and the splice grafting presented 100 per cent and 90 per cent graft takes, respectively (Pereira *et al.*, 2004).

2.2.2 Softwood grafting

Amin (1974) was the first Indian who coined the term "softwood grafting" in vegetative propagation of mango. He tried this technique and succeeded in establishing *in situ* mango orchards in the arid zone of Gujarat state. Gaur (1984) studied the comparative grafting methods and opined that softwood grafting is an economically viable technique in mango.

2.2.2.1 Softwood grafting of fruits

2.2.2.1.1 Mango

The skill and experience of grafters had a significant effect on graft success (Simon *et al.*, 2010). They also reported that, the higher survival (> 75 %) and reduced time to graft-take (19 days) were achieved with thicker rootstocks (0.7 mm) than thinner rootstocks (0.3 mm) and the early emerging plants produced more leaves than late emerging plants after grafted.

The effect of different rootstocks on success of softwood grafting was assessed where seedling progeny of Amrapali, Sindhu, Sindhura, Baneshan and Nekkare were used. Alphonso variety grafted on Sindhura showed significantly highest graft success (77.80 %) and Nekkare recorded maximum graft survival (64.77 %) which was on par with Sindhura. Growth parameters like sprout height, graft diameter and number of leaves were maximum on Sindhura and Beneshan (Shantagouda *et al.*, 2008).

An experiment was conducted by Hossain (2007) on the effect of scion maturity on the success and survivability of cleft grafting in mango. Two types of scions were used *viz.*, deep green scion (mature scion) and light green scion (immature scion). The highest success (96.66 %), survivability (93.33 %), stionic height (88.58 cm), length (30.84 cm), diameter (0.69 mm) of scion and number of leaves (33.36) were found in deep green scion on one year old stock along with the scion covered with polythene cap.

The influence of seven polyembryonic and a monoembryonic rootstock on performance of Dashehari was studied. Dashehari grafted on 'Bappakai' rootstock recorded significantly maximum height of scion (86.00 cm), number of branches (9.73) and leaves (179.00), higher stock scion ratio (0.98), canopy (volume), nitrogen and chlorophyll content in leaves. Amongst all the rootstocks, 'Bappakai' was the best rootstock for Dashehari followed by the 'Muvandan' and 'EC 95862' (Chandan *et al.*, 2006).

Dod *et al.* (1996) obtained 90 to 100 per cent success when scions were cut five to 10 days after defoliation when *in-situ* softwood grafting was done at Akola in Maharashtra.

Experiments were conducted on softwood grafting at Port Blair during June to October using one to two months old local seedlings as rootstocks and cv. Banganpalli as scion. The highest rate of graft union success (87.00 %), better growth of grafts and the highest number of leaves (7.0) were recorded after 60 days of grafting (Singh and Suryanarayana, 1996).

The grafts prepared from three months old scions recorded maximum number of leaves per graft (14.46) whereas, minimum height of the scion (13.22 cm) and number of leaves per graft (6.39) were observed in grafts prepared with nine months old scions (Pampanna and Sulikeri, 1995).

The grafting success decreased significantly with increasing age of the scion (Mehne, 1990). The scions taken from 5, 15, 25 or 45 year-old mother trees were grafted on the second or third new flush on the rootstocks. Scion sprouting and survival after 3 months were best (72.00 and 70.00 %, respectively) when the scions were taken from 25 year old mother trees. The results also indicated that softwood

grafting can be carried out on any growth flush from the rootstock provided that it is coppery-red in colour and that in bench and field grafting gave similar success rates (Panickar and Desai, 1989).

The *in-situ* softwood grafting on seven and eight months old rootstocks was successful and the graft-take was highest (90.00 %) under Bangalore conditions (Reddy and Melanta, 1988). They further stated that, softwood grafts could be performed on three months old rootstocks with appreciable success in polythene bags.

Softwood grafting of mango cv. Alphonso recorded maximum rate of graft success followed by wedge grafting and veneer grafting on four months old Nekkare rootstocks raised in polybags (Swamy, 1988).

The trials showed significant differences in graft union success, survival and growth of scion among the different methods. The softwood grafting during the period July to September recorded highest success (70-100%) and the grafts which survived produced maximum scion growth compared to veneer grafting (Tayde *et al.*, 1988).

The veneer grafting in mango with five to six month old scion shoots for grafting obtained the success of 80 per cent in June (Shailendra and Sinha, 1987). He observed maximum sprouting (87.5 %) and survival (82.5 %) with four months old scion followed by three months old scions (70 % sprouting and 65 % survival). The one and two months old scions failed completely and found unsuitable.

The scion growth was 4.17 to 5.04 cm long in four and three month old scions, respectively (Panicker, 1986).

A 100 per cent success of softwood grafting in mango was obtained during June month. The one month old Nekkare rootstocks recorded the highest graft union success rate (90 %) followed by 85 per cent and 82.50 per cent on two month old and one and a half month old rootstocks, respectively by softwood grafting (Singh *et al.*, 1984).

Softwood grafting on *in-situ* raised mango seedlings was done from February to September recording more than 70 per cent success. Further, they obtained more than 85 per cent success when grafting was carried out between April and August.

The spring and summer grafts produced more vegetative growth. The period from October to January was not favourable in western parts of India (Patel and Amin, 1981).

The period from March to September was very much congenial for the softwood grafting of mango in drier parts of Gujarat (Amin, 1979).

Nagawade *et al.* (1979) reported the success of 34.56 and 29.76 per cent in the month of July and August, respectively under extreme dry conditions of Rahuri (Maharashtra).

The use of the scions of non flowering shoots resulted 90 per cent success in mango whereas, 70 per cent success was noted with the use of flowering shoots. They also found better subsequent growth with larger scions (Majumdar *et al.*, 1972).

2.2.2.1.2 Sapota

Among the 23 cultivars tried, cricket ball, PKM-2, Kalipatti and Long Oval had shown less response to soft wood grafting as against higher response to the same by Kirthi barthi, Mohangootee, Murabha and Pala (Shirol *et al.*, 2005).

The initial and final graft take was highest in the use of invigorated rootstock for softwood grafting of sapota. The maximum success was ascribed to the prevailing favourable conditions like higher temperature (36.6 °C), minimum temperature (20.9 °C) and optimum humidity (65 %) resulting in increased cell activity and better union of the stock and scion (Pampanna and Sulikeri, 2000).

Waghmare (1990) studied the effect of age of rootstocks (6, 9, 12 and 15 months) of Rayan on softwood grafting of sapota and recorded the maximum success (59 %) on 15 months old rootstock closely followed by 12 months old rootstock (56 %).

2.2.2.1.3 Jack

A study to standardize the age of the rootstock on success of softwood grafting in jack showed that four months old rootstocks recorded the maximum values for the characters *viz.*, graft success and graft survival percentage, days taken for first and last

sprouting, number of sprouts, sprouting percentage, number of leaves, leaf area, plant height and stem girth which was followed by five months old rootstocks (Maheswari and Nevitha, 2015).

Among the different ages of rootstocks for softwood grafting, the maximum graft union success (60 %) was recorded in 120 days old rootstock followed by 90 days old rootstock with 51.29 per cent success (Pandiyan *et al.*, 2011).

Among the different methods of grafting (inarching, approach and softwood grafting), softwood grafting on two months old rootstock recorded least number of days (20.6) for graft union (Baskaran *et al.*, 2008).

Swamy and Melanta (1994) worked on softwood grafting in jack and obtained a success of 36.67 per cent at 60 days after grafting on six months rootstocks. Similar results were obtained with four months old rootstocks in Dharwad conditions. February and March were the most congenial months for softwood grafting in Jack (Swamy, 1993).

Desai and Desai (1989) stated that, softwood grafting is a simple and rapid method. They recorded the success rate from 33.33 to 80.00 per cent by using six months old cuttings of 2.50 to 10.00 cm long scions.

2.2.2.1.4 Cashew

Softwood grafting can be done successfully with apical bud in which maximum number of sprouted grafts, maximum sprouting percentage, minimum days taken for leaf emergence, maximum number of leaves per graft, minimum mortality (16.44 %) and maximum survival (75.81 %) were observed after 75 days of grafting. The range of graft height of 21.61 cm to 28.24 cm, 23.53 cm to 32.00 cm and 26.78 cm to 35.34 cm was recorded respectively at 30, 60 and 90 days of grafting (Shinde *et al.*, 2015).

The scion source and tree age had no effect on grafting success. Immature scions performed better in August while mature scions did well in October. There were significant differences for graft take of mature scions as compared to immature scions with 57.5 and 72.5 per cent in August and October, respectively (Chipojola *et al.*, 2013).

There was a significant effect of season of grafting as well as age of rootstock on per cent of survived grafts and obtained the best results when softwood grafting was done on 45 days old seedlings during May in variety 'V-4' (97.00 %) as well as 'V-6' (90.4 %) in cashew (Shingre *et al.*, 2003).

2.2.2.2 Varietal response to softwood grafting in mango

Varieties differ in their genetic and physiological make up and behave differently in varying agro-climatic conditions. In grafting mechanism, anatomical structure of an individual plays an important role in grafting success and subsequent growth and development.

The days taken for scion sprouting was observed minimum in Dashehari and maximum days in Rajapuri. The per cent success of soft wood grafting was maximum in Kesar and minimum in Local-4. Similarly maximum height of scion at 30, 60 and 90 days grafting was observed under treatment Kesar, Rajapuri and Dashehari and minimum in treatment Local-4 and Badam, respectively. The maximum per cent survival of grafts was recorded in Kesar while the minimum was found in Local-1 at 30 days grafting and in Local-3 at 60 days grafting. The maximum number of leaves of scion bud after 30, 60 and 90 days grafting was observed in Kesar, Local-2 and Dashehari, while the minimum number of leaves of scion bud after 30, 60 and 90 days grafting was observed in Local-4 and Local-1 (Prajapati *et al.*, 2014).

Maximum sprout initiation days of 12.11 and 12.13 were registered under cultivars of Dudhia and Maldah when performed at 25 cm grafting height, respectively. However, the maximum success and survival per cent were noticed in Maldah followed by Amrapali whereas, Chousa had the minimum. Interaction effect between cultivars and grafting height on survival per cent attained the maximum when grafting was performed at 100 cm height in Maldah. Similarly, the linear and radial growth of bud in case of cultivar were achieved maximum of 12.23 cm and 1.78 cm by Zardalu and Mahmood Bahar. Moreover, maximum number of 14.05 leaves was found in Mahmood Bahar and minimum of 11.93 in Prabha Shankar (Jagannath *et al.*, 2012).

A study was conducted by Omima *et al.* (2012) to classify the grafts, according to their compatibility between the scions and the rootstocks. Keitt,

Alphonso and Ewais were saddle grafted onto 21 days old of Zebda and Sukkary seedlings and top-cleft grafted onto 9 months old of the same rootstocks. Further, each of the rootstocks was grafted on the other one. In the rootstocks of 21 days age, high compatibility grafts included the grafts of Sukkary/Sukkary (S.), Keitt (K.)/Sukkary, Alphonso (Al.)/Sukkary, Zebda/Zebda (Z.), Keitt/Zebda and Alphonso/Zebda whereas, moderate compatibility grafts included S./Z., Z./S., E./S. and E./Z.. In the rootstocks of nine months age, high compatibility grafts included S./S., K./S., Al./S., Z./S., E./S., while the moderate compatibility grafts included K./Z., Al./Z., S./Z. and E./Z.

Among the different cultivar tested for softwood grafting, Zardalu took only 13.54 days for sprout initiation. The maximum success per cent of 59.79 in Maldah after 30 days of grafting time and maximum survival per cent of 56.04 in Maldah after 60 days was found. The variety Chousa obtained maximum number of leaves (10.06). Apart from this maximum linear and radial growth after 90 days were noticed in Mallika and Mahmood Bahar, respectively (Jagannath *et al.*, 2011).

Baita *et al.* (2010) studied the four morphotypes (Binta Siga, Gwaiwar Rago, Dankamaru and Fafaranda) factorially combined with three scions (Alphonso, Peach and Taymour) and showed that Binta Siga was the best rootstock in terms of plant establishment probably due to production of higher number of roots, stem diameter, number of leaves, percentage take and general crop vigor. Taymour was observed to be the best scion in terms of compatibility with most of the rootstocks as expressed by its superior performance.

Seedlings of *M. comptosperma* as rootstock showed more vigour, success and survival after grafting of *M. indica* scions (Singh, 2007).

Dashehari recorded maximum graft success (80.00 %), highest scion length (31.3 cm) and maximum height of new graft (24.1 cm) and Amrapali showed minimum success of 53.33 per cent, minimum scion length (20.0 cm) and minimum height of new graft with 13.2 cm (Gurudatta *et al.*, 2004).

Kulwal and Tayde (1989) studied the response of nine mango varieties to softwood grafting under semi-arid conditions of Akola (Maharashtra) and found that, the success varied from 72 to 100 per cent in August. Maximum success (100.00 %)

was recorded in four varieties, namely Pairi, Kesar, Pundur and Panchadharkalsa, while it was the lowest (72.00 %) in Totapuri. Further, they reported that the varieties Pairi and Langra responded differently in various months of grafting.

Shankara (1987) studied the varietal reaction to veneer, epicotyl and wedge grafting in five mango varieties. In veneer grafting, the highest success (38.88 %) was obtained in Mallika followed by Neelum (26.66 %), Alphonso (18.88 %) and Totapuri (16.66 %) in August-September. In epicotyl grafting, maximum success (55.55 %) was in Totapuri followed by Neelum (48.88 %), Mallika (32.22 %), Alphonso (23.33 %) and Pairi (10.00 %) in June-July, while Mallika recorded the highest success (51.10 %) followed by Pairi (34.44 %), Neelum (29.99 %), Alphonso (21.11 %) and Totapuri (20.00 %) with green wood wedge grafting in February to March period at Dharwad (Karnataka).

Hulamani and Nachegowda (1981) studied green wood wedge grafting in mango using three varieties. They noted the highest success (80.00 %) in Mallika followed by Pairi (75.00 %). The least success (38.00 %) was observed in Alphonso variety at Bangalore.

Nagawade *et al.* (1979) conducted softwood grafting trial in mango using three varieties and obtained 32.22, 27.00 and 44.46 per cent success with Alphonso, Pairi and Kesar, respectively in the month of July. Similarly, Maiti and Biswas (1980) studied the response of 14 varieties of mango to epicotyl grafting and observed highest success (96.00 %) in Fazli followed by Rani Pasand (94.00 %) and Kohinoor (90.00 %) with defoliated scions. With non-defoliated scions shoots, the highest success (85.00 %) was noted in Kohinoor followed by Fazali (84.00 %), Rane Pasand (84.00 %) and Alphonso (76.00 %).

Singh and Srivastava (1979) studied varietal behaviour to stone grafting in mango. They obtained higher success (96 %) with Rataul followed by Mallika (90 %) and Dashehari (80 %) whereas, minimum success was recorded in Chausa and Lucknow Safeda.

Among the four varieties in wedge grafting of mango, 48, 52, 52 and 42 per cent success was recorded in Gopalbhog, Mohanbhog, Langra and Fazli, respectively (Farooqui and Fakir, 1973).

Jagirdar and Bhatti (1968) studied the varietal response to veneer grafting in mango. They used eight varieties grafted in March-April, 1966 and 1967. Dashehari showed 90 per cent success during drought spring of 1966 whereas, Sindhura, Langra and Banganapally showed over 90 per cent in the cooler moist spring of 1967. However, Dashehari exceeded 80 per cent success.

2.2.3 Stone grafting

Nowadays, stone (epicotyl) grafting is being a very important technique for raising mango saplings, becoming popular and commercial in India and elsewhere as inarching is a slow, laborious, expensive and cumbersome process including wastage of scion-wood (Alam *et al.*, 2006). Traub and Auchter (1934) first reported about stone grafting of mango. It has many advantages over the methods as the nursery-life is shortened by a year as well as the grafts are small in size and can therefore, easily be transported without damage (Majumdar, 1989). Further, this technique requires less time in process of propagation and proved to be cheaper (Kulwal and Tayde, 1989). Due to graft-success, convenience and ease of stone grafting in commercial cultivars, it would be economically viable compared to traditional methods (Patil *et al.*, 1991). It is gaining popularity in the states like Maharashtra, Karnataka and Kerala (Majumdar, 1989).

2.2.3.1 Stone grafting in fruits

2.2.3.1.1 Mango

The influence of epicotyl (stone) grafting in different media on plant growth was studied under shade conditions where mango stones of different unknown commercial cultivars were used for raising seedling rootstocks and Dashehari variety was used as scion. Among all the treatments the stone grafting on 10 days old seedling rootstocks resulted in highest success in terms of sprouting, survival, vegetative and root growth in comparison to grafts grafted on 13 day old seedling rootstocks (Prabhat and Nidhika, 2016).

The number of leaves ranging from 7.6 to 10 at 120 days of grafting in stone grafting of “Amrapali” mango was reported by Singh *et al.* (2014). The graft height of 22.8 cm to 24.00 cm and 26.00 cm to 28.40 cm at 30 and 120 days of grafting, respectively was also reported.

Mango seedlings of 5, 10, 15 and 20 days were grafted with un-defoliated and 5, 10 and 15 days pre-defoliated scion. Among different treatment combinations, maximum initial (86.70 %) and final success (56.70 %) of grafts were found in the grafts of 15 days old seedlings and 10 days pre defoliated scion. Fifteen days old seedlings and 10 days pre-defoliated scion performed best for all growth parameters (Upadhyaya *et al.*, 2014).

The stone grafting in mango was by carried out by Nalage *et al.* (2010) with three lengths of scion stick and the maximum number of sprouted grafts, maximum sprouting percentage, minimum days for leaf emergence, maximum number of leaves per graft, minimum mortality (%) and maximum survival (%) of grafts were recorded in grafts when they were made using 10 cm long scion sticks. The maximum growth in terms of height and girth (above the union) were recorded in grafts made with the use of 20 cm long scion sticks.

An experiment was carried out on stone grafting in mango with seven growth media and six sub treatments including grafting on 5, 7, 9, 11, 13 and 15-day-old rootstocks. Sprouting was significantly high with the use of 7-day old rootstock for grafting followed by 9 and 5 days old rootstock. The highest survival was observed with 7 days old stock whereas, the survival rate decreased when the age of the stock increased to 15 days. Vegetative growth *viz.*, sprout length and sprout diameter were the highest in plants grafted on 7 days old rootstock followed by 9 and 11 days old rootstocks (Kaur and Malhi, 2006).

The graft success of 24.00 per cent in 'Pairi' to 79.50 per cent in 'Mallika' was reported in the stone grafting under semi arid conditions of Raichur in Karnataka (Reddy *et al.*, 1994).

Earlier workers have reported varying degrees of success of stone grafting in different names such as bench grafting, epicotyl grafting, seedling grafting *etc.* Success in stone grafting may vary depending upon use of rootstock, variety of scion, length of scion, grafting season *etc.* (Kashyap *et al.*, 1989).

Reddy and Kohli (1989) got better results from older seedlings using cleft method onto 4, 6, 8, 10 and 14 days old Alphonso seedling as rootstocks. Anwaruddin and Sunarjono (1987) conducted an experiment at Cipaku Experimental Farm, Bogor

to study the effect of scion length on success of grafting on four cultivars (Hepe, Sitokong, Chanee and Kan Yaow) and three scion length (1 node, 2 nodes and 3 nodes). The scion was inserted 1 cm above or 1 cm below the cotyledon scars and wrapped with plastic film. They reported that 2-node scions tended to have the best graft union of the cultivars and Kan Yaow and Stiakong had the best graft take.

Negawekar *et al.* (1984) studied the effect of various factors on survival of stone grafting of mango where the terminal or sub terminal part of shoots was used as scions. The survival (60.60-63.00 %) and subsequent growth was similar.

Chakrabarty and Sadhu (1983) conducted trials in June, July and August at West Bengal, India. In this study 5, 10 or 15 days old seedling rootstocks were grafted with 1, 2 or 4 months old shoots of the scion cultivars Bombai, Himsagor and Langra. The combination of 5 days old seedling rootstock and 1 month scion shoots gave the highest success rate and scions with 10 cm long gave better results than those of 5 or 15 cm long.

Singh and Shrivastava (1980) obtained higher success (70.00 %) in stone grafting of mango with 10 days prior defoliation.

2.2.3.1.2 Jack

The effect of scion maturity and stock leaf retention on the graft success and survivability of stone grafting in jackfruit scions was studied. The experiment consisted of two types of scion *viz.*, terminal and sub terminal portion of scion shoot. The highest graft success (86.00 %) and survivability (86.00 %) were recorded when terminal portion was grafted as scion on the rootstock retaining leaves (Debanath, 2007).

2.2.3.1.3 Walnut

Qureshi *et al.* (2014) conducted epicotyl grafting in walnut using scion wood of terminal and basal portion of one-year-old scion wood of Wussan selection. Grafting done with the terminal portion of the scion has shown more success than the basal portion of the scion.

2.2.3.2 The varietal influence on stone grafting.

The success of stone grafting of six mango cultivars *viz.*, ‘Amrapali’, ‘Dashehari’, ‘Langra’, ‘Lucknow Safeda’, ‘Mallika’ and ‘Chausa’ was studied under Lucknow conditions of Uttar Pradesh, India. Overall performance of stone grafting operation was observed in terms of success of grafting (%), diameter of rootstock and scion (cm), sprout length of graft (cm), height of graft (cm), leaf length (cm) and leaf width (cm) after 90 days of grafting of these six cultivars. Results clearly revealed that the highest success per cent and overall performance of stone grafting operations was recorded by using scion-stick of cultivar ‘Amrapali’ whereas, minimum success per cent was in cultivar ‘Lucknow Safeda’ under Lucknow conditions. The number of leaves in grafts was found significantly maximum in ‘Amrapali’ (3.39 and 7.67 after 30 and 90 days of grafting, respectively) whereas, it was minimum in cultivars ‘Chausa’ (2.54) and ‘Lucknow Safeda’ (4.78) after 30 and 90 days of grafting, respectively (Ram *et al.*, 2015).

Bhuiyan *et al.* (2010) studied the growth of plants produced by epicotyl (stone) grafting with different rootstock-scion combinations in respect of growth in mango. The result revealed that the combinations of the scion of the same cultivar grafted onto the rootstock of the same cultivar performed better in respect of morphological growth compared to other combinations.

A study for rapid multiplication of mango through stone grafting was conducted where mango seedlings of 5, 10, 15, 20, 25 and 30 days were grafted with three varieties of scion *viz.*, BARI Aam-1, BARI Aam-3 and Langra. Maximum number of finally successful grafts (66.67 %) was recorded in variety Langra grafted on 15 days old seedlings followed by the same variety grafted on 20 days old seedlings (53.33 %). BARI Aam-1 grafted on 15 or 20 days old seedlings gave moderate success (46.67 %). Minimum success (10.00 %) was got in BARI Aam-3 grafted onto 5 and 30 days old seedlings. The tallest shoots (25.07 and 24.73 cm consecutively) were produced by Langra grafted on 15 and 20 days old seedlings. The number of leaves ranged from 9.20 in ‘BARI Aam-1’ to 12.88 in ‘Langra’ after five months of grafting (Alam *et al.*, 2006).

A trial was conducted to ascertain the optimal period of stone grafting in Khader, Mallika, and Baneshan cultivars of mango in the Northeastern dry zone of Karnataka out of the 3 months *viz.*, June, July and August fortnight intervals. The first fortnight of June grafting exhibited the earliest sprouting of 28.71 days, but it was late by 6.39 days in first fortnight of August grafting. Khader took minimum number of days for sprouting (27.30 days). Grafting in second fortnight of June has given maximum percentage (75.50 %) of sprouting. August grafting proved very poor. Khader showed the higher percentage of survival (46.60 %). The first fortnight of June grafted plants expressed maximum graft take whereas, grafting in August showed poorest graft take (Prashanth, 2006).

Reddy *et al.* (1994) studied the effect of different scion varieties of mango and time of grafting on the success of the epicotyls grafts where scions from 14 different varieties including eight varieties and six hybrids were used. The results indicated that, August and September were the ideal months for grafting. Among the varieties Neelum and Khader and among the hybrids Mallika and Au Rumani were the most suitable ones.

Chakrabarty and Sadhu (1989) had a faster graft-take in Langra than in Bombai and Himsagar. Singh *et al.* (1989) conducted an experiment with 2 to 4 months old Dashehari scion and noted that the success rate was higher in August than in July and September grafted scion remained green and did not sprout until the following spring.

Maiti and Biswas (1980) observed that, stone grafting the defoliated scion shoots always produced higher percentage of successful grafts than the non defoliated shoots and the success varied from 90 to 96 per cent in the different varieties of mango against 76 to 85 per cent in non defoliated shoots. In case of variety, maximum success (50.33 %) was achieved from the grafts made with Langra scion whereas, the grafts of BARI Aam-3 secured minimum success (28.89 %).

Singh and Srivastava (1979) studied varietal behaviour to stone grafting in mango and obtained higher success (96.00 %) with Rataul followed by Mallika (90.00 %) and Dashehari (80.00 %) whereas, minimum success was recorded in Chausa and Lucknow Safeda.

3. MATERIAL AND METHODS

An investigation on “Identification of elite clones of Kari Ishada mango cultivar in major growing parts of Uttara Kannada district and its grafting studies” was carried out. Survey was made during the fruiting season in Ankola and Kumta taluks of Uttara Kannada district. The fruits and scions were brought to the Department of Fruit Science, Kittur Rani Channamma College of Horticulture, Arabhavi and were used for studying the physicochemical characters as well as the grafting performances, respectively during 2015-16. The details of the materials used and the techniques adopted during the investigation are presented here under.

3.1 Experiment-IA: Survey and identification of elite clones of Kari Ishada mango cultivar in major growing parts of Uttar Kannada district.

Location	: Uttar Kannada district (Ankola and Kumta).
Variety	: Kari Ishada.
Selections	: 31.

3.1.1 Geographical location of the experimental site

Ankola and Kumta are located on the Arabian sea coast in Uttara Kannada district of Karnataka and are adjacent to the vast Western Ghats. Ankola is at 14.39°N 74.18°E. It has an average elevation of 17 m. Kumta is located at 14.42°N 74.4° E with an average elevation of 3 m. Ankola and Kumta are about 270 km and 290 Km away from Kittur Rani Channamma College of Horticulture, Arabhavi, respectively.

3.1.2 Climate

Summer temperatures range between 30 °C and 35 °C while winter temperatures drop down marginally to between 20 °C and 33 °C in Ankola whereas in Kumta the temperature is 30 °C to 34 °C in summer and 20.8 °C to 32.8 °C in winter.

3.1.3 Tree details

The tree details of the Kari Ishada selections are presented in the table 1

Table 1. Tree details of Kari Ishada selections

Sl. No.	Tree	Place	Farmer Name
1	KIS-1	Bole, Ankola	Shailesh R. N.
2	KIS-2	Bole, Ankola	Shailesh R. N.
3	KIS-3	Bole, Ankola	Bellu Nayak
4	KIS-4	Bole, Ankola	Bellu Nayak
5	KIS-5	Bole, Ankola	Bellu Nayak
6	KIS-6	Bole, Ankola	Ganesh R.
7	KIS-7	Bole, Ankola	Nagaraj N.
8	KIS-8	Bole, Ankola	Naina nayak
9	KIS-9	Vandige, Ankola	Naina nayak
10	KIS-10	Vandige, Ankola	Venkatraman Raman.
11	KIS-11	Vandige, Ankola	Venkatraman Raman.
12	KIS-12	Jambugodu, Ankola	Shailesh R. N.
13	KIS-13	Seelya, Ankola	Subburaya Nayak
14	KIS-14	Seelya, Ankola	Rajesh S
15	KIS-15	Seelya, Ankola	Manohara S
16	KIS-16	Basugodu, Ankola	Laxman Beeran
17	KIS-17	Basugodu, Ankola	Laxman Beeran
18	KIS-18	Pujigeri, Ankola	Gopalakrishna H
19	KIS-19	Basugodu, Ankola	Balakrishna
20	KIS-20	Basugodu, Ankola	Vanitha Balakrishna
21	KIS-21	HRS Ichkada, Ankola	HRS
22	KIS-22	Ankola	Ganapathi Naraayan
23	KIS-23	HRS Ichkada, Ankola	HRS
24	KIS-24	Ankola	Venkatraman Nayak
25	KIS-25	Ankola	Venkatraman Nayak
26	KIS-26	Kagal Kumta	Honnayya H. Naik
27	KIS-27	Kagal, Kumta	Honnayya H. Naik
28	KIS-28	Kagal, Kumta	Honnayya H. Naik
29	KIS-29	Bada, Kumta	Devidas R
30	KIS-30	Bada, Kumta	Ganesh Vinayak
31	KIS-31	Bada, Kumta	Ganesh Vinayak

3.1.4 Tree Characters

3.1.4.1 Visual observations

The following tree characters were recorded by visual observations.

i. Approximate age

- a. Old (>40 years)
- b. Medium (20-40 years)
- c. Young (< 20 years)

ii. Tree height

- a. Large (> 15 m)
- b. Medium (10-15 m)
- c. Small (<10 m)

iii) Flowering season

Flowering season was noted down during the peak flowering of the tree.

- a. Early (Before January 15)
- b. Mid (January 15 to February 1)
- c. Late (After February 1)

iv) Fruiting (harvest) season

Fruiting (harvest) season was noted down during the peak fruiting of the tree.

- a. Early (Before May 15)
- b. Mid (May 15 to May 31)
- c. Late (After May 31)

3.1.4.2 Tree spread (m)

The spread of the tree canopy was recorded with the help of measuring tape in East-West and North-South directions and was expressed in meters.

3.1.4.3 Tree height (m)

The approximate tree height was noted and was expressed in meters.

3.1.4.4 Yield (kg/tree)

The number of fruits produced by the selected tree was recorded which was multiplied by the average fruit weight and was expressed in kilograms per tree.

3.2 Experiment-IB: Evaluation of the Kari Ishada selections for the morphological and qualitative parameters of the fruits.

Treatments	: 31
Replications	: 2
Design	: CRD
Sample size	: 10 Fruits per tree

3.2.1 Collection of fruits

Ten fruits were collected from each of the selected elite trees from the farmers' field in villages of Ankola and Kumta. Twenty five trees from Ankola and six trees from Kumta were selected. The fruits were labeled after they were plucked from the tree.

3.2.2 Observations recorded

The following observations were recorded after collection of each trees from different places.

3.2.2.1 Fruit characters:

3.2.2.1.1 Fruit weight (g)

The weight of the fruit was recorded using electronic balance and expressed in grams.

3.2.2.1.2 Pulp weight (g)

The weight of the pulp was recorded by subtracting the fruit weight from peel weight and stone weight and expressed in grams.

3.2.2.1.3 Peel weight (g)

The weight of the peel was recorded using electronic balance and expressed in grams.

3.2.2.1.4 Fruit length (mm)

The length of fruit was measured from the tip of the fruit to other end using digital vernier calipers and expressed in millimeters.

3.2.2.1.5 Fruit width (mm)

The fruit width was taken by measuring the horizontal distance of the fruit at the center using digital vernier calipers and expressed in millimeters.

3.2.2.1.6 Fruit thickness (mm)

The fruit thickness was taken by measuring the depth of the fruit at the center using digital vernier calipers and expressed in millimeters.

3.2.2.1.7 Fruit volume (ml)

The fruit volume was measured by the water displacement method and expressed in milliliters.

3.2.2.1.8 Pulp (%)

The pulp percentage per fruit was calculated by following formula and expressed in percentage.

$$\text{Pulp (\%)} = \frac{\text{Pulp weight of fruit}}{\text{Total weight of fruit}} \times 100$$

3.2.2.1.9 Peel (%)

The peel percentage per fruit was calculated by following formula and expressed in percentage.

$$\text{Peel (\%)} = \frac{\text{Peel weight of fruit}}{\text{Total weight of fruit}} \times 100$$

3.2.2.1.10 Stone (%)

The stone percentage per fruit was calculated by following formula and expressed in percentage.

$$\text{Stone (\%)} = \frac{\text{Stone weight of fruit}}{\text{Total weight of fruit}} \times 100$$

3.2.2.1.11 Pulp to stone ratio

The ratio of pulp to stone was calculated by the following formula

$$\frac{\text{Pulp}}{\text{Stone}} = \frac{\text{Pulp weight of fruit}}{\text{Stone weight of fruit}}$$

3.2.2.1.12 Fruit to stone ratio

The ratio of fruit to stone was calculated by the following formula

$$\frac{\text{Fruit}}{\text{Stone}} = \frac{\text{Fruit weight}}{\text{Stone weight}}$$

3.2.2.1.13 Peel to pulp ratio

The ratio of peel to pulp was calculated by the following formula

$$\frac{\text{Peel}}{\text{Pulp}} = \frac{\text{Peel weight of fruit}}{\text{Pulp weight of fruit}}$$

3.2.2.2 Stone characters

3.2.2.2.1 Stone weight (g)

The weight of the stone was recorded using electronic balance and expressed in grams.

3.2.2.2.2 Stone length (mm)

The length of stone was measured from the tip of the stone to other end using digital vernier calipers and expressed in millimeters.

3.2.2.2.3 Stone width (mm)

The stone width was taken by measuring the horizontal distance of the stone at the centre using digital vernier calipers and expressed in millimeters.

3.2.2.2.4 Stone thickness (mm)

The stone thickness was taken by measuring the depth of the stone at the centre using digital vernier calipers and expressed in millimeters.

3.2.2.3 Quality parameters

3.2.2.3.1 Total soluble solids (°B)

Total soluble solids of the pulp was recorded with the help of Erma hand refractometer and expressed in °B.

3.2.2.3.2 Titrable acidity (%)

The acidity was determined by titrating the known volume of fruit juice against 0.01 N NaOH solution using phenolphthalein as indicator and the value was expressed as gram of malic acid per 100 gram of sample as malic acid is the major acid found in ripe mango (Anon., 1976).

3.2.2.3.3 Total sugars (%)

The percentage of total sugars present in the fruit pulp was estimated by the principle of reducing sugar after inversion (Anon., 1984). One milliliter of evaporated extract was taken and kept in boiling water till the alcohol was completely evaporated and allowed it to cool. Then phenolphthalein indicator was added followed by 1 N sodium hydroxide till the solution turned to pink. Again 0.1 N hydrochloric acid was added to discolour the solution. Then, Dinitrosalicylic acid (DNSA) method for estimation of reducing sugar was followed. The values obtained were expressed as percentage on pulp weight basis.

3.2.2.3.4 Reducing sugars (%)

The percentage of reducing sugars in the mango pulp was determined by Dinitrosalicylic acid (DNSA) method (Miller, 1972). A known volume of alcohol extract was allowed to evaporate the alcohol completely. Clear solution was taken for the estimation of reducing sugar using DNSA- reagent by following the above method and values were expressed in percentage.

3.2.2.3.5 Non reducing sugars (%)

The percentage of non reducing sugars was obtained by subtracting the values of reducing sugars from total sugar which was multiplied by the correction factor.

$$\text{Non-reducing sugar (\%)} = [\text{Total sugars (\%)} - \text{reducing sugars (\%)}] \times 0.95$$

3.2.2.3.6 Brix acid ratio

The ratio of Brix (TSS) to acid was calculated by the following formula

$$\frac{\text{Brix}}{\text{Acid}} = \frac{\text{TSS of the fruit}}{\text{Titration acidity of fruit}}$$

3.2.2.4 Post harvest parameters

3.2.2.4.1 Physiological loss in weight (PLW)

The physiological loss in weight is calculated by formula and expressed in percentage.

$$\text{PLW} = \frac{W_1 - W_2}{W_1} \times 100$$

W_1 - Initial weight of the fruit.

W_2 - Final weight of the fruit.

3.2.2.4.2 Shelf life

The shelf life was determined by the number of days the fruits were edible and acceptable for consumption.

3.2.2.4.3 Specific gravity (g/cc)

The specific gravity is calculated by taking the ratio of fruit weight to fruit volume after harvest and expressed as g per cc.

3.2.2.4.4 Sensory evaluation of fruits

The sensory evaluation was done by 20 respondents and scores were given based on the score scale for peel colour, pulp colour, pulp texture, taste and overall acceptance.

Score scale used for scoring

Excellent	: 7.1-9.
Very good	: 5.1-7.0
Good	: 3.1-5.0
Fair	: 1.1-3.0
Poor	: 0.0-1.0

3.3 Experiment II: Grafting studies of Kari Ishada selections

The superior Kari Ishada selections (10 out of 31) were selected based on the morphological, qualitative, post harvest and sensory characters. The scions from the mother tree of these ten selections were brought and they were grafted using two methods of grafting (Stone grafting and softwood grafting).

3.3.1 Details of experiment

Design: Factorial Completely Randomized Design (FCRD)

Factors: 2

Factor 1: Grafting methods (2 types: Softwood grafting and stone grafting)

Factor 2: Kari Ishada selections (10 selections : 'KIS-3', 'KIS-4', 'KIS-7', 'KIS-11', 'KIS-13', 'KIS-15', 'KIS-17', 'KIS-24', 'KIS-25', 'KIS-27').

Treatments

- T₁ : 'KIS-3' stone grafting
 T₂ : 'KIS-4' stone grafting
 T₃ : 'KIS-7' stone grafting
 T₄ : 'KIS-11' stone grafting
 T₅ : 'KIS-13' stone grafting
 T₆ : 'KIS-15' stone grafting
 T₇ : 'KIS-17' stone grafting
 T₈ : 'KIS-24' stone grafting
 T₉ : 'KIS-25' stone grafting
 T₁₀ : 'KIS-27' stone grafting
 T₁₁ : 'KIS-3' soft wood grafting
 T₁₂ : 'KIS-4' soft wood grafting
 T₁₃ : 'KIS-7' soft wood grafting
 T₁₄ : 'KIS-11' soft wood grafting
 T₁₅ : 'KIS-13' soft wood grafting
 T₁₆ : 'KIS-15' soft wood grafting
 T₁₇ : 'KIS-17' soft wood grafting
 T₁₈ : 'KIS-24' soft wood grafting
 T₁₉ : 'KIS-25' soft wood grafting
 T₂₀ : 'KIS-27' soft wood grafting
 *'KIS : Kari Ishada Selection

These were grafted on local rootstock.

- Number of replications : 2
 Number of grafts per replication : 10
 Total number of grafts : 400

3.3.2 Rootstock

Seven to ten days old seedlings of local variety were used as rootstocks for stone grafting and the one year old seedlings of local variety were used as rootstocks for soft wood grafting.

3.3.3 Scions

The healthy scions from the particular mother trees of pencil size thickness were collected for grafting from Ankola and Kumta and were brought to Kittur Rani Channamma College of Horticulture, Arabhavi for grafting. The scions were transported in the ice box after rolling them in the wet newspaper. These scions were grafted the next day after collection.

3.3.4 Grafting methods

Stone grafting and softwood grafting are the two grafting methods used in the experiment. The grafting was done in the month of August in the year of 2015.

3.3.4.1 Stone grafting

The seven to ten days old seedlings of the local variety were used as rootstocks for the stone grafting. The thickness of scion and the rootstock was matched and the transverse cut was given on the rootstock at about 5 cm from the base. After this, a longitudinal cut of 4 to 5 cm length was given on the rootstock. The top of the rootstock appeared like the letter 'V'. A scion of about 9-10 cm length and the same thickness as that of the rootstock was selected. The lower end of the scion was cut into gently sloping wedge of about 3 to 4 cm by removing the bark and a little wood from the two opposite sides. The wedge shaped scion thus prepared was carefully inserted into the 'V' shaped slit of the stock and secured firmly with 1.5 cm wide and 35 cm long, 200 gauge white transparent polythene strip. The scions were covered with small transparent polythene strip to avoid contamination or desiccation of the scions by creating humidity near and above the union region. This polythene strip also maintains the temperature and helps for graft union. Soon after grafting, the grafts were kept in shade house.

3.3.4.2 Softwood grafting

One year old seedlings of the local variety were used for the softwood grafting. At about 15-20 cm height, a transverse cut was given on the rootstock. The girth of rootstock in that region is almost equal to that of the scion. After this, a longitudinal cut of 4 to 5 cm length was given on the rootstock and then the scion was inserted after which procedure was continued as in epicotyl grafting.

3.3.5 Aftercare of the grafts

Watering was done regularly using rose can. The sprouts arising from the rootstock below the graft union were removed manually as and when they appeared. Necessary plant protection measures were taken.

3.3.6 Observations recorded

3.3.6.1 Graft success (%)

Those grafts in which scion had sprouted and remained alive without shrivelling after 60 days of grafting were noted and percentage of success was worked out.

$$\text{Graft success} = \frac{\text{Number of grafts alive}}{\text{Total number grafts}} \times 100$$

3.3.5.2 Graft Survival (%)

Survival percentage of the grafts was calculated after 90 days of grafting by the following formula and expressed in percentage.

$$\text{Graft survival} = \frac{\text{Number of grafts alive}}{\text{Total number of successful grafts}} \times 100$$

3.3.5.3 Number of days for sprouting

The total number of days taken by the graft to sprout after grafting was noted down.



Plate 1. General view of the grafts of Kari Ishada selections

3.3.5.4 Graft height (cm)

Graft height was measured with scale at monthly intervals after grafting and was expressed in centimeters.

3.3.5.5 Number of sprouts per graft

The number of sprouts arose from the scion were recorded at monthly intervals.

3.3.5.6 Number of leaves per graft

The number of leaves arose from the scion were recorded at monthly intervals.

3.3.5.7 Shoot girth (mm)

The girth of the sprout was measured from a marked point with the help of digital vernier calipers and was expressed in millimeters.

3.3.5.8 Sprout length (cm)

The sprout length was measured with scale at monthly intervals after grafting and expressed in centimeters.

3.4 Statistical analysis

The data on various characters were subjected to Fisher's method of analysis of variance and the interpretation of data as given by Panse and Sukhatme (1967). The level of significance used for 'F' and 't' tests was $p=0.05$. Critical difference (CD) values were calculated whenever the 'F' test was significant.

4. EXPERIMENTAL RESULTS

A survey was conducted to identify the elite clones of Kari Ishada mango variety in Ankola and Kumta of Uttara Kannada district. The evaluation of morphological and qualitative parameters of 31 Kari Ishada selections was undertaken. Out of these 31 selections, ten were selected for their desirable characters. The effect of stone and softwood grafting of these ten selections were investigated. The results obtained are presented below.

4.1 Experiment-I: Identification of the elite clones of Kari Ishada mango cultivar in major growing parts of Uttara Kannada district.

4.1.1 Tree characters of Kari Ishada Selections

Tree characters like flowering season, fruiting season, age, canopy spread, height and fruit yield of the Kari Ishada selections were recorded and are presented in table 2.

4.1.1.1 Flowering season

The peak flowering season was early (Jan 15th -31st) for 'KIS-9', 'KIS-10' and 'KIS-22' whereas it was late (after Feb 15th) for 'KIS-14' and 'KIS-19'. The remaining selections had the mid flowering season from Feb 1st-15th (Table 2).

4.1.1.2 Fruiting season

The fruiting season of 'KIS-6', 'KIS-12', 'KIS-14', 'KIS-15', 'KIS-19', 'KIS-22', 'KIS-28' and 'KIS-29' was between June 1st-15th whereas fruiting season was during May 15th-31st for the remaining selections (Table 2).

4.1.1.3 Age of tree

Among the 31 Kari Ishada selections, 12 selections ('KIS-3', 'KIS-6', 'KIS-7', 'KIS-12', 'KIS-14', 'KIS-16', 'KIS-17', 'KIS-18', 'KIS-21', 'KIS-23', 'KIS-24' and 'KIS-27') were in old age group with the age of above 40 years and 17 trees ('KIS-1', 'KIS-2', 'KIS-8', 'KIS-9', 'KIS-10', 'KIS-11', 'KIS-13', 'KIS-15', 'KIS-19',

Table 2. Tree morphological parameters of Kari Ishada selections

Selections	Flowering season	Fruiting season	Age of tree	Tree spread (m)		Tree height	Yield (kg/tree)
				NS	EW		
KIS-1	Feb 1 st -15 th	May 15 th -31 st	Medium	08	07	Medium	250
KIS-2	Feb 1 st -15 th	May 15 th -31 st	Medium	07	06	Medium	096
KIS-3	Feb 1 st -15 th	May 15 th -31 st	old	16	14	Large	624
KIS-4	Feb 1 st -15 th	May 15 th -31 st	Young	06	6.5	Small	078
KIS-5	Feb 1 st -15 th	May 15 th -31 st	Young	6.5	5.5	Small	061
KIS-6	Feb 1 st -15 th	June 1 st -15 th	Old	20	18	Large	495
KIS-7	Feb 1 st -15 th	May 15th-31st	Old	16	19	Large	561
KIS-8	Feb 1 st -15 th	May 15th-31st	Medium	07	8.5	Medium	336
KIS-9	Jan 15 th -31 st	May 15th-31st	Medium	09	07	Medium	280
KIS-10	Jan 15 th -31 st	May 15th-31st	Medium	6.5	08	Medium	258
KIS-11	Feb 1 st -15 th	May 15th-31st	Medium	14	12	Medium	450
KIS-12	Feb 1 st -15 th	June 1 st -15 th	Old	22	18	Large	537
KIS-13	Feb 1 st -15 th	May 15th-31st	Medium	15	13	Medium	327
KIS-14	After Feb 15 th	June 1 st -15 th	Old	22	19	Large	504
KIS-15	Feb 1 st -15 th	June 1 st -15 th	Medium	10	08	Medium	143
KIS-16	Feb 1 st -15 th	May 15th-31st	Old	18	17	Large	516
KIS-17	Feb 1 st -15 th	May 15th-31st	Old	18	16	Large	400
KIS-18	Feb 1 st -15 th	May 15th-31st	Old	22	19	Large	504
KIS-19	After Feb 15 th	June 1 st -15 th	Medium	08	07	Medium	117
KIS-20	Feb 1 st -15 th	May 15th-31st	Medium	09	7.5	Medium	143
KIS-21	Feb 1 st -15 th	May 15th-31st	Old	18	16	Large	506
KIS-22	Jan 15 th -31 st	June 1 st -15 th	Medium	08	09	Medium	281
KIS-23	Feb 1 st -15 th	May 15th-31st	Old	19	17	Large	427
KIS-24	Feb 1 st -15 th	May 15th-31st	Old	22	18	Large	491
KIS-25	Feb 1 st -15 th	May 15th-31st	Medium	09	11	Medium	477
KIS-26	Feb 1 st -15 th	May 15th-31st	Medium	17	15	Large	421
KIS-27	Feb 1 st -15 th	May 15th-31st	Old	15	16.5	Large	486
KIS-28	Feb 1 st -15 th	June 1 st -15 th	Medium	07	09	Medium	216
KIS-29	Feb 1 st -15 th	June 1 st -15 th	Medium	14	15	Large	377
KIS-30	Feb 1 st -15 th	May 15th-31st	Medium	07	06	Medium	144
KIS-31	Feb 1 st -15 th	May 15th-31st	Medium	06	08	Medium	175
Range	-	-	-	6-22	5.5-19	-	61-624
Mean	-	-	-	12.96	12.15	-	344.50
SD	-	-	-	5.73	4.83	-	166.79

NS= North-South, EW= East-West.

Age : Old (>40 years); Medium (20-40 years); Young (< 20 years).

Tree height : Large (> 15 m), Medium (10-15 m), Small (<10 m)

‘KIS-20’, ‘KIS-22’, ‘KIS-25’, ‘KIS-26’, ‘KIS-28’, ‘KIS-29’, ‘KIS-30’ and ‘KIS-31’) belonged to medium age group between 20-40 years. ‘KIS-4’ and ‘KIS-5’ belonged to young age group of less than 20 years.

4.1.1.4 Tree spread

The spread of trees varied with the Kari Ishada selections. Highest canopy spread (NS- 22.00 m and EW-19.00 m) was recorded in ‘KIS-14’ and ‘KIS-18’ whereas, lowest canopy spread (NS-6.5 m and EW-5.5 m) was recorded in ‘KIS-5’.

4.1.1.5 Tree height

Among the 31 Kari Ishada selections, 14 selections (‘KIS-3’, ‘KIS-6’, ‘KIS-7’, ‘KIS-12’, ‘KIS-14’, ‘KIS-16’, ‘KIS-17’, ‘KIS-18’, ‘KIS-21’, ‘KIS-23’, ‘KIS-24’, ‘KIS-26’, ‘KIS-27’ and ‘KIS-29’) had large tree height of above 15 m and 14 of them (‘KIS-1’, ‘KIS-2’, ‘KIS-8’, ‘KIS-9’, ‘KIS-10’, ‘KIS-11’, ‘KIS-13’, ‘KIS-15’, ‘KIS-19’, ‘KIS-20’, ‘KIS-22’, ‘KIS-25’, ‘KIS-28’, ‘KIS-30’ and ‘KIS-31’) were of medium tree height with 10-15 m. ‘KIS-4’ and ‘KIS-5’ had small tree height below 5 m.

4.1.1.6 Yield

‘KIS-3’ recorded the highest yield of 624 kg per tree which was followed by ‘KIS-7’ (561 kg/tree) whereas, ‘KIS-5’ recorded the lowest yield of 61 kg per tree which was followed by ‘KIS-4’ (78 kg/tree).

4.1.2 Fruit characters of Kari Ishada selections

The difference among the selections was significant for the fruit parameters. Data on fruit physical parameters like fruit weight, pulp weight, peel weight, fruit length, fruit width, fruit thickness and fruit volume are presented in table 3, plate 2 a, plate 2 b and plate 2 c.

4.1.2.1 Fruit weight

The highest fruit weight was recorded in ‘KIS-25’ (477.25 g) which was on par with ‘KIS-3’ (445.83 g), ‘KIS-12’ (429.25 g) and ‘KIS-1’ (416.33 g) whereas, the lowest fruit weight was found in ‘KIS-20’ (237.50 g) which was on par with ‘KIS-30’ (240.00 g), ‘KIS-2’ (240.58 g), ‘KIS-6’ (247.50 g), ‘KIS-31’ (249.50 g), ‘KIS-11’

Table 3. Fruit morphological parameters of Kari Ishada selections

Selections	Fruit weight (g)	Pulp weight (g)	Peel weight (g)	Fruit length (mm)	Fruit width (mm)	Fruit thickness (mm)	Fruit volume (ml)
KIS-1	416.33	268.00	98.33	100.37	97.18	89.99	400.00
KIS-2	240.58	142.83	62.08	81.47	83.72	74.26	230.00
KIS-3	445.83	310.25	95.25	91.53	100.95	92.17	435.00
KIS-4	391.75	266.00	78.25	91.82	92.99	85.69	380.00
KIS-5	306.00	173.50	83.00	87.99	89.14	79.61	297.50
KIS-6	247.50	124.33	73.69	77.63	77.24	70.84	242.50
KIS-7	329.83	218.17	73.00	86.09	90.47	80.86	310.00
KIS-8	395.08	248.33	90.17	97.49	94.48	85.04	375.00
KIS-9	279.75	138.58	95.83	83.39	88.10	78.89	275.00
KIS-10	344.08	223.88	85.63	92.53	95.52	82.88	335.00
KIS-11	250.00	149.25	71.75	79.52	85.53	76.73	240.00
KIS-12	429.25	283.67	99.50	93.46	96.80	87.09	420.00
KIS-13	272.75	169.50	66.92	84.00	82.93	76.27	270.00
KIS-14	252.17	152.58	61.00	81.36	83.48	76.96	250.00
KIS-15	286.79	184.00	68.25	80.53	85.28	76.65	275.00
KIS-16	396.92	244.33	85.08	94.23	93.54	84.33	385.00
KIS-17	266.83	184.00	48.50	80.48	83.44	76.03	250.00
KIS-18	335.88	228.88	74.21	91.99	91.02	80.90	320.00
KIS-19	293.71	174.21	85.83	83.52	88.23	79.08	290.00
KIS-20	237.50	128.02	71.99	73.12	69.62	67.41	232.50
KIS-21	281.04	173.08	68.67	82.26	86.50	75.12	265.00
KIS-22	281.42	172.25	65.67	87.72	86.51	77.32	275.00
KIS-23	355.67	228.83	76.00	92.98	97.50	82.86	345.00
KIS-24	280.83	177.08	64.58	81.85	87.19	76.02	270.00
KIS-25	477.25	295.13	125.33	101.05	99.52	82.27	465.00
KIS-26	280.67	170.67	67.33	85.07	86.84	77.90	270.00
KIS-27	285.67	183.42	60.50	84.21	88.49	79.47	275.00
KIS-28	269.50	169.67	61.17	84.86	85.18	75.24	265.00
KIS-29	251.00	162.00	56.00	81.50	76.82	70.18	245.00
KIS-30	240.00	137.33	60.00	82.50	77.98	70.21	232.50
KIS-31	249.50	156.50	55.50	77.00	71.96	69.04	240.00
S.Em ±	21.75	17.64	6.90	2.13	2.53	1.82	19.47
C.D at 5%	62.73	50.87	19.90	6.13	7.29	5.25	56.15





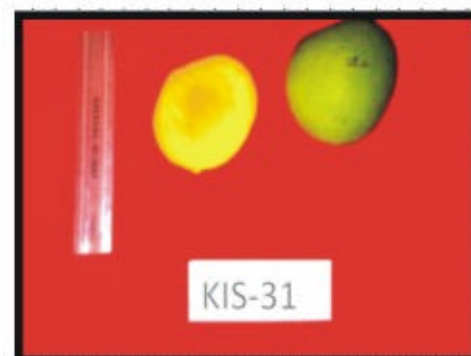
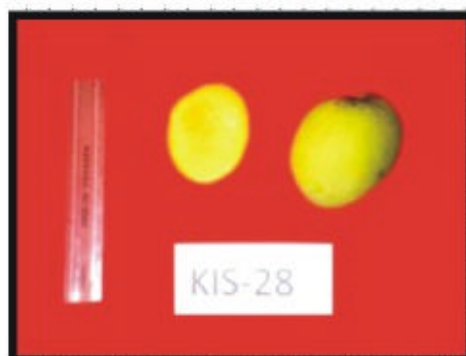
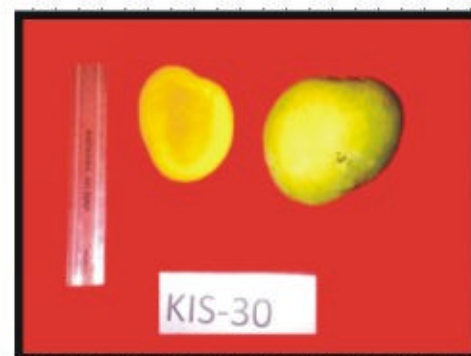
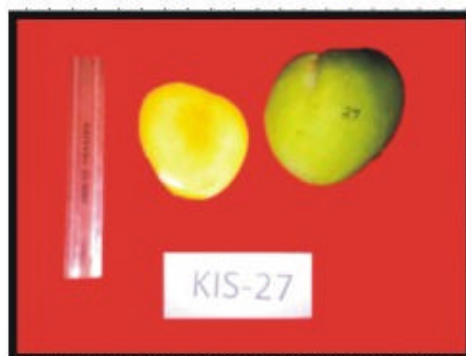
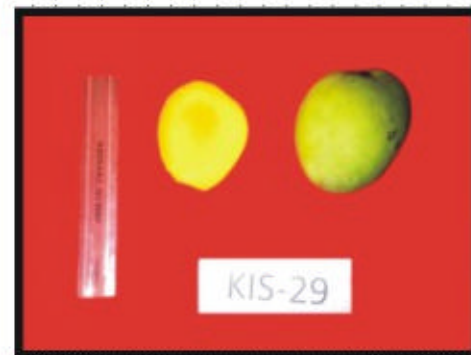
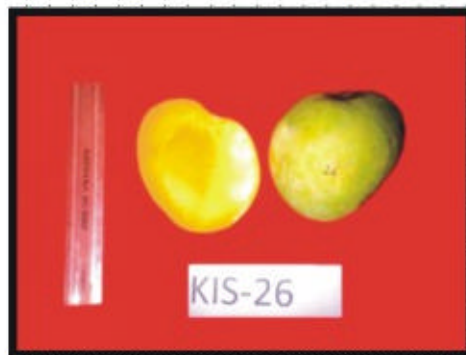
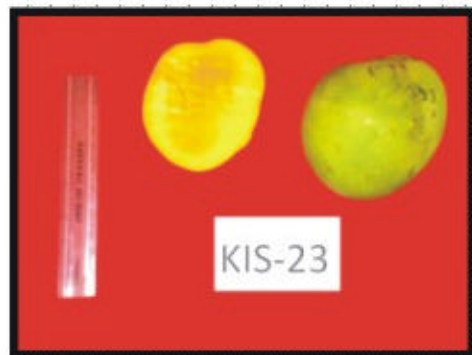


Plate 2c. Morphological variation in fruits of Kari Ishada selections

(250.00 g), 'KIS-29' (251.00 g), 'KIS-14' (252.17 g), 'KIS-17' (266.83 g), 'KIS-28' (269.50 g), 'KIS-13' (272.75 g), 'KIS-9' (279.75 g), 'KIS-26' (280.67 g), 'KIS-21' (281.04 g), 'KIS-22' (281.42 g) and 'KIS-15' (286.79 g). Fruit weight is graphically presented in fig. 1.

4.1.2.2 Pulp weight

Pulp weight was maximum in 'KIS-3' (310.25 g) which was on par with 'KIS-25' (295.13 g), 'KIS-12' (283.67 g), 'KIS-1' (268.00 g) and 'KIS-4' (266.00 g) whereas, the minimum pulp weight was found in 'KIS-6' (124.33 g) which was on par with 'KIS-20' (128.02 g), 'KIS-30' (137.33 g), 'KIS-9' (138.58 g), 'KIS-2' (142.83 g), 'KIS-11' (149.25 g), 'KIS-14' (152.58 g), 'KIS-31' (156.50 g), 'KIS-29' (162.00 g), 'KIS-13' (169.50 g), 'KIS-28' (169.67 g), 'KIS-26' (170.67 g), 'KIS-22' (172.25 g), 'KIS-21' (173.08 g), 'KIS-19' (174.21 g) and 'KIS-24' (177.08 g).

4.1.2.3 Peel weight

The lowest peel weight was recorded in 'KIS-17' (48.50 g), which was on par with 'KIS-31' (55.50 g), 'KIS-29' (56.00 g), 'KIS-30' (60.00 g), 'KIS-27' (60.50 g), 'KIS-14' (61.00 g), 'KIS-28' (61.17 g), 'KIS-2' (62.08 g), 'KIS-24' (64.58 g), 'KIS-22' (65.67 g), 'KIS-13' (66.92 g), 'KIS-26' (67.33 g) and 'KIS-15' (68.25 g) whereas, the highest peel weight was found in 'KIS-25' (125.33 g) which was followed by 'KIS-12' (99.50 g).

4.1.2.4 Fruit length

The maximum fruit length was recorded in 'KIS-25' (101.05 mm) which was on par with 'KIS-1' (100.37 mm) and 'KIS-8' (97.49 mm) whereas, the minimum fruit length was found in 'KIS-20' (73.12 mm) which was on par with 'KIS-31' (77.00 mm) and 'KIS-6' (77.63 mm).

4.1.2.5 Fruit width

The maximum fruit width was recorded in 'KIS-3' (100.95 mm) which was on par with 'KIS-25' (99.52 mm), 'KIS-23' (97.50 mm), 'KIS-1' (97.18 mm), 'KIS-12' (96.80 mm), 'KIS-10' (95.52 mm), 'KIS-8' (94.48 mm) and 'KIS-16' (93.54 mm) whereas, the minimum fruit width was found in 'KIS-20' (69.62 mm) which was on par with 'KIS-31' (71.96 mm) and 'KIS-29' (76.82 mm).

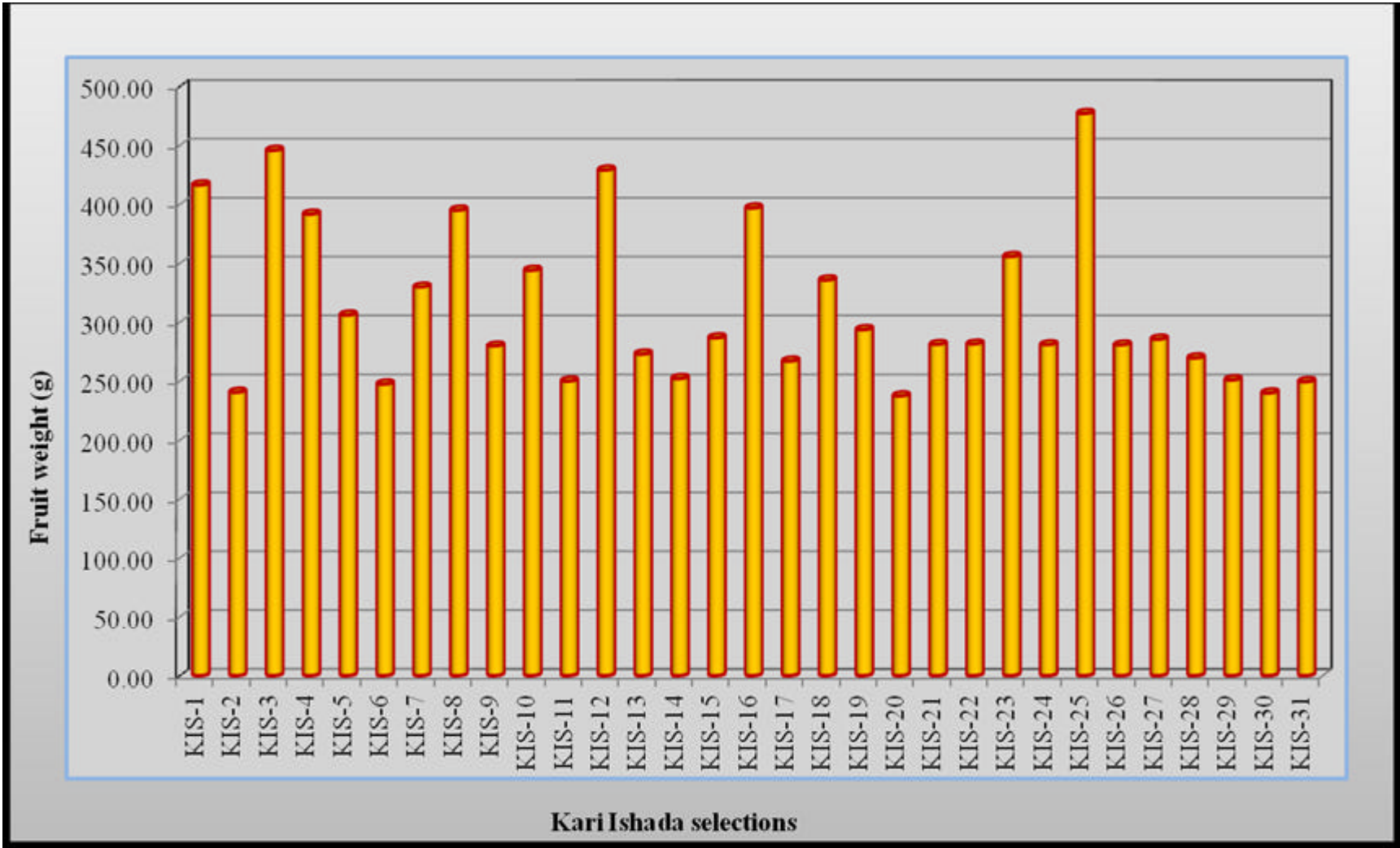


Fig. 1. Fruit weight of Kari Ishada selections

4.1.2.6 Fruit thickness

The maximum fruit thickness was found in 'KIS-3' (92.17 mm) which was on par with 'KIS-1' (89.99 mm), 'KIS-12' (87.09 mm) and 'KIS-4' (85.69 mm) whereas, the minimum fruit thickness was found in 'KIS-20' (67.41 mm) which was on par with 'KIS-31' (69.04 mm), 'KIS-29' (70.18 mm), 'KIS-30' (70.21 mm) and 'KIS-6' (70.84 mm).

4.1.2.7 Fruit volume (ml)

The maximum fruit volume was found in 'KIS-25' (465.00 ml) which was on par with 'KIS-3' (435.00 ml) and 'KIS-12' (420.00 ml) whereas, the fruit volume was minimum in 'KIS-2' (230.00 ml) which was on par with 'KIS-20' (232.50 ml), 'KIS-30' (232.50 ml), 'KIS-31' (240.00 ml), 'KIS-11' (240.00 ml), 'KIS-6' (242.50 ml), 'KIS-29' (245.00 ml), 'KIS-28' (265.00 ml) and 'KIS-21' (265.00 ml).

4.1.2.8 Pulp percentage

Pulp percentage, peel percentage, stone percentage, pulp to stone ratio, fruit to stone ratio and pulp to peel ratio are presented in table-4.

The highest percentage of pulp was found in 'KIS-3' (69.56 %) which was on par with 'KIS-17' (67.91 %), 'KIS-4' (67.79 %), 'KIS-18' (67.64 %), 'KIS-12' (66.08 %), 'KIS-7' (66.03 %), 'KIS-10' (64.66 %), 'KIS-23' (63.54 %), 'KIS-1' (63.54 %), 'KIS-8' (63.00), 'KIS-24' (62.94 %) and 'KIS-28' (62.75 %) but, the lowest percentage of pulp was recorded in 'KIS-9' (49.68 %) which was on par with 'KIS-6' (50.25 %), 'KIS-20' (53.89 %) and 'KIS-5' (56.22 %). Pulp percentage is graphically presented in fig. 2.

4.1.2.9 Peel percentage

The peel percentage was lowest in 'KIS-17' (18.89 %) which was on par with 'KIS-4' (20.10 %), 'KIS-27' (20.83 %), 'KIS-3' (21.39 %), 'KIS-23' (21.48%), 'KIS-16' (21.48 %), 'KIS-7' (22.20 %), 'KIS-31' (22.24 %), 'KIS-28' (22.30 %), 'KIS-18' (22.47 %), 'KIS-8' (22.64 %), 'KIS-28' (22.73 %), 'KIS-24' (22.91 %), 'KIS-12' (23.14 %), 'KIS-22' (23.44 %) and 'KIS-15' (23.91 %) whereas, the highest peel percentage was recorded in 'KIS-9' (33.85 %) which was on par with 'KIS-20'

Table 4. Relative content of pulp, peel and stone in fruits of Kari Ishada selections

Selections	Pulp (%)	Peel (%)	Stone (%)	Pulp to Stone ratio	Fruit to Stone ratio	Pulp to Peel ratio
KIS-1	63.54	24.16	12.30	5.60	8.56	2.91
KIS-2	58.65	26.21	15.14	4.07	6.82	2.51
KIS-3	69.56	21.39	9.05	7.89	11.28	3.31
KIS-4	67.79	20.10	12.12	5.59	8.25	3.61
KIS-5	56.22	27.24	16.54	3.59	6.27	2.16
KIS-6	50.25	29.77	19.98	2.53	5.02	1.69
KIS-7	66.03	22.20	11.77	5.62	8.52	3.32
KIS-8	63.00	22.64	14.36	4.49	7.09	2.98
KIS-9	49.68	33.85	16.47	3.16	6.38	1.51
KIS-10	64.66	25.05	10.28	6.52	10.00	2.62
KIS-11	59.09	29.18	11.73	5.30	8.75	2.31
KIS-12	66.08	23.14	10.78	6.31	9.52	2.95
KIS-13	62.19	24.61	13.20	5.03	7.97	2.63
KIS-14	60.58	24.24	15.18	4.29	6.96	2.56
KIS-15	64.00	23.91	12.09	5.37	8.37	2.72
KIS-16	61.82	21.48	16.70	4.15	6.57	2.91
KIS-17	67.91	18.89	13.19	5.37	7.78	4.47
KIS-18	67.64	22.47	9.89	7.00	10.27	3.23
KIS-19	58.74	29.60	11.67	5.18	8.74	2.03
KIS-20	53.89	30.32	15.79	3.42	6.34	1.78
KIS-21	61.29	24.52	14.19	4.54	7.30	2.67
KIS-22	60.88	23.44	15.68	4.22	6.74	2.78
KIS-23	63.54	21.48	14.98	4.41	6.89	2.97
KIS-24	62.94	22.91	14.15	4.58	7.23	2.79
KIS-25	60.03	26.97	13.01	5.28	8.50	2.32
KIS-26	60.42	24.27	15.31	4.16	6.76	2.80
KIS-27	64.27	20.83	14.90	4.38	6.81	3.12
KIS-28	62.75	22.73	14.52	4.61	7.25	2.77
KIS-29	64.54	22.30	13.16	4.92	7.62	2.89
KIS-30	57.21	25.00	17.79	3.22	5.63	2.29
KIS-31	62.71	22.24	15.05	4.18	6.66	2.82
S.Em ±	2.37	1.66	1.37	0.56	0.64	0.32
C.D at 5%	6.84	4.80	3.96	1.60	1.85	0.92

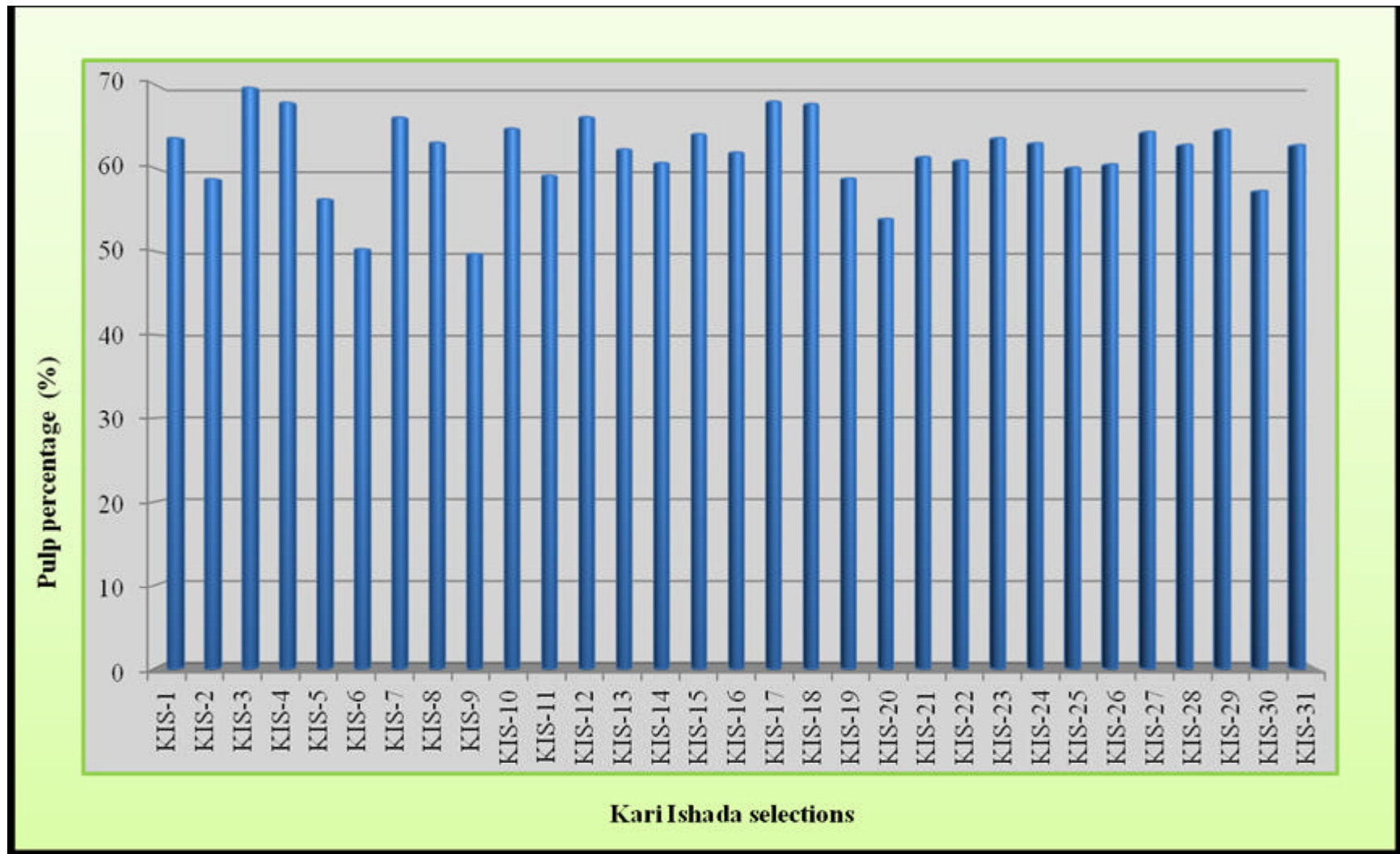


Fig. 2. Percentage of pulp in fruits of Kari Ishada selections

(30.32 %), 'KIS-6' (29.77 %), 'KIS-19' (29.60 %) and 'KIS-11' (29.18 %). Peel percentage is graphically presented in fig. 3

4.1.2.10 Stone percentage

The stone percentage was lowest in 'KIS-3' (9.05 %) which was on par with 'KIS-18' (9.89%), 'KIS-10' (10.28 %) and 'KIS-12' (10.78 %) whereas, the highest stone percentage was recorded in 'KIS-6' (19.98 %) which was on par with 'KIS-30' (17.79%). Stone percentage is graphically presented in fig. 4.

4.1.2.11 Pulp to stone ratio

The pulp to stone ratio was highest in 'KIS-3' (7.89) which was on par with 'KIS-18' (7.00), 'KIS-10' (6.52) and 'KIS-12' (6.31) whereas, the lowest pulp to stone ratio was found in 'KIS-6' (2.53) which was on par with 'KIS-9' (3.16), 'KIS-30' (3.22), 'KIS-20' (3.42) and 'KIS-5' (3.59).

4.1.2.12 Fruit to stone ratio

The fruit to stone ratio was highest in 'KIS-3' (11.28) which was on par with 'KIS-18' (10.27) and 'KIS-12' (9.52) whereas the lowest fruit to stone ratio was recorded in 'KIS-6' (5.02) which was on par with 'KIS-30' (5.63), 'KIS-5' (6.27), 'KIS-20' (6.34), 'KIS-9' (6.38), 'KIS-16' (6.57), 'KIS-22' (6.74), 'KIS-26' (6.76), 'KIS-27' (6.81). and 'KIS-2' (6.82).

4.1.2.13 Pulp to peel ratio

The pulp to peel ratio was highest in 'KIS-17' (4.47) which was on par with 'KIS-4' whereas, the lowest pulp to peel ratio was recorded in 'KIS-9' (1.51) which was on par with 'KIS-6' (1.69), 'KIS-20' (1.78%) and 'KIS-19' (2.03).

4.1.3 Stone characters

The difference among the selections was significant for the stone parameters. Data on stone physical parameters like stone weight, stone length, stone width and stone thickness are presented in table 5, plate 3 a and plate 3 b.

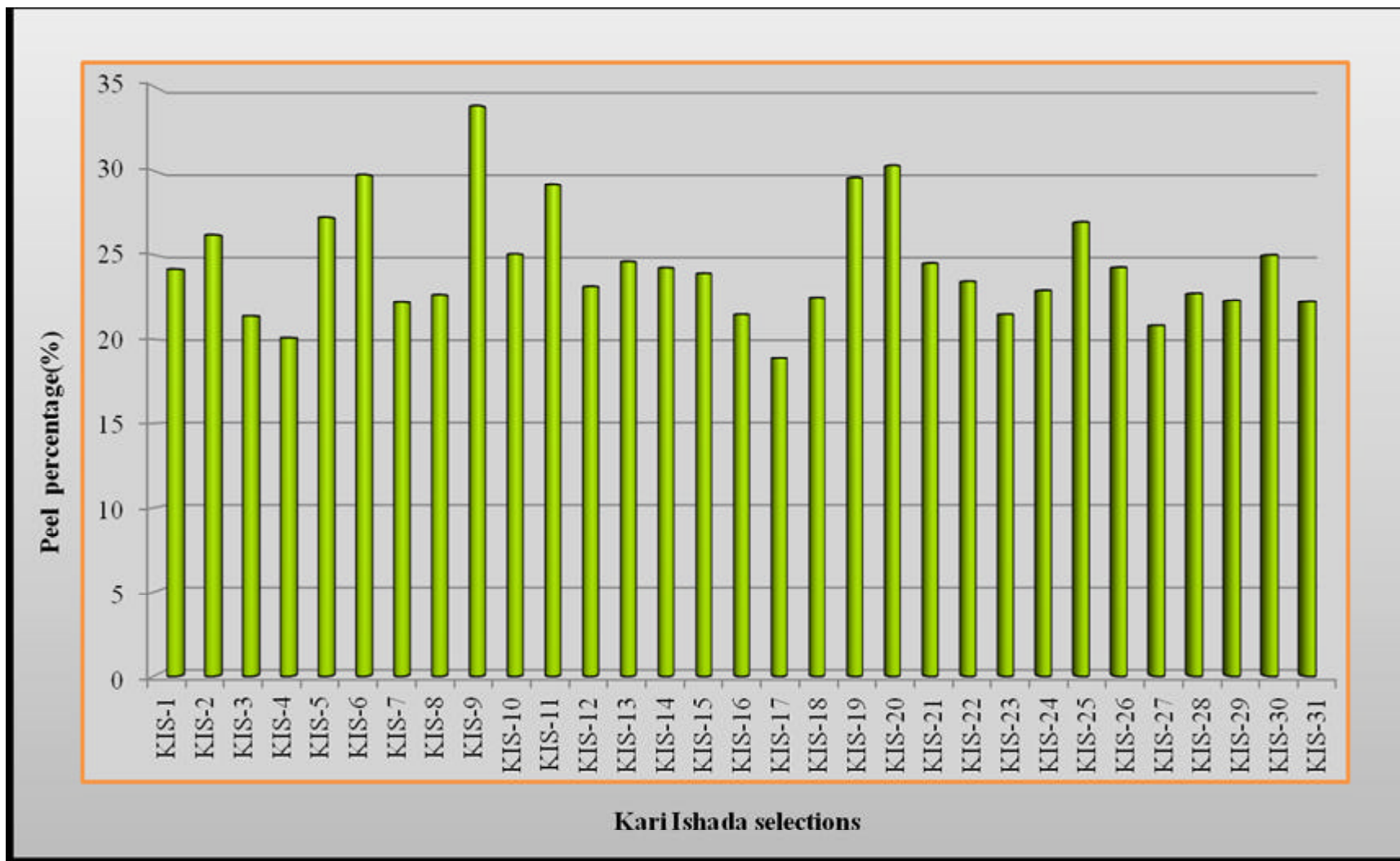


Fig. 3. Percentage of peel in fruits of Kari Ishada selections

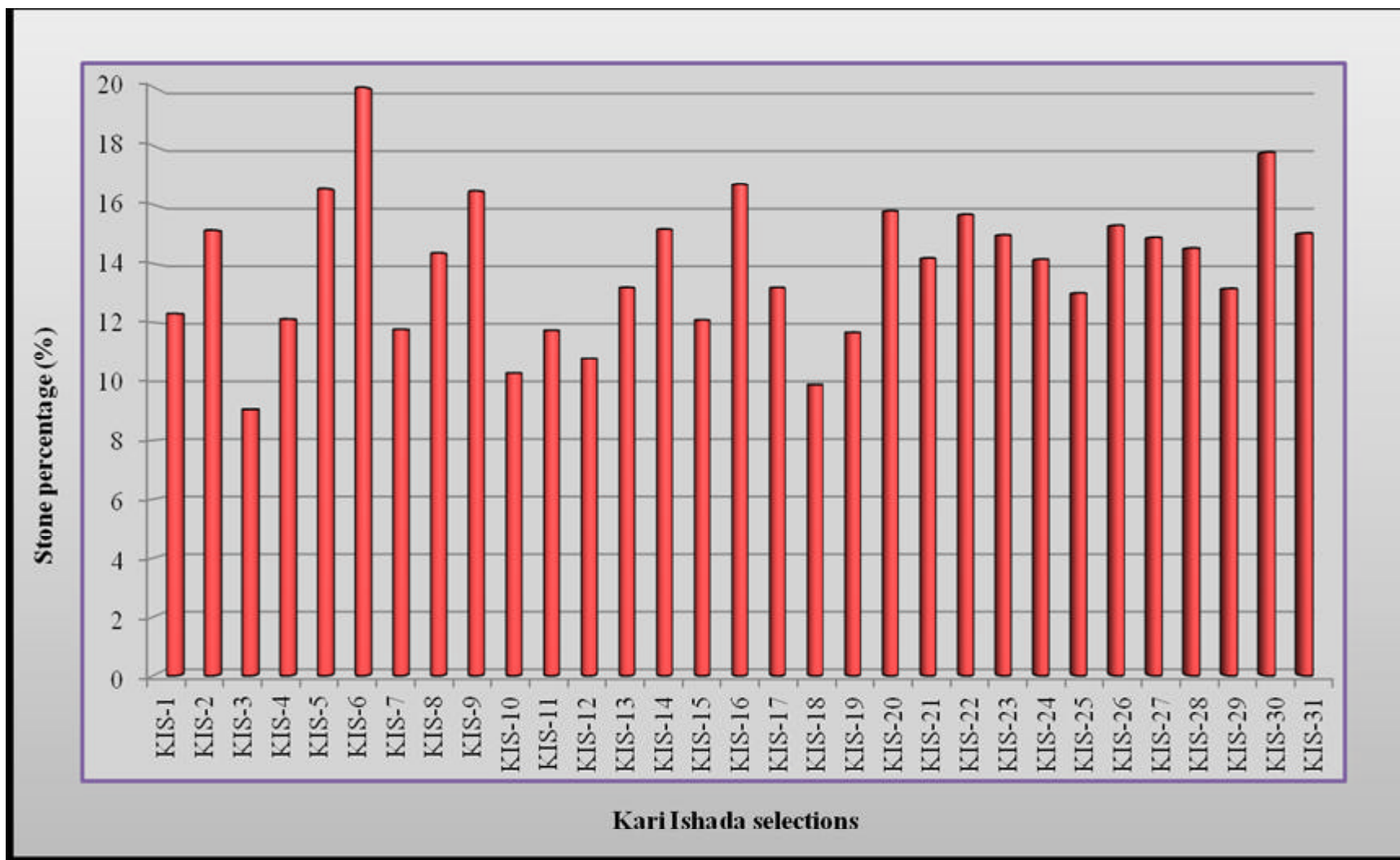


Fig. 4. Percentage of stone in fruits of Kari Ishada selections

Table 5. Stone parameters of Kari Ishada selections

Selections	Stone weight (g)	Stone length (mm)	Stone width (mm)	Stone thickness (mm)
KIS-1	50.00	70.27	43.28	24.28
KIS-2	35.67	59.72	37.95	21.47
KIS-3	40.33	63.47	38.86	23.98
KIS-4	47.50	63.26	40.41	26.20
KIS-5	49.50	64.38	39.84	25.95
KIS-6	49.49	59.08	35.51	21.10
KIS-7	38.67	60.70	38.15	23.90
KIS-8	56.58	73.74	42.39	23.92
KIS-9	45.33	61.61	38.87	29.15
KIS-10	34.58	64.20	38.13	23.48
KIS-11	29.00	60.49	36.25	20.75
KIS-12	46.08	72.10	39.98	24.30
KIS-13	36.33	61.04	37.23	21.10
KIS-14	38.58	61.28	39.04	25.63
KIS-15	34.54	63.38	36.02	22.84
KIS-16	67.50	75.30	40.92	25.31
KIS-17	34.33	62.39	37.41	20.83
KIS-18	32.79	64.39	37.42	22.28
KIS-19	33.67	62.66	38.04	18.07
KIS-20	37.50	48.81	33.25	18.49
KIS-21	39.29	59.10	36.99	22.83
KIS-22	43.50	65.06	38.20	24.22
KIS-23	50.83	66.93	38.49	24.73
KIS-24	39.17	59.18	36.56	22.85
KIS-25	56.92	69.80	42.08	25.19
KIS-26	42.67	65.37	38.70	23.13
KIS-27	41.92	65.90	40.43	22.97
KIS-28	38.67	61.23	38.50	28.79
KIS-29	33.00	55.57	35.96	22.48
KIS-30	42.67	56.70	37.99	21.00
KIS-31	37.50	55.95	36.50	20.50
S.Em ±	05.19	2.64	1.21	1.37
C.D at 5%	14.96	7.61	3.49	3.95

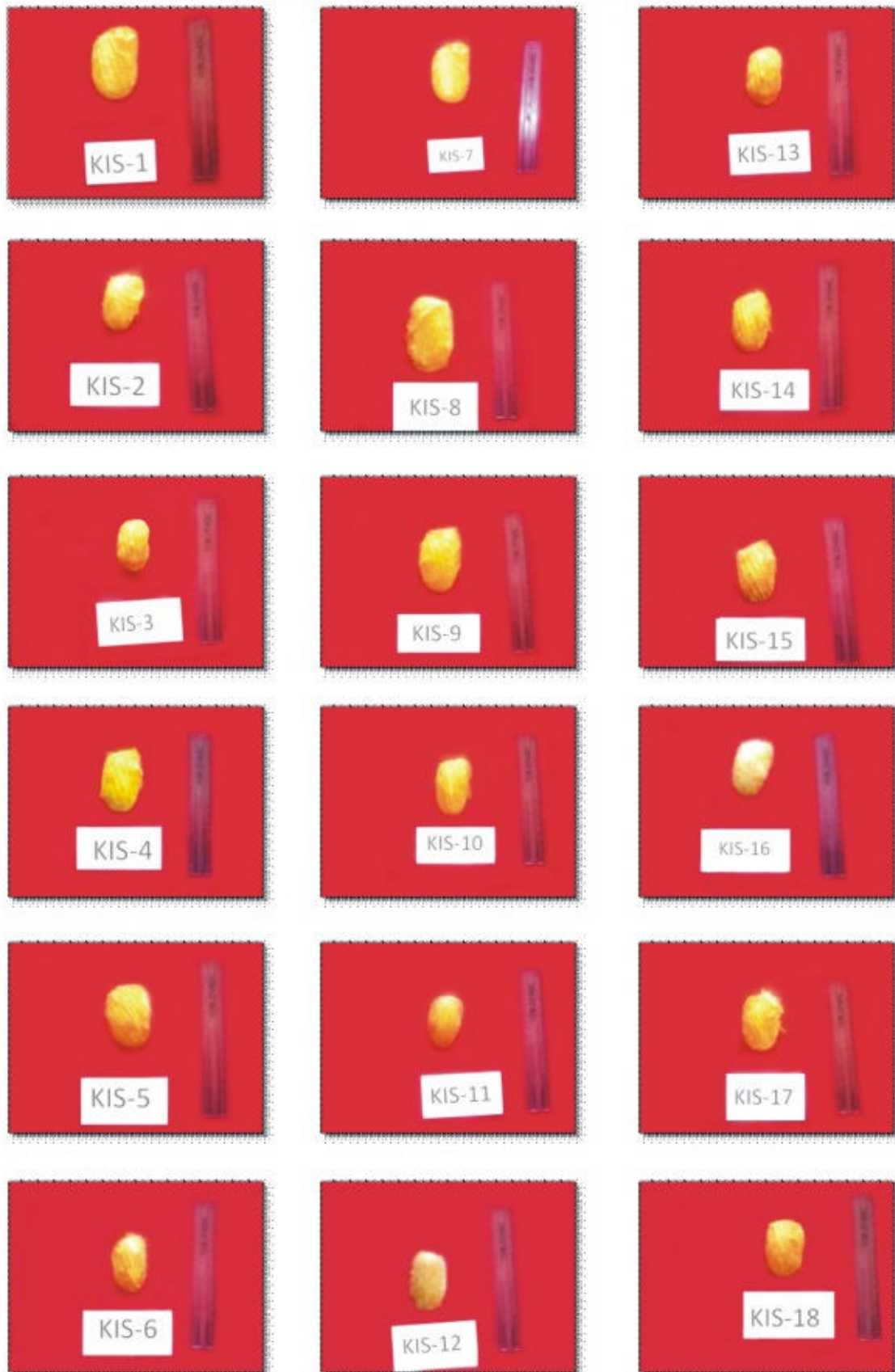
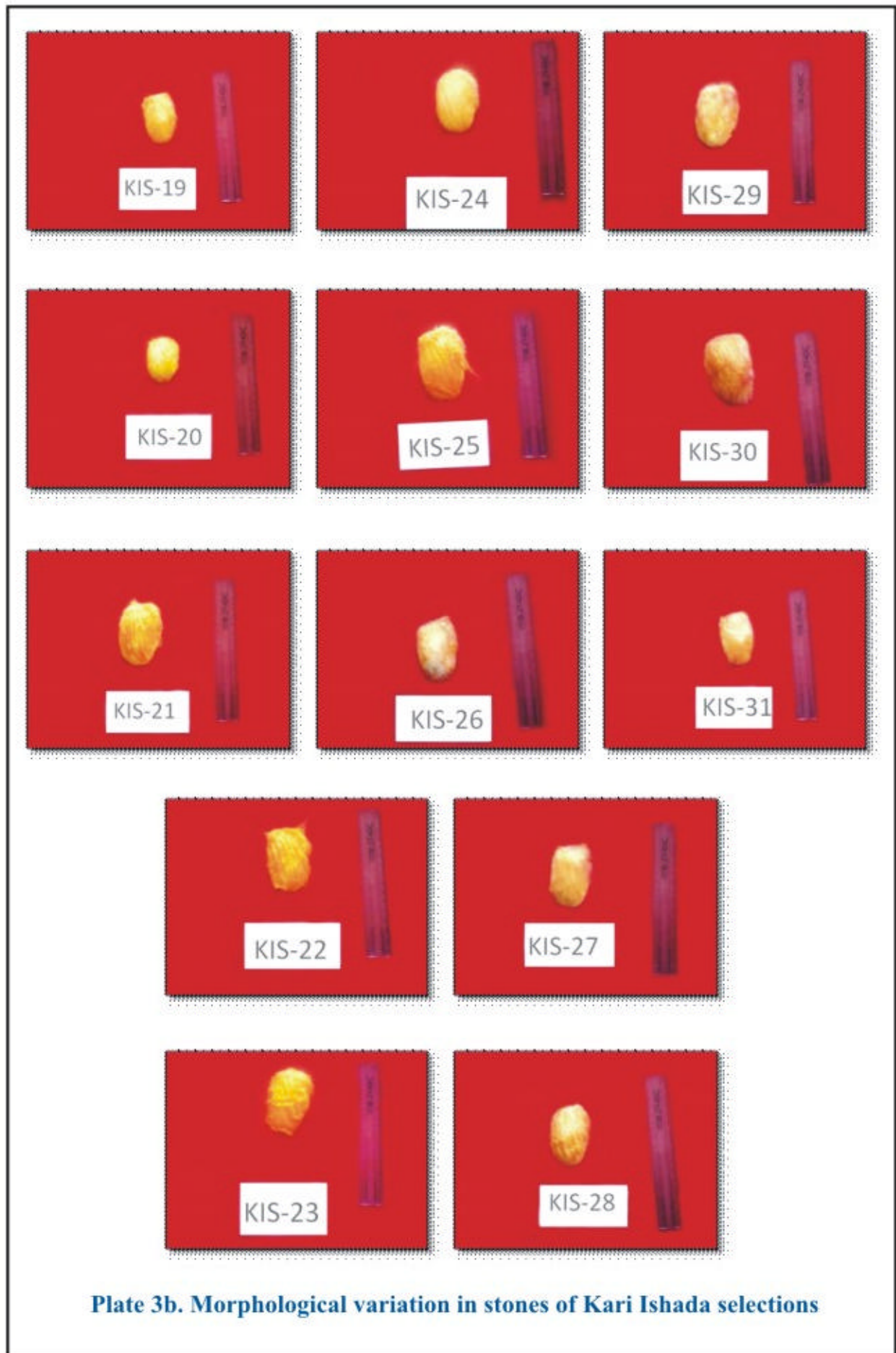


Plate 3a. Morphological variation in stones of Kari Ishada selections



4.1.3.1 Stone weight

The lowest stone weight was found in 'KIS-11' (29.00 g) which was on par with 'KIS-18' (32.79 g), 'KIS-29' (33.00 g), 'KIS-19' (33.67 g), 'KIS-17' (34.33 g), 'KIS-15' (34.54 g), 'KIS-10' (34.58 g), 'KIS-2' (35.67 g), 'KIS-13' (36.33 g), 'KIS-20' (37.50 g), 'KIS-31' (37.50 g), 'KIS-14' (38.58 g), 'KIS-7' (38.67 g), 'KIS-28' (38.67 g), 'KIS-24' (39.17 g), 'KIS-21' (39.29 g), 'KIS-3' (40.33 g), 'KIS-27' (41.92 g), 'KIS-26' (42.67 g) and 'KIS-22' (43.50 g) whereas, the highest stone weight was recorded in 'KIS-16' (67.50 g) which was on par with 'KIS-8' (56.58 g).

4.1.3.2 Stone length

The stone length was minimum in 'KIS-20' (48.81 mm) which was on par with 'KIS-29' (55.57 mm) and 'KIS-31' (55.95 mm) whereas, the maximum stone length was found in 'KIS-16' (75.30 mm) which was on par with 'KIS-8' (73.42 mm), 'KIS-12' (72.10 mm), 'KIS-1' (70.27 mm) and 'KIS-25' (69.80 mm).

4.1.3.3 Stone width

The stone width was minimum in 'KIS-20' (33.25 mm) which was on par with 'KIS-6' (35.51 mm), 'KIS-29' (35.96 mm), 'KIS-15' (36.02 mm) and 'KIS-11' (36.25 mm) whereas, the maximum stone width was recorded in 'KIS-8' (42.39 mm) which was on par with 'KIS-25' (42.08 mm) and 'KIS-16' (40.92 mm).

4.1.3.4 Stone thickness

The stone thickness was minimum in 'KIS-19' (18.07 mm) which was on par with 'KIS-20' (18.49 mm), 'KIS-11' (20.75 mm), 'KIS-17' (20.83 mm) and 'KIS-30' (21.00 mm) whereas, the maximum stone thickness was recorded in 'KIS-9' (29.15 mm) which was on par with 'KIS-28' (28.79 mm), 'KIS-4' (26.20 mm), 'KIS-5' (25.95 mm) and 'KIS-14' (25.63 mm).

4.1.4 Quality parameters

There was significant difference among the Kari Ishada selections for the quality parameters of the fruits like total soluble sugars (TSS), titrable acidity (TA), total sugars, reducing sugars, non reducing sugars and Brix acid ratio which are presented in table 6.

Table 6. Quality parameters of Kari Ishada selections

Selections	TSS (°B)	Titration acidity (%)	Total sugars (%)	Reducing sugars (%)	Non reducing sugars (%)	Brix acid ratio
KIS-1	19.17	0.40	17.32	6.18	10.58	48.24
KIS-2	17.83	0.44	15.13	5.38	09.26	41.10
KIS-3	20.92	0.35	18.39	7.65	10.20	59.61
KIS-4	20.17	0.37	19.92	6.45	12.79	54.94
KIS-5	16.17	0.45	13.16	3.11	09.55	35.79
KIS-6	17.50	0.44	14.32	4.38	09.45	40.44
KIS-7	19.22	0.35	18.02	6.87	10.59	55.61
KIS-8	15.67	0.56	13.38	2.87	09.99	28.16
KIS-9	17.00	0.43	14.60	3.96	10.10	40.00
KIS-10	16.67	0.55	13.65	3.47	09.67	30.45
KIS-11	17.90	0.43	15.38	4.04	10.77	41.29
KIS-12	16.72	0.40	14.11	3.82	09.77	41.86
KIS-13	19.75	0.33	17.31	7.05	09.74	60.36
KIS-14	18.00	0.45	16.53	4.09	11.82	39.82
KIS-15	19.17	0.34	17.44	4.87	11.93	56.19
KIS-16	18.00	0.41	15.98	4.57	10.84	43.75
KIS-17	16.75	0.45	14.33	3.48	10.30	37.31
KIS-18	17.00	0.41	15.04	3.48	10.98	41.64
KIS-19	17.00	0.44	14.88	3.10	11.19	39.05
KIS-20	17.72	0.41	14.39	3.22	10.61	43.62
KIS-21	18.92	0.40	16.74	4.67	11.46	47.47
KIS-22	17.47	0.43	16.99	4.38	11.98	40.60
KIS-23	19.42	0.39	18.28	6.32	11.36	49.25
KIS-24	22.83	0.38	21.21	7.35	13.17	61.56
KIS-25	21.17	0.34	18.64	8.09	10.02	63.66
KIS-26	17.33	0.48	15.31	4.23	10.52	35.95
KIS-27	18.39	0.41	15.92	4.56	10.79	45.05
KIS-28	15.50	0.53	12.34	2.13	09.71	29.68
KIS-29	17.42	0.47	13.51	3.21	09.79	36.84
KIS-30	16.67	0.45	13.58	2.68	10.36	37.14
KIS-31	16.30	0.47	13.36	2.88	09.95	34.35
S.Em ±	0.62	0.026	0.61	0.30	0.59	10.18
C.D at 5%	1.80	0.074	1.76	0.87	1.72	3.53

4.1.4.1 Total soluble solids (TSS)

The highest TSS was found in 'KIS-24' (22.83 °B) which was on par with 'KIS-25' (21.17 °B) whereas, the lowest TSS was recorded in 'KIS-28' (15.50 °B) which was on par with 'KIS-8' (15.67 °B), 'KIS-5' (16.17 °B) and 'KIS-31' (16.30 °B). TSS is graphically presented in fig. 5.

4.1.4.2 Titrable acidity (TA)

The titrable acidity was highest in 'KIS-8' (0.56 %) which was on par with 'KIS-10' (0.55 %) and 'KIS-28' (0.53 %) whereas, the lowest titrable acidity was found in 'KIS-13' (0.33 %) which was on par with 'KIS-25' (0.34 %) and 'KIS-15' (0.34 %).

4.1.4.3 Total sugars (%)

The total sugars was highest in 'KIS-24' (21.21 %) which was on par with 'KIS-4' (19.92 %) whereas, the lowest total sugars was recorded in 'KIS-28' (12.34 %) which was on par with 'KIS-5' (13.16 %), 'KIS-31' (13.36 %) and 'KIS-8' (13.38 %).

4.1.4.4 Reducing sugars (%)

The reducing sugars was highest in 'KIS-25' (8.09 %) which was on par with 'KIS-3' (7.65 %) and 'KIS-24' (7.35 %) whereas, the lowest reducing sugars was recorded in 'KIS-28' (2.13 %) which was on par with 'KIS-30' (2.68 %) and 'KIS-8' (2.87 %).

4.1.4.5 Non reducing sugars (%)

The non reducing sugars was highest in 'KIS-24' (13.17 %) which was on par with 'KIS-4' (12.79 %), 'KIS-22' (11.98 %), 'KIS-15' (11.93 %) and 'KIS-14' (11.82 %) and 'KIS-21' (11.46 %) whereas, the lowest non reducing sugars was found in 'KIS-2' (9.26 %) which was on par with 'KIS-6' (9.45 %) and 'KIS-5' (9.55 %).

4.1.4.6 Brix acid ratio

The Brix acid ratio was highest in 'KIS-25' (63.66) which was on par with 'KIS-24' (61.56) and 'KIS-13' (60.36) whereas, the lowest Brix acid ratio was

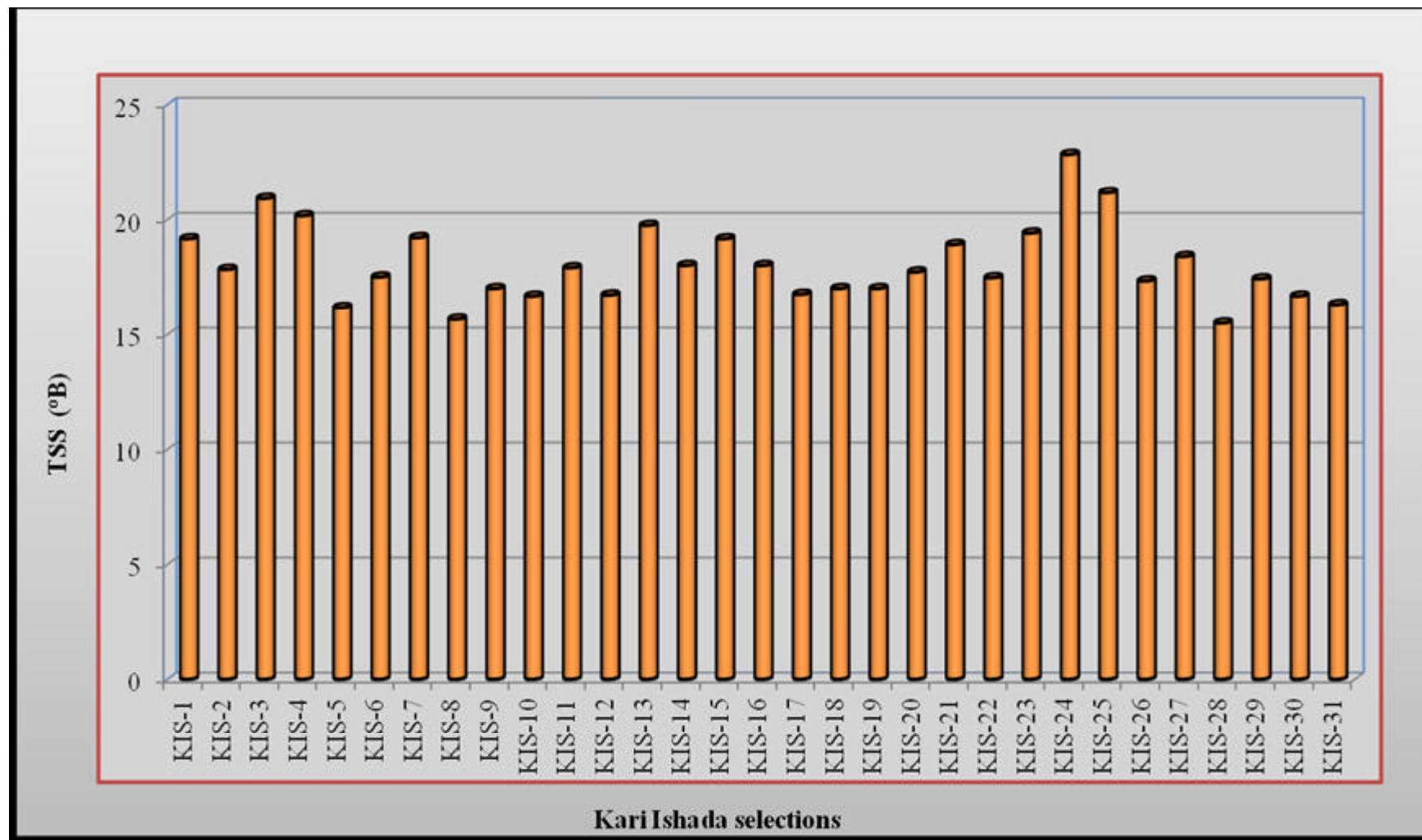


Fig. 5. TSS of Kari Ishada selections

recorded in 'KIS-8' (28.16) which was on par with 'KIS-28' (29.68) and 'KIS-10' (30.45).

4.1.5 Post harvest parameters

The post harvest qualities like physiological loss in weight (PLW), shelf life and specific gravity are shown in table 7. There was significant variation among the different Kari Ishada selections for PLW and shelf life but, the specific gravity showed non significant difference among the selections.

4.1.5.1 Physiological loss in weight (PLW)

The PLW was lowest in 'KIS-4' (3.77 %) which was on par with 'KIS-3' (4.00 %), 'KIS-7' (4.00 %) and 'KIS-12' (4.43 %) whereas, the highest PLW was recorded in 'KIS-22' (6.18 %) which was on par with 'KIS-5' (6.05 %) and 'KIS-21' (6.02 %)

4.1.5.2 Shelf life

The highest shelf life was found in 'KIS-4' (8.25 days) and 'KIS-7' (8.25 days) which was on par with 'KIS-3' (8.00 days) whereas, the lowest shelf life was found in 'KIS-22' (5.75 days), 'KIS-21' (5.75 days), 'KIS-12' (5.75 days) and 'KIS-29' (5.75 days). Shelf life is graphically presented fig. 6.

4.1.5.3 Specific gravity

There was non significant difference among the selections for the specific gravity. However, the highest specific gravity was found in 'KIS-17' (1.07 g/cc) and the lowest specific gravity was found in 'KIS-13' (1.01 g/cc), 'KIS-14' (1.01 g/cc) and 'KIS-19' (1.01 g/cc).

4.1.6 Sensory evaluation

There was significant difference for sensory evaluation scores of the Kari Ishada selections for the parameters like pulp colour, peel colour, pulp texture, taste and overall acceptance which are presented in table 8 and fig.7.

Table 7. Post harvest parameters of Kari Ishada selections

Selections	PLW (%)	Shelf life (days)	Specific gravity (g/cc)
KIS-1	4.97	7.00	1.04
KIS-2	4.95	7.50	1.05
KIS-3	4.00	8.00	1.02
KIS-4	3.77	8.25	1.03
KIS-5	6.05	6.00	1.03
KIS-6	5.75	6.25	1.02
KIS-7	4.00	8.25	1.06
KIS-8	5.14	7.00	1.05
KIS-9	5.48	6.75	1.02
KIS-10	5.08	6.75	1.03
KIS-11	4.79	7.25	1.04
KIS-12	4.43	5.75	1.02
KIS-13	5.12	7.25	1.01
KIS-14	5.64	6.50	1.01
KIS-15	5.38	6.75	1.04
KIS-16	5.25	7.00	1.03
KIS-17	5.80	6.00	1.07
KIS-18	5.32	6.75	1.05
KIS-19	5.79	6.00	1.01
KIS-20	5.76	6.25	1.02
KIS-21	6.02	5.75	1.06
KIS-22	6.18	5.75	1.02
KIS-23	5.19	6.25	1.03
KIS-24	4.88	7.25	1.04
KIS-25	5.16	7.00	1.03
KIS-26	5.03	7.00	1.04
KIS-27	4.93	7.00	1.04
KIS-28	5.24	6.75	1.02
KIS-29	5.70	5.75	1.02
KIS-30	5.37	6.75	1.03
KIS-31	5.70	7.00	1.04
S.Em ±	0.27	0.42	0.016
C.D at 5%	0.77	1.20	NS

NS=Non Significant

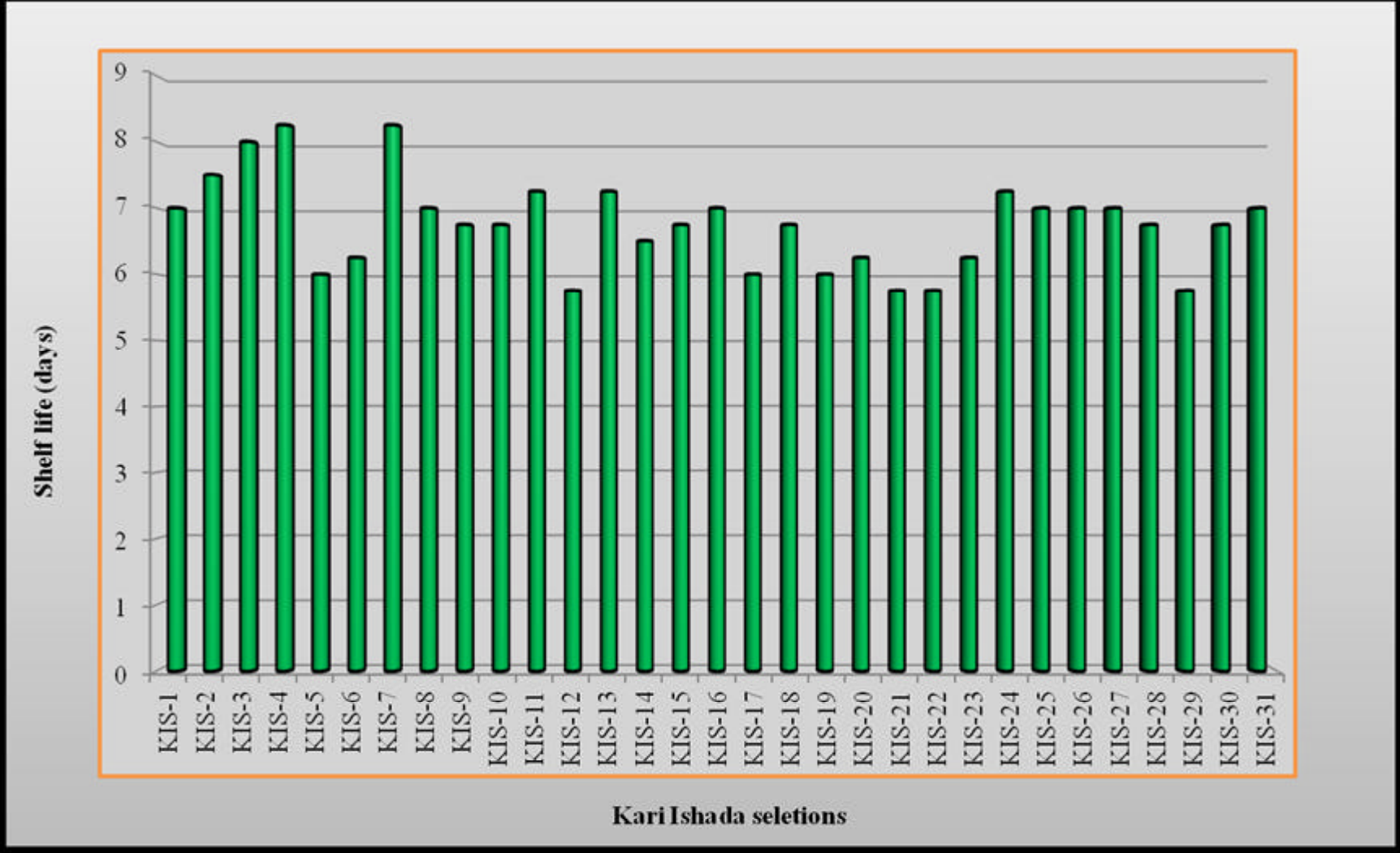


Fig. 6. Shelf life of Kari Ishada selections

Table 8. Sensory evaluation of Kari Ishada selections

Selections	Peel colour	Pulp colour	Pulp Texture	Taste	Overall acceptance
KIS-1	5.15	6.88	5.15	4.82	5.25
KIS-2	5.92	5.54	5.82	5.36	5.54
KIS-3	5.61	6.82	7.17	6.95	7.53
KIS-4	5.15	6.97	6.21	7.26	7.27
KIS-5	4.74	6.74	6.86	6.44	6.00
KIS-6	4.00	6.20	5.75	5.25	5.79
KIS-7	5.44	6.56	6.38	7.56	7.41
KIS-8	4.14	5.93	5.34	4.82	4.66
KIS-9	3.64	6.18	6.18	4.44	5.10
KIS-10	3.32	6.79	6.35	5.86	5.48
KIS-11	4.57	6.83	7.33	7.96	7.31
KIS-12	3.35	5.46	6.12	5.18	5.77
KIS-13	5.71	6.34	6.96	7.44	7.32
KIS-14	5.43	5.72	6.01	7.04	6.81
KIS-15	4.11	7.14	7.08	7.58	7.43
KIS-16	4.44	6.63	5.88	5.44	5.63
KIS-17	4.45	7.36	6.69	6.54	6.91
KIS-18	4.70	7.01	6.05	6.86	6.82
KIS-19	4.55	5.71	5.99	5.09	5.38
KIS-20	4.01	3.70	4.93	3.96	3.96
KIS-21	3.71	5.07	5.91	6.22	6.40
KIS-22	3.25	6.66	5.71	6.63	5.55
KIS-23	4.14	5.99	5.82	5.15	5.41
KIS-24	5.36	6.78	7.38	6.74	7.23
KIS-25	4.97	5.57	6.40	6.94	6.23
KIS-26	3.22	5.36	6.21	5.76	6.11
KIS-27	3.69	5.79	6.11	6.56	6.88
KIS-28	3.61	5.25	6.29	5.65	5.47
KIS-29	3.16	4.57	5.24	4.04	5.20
KIS-30	3.29	5.28	5.06	4.90	5.01
KIS-31	3.08	4.65	5.81	5.91	4.51
S.Em ±	0.30	0.35	0.31	0.29	0.34
C.D at 5%	0.87	1.01	0.89	0.82	0.98

Sensory scores: Excellent (7.1-9.0); Very good (5.1-7.0); Good (3.1-5.0); Fair (1.1-3.0) and Poor (0.0-1.0).

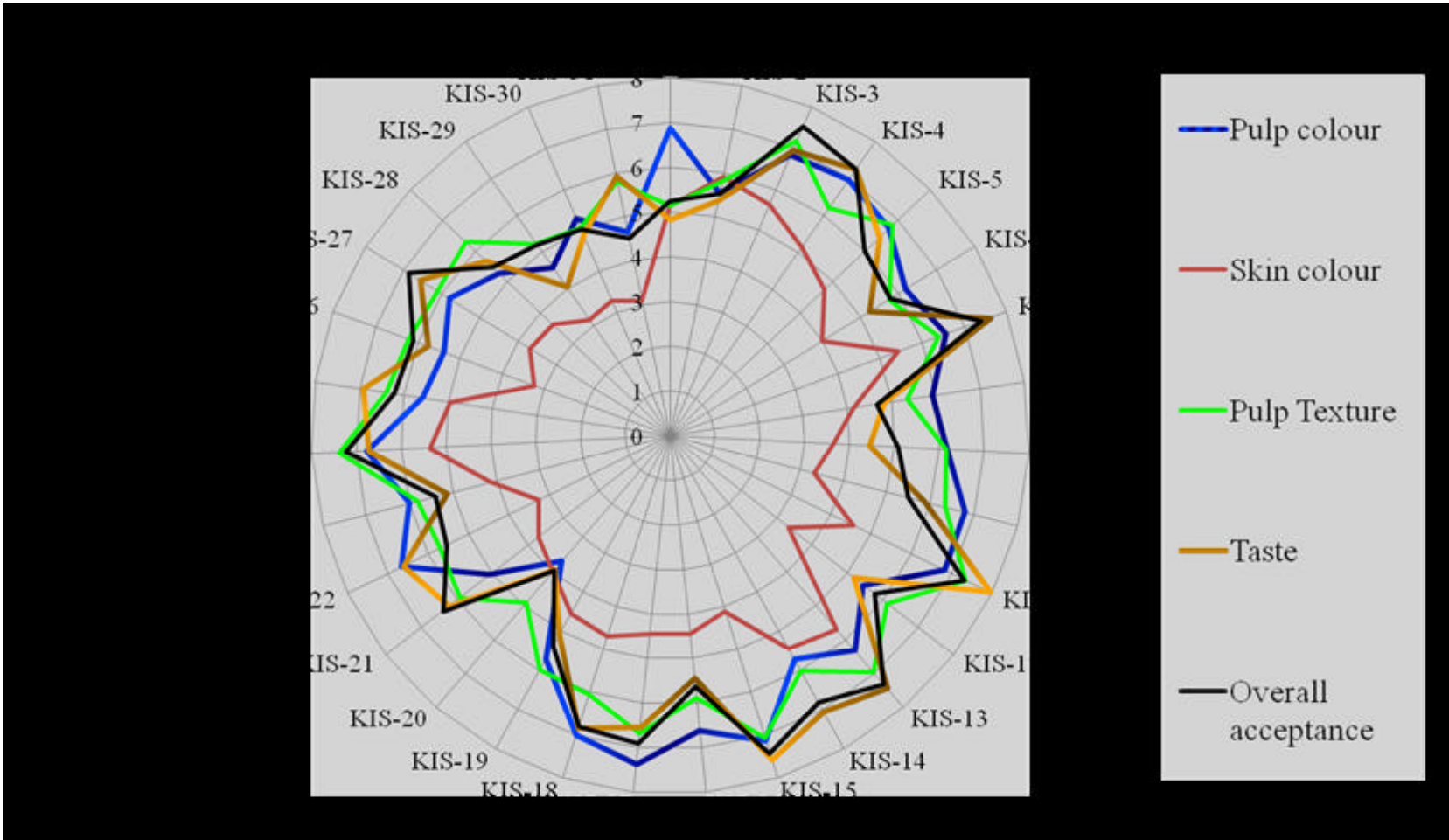


Fig. 7. Sensory evaluation of Kari Ishada selections

4.1.6.1 Peel colour

The score for peel colour was highest in 'KIS-2' (5.92) which was on par with 'KIS-13' (5.71), 'KIS-3' (5.61), 'KIS-7' (5.44), 'KIS-14' (5.43) and 'KIS-24' (5.36) whereas, the lowest score for peel colour was in 'KIS-31' (3.08) which was on par with 'KIS-29' (3.16), 'KIS-26' (3.22) 'KIS-10' (3.32) and 'KIS-12' (3.35).

4.1.6.2 Pulp colour

The score for pulp colour was highest in 'KIS-17' (7.36) which was on par with 'KIS-15' (7.14), 'KIS-4' (6.97), 'KIS-1' (6.88), 'KIS-11' (6.83), 'KIS-3' (6.82), 'KIS-10' (6.79), 'KIS-24' (6.78) and 'KIS-5' (6.74) whereas, the lowest score for pulp colour was found in 'KIS-20' (3.70) which was on par with 'KIS-29' (4.57) and 'KIS-31' (4.65).

4.1.6.3 Texture

The score for pulp texture was highest in 'KIS-24' (7.38) which was on par with 'KIS-11' (7.33), 'KIS-3' (7.17), 'KIS-15' (7.08), 'KIS-13' (6.96), 'KIS-5' (6.86) and 'KIS-17' (6.69) whereas, the lowest score for texture was found in 'KIS-20' (4.93) which was on par with 'KIS-30' (5.06), 'KIS-1' (5.15), 'KIS-29' (5.24), 'KIS-8' (5.34) and 'KIS-22' (5.71)

4.1.6.4 Taste

The score for taste was highest in 'KIS-11' (7.96) which was on par with 'KIS-15' (7.58), 'KIS-7' (7.56), 'KIS-13' (7.44) and 'KIS-4' (7.26) whereas, the lowest score for taste was recorded in 'KIS-20' (3.96) which was on par with 'KIS-29' (4.04) and 'KIS-9' (4.44).

4.1.6.5 Overall acceptance

The score for overall acceptance was highest in 'KIS-3' (7.53) which was on par with 'KIS-15' (7.43), 'KIS-7' (7.41), 'KIS-13' (7.32) and 'KIS-4' (7.27) whereas, the lowest score for overall acceptance was recorded in 'KIS-20' (3.96) which was on par with 'KIS-31' (4.51) and 'KIS-8' (4.66).

4.2 Experiment-II: Grafting studies of Kari Ishada selections

Based on the morphological and qualitative characters of the fruits, the selections 'KIS-3', 'KIS-4', 'KIS-7', 'KIS-11', 'KIS-13', 'KIS-15', 'KIS-17', 'KIS-24', 'KIS-27' and 'KIS-25' were superior with better traits among the 31 Kari Ishada selections in the present study. These ten selections were further studied for their response to grafting methods *viz.*, stone grafting and softwood grafting. The results obtained are presented here.

4.2.1 Graft success

The difference in the graft success was significant among the grafting methods, Kari Ishada selections and the interaction between the Kari Ishada selections and the grafting methods (Table 9 and fig. 8).

The graft success was high in stone grafting (62.00 %) compared to graft success of softwood grafting (53.50 %)

The highest graft success was noted in 'KIS-15' (75.00 %) which was on par with 'KIS-27' (72.50 %) and 'KIS-25' (70.00 %) while the lowest graft success was recorded in 'KIS-7' (40.00 %) which was on par with 'KIS-24' (45.00 %) and 'KIS-13' (45.00).

The interaction effect showed that, the stone grafting of 'KIS-15' got the highest graft success (85.00 %) which was on par with stone grafting of 'KIS-25' (75.00 %) and softwood grafting of 'KIS-27' (75.00 %) whereas, the lowest graft success was found in softwood grafting of 'KIS-7' (35.00 %) which was on par with softwood grafting of 'KIS-13' (40.00 %), stone grafting of 'KIS-7' (45.00 %), stone grafting of 'KIS-24' (45.00 %) and softwood grafting of 'KIS-24' (45.00 %).

4.2.2 Graft survival

The data related to the graft survival is presented in table 9. The graft survival was significantly different among the grafting methods (Stone grafting and softwood grafting). Graft survival showed non significant difference among the different Kari Ishada selections and their interaction with the grafting methods.

Table 9. Effect of grafting methods on graft success and graft survival of Kari Ishada selections

Selections	Graft success (%)			Graft survival (%)		
	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)
	Stone grafting	Softwood grafting		Stone grafting	Softwood grafting	
KIS-3	65.00 (53.78)	65.00 (53.78)	65.00 (53.78)	53.57 (47.05)	61.90 (51.92)	57.74 (49.49)
KIS-4	65.00 (53.78)	40.00 (39.23)	52.50 (46.51)	69.05 (56.21)	50.00 (45.00)	59.52 (50.61)
KIS-7	45.00 (42.12)	35.00 (36.22)	40.00 (39.17)	55.00 (47.88)	45.83 (42.37)	50.42 (45.13)
KIS-11	65.00 (53.78)	50.00 (45.00)	57.50 (49.39)	69.05 (56.21)	60.00 (50.77)	64.52 (53.49)
KIS-13	50.00 (45.00)	40.00 (39.23)	45.00 (42.12)	70.83 (57.31)	62.50 (52.50)	66.67 (54.93)
KIS-15	85.00 (67.50)	65.00 (53.78)	75.00 (60.64)	76.39 (60.94)	61.90 (51.92)	69.15 (56.43)
KIS-17	55.00 (47.88)	55.00 (47.88)	55.00 (47.88)	73.33 (59.09)	63.33 (52.75)	68.33 (55.92)
KIS-24	45.00 (42.12)	45.00 (42.12)	45.00 (42.12)	67.50 (55.38)	55.00 (47.88)	61.25 (51.63)
KIS-25	75.00 (60.11)	65.00 (53.78)	70.00 (56.95)	59.82 (50.67)	46.43 (42.95)	53.13 (46.81)
KIS-27	70.00 (57.10)	75.00 (60.11)	72.50 (58.61)	72.92 (59.07)	66.96 (54.96)	69.94 (57.02)
Mean (Grafting method)	62.00 (52.32)	53.50 (47.11)		66.75 (54.99)	57.39 (49.30)	
	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)
S.Em ±	1.38 (0.84)	3.09 (1.88)	4.38 (2.67)	2.26 (1.37)	5.04 (3.06)	7.05 (4.33)
C.D at 5%	4.10 (2.50)	9.16 (5.58)	12.95 (7.89)	6.68 (4.05)	NS	NS

NS=Non Significant.

Graft success and graft survival was recorded on the 60th and 90th day after grafting, respectively.

Values in parenthesis are arc sign transformation data.

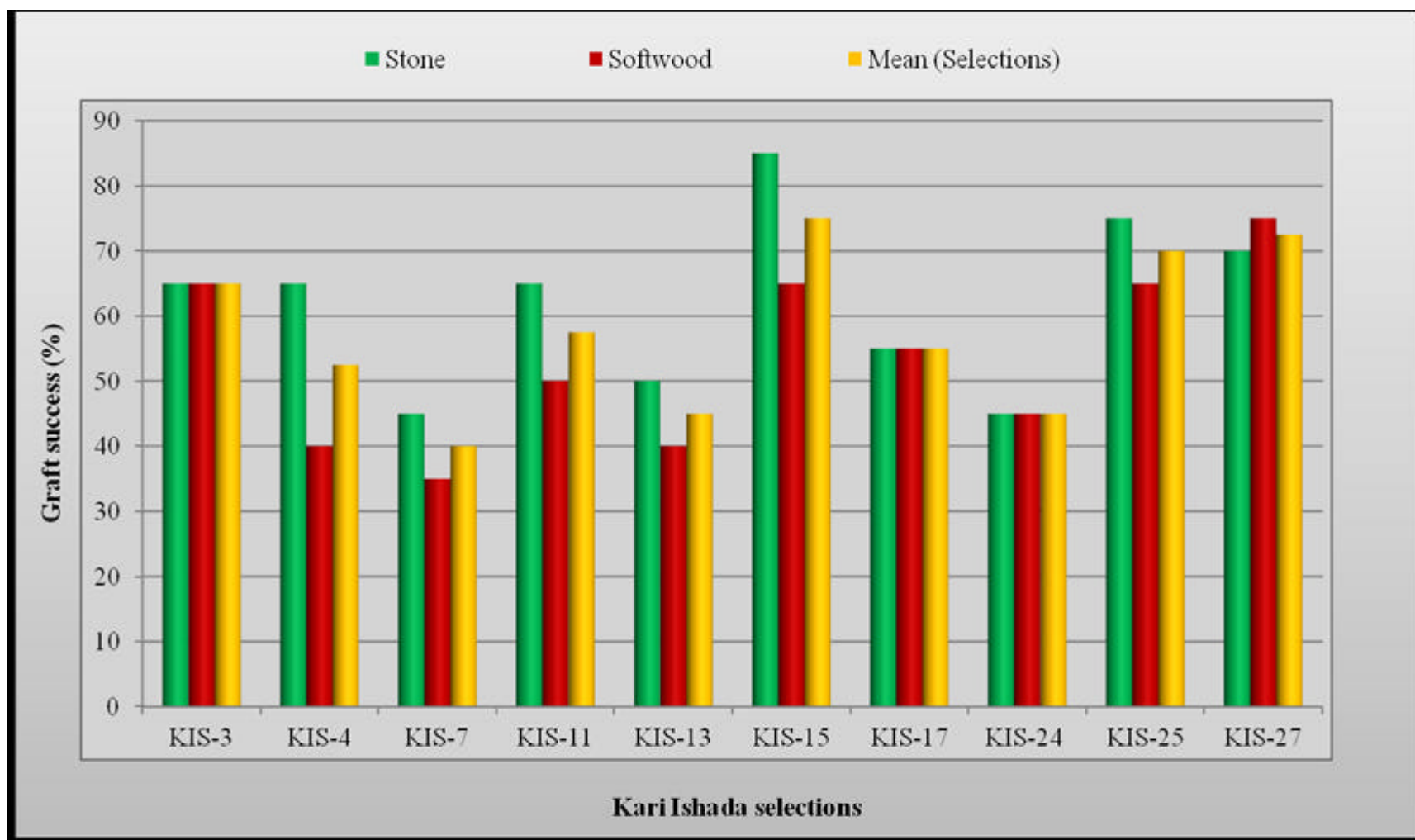


Fig. 8. Graft success of Kari Ishada selections

Graft survival was highest in stone grafting (66.75 %) and lowest graft survival was recorded in softwood grafting (57.39 %).

There was non significant difference among the Kari Ishada selections for the graft survival. However, the maximum graft survival was recorded in 'KIS-27' (69.94 %) and the minimum graft survival was found in 'KIS-7' (50.42 %).

Non significant difference was found in the interaction of grafting methods and the Kari Ishada selections. However, the maximum graft survival was recorded in stone grafting of 'KIS-15' (76.39 %) and the minimum graft survival was found in softwood grafting of 'KIS-7' (45.83 %).

4.2.3 Number of days for sprouting

Table 10 presents the number of days for sprouting in different treatments. The difference in the number of days for sprouting was significant among the grafting methods, Kari Ishada selections and their interaction.

The number of days taken for sprouting was minimum in stone grafting (14.50) and the maximum number of days for sprouting was recorded in softwood grafting (16.10).

The number of days taken for sprouting was minimum in 'KIS-15' (13.47) which was followed by 'KIS-27' (13.90) whereas, the maximum number of days for sprouting was recorded in 'KIS-7' (17.20) which was followed by 'KIS-24' (16.40) and 'KIS-13' (16.34) which were on par with each other.

The minimum number of days taken for sprouting was recorded in stone grafting of 'KIS-15' (12.41) which was followed by stone grafting of 'KIS-25' (13.06) and stone grafting of 'KIS-27' (13.41) which were on par with each other whereas the maximum number of days taken for sprouting was recorded in softwood grafting of 'KIS-7' (18.33) which was followed by softwood grafting of 'KIS-4' (17.90).

4.2.4 Graft height

The data pertaining to average graft height is presented in table 11. The graft height was significantly different among the grafting methods, Kari Ishada selections

Table 10. Effect of grafting methods on number of days taken for sprouting of Kari Ishada selections

Number of days taken for sprouting			
Selections	Grafting method		Mean (Selections)
	Stone grafting	Softwood grafting	
KIS-3	13.78	15.15	14.47
KIS-4	14.16	17.90	16.03
KIS-7	16.07	18.33	17.20
KIS-11	14.72	16.10	15.41
KIS-13	15.80	16.88	16.34
KIS-15	12.41	14.54	13.47
KIS-17	15.18	15.82	15.50
KIS-24	16.36	16.45	16.40
KIS-25	13.06	15.46	14.26
KIS-27	13.41	14.40	13.90
Mean (Grafting method)	14.50	16.10	
	Grafting method (G)	Selections (S)	Interaction (GxS)
S.Em ±	0.04	0.09	0.13
C.D at 5%	0.12	0.26	0.37

Table 11. Effect of grafting methods on graft height of Kari Ishada selections

Selections	Graft height (cm)								
	30 DAG			60 DAG			90 DAG		
	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)
	Stone grafting	Softwood grafting		Stone grafting	Softwood grafting		Stone grafting	Softwood grafting	
KIS-3	13.65	23.75	18.70	16.75	25.16	20.96	24.05	29.38	26.71
KIS-4	13.50	20.42	16.96	16.39	21.72	19.05	23.63	24.23	23.93
KIS-7	12.35	18.63	15.49	14.62	21.40	18.01	21.62	23.31	22.46
KIS-11	13.17	22.25	17.71	16.49	24.22	20.35	23.13	26.35	24.74
KIS-13	12.53	20.61	16.57	15.58	22.20	18.89	22.63	25.67	24.15
KIS-15	15.00	24.42	19.71	17.62	27.92	22.77	25.48	33.79	29.63
KIS-17	12.55	22.84	17.69	15.95	24.42	20.19	22.93	26.95	24.94
KIS-24	11.60	20.99	16.29	14.22	22.42	18.32	20.54	25.82	23.18
KIS-25	14.50	23.08	18.79	17.77	24.38	21.08	25.05	28.07	26.56
KIS-27	14.00	25.75	19.88	17.09	29.57	23.33	24.43	34.10	29.26
Mean (Grafting method)	13.28	22.27		16.25	24.34		23.35	27.77	
	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)
S.Em ±	0.09	0.19	0.27	0.11	0.25	0.36	0.19	0.42	0.59
C.D at 5%	0.25	0.57	0.81	0.33	0.74	1.05	0.55	1.23	1.75

DAG – Days after grafting.

and their interaction on 30th, 60th and 90th day after grafting. There was gradual increase in the graft height from 30th to 90th day after grafting.

Among the two grafting methods, the graft height was highest in softwood grafting on 30th (22.27 cm), 60th (24.34 cm) and 90th day after grafting (27.77 cm) whereas, the lowest graft height was recorded in stone grafting on 30th (13.28 cm), 60th (16.25 cm) and 90th day after grafting (23.35 cm).

Among the Kari Ishada selections, the graft height on 30th day after grafting was highest in 'KIS-27' (19.88 cm) which was on par with 'KIS-15' (19.71 cm) and lowest graft height was recorded in 'KIS-7' (15.49 cm) which was followed by 'KIS-24' (16.29 cm). On the 60th day after grafting, the graft height was maximum in 'KIS-27' (23.33 cm) which was on par with 'KIS-15' (22.77 cm) whereas, minimum graft height was recorded in 'KIS-7' (18.01 cm) which was on par with 'KIS-24' (18.32 cm). On the 90th day after grafting, the graft height was highest in 'KIS-15' (29.63 cm) which was on par with 'KIS-27' (29.26 cm) and the lowest graft height was recorded in 'KIS-7' (22.46 cm) which was on par with 'KIS-24' (23.93 cm).

The interaction of the grafting methods and the Kari Ishada selections showed that, the graft height on the 30th day after grafting was highest in softwood grafting of 'KIS-27' (25.75 cm) which was followed by softwood grafting of 'KIS-15' (24.42 cm) while the lowest graft height was recorded in stone grafting of 'KIS-24' (11.60 cm) which was on par with stone grafting of 'KIS-7' (12.35 cm). On the 60th day after grafting, the graft height was highest in softwood grafting of 'KIS-27' (29.57 cm) which was followed by softwood grafting of 'KIS-15' (27.92 cm) while the lowest graft height was recorded in stone grafting of 'KIS-24' (14.22 cm) which was on par with stone grafting of 'KIS-7' (14.62 cm). On the 90th day after grafting, the graft height was highest in softwood grafting of 'KIS-27' (34.10 cm) which was on par with softwood grafting of 'KIS-15' (33.79 cm) while the lowest graft height was recorded in stone grafting of 'KIS-24' (20.54 cm) which was on par with stone grafting of 'KIS-7' (21.62 cm).

4.2.5 Number of sprouts per graft

The data on average number of sprouts per graft is presented in table 12. The number of sprouts was significantly different among the grafting methods, Kari

Table 12. Effect of grafting methods on number of sprouts of Kari Ishada selections

Selections	Number of sprouts								
	30 DAG			60 DAG			90 DAG		
	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)
	Stone grafting	Softwood grafting		Stone grafting	Softwood grafting		Stone grafting	Softwood grafting	
KIS-3	1.47	1.35	1.41	1.73	1.68	1.70	2.02	1.75	1.88
KIS-4	1.37	1.10	1.24	1.66	1.28	1.43	1.97	1.45	1.71
KIS-7	1.20	1.10	1.15	1.33	1.20	1.30	1.52	1.25	1.39
KIS-11	1.35	1.15	1.25	1.65	1.27	1.46	1.89	1.40	1.64
KIS-13	1.11	1.10	1.11	1.44	1.25	1.35	1.65	1.38	1.51
KIS-15	1.85	1.42	1.63	2.05	1.76	1.90	2.45	2.10	2.28
KIS-17	1.31	1.22	1.27	1.59	1.40	1.50	1.75	1.51	1.63
KIS-24	1.10	1.15	1.13	1.26	1.40	1.33	1.44	1.45	1.44
KIS-25	1.66	1.26	1.46	1.97	1.46	1.71	2.28	1.60	1.94
KIS-27	1.65	1.58	1.61	1.75	1.94	1.85	2.15	2.38	2.27
Mean (Grafting method)	1.41	1.24		1.64	1.46		1.91	1.63	
	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)
S.Em ±	0.02	0.04	0.05	0.02	0.04	0.06	0.02	0.05	0.07
C.D at 5%	0.05	0.11	0.16	0.05	0.12	0.17	0.07	0.15	0.21

DAG – Days after grafting.

Ishada selections and their interaction on 30th, 60th and 90th day after grafting. There was gradual increase of the number of sprouts from 30th to 90th day after grafting.

Among the two grafting methods, the number of sprouts was highest in stone grafting on 30th (1.41), 60th (1.64) and 90th day after grafting (1.91) whereas, the lowest number of sprouts was recorded in softwood grafting on 30th (1.24), 60th (1.46) and 90th day after grafting (1.63).

Among the Kari Ishada selections, the number of sprouts on 30th day after grafting was highest in 'KIS-15' (1.63) which was on par with 'KIS-27' (1.61) while the lowest number of sprouts was recorded in 'KIS-13' (1.11) which was on par with 'KIS-24' (1.13) and 'KIS-7' (1.15). On the 60th day after grafting, the maximum number of sprouts was recorded in 'KIS-15' (1.90) which was on par with 'KIS-27' (1.85) while the minimum number of sprouts was recorded in 'KIS-7' (1.30) which was on par with 'KIS-24' (1.33) and 'KIS-13' (1.35). On the 90th day after grafting, the maximum number of sprouts was recorded in 'KIS-15' (2.28) which was on par with 'KIS-27' (2.27) while the minimum number of sprouts was recorded in 'KIS-7' (1.39) which was on par with 'KIS-24' (1.44) and 'KIS-13' (1.51).

The interaction of grafting methods and the Kari Ishada selections showed that, the number of sprouts on the 30th day after grafting was maximum in stone grafting of 'KIS-15' (1.85) which was followed by stone grafting of 'KIS-25' (1.66) and stone grafting of 'KIS-27' (1.65) which were on par with each other whereas, the minimum number of sprouts was recorded in softwood grafting of 'KIS-7' (1.10), softwood grafting of 'KIS-13' (1.10), softwood grafting of 'KIS-4' (1.10) and stone grafting of 'KIS-24' (1.10) which were on par with stone grafting of 'KIS-13' (1.11), softwood grafting of 'KIS-11' (1.15), softwood grafting of 'KIS-24' (1.15), softwood grafting of KIS-17 (1.22) and softwood grafting of 'KIS-25' (1.26). On the 60th day after grafting, the maximum number of sprouts was recorded in stone grafting of 'KIS-15' (2.05) which was on par with stone grafting of 'KIS-25' (1.97) and softwood grafting of 'KIS-27' (1.94) whereas, the minimum number of sprouts was recorded in softwood grafting of 'KIS-7' (1.20) which was on par with softwood grafting of 'KIS-13' (1.25), stone grafting of 'KIS-24' (1.26), softwood grafting of 'KIS-11' (1.27), softwood grafting of 'KIS-4' (1.28) and stone grafting of 'KIS-7' (1.33). On the 90th day after grafting, the maximum number of sprouts was recorded

in stone grafting of 'KIS-15' (2.45) which was on par with softwood grafting of 'KIS-27' (2.38) and stone grafting of 'KIS-25' (2.28) whereas, the minimum number of sprouts was recorded in softwood grafting of 'KIS-7' (1.25) which was on par with softwood grafting of 'KIS-13' (1.38), softwood grafting of 'KIS-11' (1.40), stone grafting of 'KIS-24' (1.44), softwood grafting of 'KIS-4' (1.45) and softwood grafting of 'KIS-24' (1.45).

4.2.6 Number of leaves per graft

The data on average number of leaves per graft is presented in table 13. The number of leaves was significantly different among the grafting methods, Kari Ishada selections and their interaction on 30th, 60th and 90th day after grafting. There was gradual increase of the number of leaves from 30th to 90th day after grafting.

Among the two grafting methods, the number of leaves per graft was highest in stone grafting on 30th (5.46), 60th (7.20) and 90th day after grafting (8.76) whereas, the lowest number of leaves per graft was found in softwood grafting on 30th (4.74), 60th (6.69) and 90th day after grafting (8.24).

Among the Kari Ishada selections, the number of leaves on 30th day after grafting was highest in 'KIS-15' (6.48) which was on par with 'KIS-27' (6.24) and 'KIS-25' (6.12) while the lowest number of leaves per graft was recorded in 'KIS-7' (3.48) which was followed by 'KIS-13' (4.15). On the 60th day after grafting, the highest number of leaves was recorded in 'KIS-15' (8.32) which was on par with 'KIS-25' (8.16) and 'KIS-27' (8.09) while the lowest number of leaves per graft was found in 'KIS-7' (5.35) which was on par with 'KIS-24' (5.60). On the 90th day after grafting, the highest number of leaves was recorded in 'KIS-15' (9.82) which was on par with 'KIS-27' (9.55) and 'KIS-25' (9.32) while the lowest number of leaves per graft was found in 'KIS-7' (7.01) which was on par with 'KIS-24' (7.51).

The interaction of the grafting methods and the Kari Ishada selections showed that, on the 30th day after grafting, the highest number of leaves was recorded in stone grafting of 'KIS-15' (7.18) which was on par with stone grafting of 'KIS-25' (6.86) whereas, the lowest number of leaves per graft was recorded in softwood grafting of 'KIS-7' (3.26) which was on par with softwood grafting of 'KIS-4' (3.45), stone grafting of 'KIS-7' (3.69), stone grafting of 'KIS-24' (3.71) and softwood grafting of

Table 13. Effect of grafting methods on number of leaves of Kari Ishada selections

Selections	Number of leaves								
	30 DAG			60 DAG			90 DAG		
	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)
	Stone grafting	Softwood grafting		Stone grafting	Softwood grafting		Stone grafting	Softwood grafting	
KIS-3	6.15	5.72	5.93	8.05	7.50	7.77	9.37	8.77	9.07
KIS-4	5.75	3.45	4.60	7.45	5.68	6.56	8.95	6.81	7.88
KIS-7	3.69	3.26	3.48	5.28	5.42	5.35	7.35	6.67	7.01
KIS-11	5.26	4.75	5.00	7.17	6.38	6.77	8.50	8.32	8.41
KIS-13	4.53	3.77	4.15	5.86	5.82	5.84	8.07	7.98	8.02
KIS-15	7.18	5.78	6.48	9.07	7.56	8.32	10.40	9.25	9.82
KIS-17	5.15	4.95	5.05	6.72	7.31	7.02	8.33	8.46	8.39
KIS-24	3.71	4.17	3.94	5.12	6.08	5.60	6.85	8.17	7.51
KIS-25	6.86	5.38	6.12	8.89	7.44	8.16	10.03	8.61	9.32
KIS-27	6.32	6.17	6.24	8.40	7.77	8.09	9.73	9.37	9.55
Mean (Grafting method)	5.46	4.74		7.20	6.69		8.76	8.24	
	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)
S.Em ±	0.06	0.13	0.19	0.06	0.12	0.18	0.09	0.20	0.28
C.D at 5%	0.18	0.40	0.56	0.16	0.37	0.52	0.26	0.59	0.84

DAG – Days after grafting.

'KIS-13' (3.77). On the 60th day after grafting, the highest number of leaves was recorded in stone grafting of 'KIS-15' (9.07) which was on par with stone grafting of 'KIS-25' (8.89) whereas, the lowest number of leaves per graft was recorded in stone grafting of 'KIS-24' (5.12) which was on par with stone grafting of 'KIS-7' (5.28) and softwood grafting of 'KIS-7' (5.42). On the 90th day after grafting, the highest number of leaves was recorded in stone grafting of 'KIS-15' (10.40) which was on par with stone grafting of 'KIS-25' (10.03) and stone grafting of 'KIS-27' (9.73) whereas, the lowest number of leaves per graft was found in softwood grafting of 'KIS-7' (6.67) which was on par with softwood grafting of 'KIS-4' (6.80), stone grafting of 'KIS-24' (6.85) and stone grafting of 'KIS-7' (7.35).

4.2.7 Shoot girth

The data pertaining to average shoot girth is presented in table 14. The shoot girth was significantly different among the grafting methods, Kari Ishada selections and their interaction on 30th, 60th and 90th day after grafting. There was a gradual increase of the shoot girth from 30th to 90th day after grafting.

Among the two grafting methods, the shoot girth was highest in stone grafting on 30th (4.24 mm), 60th (5.12 mm) and 90th after grafting (5.68 mm) whereas, the lowest shoot girth was found in softwood grafting on 30th (4.00 mm), 60th (4.76 mm) and 90th day after grafting (5.16 mm).

Among the Kari Ishada selections, the shoot girth on 30th day after grafting was highest in 'KIS-15' (4.65 mm) which was on par with 'KIS-25' (4.53 mm), 'KIS-27' (4.53 mm) and 'KIS-3' (4.43 mm) whereas, the lowest shoot girth was recorded in 'KIS-7' (3.46 mm) which was on par with 'KIS-24' (3.67 mm). On the 60th day after grafting, the shoot girth was maximum in 'KIS-15' (5.70 mm) which was on par with 'KIS-27' (5.58 mm) whereas, the minimum shoot girth was recorded in 'KIS-7' (4.12 mm) which was followed by 'KIS-24' (4.41 mm). On the 90th day after grafting, the shoot girth was maximum in 'KIS-15' (6.31 mm) which was on par with 'KIS-27' (6.21 mm) whereas, the minimum shoot girth was recorded in 'KIS-7' (4.52 mm) which was followed by 'KIS-24' (4.86 mm).

The interaction of the grafting methods and the Kari Ishada selections showed that, on the 30th day after grafting, the shoot girth was highest in stone grafting of

Table 14. Effect of grafting methods on shoot girth of Kari Ishada selections

Selections	Shoot girth (mm)								
	30 DAG			60 DAG			90 DAG		
	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)
	Stone grafting	Softwood grafting		Stone grafting	Softwood grafting		Stone grafting	Softwood grafting	
KIS-3	4.45	4.42	4.43	5.29	5.11	5.20	5.83	5.52	5.67
KIS-4	4.38	3.36	3.87	5.21	4.07	4.64	5.72	4.43	5.07
KIS-7	3.65	3.27	3.46	4.43	3.81	4.12	4.97	4.07	4.52
KIS-11	4.31	3.90	4.11	5.11	4.69	4.90	5.61	5.06	5.34
KIS-13	3.97	3.74	3.85	4.73	4.39	4.56	5.25	4.73	4.99
KIS-15	4.82	4.49	4.65	5.95	5.46	5.70	6.64	5.98	6.31
KIS-17	4.02	4.20	4.11	4.87	4.89	4.88	5.43	5.29	5.36
KIS-24	3.48	3.86	3.67	4.25	4.56	4.41	4.77	4.94	4.86
KIS-25	4.78	4.28	4.53	5.83	4.96	5.39	6.46	5.34	5.90
KIS-27	4.55	4.51	4.53	5.53	5.63	5.58	6.15	6.27	6.21
Mean (Grafting method)	4.24	4.00		5.12	4.76		5.68	5.16	
	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)
S.Em ±	0.04	0.08	0.11	0.02	0.05	0.07	0.02	0.05	0.08
C.D at 5%	0.11	0.24	0.34	0.07	0.15	0.21	0.07	0.16	0.22

DAG – Days after grafting.

'KIS-15' (4.82 mm) which was on par with stone grafting of 'KIS-25' (4.78 mm), stone grafting of 'KIS-27' (4.55 mm), softwood grafting of 'KIS-27' (4.51 mm) and softwood grafting of 'KIS-15' (4.49 mm) while the lowest shoot girth was found in softwood grafting of 'KIS-7' (3.27 mm) which was on par with softwood grafting of 'KIS-4' (3.36 mm). On the 60th day after grafting, the highest shoot girth was recorded in stone grafting of 'KIS-15' (5.95 mm) which was on par with stone grafting of 'KIS-25' (5.83 mm) while the lowest shoot girth was found in softwood grafting of 'KIS-7' (3.81 mm) which was followed by softwood grafting of 'KIS-4' (4.07 mm). On the 90th day after grafting, the shoot girth was highest in stone grafting of 'KIS-15' (6.64 mm) which was followed by stone grafting of 'KIS-25' (6.46 mm) while the lowest shoot girth was found in softwood grafting of 'KIS-7' (4.07 mm) which was followed by softwood grafting of 'KIS-4' (4.43 mm).

4.2.8 Sprout length (cm)

The data pertaining to average sprout length is presented in table 15. The sprout length was significantly different among the grafting methods, Kari Ishada selections and their interaction on 30th, 60th and 90th day after grafting. There was gradual increase of the sprout length from 30th to 90th day after grafting.

Among the two grafting methods, the sprout length was highest in stone grafting on 30th (4.08 cm), 60th (4.54 cm) and 90th day after grafting (5.14 cm) whereas, the lowest sprout length was found in softwood grafting on 30th (3.29 cm), 60th (3.70 cm) and 90th day after grafting (4.38 cm).

Among the Kari Ishada selections, the sprout length on 30th day after grafting was highest in 'KIS-15' (4.53 cm) which was on par with 'KIS-27' (4.45 cm) whereas, the lowest sprout length was recorded in 'KIS-7' (2.80 cm) which was on par with 'KIS-24' (2.96 cm). On the 60th day after grafting, the sprout length was maximum in 'KIS-15' (5.02 cm) which was on par with 'KIS-27' (4.99 cm) whereas, the minimum sprout length was recorded in 'KIS-7' (2.98 cm) which was on par with 'KIS-24' (3.17 cm). On the 90th day after grafting, the sprout length was maximum in 'KIS-15' (5.61 cm) which was on par with 'KIS-27' (5.57 cm) whereas, the minimum sprout length was recorded in 'KIS-7' (3.93 cm) which was on par with 'KIS-24' (4.12 cm).

Table 15. Effect of grafting methods on sprout length of Kari Ishada selections

Selections	Sprout length (cm)								
	30 DAG			60 DAG			90 DAG		
	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)	Grafting method		Mean (Selections)
	Stone grafting	Softwood grafting		Stone grafting	Softwood grafting		Stone grafting	Softwood grafting	
KIS-3	4.27	3.80	4.03	4.88	4.17	4.53	5.32	4.77	5.04
KIS-4	4.20	2.37	3.28	4.78	2.86	3.82	5.20	3.49	4.34
KIS-7	3.28	2.33	2.80	3.40	2.57	2.98	4.40	3.45	3.93
KIS-11	4.18	3.38	3.78	4.74	3.91	4.32	5.27	4.72	4.99
KIS-13	3.50	2.74	3.12	3.73	3.15	3.44	4.59	4.09	4.34
KIS-15	5.20	3.86	4.53	5.70	4.34	5.02	6.14	5.08	5.61
KIS-17	3.63	3.61	3.62	3.92	4.10	4.01	4.49	4.51	4.50
KIS-24	2.98	2.95	2.96	2.95	3.40	3.17	4.34	3.90	4.12
KIS-25	4.83	3.67	4.25	5.71	4.12	4.92	5.75	4.54	5.15
KIS-27	4.73	4.17	4.45	5.56	4.43	4.99	5.92	5.22	5.57
Mean (Grafting method)	4.08	3.29		4.54	3.70		5.14	4.38	
	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)	Grafting method (G)	Selections (S)	Interaction (GxS)
S.Em ±	0.04	0.09	0.13	0.05	0.10	0.15	0.05	0.11	0.16
C.D at 5%	0.12	0.26	0.37	0.14	0.31	0.43	0.15	0.33	0.47

DAG – Days after grafting.



Plate 4. The grafts of Kari Ishada selections after stone grafting (A) and softwood grafting (B)

The interaction of the grafting methods and the Kari Ishada selections showed that, on the 30th day after grafting, the sprout length was highest in stone grafting of 'KIS-15' (5.20 cm) which was followed by stone grafting of 'KIS-25' (4.83 cm) while the lowest sprout length was found in softwood grafting of 'KIS-7' (2.33 cm) which was on par with softwood grafting of 'KIS-4' (2.37 cm). On the 60th day after grafting, the sprout length was highest in stone grafting of 'KIS-25' (5.71 cm) which was on par with stone grafting of 'KIS-15' (5.70 cm) and stone grafting of 'KIS-27' (5.56 cm) while the lowest sprout length was found in softwood grafting of 'KIS-7' (2.57 cm) which was followed by softwood grafting of 'KIS-4' (2.86 cm) and stone grafting of 'KIS-24' (2.95 cm). On the 90th day after grafting, the sprout length was highest in stone grafting of 'KIS-15' (6.14 cm) which was on par with stone grafting of 'KIS-27' (5.92 cm) and stone grafting of 'KIS-25' (5.75 cm) while the lowest sprout length was found in softwood grafting of 'KIS-7' (3.45 cm) which was on par with softwood grafting of 'KIS-4' (3.49 cm) and softwood grafting of 'KIS-24' (4.54 cm).

5. DISCUSSION

Mango has a very broad genetic diversity in India representing a large gene pool. In fact, most of the present day commercial varieties are chance selections from natural seedlings. But, distinct clonal differences have been observed in the same variety in different regions. The 'Kari Ishada' variety of mango is highly popular in Uttara Kannada district of Karnataka which is clonally propagated through grafting. Even though the planting material has been multiplied vegetatively by grafting, clonal variation is routinely observed under field conditions. The clones might have mutated at micro and macro level leading to the variation. The exploitation of variation in clones for the selection of superior individuals followed by vegetative propagation has been one of the consistent themes throughout horticultural history (Mukunda, 2004). The clonal variations are often manifested in fruit characteristics besides other vegetative characteristics and yield attributes.

In the present investigation, 31 elite trees were selected and studied for their variation. All these trees were propagated vegetatively by grafting the scions from the Kari Ishada variety. These clones were studied in the present investigation for the variation in fruit morphological and qualitative parameters. The results obtained in the study are discussed in reference to other relevant reports in the literature on mango and other fruit crops as follows.

5.1 Experiment-I: Identification of the elite clones of Kari Ishada mango variety in major growing parts of Uttara Kannada District

5.1.1 Tree characters of Kari Ishada Selections

The morphological characteristics of tree are important aspects for a fruit breeder. The existence of differences in flowering season, fruiting season, tree age, canopy spread, height and fruit yield depict the enormity of variation present in Kari Ishada selections under the study.

About 85 locally available mango clones were surveyed by Singh and Ranganath (1997) in South and North Andaman and six clones with early flowering

habit and bearing good yield of quality fruits were selected for the further study. In the present investigation, the peak flowering season for different Kari Ishada selections varied from mid January to end of February and the peak fruiting season varied from mid May to mid June (Table 1). Similarly, fruiting period varied from first week of July in 'Local selection-1' to fourth week of July in 'Gola' (Kaur *et al.*, 2014). This variation in flowering and fruiting character may be due to the genetic makeup of selections.

Mango trees have different types of canopies according to propagation type, density, type of variety and eco-geographical conditions. Some varieties, such as 'Latra', are considered to have a creeper-growth habit because of its spreading nature. The biggest mango tree in the world was reported to be found in India with a spreading crown of 36.60 m x 45.70 m (Singh, 1968). The tree spread also varied among the Kari Ishada selections and highest canopy spread (NS- 22.00 m and EW- 19.00 m) was recorded in 'KIS-14' and 'KIS-18' whereas, lowest canopy spread (NS- 6.50 m and EW- 5.50 m) was found in 'KIS-5' (Table 2). Kaur *et al.* (2014) observed similar range with the highest tree spread in 'Chousa' (NS- 17.50 m and EW- 16.43 m) and the lowest in "Amrapali" (NS-5.10 m and EW-4.43 m). The tree height in mango can reach from 8.00 m to 35.00 m, depending on variety, climate, soil type and rootstock (Human, 2008). Out of the 31 Kari Ishada selections, 14 selections had large tree height of above 15.00 m, 14 selections were of medium tree height with 10.00-15.00 m and 2 selections had small tree height below 5.00 m (Table 2).

The yield was highest in 'KIS-3' with 624 kg per tree whereas, 'KIS-5' recorded the lowest yield of 61 kg per tree (Table 2). Further the yield also varied among the trees as they were of different ages. Among the selections of old age group, KIS-3 had highest yield (624 kg/tree) and 'KIS-17' had lowest yield (400 kg/tree). Among the selections of medium age group, 'KIS-25' had highest yield (477 kg/tree) whereas, 'KIS-19' had the lowest yield (117 kg/tree). 'KIS-4' had high yield (78 kg/tree) and 'KIS-5' had low yield (61 kg/tree) under young age group. The results of present investigation was supported with the work of Naik (2000) who reported the clone of 'Totapuri' mango that yielded 700.00 kg per tree at 35 years of age and Chaikiattiyos *et al.* (2000) who found that 'SK007'- a clone of 'Kaew' produced the highest fruit yield of 65.40 kg per tree at the age of 7-8 years.

The variation between the selections for different tree morphological characters may be attributed to the differences in genetic makeup of these selections and the environmental condition where they are growing. Exploitation of natural variability of the superior clones of commercial mango varieties for yield had been undertaken by several workers. 'Alphonso Bheat'- a clone of Alphonso mango isolated from Bheat in Saharanpur (Uttar Pradesh) was a low yielder (Pandey, 1984); 'Alphonso Batli'- a clone of Alphonso mango isolated from Poona (Maharashtra) was a heavy bearer (Pandey, 1984); 'Alphonso Punjab' and 'Alphonso White' (Bili Ishada) clones isolated from Punjab and North Kanara district of Karnataka state, respectively were medium to heavy yielders (Pandey, 1984); 'Paiyur 1' - a clone of Neelum had the fruit yield of 22.30 kg per tree (Vijayakumar *et al.*, 1992); 'Cardazo Mankurad' - a clone of Mankurad variety of Goa was high yielder (Mathew and Dhandar, 1997); 'Dashehari-51' clone of Dashehari tree produced an average yield of 43.40 kg fruits per tree (Negi, 2000) and 'MA-1' yielded 100.62 kg per tree (Mukunda, 2004). The high yield was also reported in 'NTI-19' (Hanumashetti and Sulikeri, 1997) and 'DT-1' (Patil *et al.*, 1997) clones of tamarind isolated from Dharwad, Karnataka.

5.1.2 Fruit characters of Kari Ishada selections

The weight of fruit will have direct impact on the yield and productivity of the clone. Among the Kari Ishada selections, the fruit weight ranged from 237.50 g in 'KIS-20' to 477.25 g in 'KIS-25' (Table 3 and fig. 1). This variation in fruit weight indicates the better chances for selection of this character. Similar results in fruit weight in the elite clones of Rumani (362.00 g), Neelum (404.20 g) and Bangalora (639.40 g) was reported by Ramaswamy (1989). Fruit weight of 121.00 g in 'Paiyur 1' (Vijayakumar *et al.*, 1991); 516.00 g in 'Osteen' (Siller *et al.*, 1994); 252.00 g in 'SK007' (Chaikiattiyos *et al.*, 2000) and 234.68 g in 'AA-5' (Mukunda, 2004) was reported. Moreover, the range of fruit weight from 178.00 g in 'BN Acc-8' to 474.00 g in 'BN Acc-25' (Begum *et al.*, 2013); 130.00 g in 'CKR Acc-19' to 380.00 g in 'CKR Acc-29' (Begum *et al.*, 2014) and 120.00 g in 'Pusa mango-7' to 510.00 g 'Pusa mango-2' (Singh *et al.*, 2015) was reported.

High pulp weight is a character which is essential for selection of the better genotypes in mango. The pulp weight among the Kari Ishada selections was found to

be varied from 124.33 g in 'KIS-6' to 310.25 g in 'KIS-3' (Table 3). Similarly, the pulp weight ranged from 76.05 g in 'CKR Acc-19' to 254.22 g in 'CKR Acc-29' (Begum *et al.*, 2014) and 50.40 g in 'Pusa mango-7' to 392.70 g in 'Pusa mango-2' (Singh *et al.*, 2015).

Peel of the mango fruit accounts to non edible portion of the fruit. Hence, less peel weight is a desirable character in mango. The peel weight in the present study varied from 48.50 g in 'KIS-17' to 125.33 g in 'KIS-25' (Table 3). Likewise, the peel weight ranged from 29.90 g in 'CKR Acc-19' to 74.10 g in 'CKR Acc-29' (Begum *et al.*, 2014) and 30.00 g in 'Pusa mango-1' to 80.00 g in 'Pusa mango-18' (Singh *et al.*, 2015).

The fruit length showed variation among the selections which ranged from 73.12 mm in 'KIS-20' to 101.05 mm in 'KIS-25'. The fruit width varied from 69.62 mm in 'KIS-20' to 100.95 mm in 'KIS-3' and the fruit thickness was in a range of 67.41 mm in 'KIS-20' to 92.17 mm in 'KIS-3' (Table 3). The variation among the accessions of 'Baneshan' ranged between 8.00 cm in 'BN Acc-5' and 13.00 cm in 'BN Acc-25' for fruit length, 6.00 cm in 'BN Acc-14' to 9.10 cm in 'BN Acc-4' for fruit width and 5.00 cm in 'BN Acc-6' to 7.90 cm in 'BN Acc-16' for thickness (Begum *et al.*, 2013) which is in conformity with the present study. Mukunda (2004); Begum *et al.* (2014); Singh *et al.* (2015) and Dinesh *et al.* (2015) also reported similar results. The variation in fruit length, fruit width and fruit thickness could not only be due to the genetic makeup of the clones but also due to the differential crop load and management of the trees under the study.

The fruit volume of Kari Ishada selections varied from 230.00 ml in 'KIS-2' to 465.00 ml in 'KIS-25' (Table 3). The clones of Alphonso also had the similar fruit volume of 227.34 ml in 'AA-5' (Mukunda, 2004). The volume of fruits was found to be lower than the fruit weight, which resulted in the value of specific gravity to be more than 1 in these selections (Table 7).

The mere pulp weight may not give the exact idea of edible portion present in the fruit. However, relative amount of the pulp gives better idea about the edible portion of fruit. The high pulp percentage, low peel percentage, low stone percentage and high pulp to stone ratio are the desirable characters in mango. Kaur *et al.*, (2014)

reported the variation in pulp/stone ratio in mango from 1.80 in ‘Local selection-1’ to 7.29 in ‘Langra Banarasi’. In the present study, pulp to stone ratio ranged from 2.53 in ‘KIS-6’ to 7.89 in ‘KIS-3’.

Pulp percentage varied between 49.68 per cent in ‘KIS-9’ and 69.56 per cent in ‘KIS-3’ (Table 4). This result is confirmed with the range of pulp contents of mango from 67.56 per cent in ‘Bemcorado’ to 83.21 per cent in ‘RC-MS-1’ (Desai and Dhandar, 2000); 53.80 per cent in ‘BN Acc-8’ to 78.10 per cent in ‘BN Acc-21’ (Begum *et al.*, 2013); 54.30 per cent in ‘CKR Acc-6’ to 67.40 per cent in ‘CKR Acc-29’ (Begum *et al.*, 2014) and 43.00 per cent in ‘Pusa mango-7’ to 77.00 per cent in ‘Pusa mango-2’ among the superior clones of mango (Singh *et al.*, 2015).

5.1.3 Stone characters

The stone weight, stone length, stone width and stone thickness which account to the non edible portion of fruit should be minimum in mango fruits for the crop improvement. Among the Kari Ishada selections, the weight of stone was found to vary from 29.00 g in ‘KIS-11’ to 67.50 g in ‘KIS-16’ (Table 5). In similar trend, the stone weight ranged from 24.00 g in ‘CKR Acc-29’ to 56.77 g in ‘CKR Acc-30’ (Begum *et al.*, 2014) and 24.00 g in ‘Pusa mango 9’ to 50 g ‘Pusa mango 2’ (Singh *et al.*, 2015).

The stone length of the selections varied from 48.81 mm in ‘KIS-20’ to 75.30 mm in ‘KIS-16’. The stone width of the selections varied from 33.25 mm in ‘KIS-20’ to 42.39 mm in ‘KIS-8’. The stone thickness of the selections varied from 18.07 mm in ‘KIS-19’ to 29.15 mm in ‘KIS-9’ (Table 5). The similar variation was found for stone length (7.57 to 8.62 cm), stone width (3.52 to 3.93 cm) and stone thickness (2.22 to 2.57 cm) in the mango accessions characterized by Kheshin *et al.* (2016).

The variation in morphological parameters of the fruits and stones in the Kari Ishada selections may be attributed to the difference in genetic makeup of individual trees that are selected.

5.1.4 Quality parameters

Total soluble solids (TSS) are measure of the amount of material dissolved in water. This dissolved material can include carbonate, bicarbonate, chloride, sulfate,

phosphate, nitrate, calcium, magnesium, sodium, organic ions and others. The TSS which mainly imparts sweetness to the pulp of fruits showed variation among different Kari Ishada selections which ranged from 15.50 °B in 'KIS-28' to 22.83 °B in 'KIS-24' (Table 6 and fig. 6). The TSS of mango fruits similarly ranged from 15.31 °B in 'Gen Alphonso' to 18.07 °B in 'MA-1' (Mukunda, 2004); 10.00 °B in 'Janisahab Karkan' to 19.50 °B in 'Clone V-2' (Pandey *et al.*, 2006); 15.20 °B in 'BN Acc-20' to 22.00 °B in 'BN Acc-23' (Begum *et al.*, 2013); 14.50 °B in 'CKR Acc-22' to 19.70 °B in 'CKR Acc-30' (Begum *et al.*, 2014) and 15.55 °B in 'Pusa mango-7' to 21.50 °B in 'Pusa mango-10' (Singh *et al.*, 2015).

The acidity present in fruit is due to the presence of organic acids, which give the sour taste to fruits. The titrable acidity in the present study was found to be varied from 0.33 per cent in 'KIS-13' to 0.56 per cent in 'KIS-8' (Table 6). Likewise, titrable acidity ranged from 0.06 per cent in 'Abdullah Great' to 0.30 per cent in 'Clone S-1' (Pandey *et al.*, 2006) and 0.20 per cent in 'Pusa mango-13' to 0.75 per cent in 'Pusa mang-3' (Singh *et al.*, 2015).

The sweetness of the fruit pulp is due to conversion of starch into sugars resulting from starch hydrolysis (Aina, 1990). In fruits, different sugars are present in certain forms like reducing and non-reducing in varying amount. Reducing sugars are those sugars (Hexose-C₆H₁₂O₆), which can reduce compounds such as alkaline silver nitrate solution, cupric salt solution *etc.* When these sugars make reduction reactions, they themselves get oxidized (Mazumdar and Majumdar, 2003). In the present study, the range was from 12.34 per cent in 'KIS-28' to 21.21 per cent in 'KIS-24' for total sugars, 2.13 per cent in 'KIS-28' to 8.09 per cent in 'KIS-25' for reducing sugars and 9.26 per cent in 'KIS-2' to 13.17 per cent in 'KIS-24' for non reducing sugars (Table 6). Similarly, the total sugars varied from 12.97 per cent in 'Gen Alphonso' to 13.93 per cent in 'AA-5' among the clones of Alphonso (Mukunda, 2004). The reducing sugars ranged from 2.12 per cent in 'Pope' to 6.18 per cent in 'Almas' and non reducing sugars ranged from 2.22 per cent in 'Collector' to 9.21 per cent in 'Pope' among mango varieties (Jamil *et al.*, 2015).

The Brix acid ratio mainly creates a sense of taste. Sweetness due to sugars from conversion of the starch and sourness from organic acids are principal components in the taste of many fruits (Kays, 1991). The quality fruits have higher

Brix-acid ratio whereas, fruits of less quality have lower Brix-acid ratio (Shafique *et al.*, 2006). Brix acid ratio of Kari Ishada selections in the present study ranged from 28.16 in 'KIS-8' to 63.66 in 'KIS-25' (Table 6). Mukunda (2004) reported the similar range of Brix acid ratio of the clones of Alphonso from 48.80 in 'Gen Alphonso' to 62.03 in 'MA-2'.

The difference in chemical constituents of the fruit can be attributed to the clonal variation. The clone might have mutated at micro and macro level leading to the variation in these quality attributes (Mukunda, 2004).

5.1.5 Post harvest parameters

The developing fruits increase in weight initially and reduce to some extent after ripening (Mannan *et al.*, 2003). Factors like respiration, transpiration and biological aspects are responsible for the physiological loss in weight (PLW) in mango during ripening. The PLW of Kari Ishada selections was in the range of 3.77 per cent in 'KIS-4' to 6.18 per cent in 'KIS-22' (Table 7). The similar trend for PLW was reported in Alphonso clones from 6.90 per cent in 'MA-2' to 12.50 per cent in 'Gen Alphonso' (Mukunda, 2004).

The longer shelf life is beneficial character in selection of the good mango genotypes. The shelf life among Kari Ishada selections ranged from 5.75 days in 'KIS-22', 'KIS-21', 'KIS-12' and 'KIS-29' to 8.25 days in 'KIS- 4' and 'KIS-7' (Table 7). The range of shelf life from 4-5 days in 'Faiz Kareem' to 8-10 days in 'Kala Chousa' varieties reported by Rajwana *et al.* (2011) is similar to the present study. The shelf life of fruit is reliant on textural softness that is due to cell wall alteration ensuring in structural changes in starch and non-starch polysaccharide (Yashoda *et al.*, 2006). Postharvest shelf life and quality of mango fruits decrease with enhanced textural softness and respiration rate during ripening period (Razzaq *et al.*, 2013).

There was non significant difference among the Kari Ishada selections for specific gravity. However, the specific gravity ranged from 1.01 g per cc in 'KIS-13', 'KIS-14' and 'KIS-19' to 1.07 g per cc in 'KIS- 17' (Table 7). Similarly, specific gravity of the mango varieties in Kerala varied from 1.00 g per cc in 'H-151' to 1.02 g per cc in 'Alphonso' (Anila and Radha, 2003).

5.1.6 Sensory evaluation

In addition to the fruit morphological and quality parameters, the sensory qualities play a vital role for the overall acceptance of the fruits. Fruit ripening phase plays a key role in the judgment of sensory attributes and acceptability. Ripening of mango involves various metabolic changes *viz.*, ethylene production, softening, increased respiration, breakdown of chlorophyll and conversion of starch into sugars *etc.*, which contribute towards the sensory profile build up of mango (Herianus *et al.*, 2003).

The coloration is a quality attribute that is more attractive to the consumer which may vary due to the difference in concentration of pigments (Chitarra and Chitarra, 2005). The sensory evaluation score for peel colour varied from 3.08 in 'KIS-31' to 5.92 in 'KIS-2' whereas, the pulp colour score varied from 3.70 in 'KIS-20' to 7.36 in 'KIS-17' (Table 8). Aina and Oladunjoye (1993) along with Tucker and Grierson (1987) reported that, color changes are attributed with biochemical changes like degradation and accumulation of various carotenoids pigments such as esters, lycopene, β -carotene and xanthophylls. Iyer (1991) found that yellow color dominates orange color.

The sensory evaluation score for pulp texture varied from 4.93 in 'KIS-20' to 7.38 in 'KIS-24' while the score for taste varied from 3.96 in 'KIS-20' to 7.96 in 'KIS-11' (Table 8). The sensory evaluation score for overall acceptance ranged from 3.96 in 'KIS-20' to 7.53 in 'KIS-3' which was most acceptable among the Kari Ishada selections. Along with 'KIS-3', the selections 'KIS-15', 'KIS-7', 'KIS-13' and 'KIS-4' were excellent for the overall acceptability (Table 8). Similarly, overall acceptance was maximum in 'MA-1' followed by 'AA-4' (Mukunda, 2004). The score ranged between 4.48 in 'Fazri' and 8.85 in 'Samar Bahisht Chousa' for overall acceptance (Naz *et al.*, 2014). The results are also in confirmation with Nagabhushanam and Mathew (1994); Anila and Radha (2003); Rajwana *et al.* (2011); Ribeiro *et al.* (2013) and Naz *et al.* (2014).

5.2 Experiment-II: Grafting studies of Kari Ishada selections

In perennial trees like mango, asexual propagation like grafting renders preservation of the variations that might be accumulated through mutations which offers scope for the selection of good clones within a cultivated variety (Iyer and Mukunda, 1998). The graft success vary depending on the genotype of scions and the grafting methods. In the present study, the best 10 out of 31 selections of Kari Ishada were vegetatively propagated through the two different grafting methods *viz.*, stone grafting and softwood grafting. The results obtained in the study are discussed here in reference to appropriate literature.

5.2.1 Graft success

The graft success in stone grafting (62.00 %) was significantly high than graft success found in softwood grafting (53.50 %) which is presented in table 9. Likewise, the success of stone grafting was reported to be 64.44 per cent (Alam *et al.*, 2006); 63.33 per cent (Kaur and Malhi, 2006); 65.00 per cent (Upadhyia *et al.*, 2014) and 69.00 per cent (Singh *et al.*, 2014). In softwood grafting, the similar success of 56.86 per cent was reported by Krishna (2000).

Higher success of stone grafting might be due to stronger and complete union of epicotyl grafted bud before sprouting. The preservation of more food material in cotyledon and actively growing stage of rootstock that enhance the graft union might be the reason for greater success in stone grafting. The equal and optimum level of metabolic activity in rootstock and scion enables proper graft union and the better success of stone grafting (Upadhyia *et al.*, 2014). The moderate temperature and high relative humidity are major factors related to success of grafts (Litz, 1997). The better growth of cambium in scion and rootstock in favorable climate helped for the higher success in stone grafting (Singh *et al.*, 2012). The congenial temperature (28.50 °C), high relative humidity (88.30 %) and good amount of shower (51.5 mm) received during the month of August has resulted in higher success in stone grafting (Appendix I).

The graft success among Kari Ishada selections ranged from 40.00 per cent in 'KIS-7' to 75.00 per cent in 'KIS-15' (Table 9). Similarly, graft success varied from

36.66 per cent in 'Kesar' to 59.99 per cent in 'Totapuri' (Shantagouda *et al.*, 2008). The variation in graft success may be attributed to the differences in endogenous phenolic components in the genotypes. The interaction of Kari Ishada selections and grafting methods got the graft success in the range of 35.00 per cent in softwood grafting of 'KIS-7' to 85.00 per cent in stone grafting of 'KIS-15' (Table 9). These findings are in confirmation with Reddy *et al.* (1994); Prashanth *et al.* (2006); Alam *et al.* (2006); Prajapati *et al.* (2014) and Ram *et al.* (2015).

The variation in graft success might be due to the compatibility of different selections with rootstocks which is affected by the method of grafting. Maiti and Biswas (1980) opined that variation in the graft success among different genotypes may be due to the genetic makeup influencing histological and physiological development within the grafts. The histological studies by Abd El-Zaher (2008) illustrated that, graft anatomical features of Jackfruit varied according to grafting types and the compatibility between scions and rootstocks that correlated with the grafting success percentage. The highest graft success in 'KIS-15' in the present study may be due to greater formation of wound periderm. The graft union is initially formed by rapidly dividing callus cells originating from the scion and rootstock, which later differentiate to form the vascular cambium and associated vascular system (Moore, 1981).

5.2.2 Graft survival

The highest graft survival of 66.75 per cent was recorded in stone grafting and lowest survival of 57.39 per cent was recorded in softwood grafting (Table 9). There was non significant differences among Kari Ishada selections and their interaction with grafting methods for the graft survival. However, graft survival ranged from 50.42 per cent in 'KIS-7' to 69.94 per cent in 'KIS-27' whereas, the interaction showed the range of 45.83 per cent in softwood grafting of 'KIS-7' to 76.39 per cent in stone grafting of 'KIS-15' (Table 9). In agreement to these findings, the survival per cent of 66.66 per cent (Reddy and Kohli, 1989); 79.80 per cent (Shakur and Reza, 1995); 76.67 per cent (Alam *et al.*, 2006); 50.55 per cent (Singh *et al.*, 2012) and 70.00 per cent (Prabhat and Nidhika, 2016) was reported in stone grafting of mango. Graft survival range of 76.35 per cent in 'Arka Puneeth' to 83.29 per cent in 'Amrapali' (Shantagouda *et al.*, 2008) and 61.18 per cent in 'Local-3' to 76.29 per cent in 'Kesar' (Prajapati *et al.*, 2014) was reported in mango.

High grafting success in stone grafting has led to the higher graft survival too. Production of new xylem and phloem permits the vascular connection between scion and rootstock, which in turn has resulted in the graft survival. The spaces in graft union region between the two graft partners lead to good connection that consequently could pass water and nutrients through the callus area towards the upper scion for feeding it to stay alive (Omima *et al.*, 2012). The non significance in graft survival among the Kari Ishada selections and their interaction with the grafting method is probably due to the greater temperature fluctuations between day and night in October (Appendix-I). Xylem and phloem might not have conducted the water and nutrients efficiently. Due to stress condition, the xylem lumen becomes narrow which hinders the translocation of water and nutrients. High rate of transpiration and low humidity adversely affect the survival of grafts (Ram and Sirohi, 1985). As a result of higher temperature, desiccation of the rootstock causes lesser reserve food material (Kulwal and Tayde, 1989). The enlarging leaf surface on scion shoots will end up with little or no water to offset the moisture that is lost by transpiration. The scion quickly becomes desiccated and dies thus causing low survival (Hartman *et al.*, 2002).

5.2.3 Number of days for sprouting

The difference in number of days for sprouting was significant among the grafting methods, Kari Ishada selections and their interaction (Table 10). The number of days for sprouting was less in stone grafting (14.50) compared to softwood grafting (16.10) which might be due to comparatively more secured cambium contacts between stock and scion in stone grafting resulting in early callus development leading to quicker repair of cells. The rapid formation of callus (parenchymatous) tissues allows translocation of vital biochemical compounds between stock and scion and has resulted in the minimum days to sprout in stone grafting. In the same way, number of days taken for sprouting varied from 11.00 to 16.00 in stone grafting of mango (Upadhyia *et al.*, 2014) and softwood grafting of mango took an average of 23.33 days to sprout (Singh *et al.*, 2012).

Among the Kari Ishad selections, the lowest of 13.47 days were taken for sprouting in 'KIS-15' whereas, the interaction found that stone grafting of 'KIS-15' got the lowest of 12.41 days to sprout (Table 10). The similar result was obtained in mango varieties like 'Langra' with 14.31 days (Alam *et al.*, 2006); 'Peach' with 12.83

days (Baita *et al.*, 2010) and ‘Rajapuri’ with 14.67 days to sprout (Ram *et al.*, 2015). The better union of stock and scion in ‘KIS-15’ in the present study might have easily supplied the required nutritional quantity to the grafts for earlier sprouting. The variation also might be due to the difference in endogenous substances such as phenols and latex. Presence of more concentrated latex and hardness of rootstock which hinders the process of graft union results in maximum days to complete sprouting (Pandiyan *et al.*, 2011).

5.2.4 Graft height

The graft height was significantly high in softwood grafting on the 30th (22.27 cm), 60th (24.34 cm) and 90th day after grafting (27.77 cm) which is presented in table 11. The softwood grafting has recorded the better height, but the increase in the graft height from 30 days to 90 days after grafting is greater in stone grafting (10.07 cm) compared to the height increase in softwood grafting (5.57 cm). The graft height was highest in ‘KIS-27’ on 30th (19.88 cm) and 60th day after grafting (23.33). ‘KIS-15’ had the highest graft height of 29.63 cm on 90th day after grafting. The interaction responded with the highest graft height in softwood grafting of ‘KIS-27’ which had recorded 25.75 cm, 29.57 cm and 34.10 cm on 30th, 60th and 90th day after grafting, respectively (Table 11). The same trend in graft height with 30.68 cm in ‘Amrapali’ on 90th day after grafting was reported by Ram *et al.* (2015). These results corroborate with the findings of Singh *et al.* (2014) and Shinde *et al.* (2015).

The better graft height of softwood grafting than stone grafting is due to the reason that, the grafting operation was done at the greater height in softwood grafting (around 15 cm) compared to stone grafting (around 5 cm). Further, the better combination of rootstock and scion with the proper development of xylem and phloem tissues from the callus cells results in the better increase in height of the grafts as seen in stone grafting. The difference in graft height among different Kari Ishada selections in the study is probably due to the variation in the vigour of individual selections and the early sprout emergence of grafts.

5.2.5 Number of sprouts per graft

The stone grafting had recorded the highest number of sprouts on 30th (1.41), 60th (1.64) and 90th day after grafting (1.91). ‘KIS-15’ had the highest number of

sprouts on 30th (1.63), 60th (1.90) and 90th day after grafting (2.28). The interaction showed that the stone grafting of 'KIS-15' had the most number of sprouts of 1.85, 2.05 and 2.45 on 30th, 60th and 90th day after grafting, respectively (Table 12). The number of sprouts of 1.94 in 'Amrapali' (Islam, 2004) and 2.05 in 'Langra' (Alam *et al.*, 2006) confirms the present study.

The selection 'KIS-15' has responded well to grafting by producing more number of sprouts probably due to the better bridging of graft union and well formed conducting tissues. The variation in the number of sprouts in grafts may be due the difference in cell division and differentiation capacity in the different Kari Ishada selections which might have happened due to the growth in meristematic cells coupled with physiological processes like photosynthesis and respiration. The difference in the number of nodes and absorption of leaf primordia also might have caused the variation in number of sprouts. Early callus formation that occurs from the rootstock component producing good union helps in the production of more number of sprouts (Asante and Barnett, 1977).

5.2.6 Number of leaves per graft

The maximum number of leaves was recorded in stone grafting after 30th (5.46), 60th (7.20) and 90th day after grafting (8.76) which is presented in table 13. Similarly, the number of leaves ranging from 7.6 to 10 at 120 days of grafting in stone grafting of mango was reported by Singh *et al.* (2014). The selection 'KIS-15' had most number of leaves on 30th (6.48), 60th (8.32) and 90th day after grafting (9.82). The interaction effect had most number of leaves in stone grafting of 'KIS-15' with 7.18, 9.07 and 10.40 on the 30th, 60th and 90th day after grafting (Table 13). Similarly, the number of leaves of 6.23, 7.63 and 8.64 in 'Pairi' was recorded at 30, 60 and 90 days after grafting, respectively (Shantagouda *et al.*, 2008). The highest number of leaves in 'KIS-15' might be due to more mechanical fit of the two cambium layers and proper hormonal level in the tissue. The different number of leaves in different Kari Ishada selections might be due to the variation in formation of callus and vascular continuity. These findings were in agreement with Singh and Suryanarayana (1996); Alam *et al.* (2006); Prajapati *et al.* (2014) and Ram *et al.* (2015).

5.2.7 Shoot girth

The shoot girth determines the vigour of grafts. The grafts with thicker shoots are considered to have better growth and vigour. Stone grafting recorded highest shoot girth on 30th (4.24 mm), 60th (5.12 mm) and 90th day after grafting (5.68 mm) which is presented in table 14. 'KIS-15' had the thickest shoot girth on the 30th (4.65 mm), 60th (5.70 mm) and 90th day after grafting (6.31 mm). Among the interactions, stone grafting of 'KIS-15' had the highest shoot girth of 4.82 mm, 5.95 mm and 6.64 mm on 30th, 60th and 90th day after grafting, respectively (Table 14). The similar shoot girth of 6.2 mm was reported in stone grafting of 'Langra' by Alam *et al.* (2006). The better uptake of nutrients and water which increase the photosynthetic efficiency due to more number of leaves (Table 13) has resulted in better growth of the shoots.

5.2.8 Sprout length (cm)

The sprout length was highest in stone grafting on 30th (4.08 cm), 60th (4.54 cm) and 90th day after grafting (5.14 cm). 'KIS-15' had the highest sprout length on the 30th (4.53), 60th (5.02 cm) and 90th day after grafting (5.61 cm). The interaction of the stone grafting and 'KIS-15' recorded the highest sprout length of 5.20 cm, 5.71 cm and 6.14 cm on 30th, 60th and 90th day after grafting, respectively (Table 15). In the same trend, highest sprout length of 6.00 cm was found in stone grafting of mango by Singh *et al.* (2014). Moreover, Shantagouda *et al.* (2008) reported the sprout length of 3.12 cm, 6.05 cm and 6.50 cm in 'Arka Puneeth' at 30, 60 and 90 days after grafting. The better sprout length of grafts are due to the early emergence of buds in 'KIS-15' which can be inferred from table 10.

Future line of work

1. Morphological and molecular characterization of the Kari Ishada variety can be undertaken.
2. The crop improvement work can be carried out to enhance the shelf life of the variety.
3. Effect of age of rootstock on the grafting of the Kari Ishada mango can be studied.

6. SUMMARY AND CONCLUSIONS

The investigation entitled “Identification of elite clones of Kari Ishada mango cultivar in major growing parts of Uttara Kannada district and its grafting studies” was carried out. Survey was done in Ankola and Kumta regions. The fruits were studied for morphological and qualitative traits in the Department of Fruit Science, Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka during 2015-16. The better selections (10 out of 31 selections) were vegetatively propagated through the two different grafting methods *viz.*, stone grafting and softwood grafting in the nursery of the college. The results obtained are summarized in this chapter.

6.1 Identification of elite clones of Kari Ishada mango cultivar in major growing parts of Uttara Kannada District

Among the 31 Kari Ishada trees selected in the present investigation, 12 belonged to old age group, 17 of them were in medium age group and two belonged to young age. The peak flowering season was from mid January to the end of February and the peak fruiting season was from mid May to mid June for the different Kari Ishada selections. The highest canopy spread (NS- 22.00 m and EW- 19.00 m) was recorded in ‘KIS-14’ and lowest canopy spread (NS- 6.50 m and EW- 5.50 m) was recorded in ‘KIS-5’. Large tree height of above 15 m was found in 14 selections and medium tree height with 10-15 m was found in 15 selections. Two selections had small tree height below 5.00 m. The fruit yield was highest in ‘KIS-3’ (624 kg/tree) and lowest yield was recorded in ‘KIS-5’ (61 kg/tree).

The maximum fruit weight (477.25 g), peel weight (125.33 g), fruit length (101.05 mm) and fruit volume (465 ml) was found in ‘KIS-25’. The maximum pulp weight (310.25 g), fruit width (100.95 mm), fruit thickness (92.17 mm), pulp percentage (69.56 %), pulp to stone ratio (7.89), fruit to stone ratio (11.28) and lowest stone percentage (9.05 %) was recorded in ‘KIS-3’. The highest pulp to peel ratio (4.47), lowest peel weight (48.50 g) and lowest peel percentage (18.89 %) was found in ‘KIS-17’. The stone weight was lowest in ‘KIS-11’ (29.00 g).

‘KIS-24’ had the highest values for TSS (22.83 °B), total sugars (21.21 %) and non reducing sugars (13.17 %). ‘KIS-25’ had highest reducing sugars (8.09 %) while

the titrable acidity was highest in 'KIS-8' (0.56 %). The highest shelf life of 8.25 days was recorded in 'KIS- 4' and 'KIS-7'.

6.2 Grafting studies of Kari Ishada selections

The graft success of stone grafting (62.00 %) was best for the Kari Ishada selections. 'KIS-15' (75.00 %) had the highest graft success and the lowest was obtained in 'KIS-7' (40.00 %). The interaction effect of the Kari Ishada selections and the grafting methods recorded the highest graft success in stone grafting of 'KIS-15' (85.00 %) and the lowest graft success was recorded in softwood grafting of 'KIS-7' (35.00 %).

Stone grafting was best for graft survival (66.75 %) while softwood grafting got least survival (57.39 %) in Kari Ishada selections. There was non significant difference among the Kari Ishada selections and their interaction with the grafting methods for the graft survival. However, the graft survival was lowest in 'KIS-7' (50.42 %) and highest in 'KIS-15' (69.15 %). Among the interactions, graft survival was highest in stone grafting of 'KIS-15' (76.39 %) and the lowest graft survival was recorded in softwood grafting of 'KIS-7' (45.83 %).

Stone grafting took less number of days to sprout (14.50) than the softwood grafting (16.10). The number of days for sprouting was lowest in 'KIS-15' (13.47) and highest in 'KIS-7' (17.20). The interaction effect showed that, the least number of days for sprouting was recorded in 'KIS-15' (12.41) and the highest was recorded in softwood grafting of 'KIS-7' (18.33).

Stone grafting proved to be the best for the Kari Ishada selections for the growth parameters like number of sprouts (1.91), number of leaves (8.76), shoot girth (5.68 mm) and sprout height (5.14 cm). 'KIS-15' showed the best results for the growth parameters like graft height (29.63 cm), number of sprouts (2.28), number of leaves (9.82), shoot girth (6.31 mm) and sprout length (5.61 cm). Among the interactions, softwood grafting of 'KIS-27' had the highest graft height (34.10). The stone grafting of 'KIS-15' was the best for growth parameters like number of sprouts (2.45), number of leaves (10.40), shoot girth (6.64 mm) and sprout length (6.14 cm).



Plate 5. Kari Ishada selection-3

The growth parameters of 'KIS-7' recorded least values for graft height (22.46 cm), number of sprouts (1.39), number of leaves (7.01), shoot girth (4.52 mm) and sprout length (3.93 cm). Among the interactions, stone grafting of 'KIS-24' had the lowest graft height (20.54). The softwood grafting of 'KIS-7' had the least values for growth parameters like number of sprouts (1.25), number of leaves (6.67), shoot girth (4.07 mm) and sprout length (3.45 cm).

Conclusion

Among the 31 Kari Ishada selections, 'KIS-3' was superior for the fruit morphological and qualitative parameters. It had the highest yield, pulp weight, fruit width, fruit thickness, pulp percentage, stone percentage, pulp to stone ratio and fruit to stone ratio. The organoleptic evaluation inferred that 'KIS-3', 'KIS-15', 'KIS-7', 'KIS-13' and 'KIS-4' were excellent for the overall acceptability.

Stone grafting was the best method of grafting compared to the softwood grafting for the Kari Ishada selections. Among the Kari Ishada selections 'KIS-15' responded best for the grafting and the response of 'KIS-7' was the least. In the interaction of the grafting methods and the Kari Ishada selections, 'KIS-27' proved to be the best for softwood grafting and 'KIS-15' was the best for stone grafting.

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**Appendix I: Meteorological data recorded during the period of experimentation
(April 2015 to March 2016 at Agricultural Research Station),
Arabhavi for the year 2015-2016)**

Month	Rainfall (mm)	Temperature (°C)		Relative humidity (%)
		Maximum	Minimum	
	2015-2016	2015-2016	2015-2016	2015-2016
April 2015	22.6	36.8	20.2	82.1
May	93.8	38.0	22.7	85.5
June	20.9	31.4	21.2	85.5
July	19.9	31.1	20.7	84.5
August	51.5	30.9	19.9	88.3
September	66.9	31.9	18.9	89.4
October	99.0	34.6	18.3	89.9
November	24.3	30.9	14.8	87.7
December	5.4	32.6	14.0	91.3
January 2016	0.3	31.5	10.4	88.9
February	1.1	35.9	14.5	91.7
March	6.4	37.3	16.3	84.3

Appendix II: List of symbols and abbreviations

Symbols	Abbreviations
%	Per cent
@	At
⁰ C	Degree celcius
cm	Centimeter
cm ²	Centimeter square
cc	Centimeter cube
m	Meter
m ²	Meter square
mm	Millimeter
mg	Milligram
μg	Microgram
g	Gram
kg	Kilogram
ml	Milliliter
⁰ B	Degree Brix
C.D	Critical difference
S.Em.	Standard Error of Mean
SD	Standard deviation
cv.	Cultivar
<i>et al.</i>	Et all (and other)
<i>i.e.</i>	That is
<i>viz.</i>	As follows
TSS	Total soluble solids
TA	Titration acidity

**IDENTIFICATION OF ELITE CLONES OF KARI ISHADA MANGO
CULTIVAR IN MAJOR GROWING PARTS OF UTTARA KANNADA
DISTRICT AND ITS GRAFTING STUDIES**

SAMPATH P. M.

2016

**Dr. NAGESH NAIK
Major Advisor**

ABSTRACT

The investigation entitled ‘Identification of elite clones of Kari Ishada mango cultivar in major growing parts of Uttara Kannada district and its grafting studies’ was carried out. Survey was made during the fruiting season in Ankola and Kumta taluks of Uttara Kannada district. The fruits and scions were brought to the Department of Fruit Science, Kittur Rani Channamma College of Horticulture, Arabhavi and were used for studying the physicochemical characters as well as the grafting performances, respectively during 2015-16.

Among the 31 Kari Ishada clones selected, the fruit yield was highest in ‘KIS-3’ (624 kg/tree). The maximum fruit weight (477.25 g), peel weight (125.33 g), fruit length (101.05 mm) and fruit volume (465 ml) was found in ‘KIS-25’. The maximum pulp weight (310.25 g), fruit width (100.95 mm), fruit thickness (92.17 mm), pulp percentage (69.56 %), pulp to stone ratio (7.89) and lowest stone percentage (9.05 %) was recorded in ‘KIS-3’. The highest pulp to peel ratio (4.47) and lowest peel percentage (18.89 %) was found in ‘KIS-17’. The stone weight was lowest in ‘KIS-11’ (29.00 g). ‘KIS-24’ had maximum TSS (22.83 °B), total sugars (21.21 %) and non reducing sugars (13.17 %). ‘KIS-25’ had maximum reducing sugars (8.09 %) while titrable acidity was highest in ‘KIS-8’ (0.56 %). The highest shelf life of 8.25 days was recorded in ‘KIS- 4’ and ‘KIS-7’.

The ten better selections were vegetatively propagated through two different grafting methods viz., stone and softwood grafting. The highest graft success (62.00 %) and survival (66.75 %) was found in stone grafting. Among the selections, the maximum graft success (75.00 %) and graft survival (69.15 %) was found in ‘KIS-15’. The interactions between the grafting methods and Kari Ishada selections showed the highest graft survival in stone grafting of ‘KIS-15’ (76.39 %).

**Gvlnj PqA f-aiA yBAr .. BUVAE .. EIAA PA F±AqA A «EAVAiAGvlnjA
vZAVNADAiE aAVNPA «ZAEUAKAZAIEA**

AVi |. J^aA

2016

qA. EAUEi EAiIRi
aARa , A°EAggA

AgAA±A

YAVNj A±EAZEUÉ , ASACZiZAVÉ Gvlnj PqA f-aiA yBAr .. AUUMR e Pj F±AqA
vZaiA aAA«EA Gvlnj vZAEUAKA DAIiE aAVN PA «ZAEUAKA CZAIIEP EAB aAAqA AVVNU
kAAPAIIEAB Gvlnj PqA f-aiA CAPKEA® aAVN PA AmA vA®EPAUMR e EAqE AVVNU °AtAUKA
±Aj Aj PA aAVN UAt °PAtUKA CZAIIEP EAB °AtAU ±A, «'UJ QvKEGJA gAtA ZIEP Aa
vEAI UAj PA aA°A«ZAAiAZP e aAAqA A-AN.

YAVNj A±EAZEIAiA°e DAIiY 31 Pj F±AqA aAgUMR YEO 'PILJ ,i-3' CwA °EZAN
EVAaj (624 PEF./aAg) °EACVNU 'PILJ ,i- 25' Uj µk °AtIEA vKEPA (477.25 UAAe), 1Yi
vKEPA (125.33 UAAe), °AtIEA Gzi (101.05 «A. «AA.) aAVN °AtIEA Yj aAAt (465 «A.
°A.) °EACVNU 'PILJ ,i-3' gP e Uj µk wGVA vKEPA (310.25 UAAe), °AtIEA CUP® (100.95
«A. «AA.), °AtIEA ZMA (92.17 «A.«AA.), wGVA EA CA±A (69.56 ±A.), wGVA aAVN NmAIa
CEA¥AvA (7.89) aAVN Pkµk NmAIa CA±P EAB (9.05 ±A.) °EACVNU 'PILJ ,i-17' gP e
Uj µk wGVA °AUa 1YiAIa CEA¥AvA (4.47) °AUKE Pkµk 1YiAIa CA±A (18.89 ±A.)
PAqASACZE 'PILJ ,i-11' Pkµk NmAIa vKEPA (29.08 UAAe) °EACVNU 'PILJ ,i-24' Uj µk
nJ ,iJ ,i (22.83 °B), MI AO ,PjE CA±A (21.21 ±A.) aAVN PjUZA ,PjE (13.17 ±A.)
°EACVNU Uj µk PjUS®e ,PjE (8.09 ±A.) 'PILJ ,i-25' gP e PAqASACZE °AUKE Uj µk
DAAVE 'PILJ ,i-8' gP e PAqASACZE Uj µk °AtIEA fAAaAcu 'PILJ ,i-4' °AUa 'PILJ ,i-7'
gP e PAqASACZE

Gvlnj Pj F±AqA DAIiUMR EAB (31 gP e 10), PA-ÅFEA ,R vEAI ZP u NmE Pk
°AUKE aAZA PAAqA Pk «ZAEUMR e , AU®P BCP aAAqA A-AN. NmE Pk °EIEA AiA±A i
(62.00 ±A.) aAVN SZAPAVAIaA aA ,AZME (66.75 ±A.) °EACVNU Pj F±AqAZA DAIiUMR YEO
Uj µk AiA±A i (75.00 ±A.) aAVN SZAPAVAIaA aA ,AZME (66.75 ±A.) 'PILJ ,i-15' gP e
PAqASACVNU Pj F±AqA DAIiUMR °AUKE Pk «ZAEUMR YGJA Yj uA°ACAZA 'PILJ ,i-
15'gA NmE Pk AiA±A i Uj µk AiA±A i (76.39 ±A.) vEaj 1ZE